# United States Patent

**Beckham et al.**

[15] **3,673,981**

[45] **July 4, 1972**


## [54] FILMING APPARATUS


[72] Inventors: **Robert R. Beckham; Emmett L. Walters; Jack G. Brown; Kenneth M. De Rose; Joseph D. Ryan,** all of Toledo, Ohio

[73] Assignee: **Libbey-Owens-Ford Company,** Toledo, Ohio



[22] Filed: **May 13, 1969**

[21] Appl. No.: **862,998**

**Related U.S. Application Data**

[60] Division of Ser. No. 664,440, Aug. 30, 1967, Pat. No. 3,495,724, which is a continuation-in-part of Ser. No. 568,514, July 29, 1966, abandoned.

[52] **U.S. Cl.** ..... **118/6,** 118/49.1, 118/503

[51] **Int. Cl.** ..... **B05c 11/00**

[58] **Field of Search** ..... 118/2, 4, 6, 7, 8, 48–49.5, 118/500, 503, 50, 50.1; 117/106–107.2



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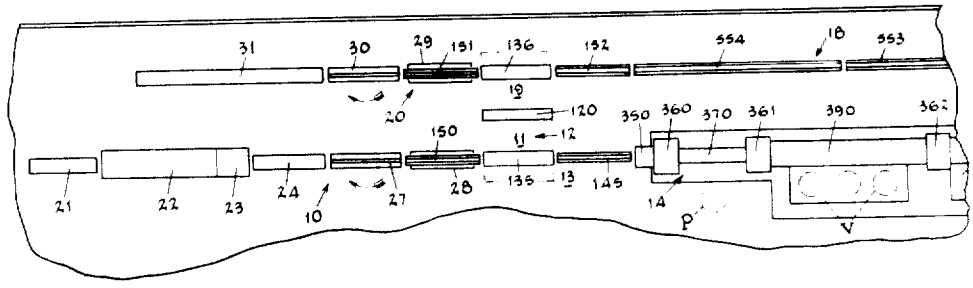
*Primary Examiner*—Morris Kaplan
*Attorney*—Collins & Oberlin

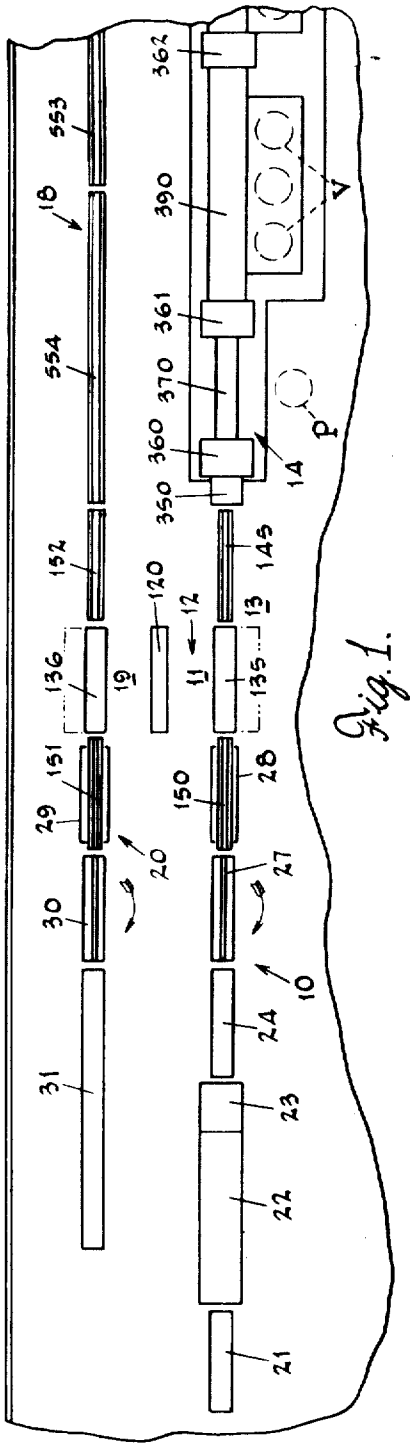


[57] **ABSTRACT**

System for the vacuum deposition of thin films on sheet material including a plurality of vacuum chambers arranged in end-to-end relation to one another, one of the chambers constituting a filming chamber, valve compartments disposed between adjacent chambers for placing them in communication when open and separating them when closed together with similar compartments located at the respective entry and exit ends of the plurality of chambers, conveying means for moving sheet material through successive chambers and including carriers for clamping individual sheets along their upper edges and maintaining same in a substantially vertical position, means responsive to the positioning of the material in the chambers to permit opening and closing of the valve compartments in predetermined sequence, and means outwardly of the entry and exit valve compartments for aligning and positioning the sheet material for travel through the chambers and subsequent unloading thereof.


**68 Claims, 161 Drawing Figures**





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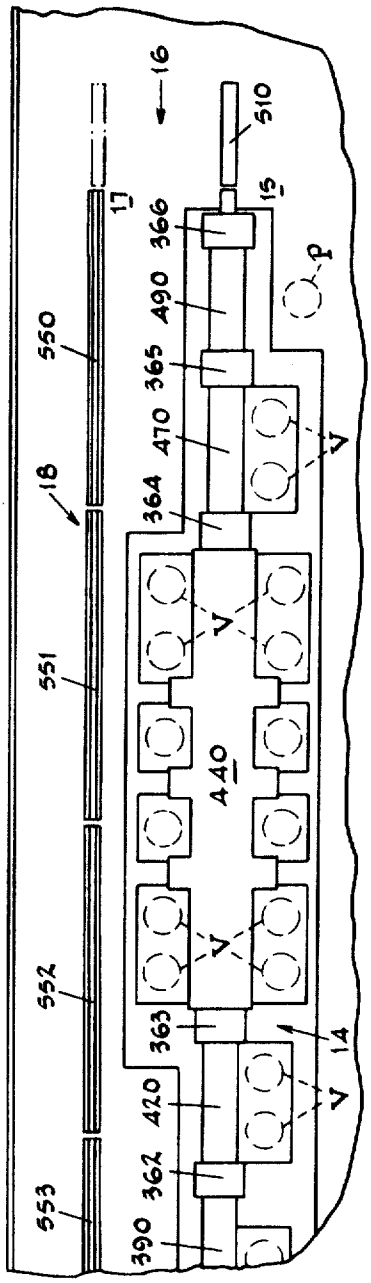

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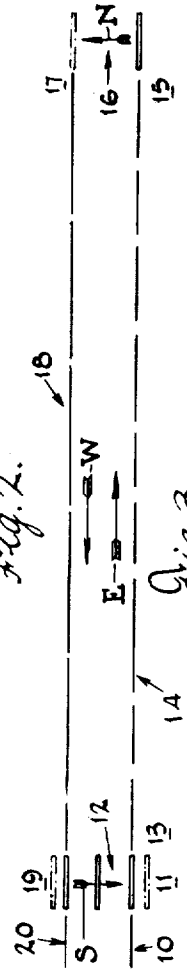

Fig. 3.

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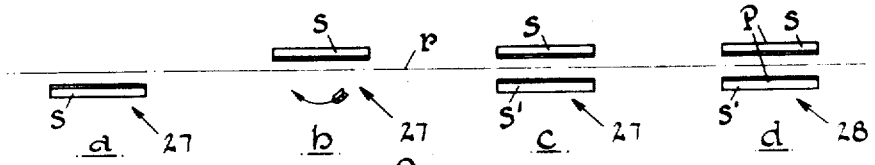


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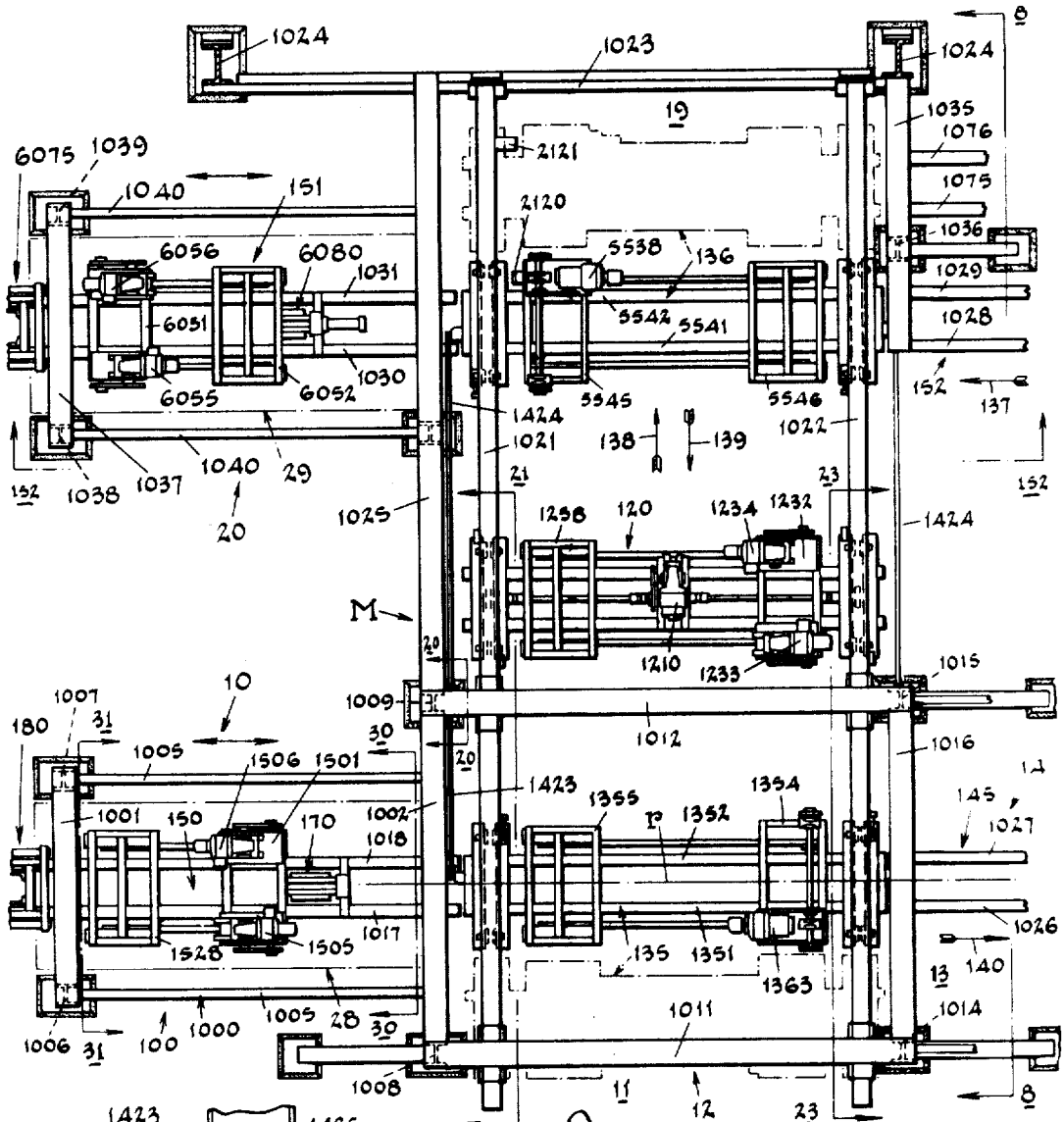


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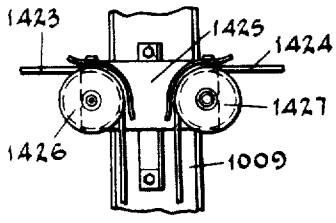


Fig. 20.

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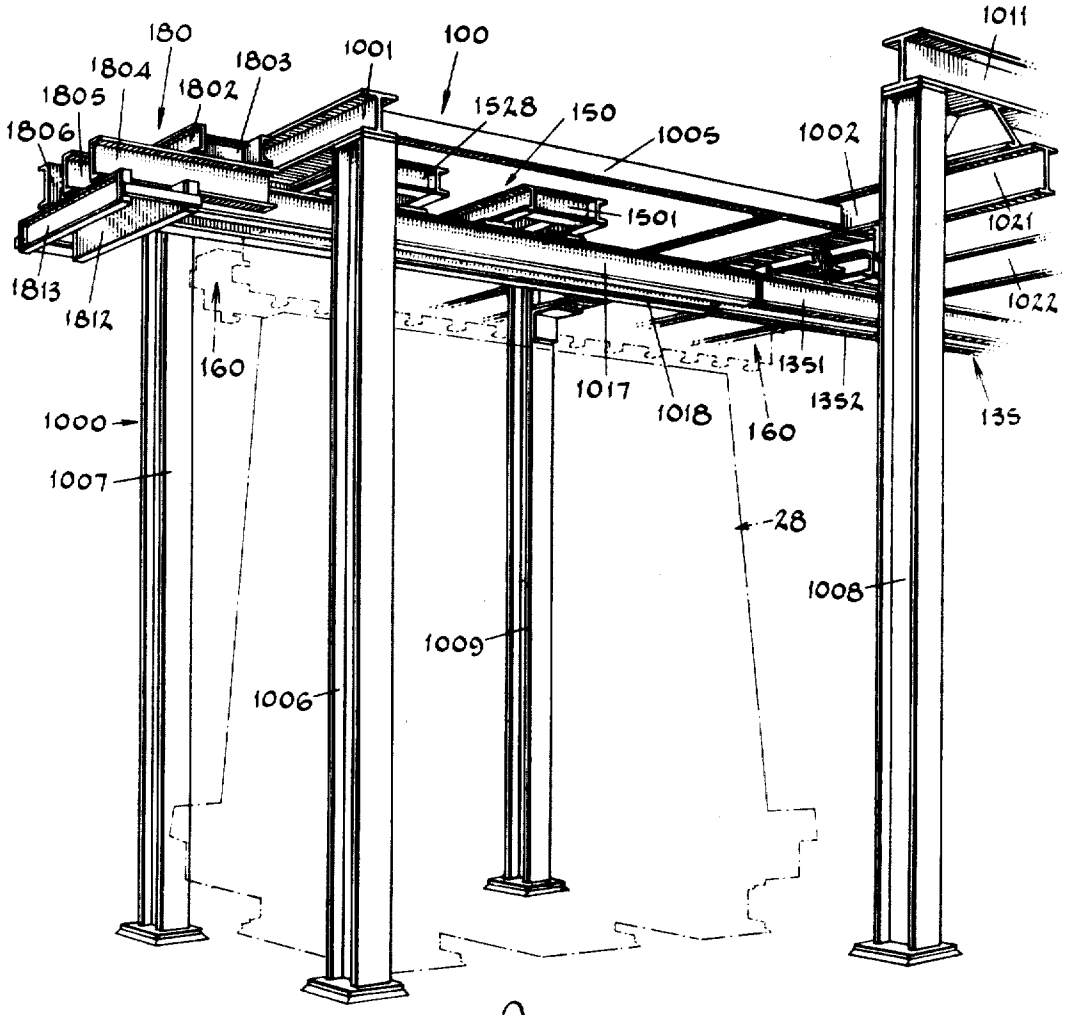


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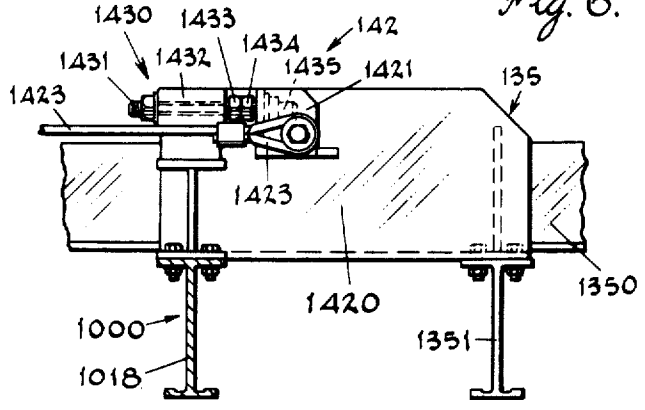


Fig. 19.

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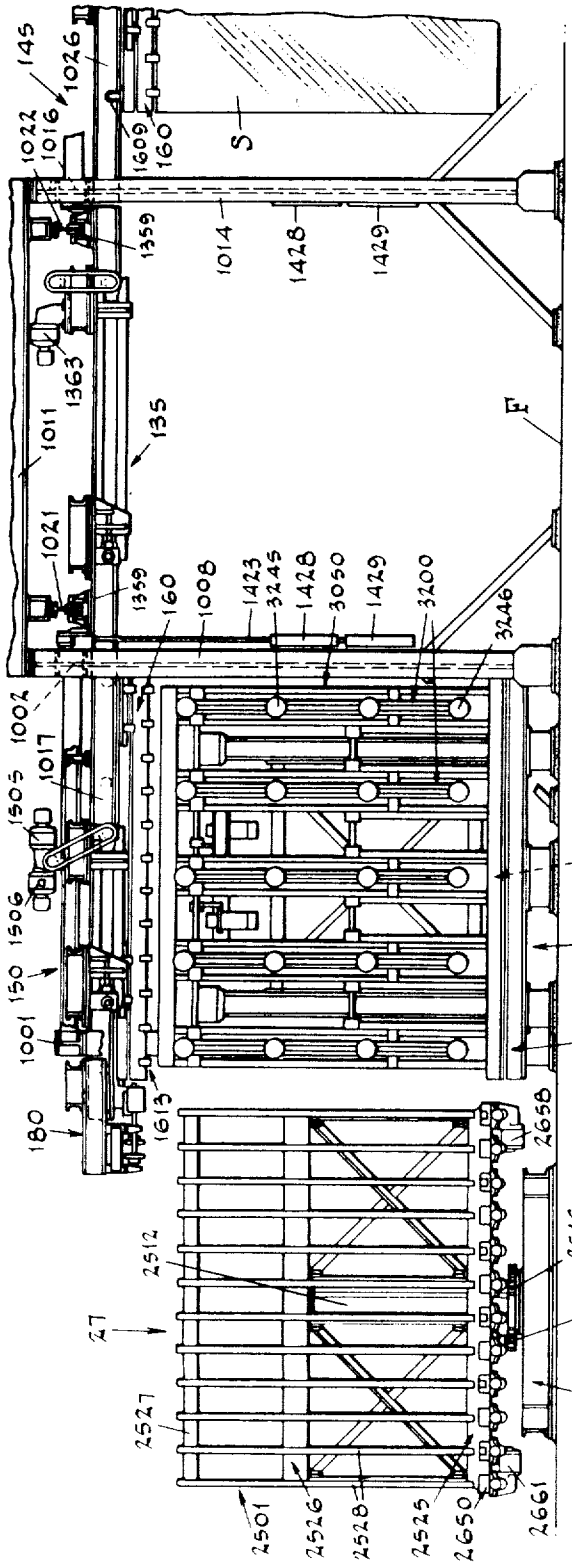


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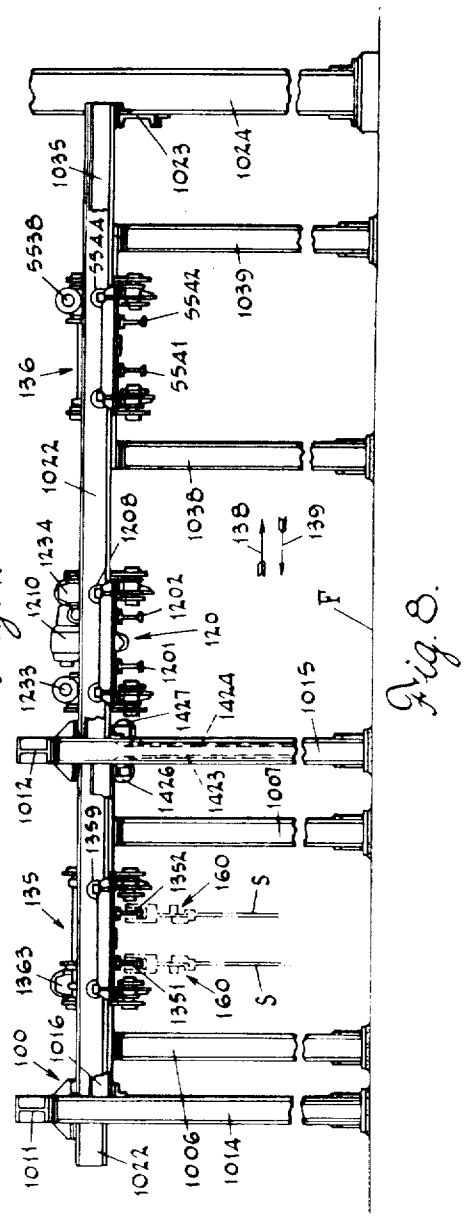


Fig. 8.

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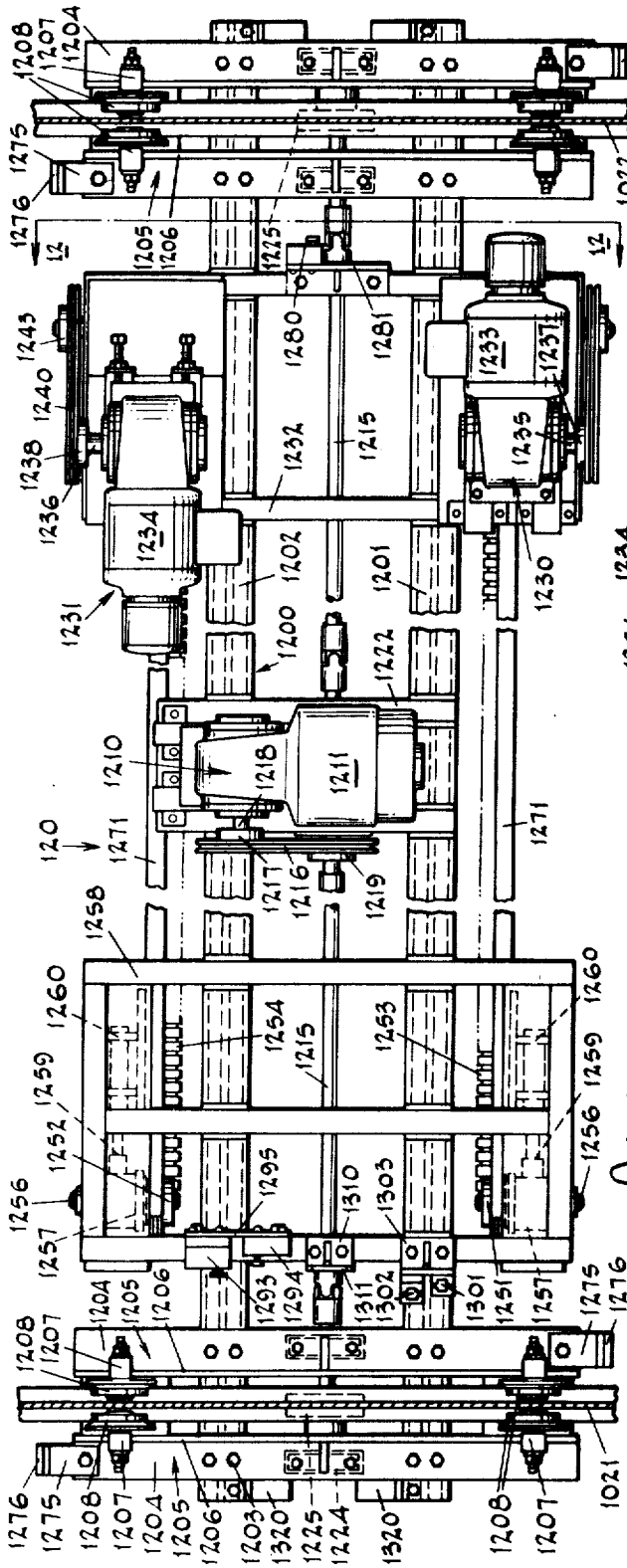

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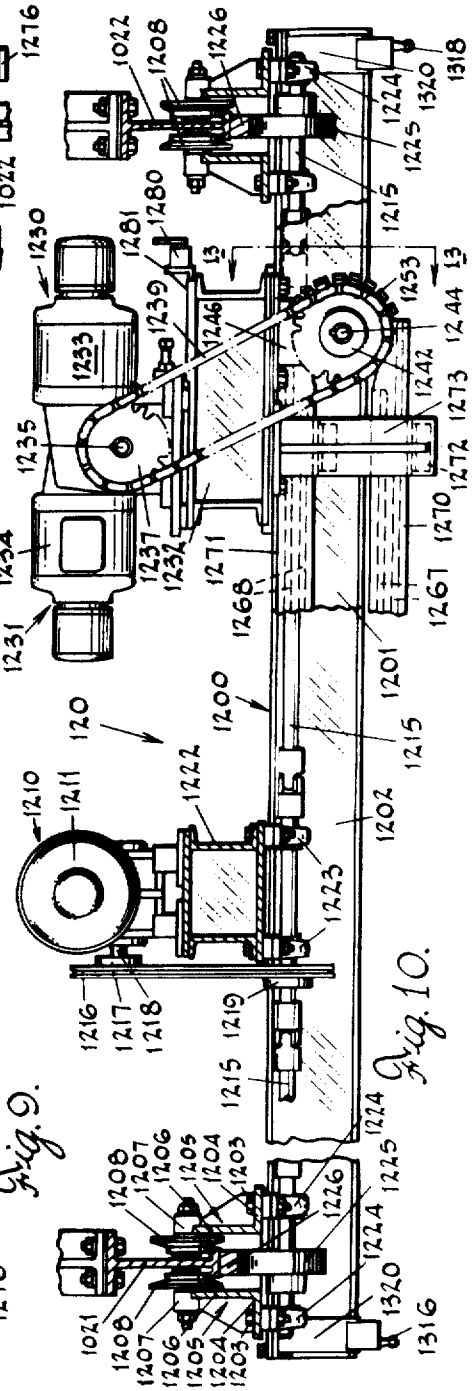

Fig. 10.

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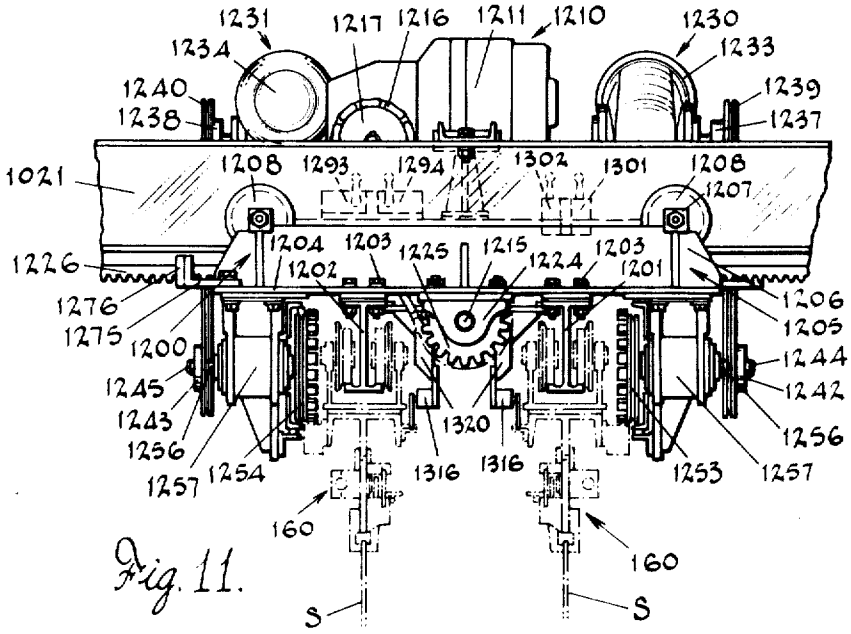


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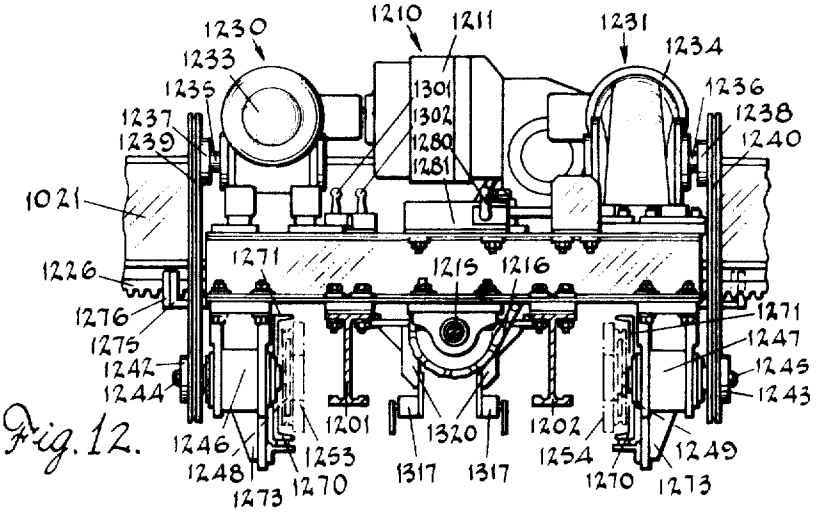


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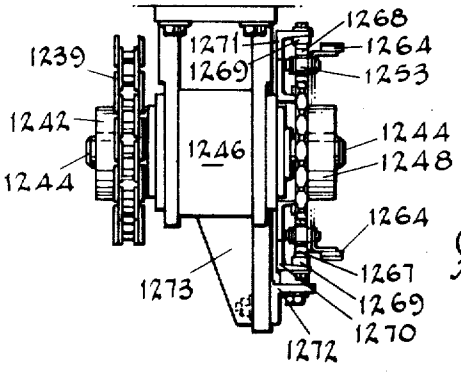


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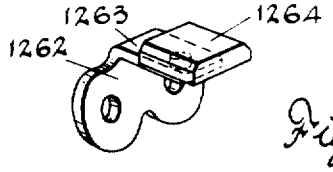


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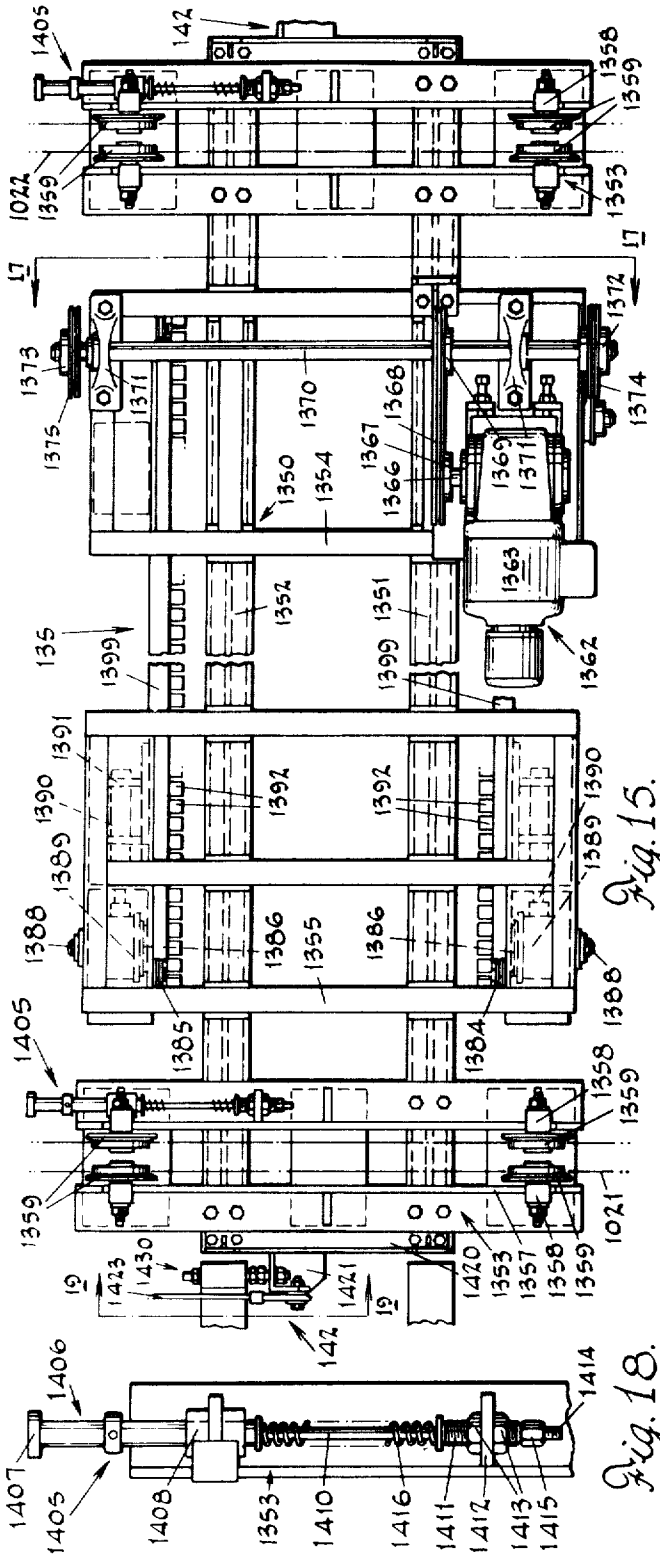

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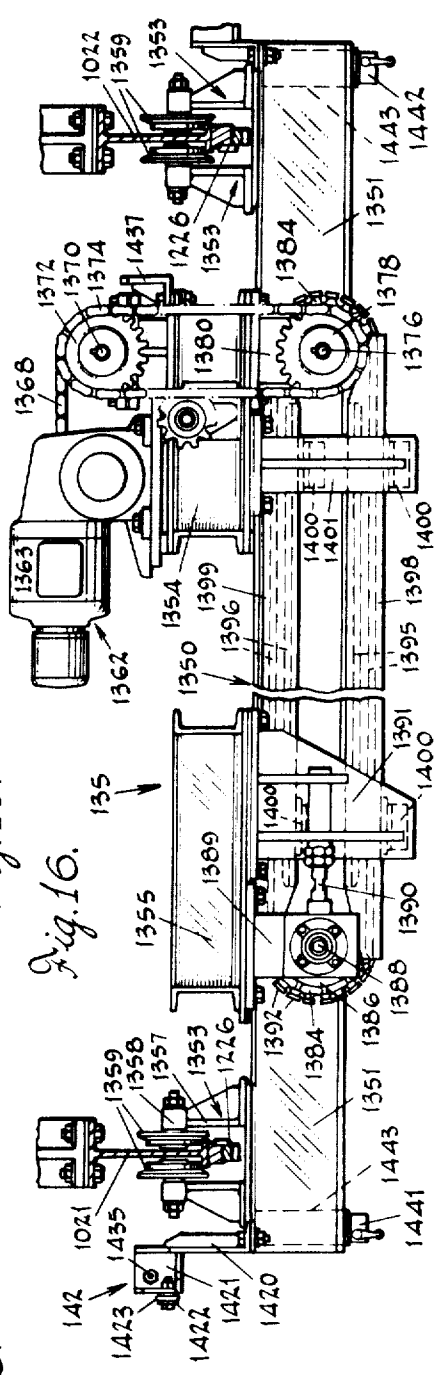

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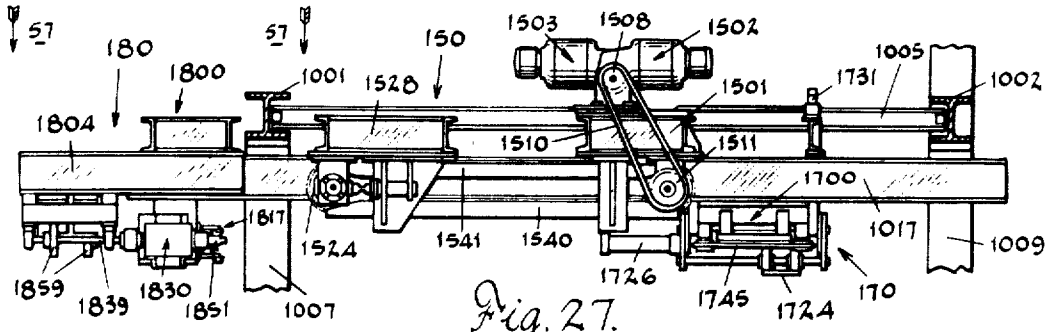


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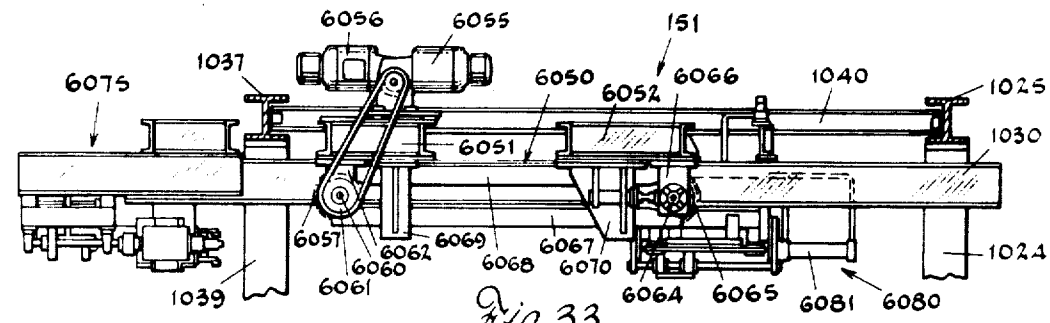


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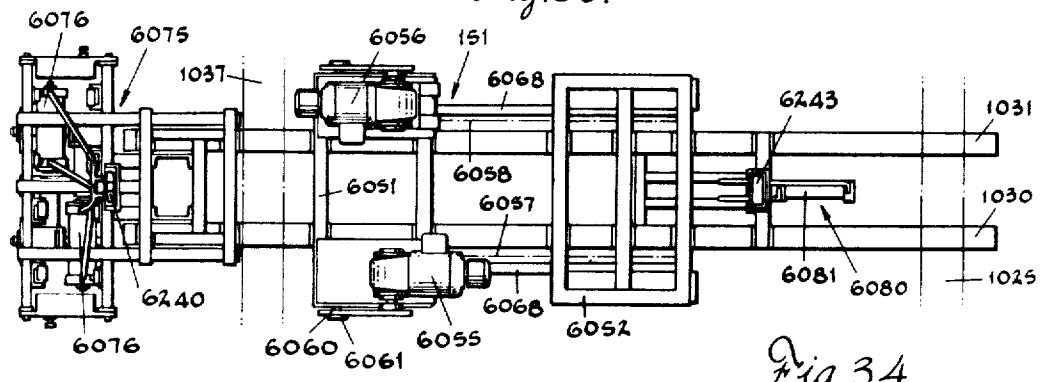


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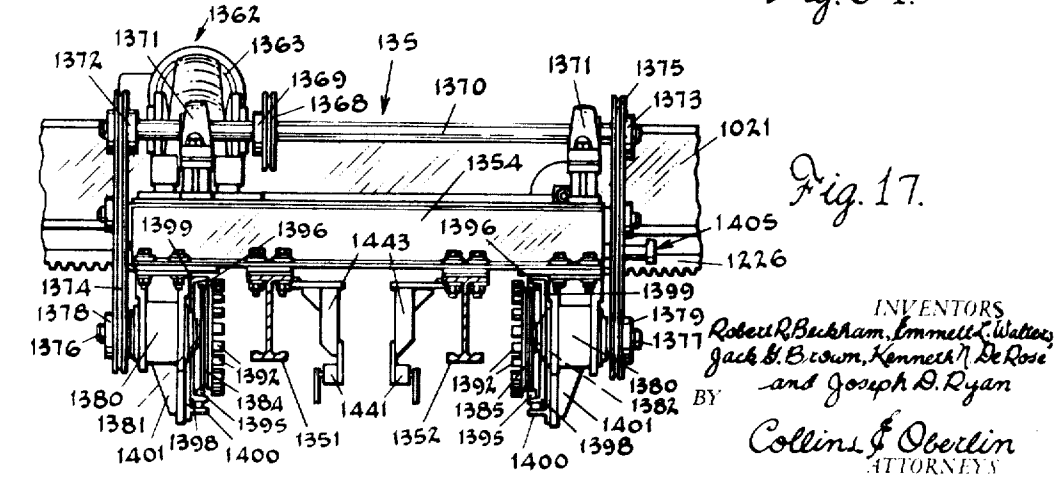


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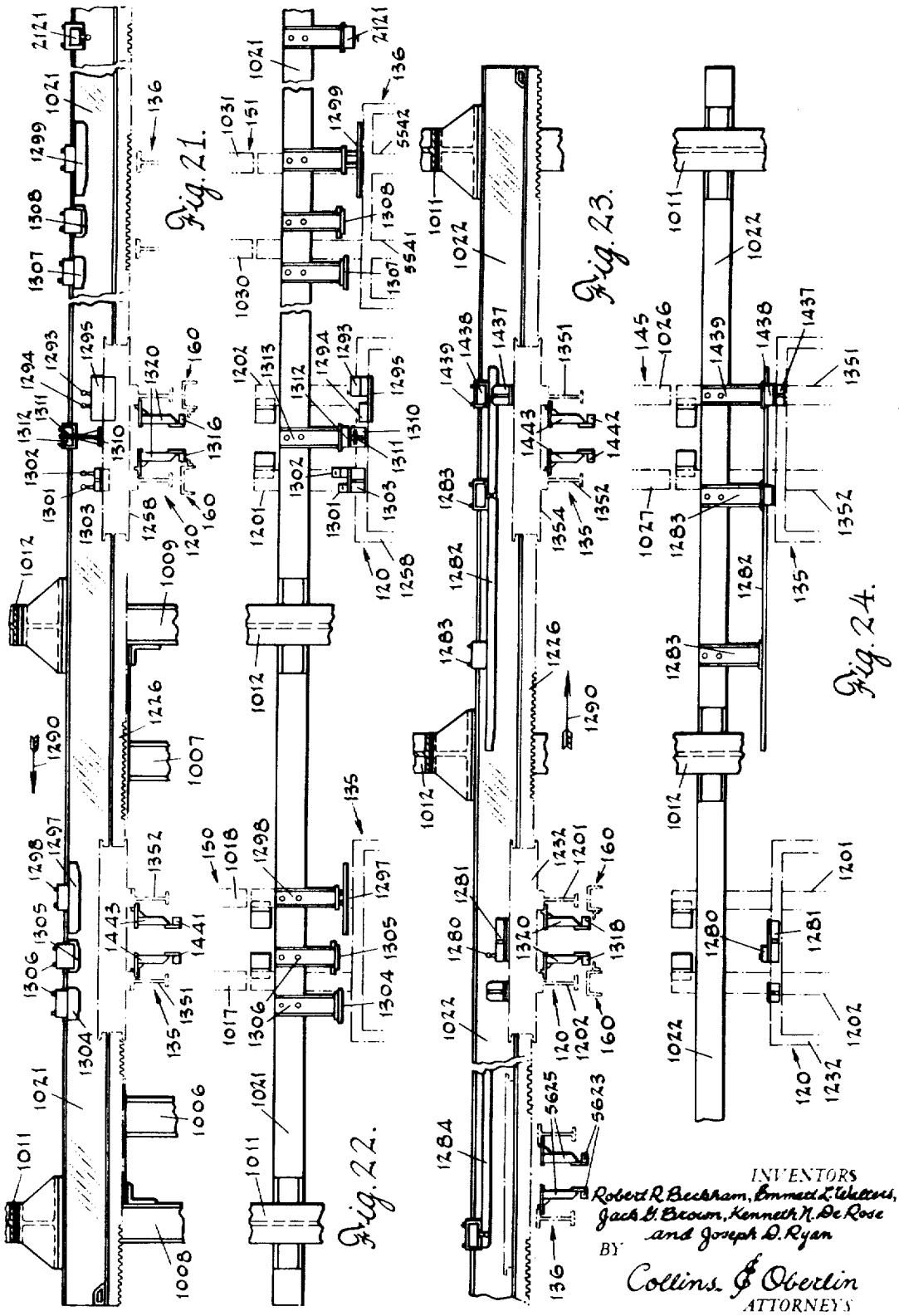

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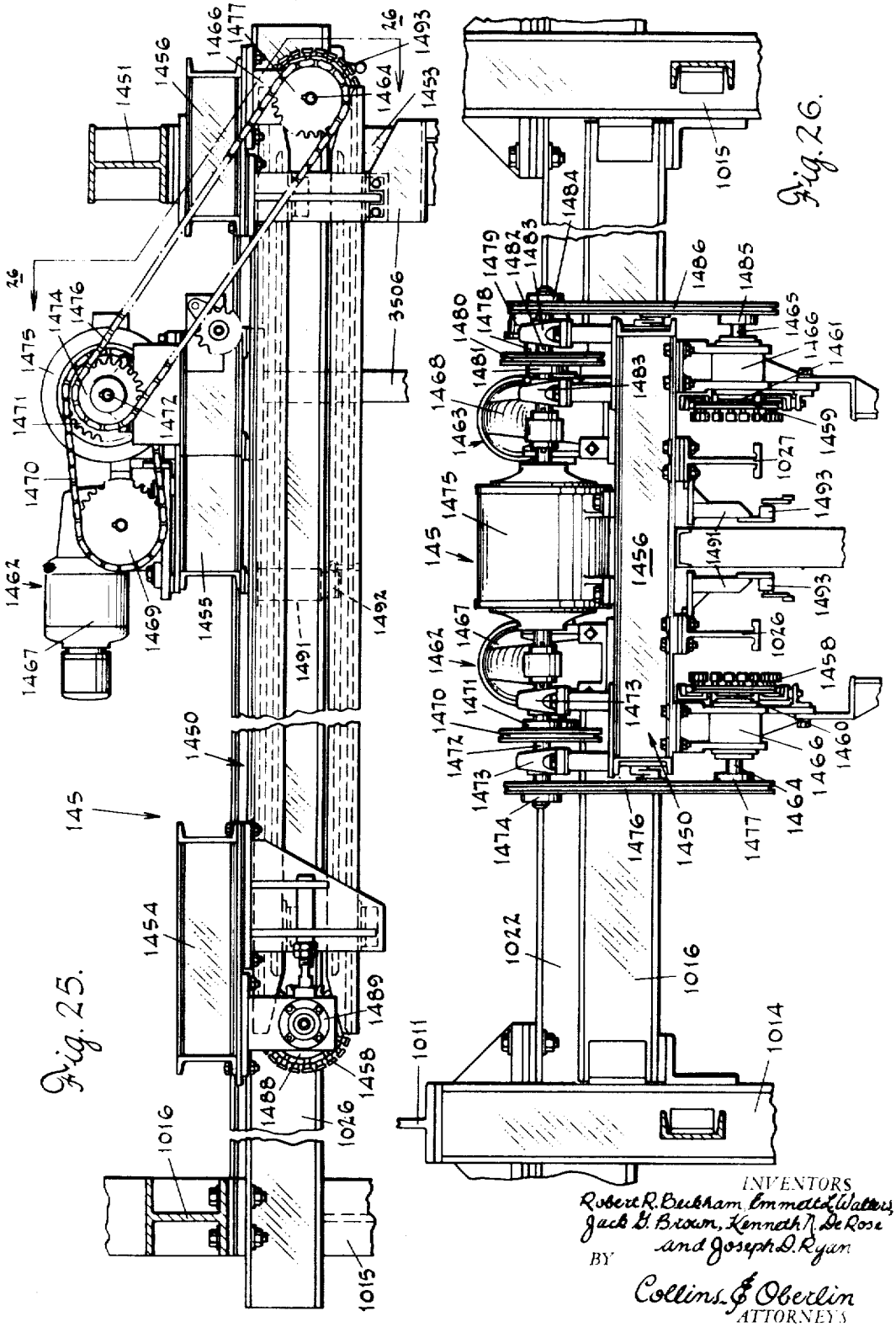


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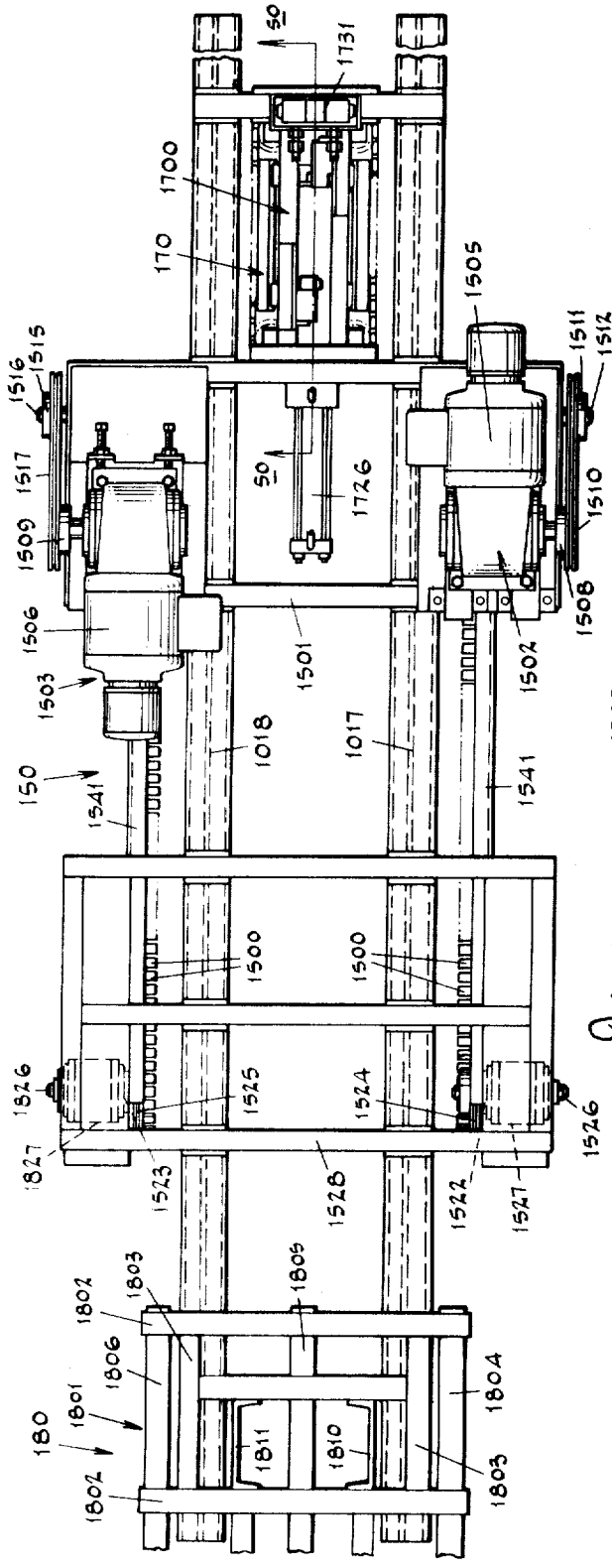

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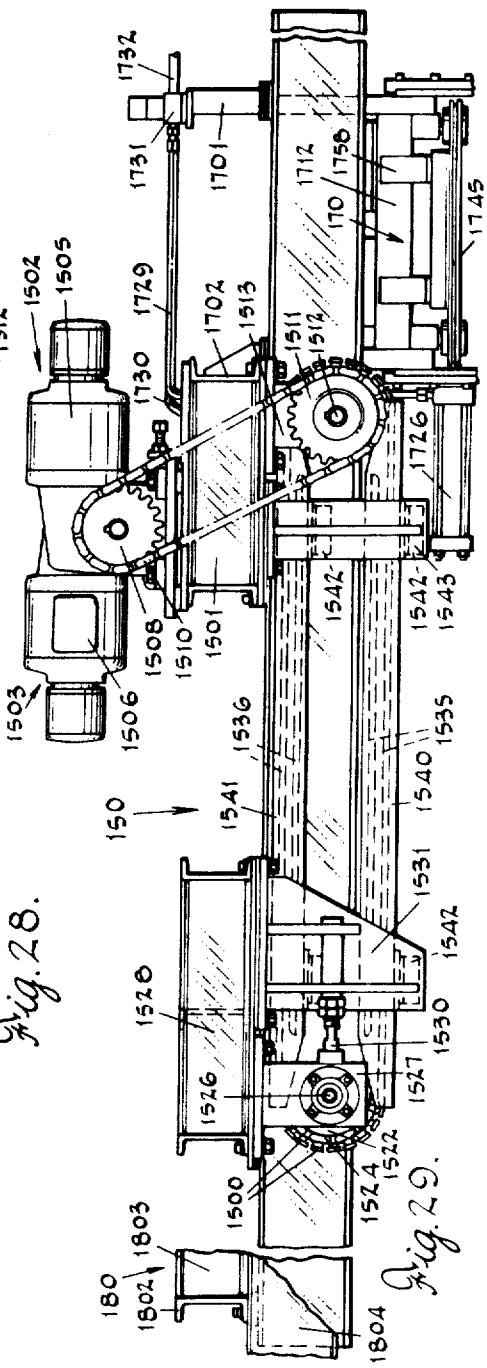

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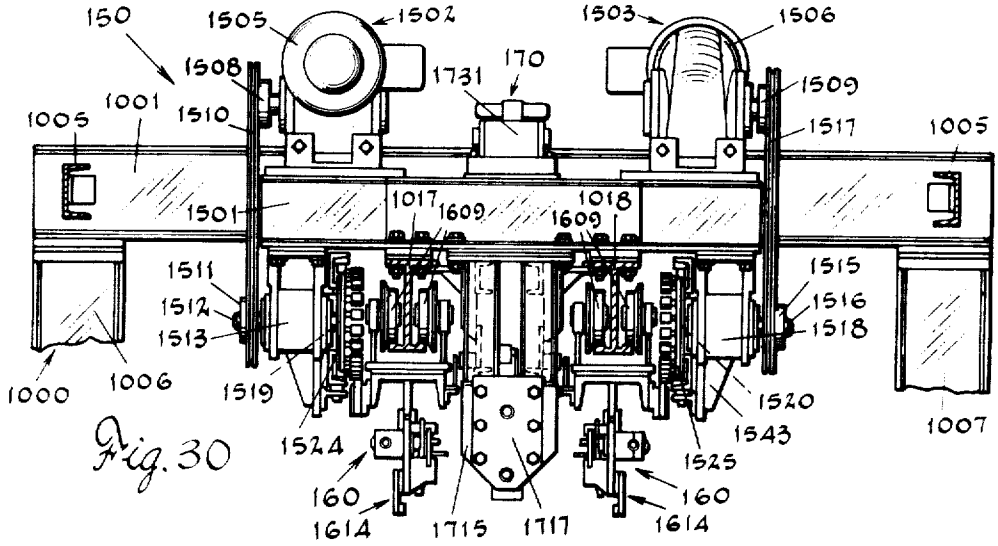


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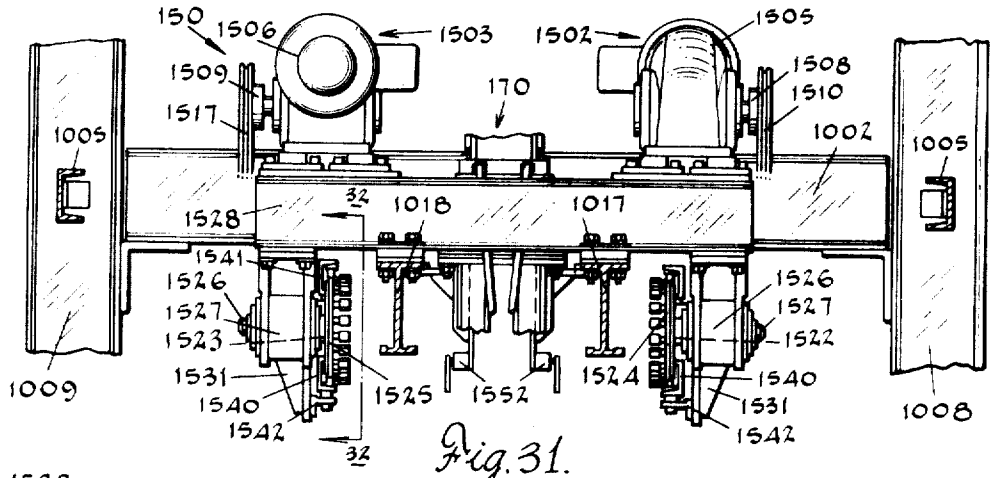


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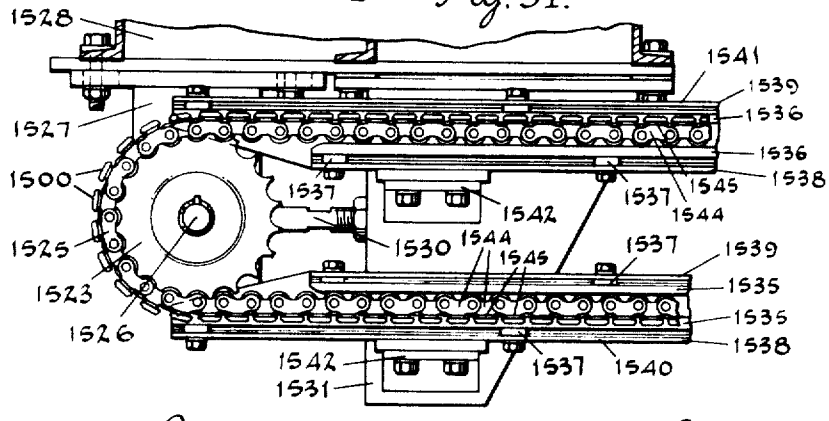


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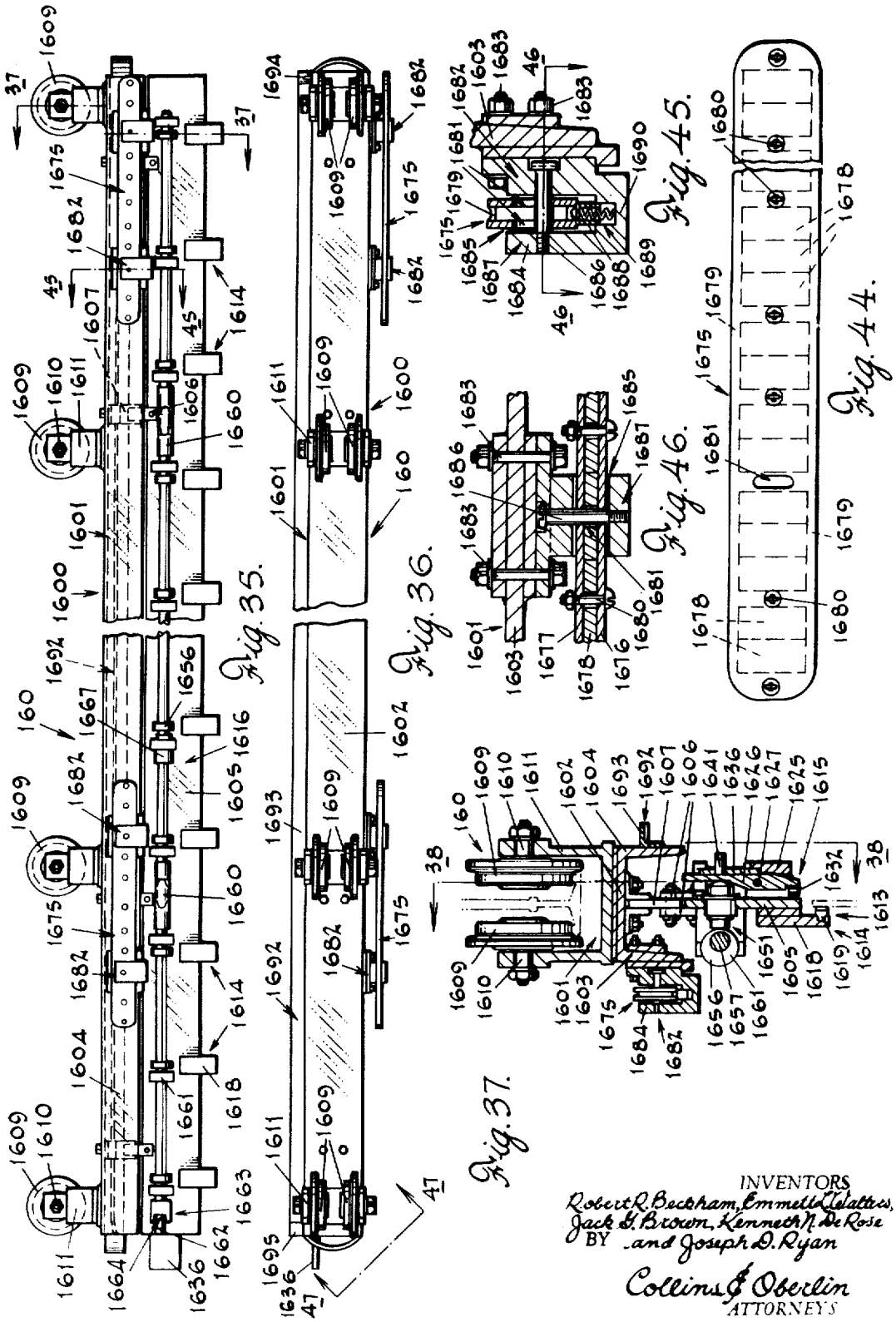

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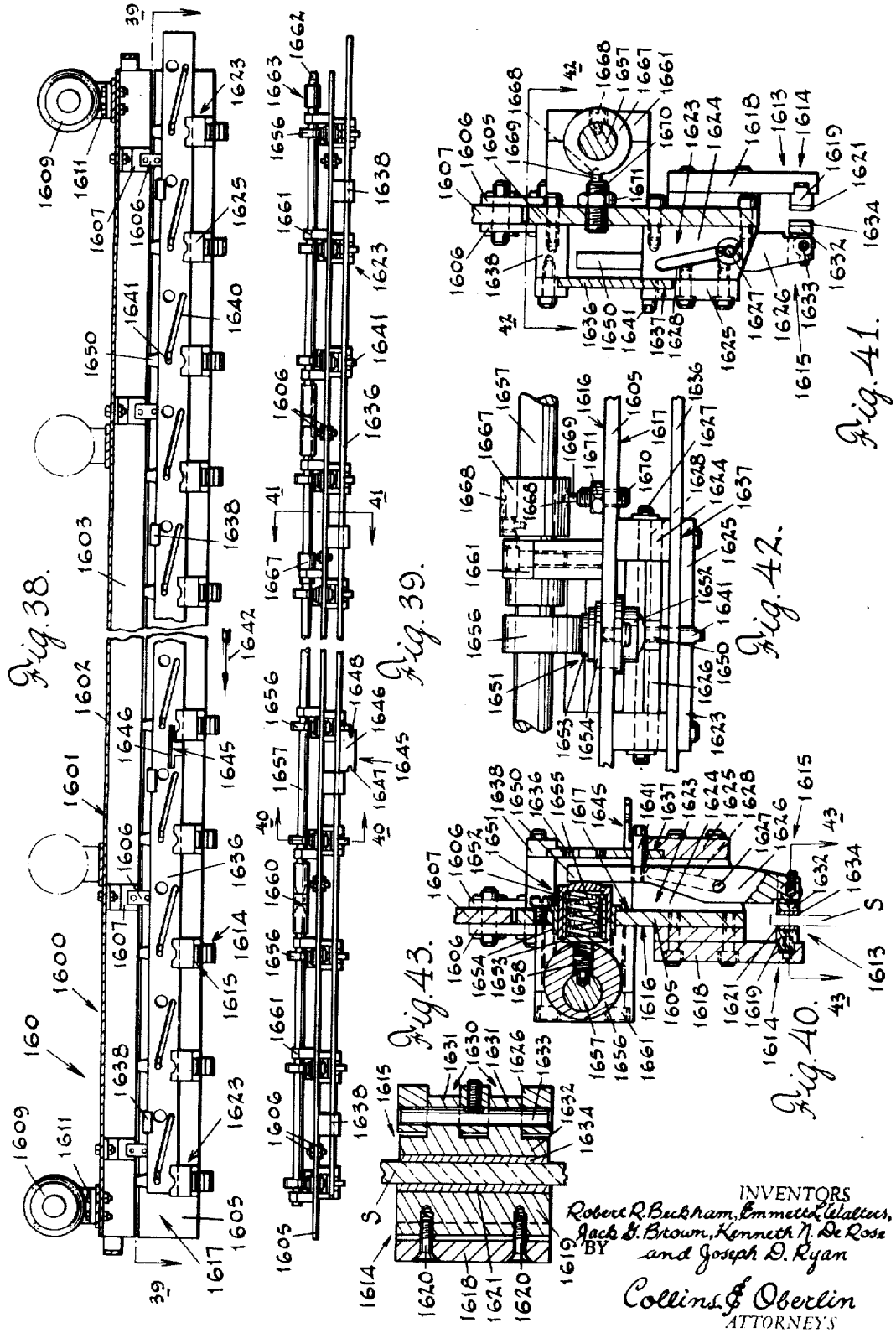

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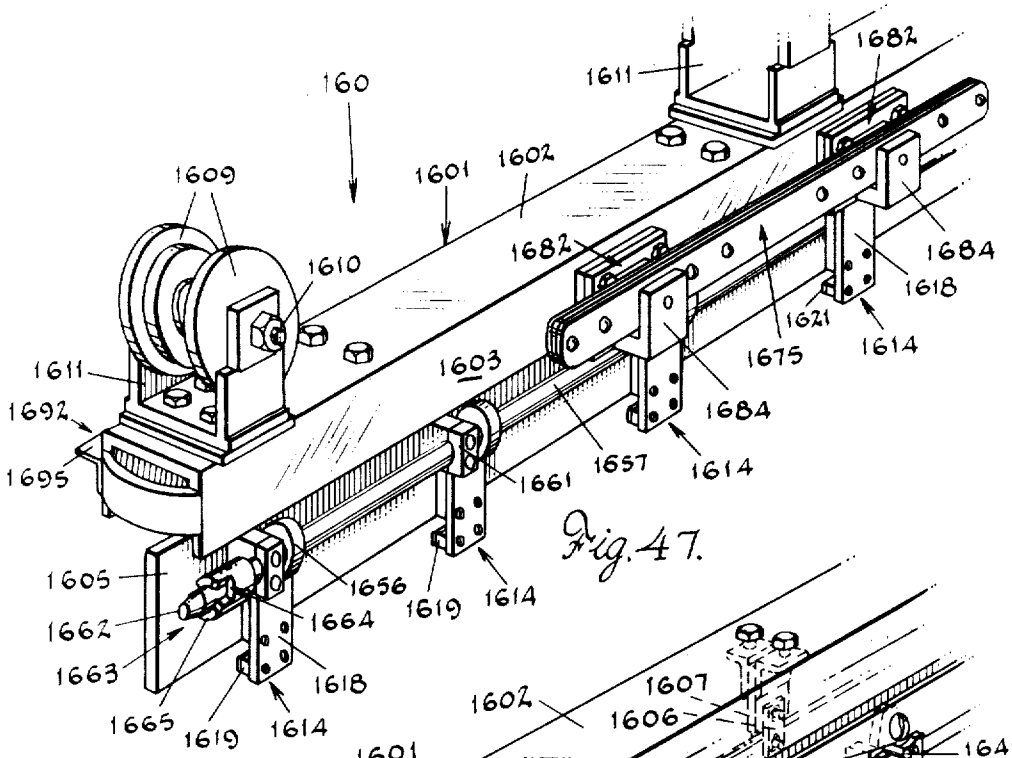


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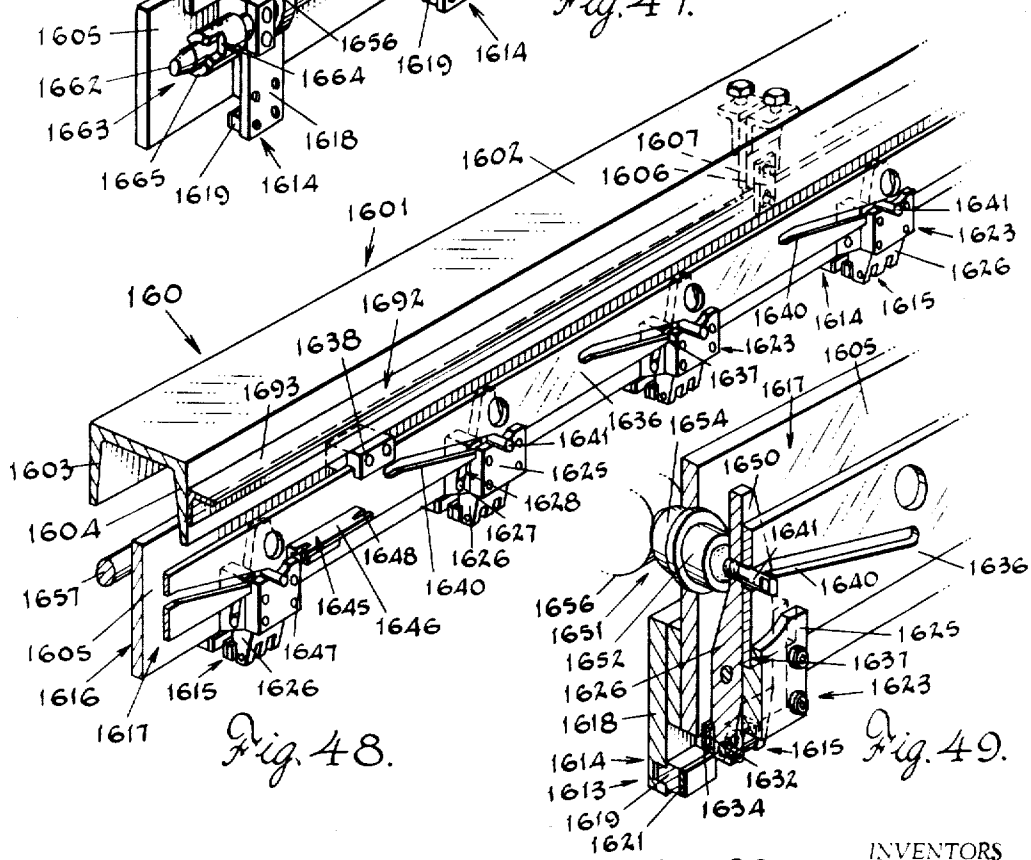


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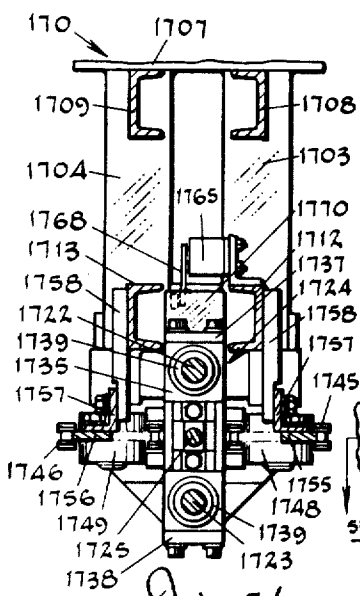


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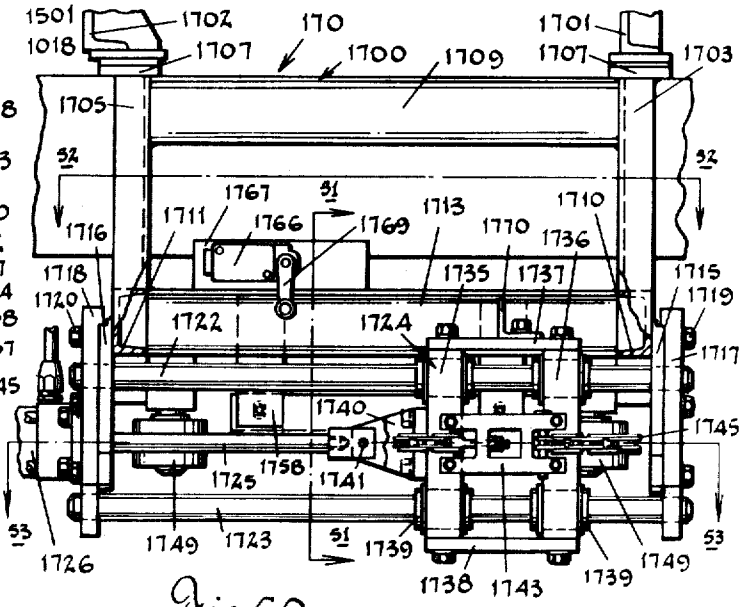


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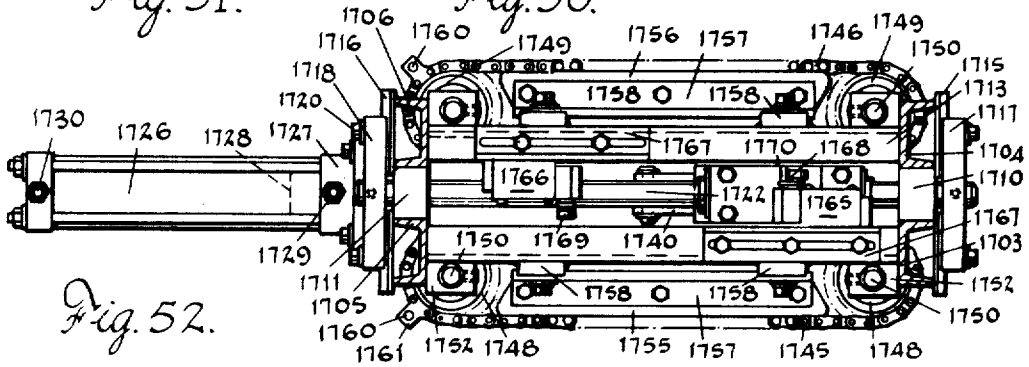


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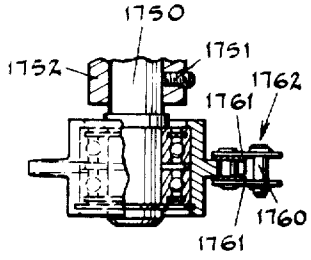


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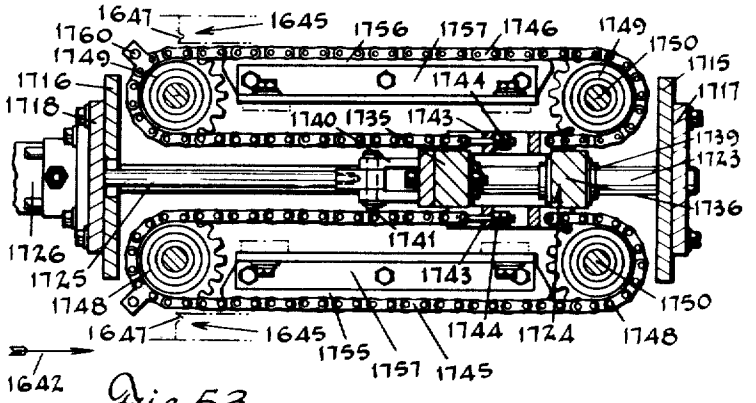


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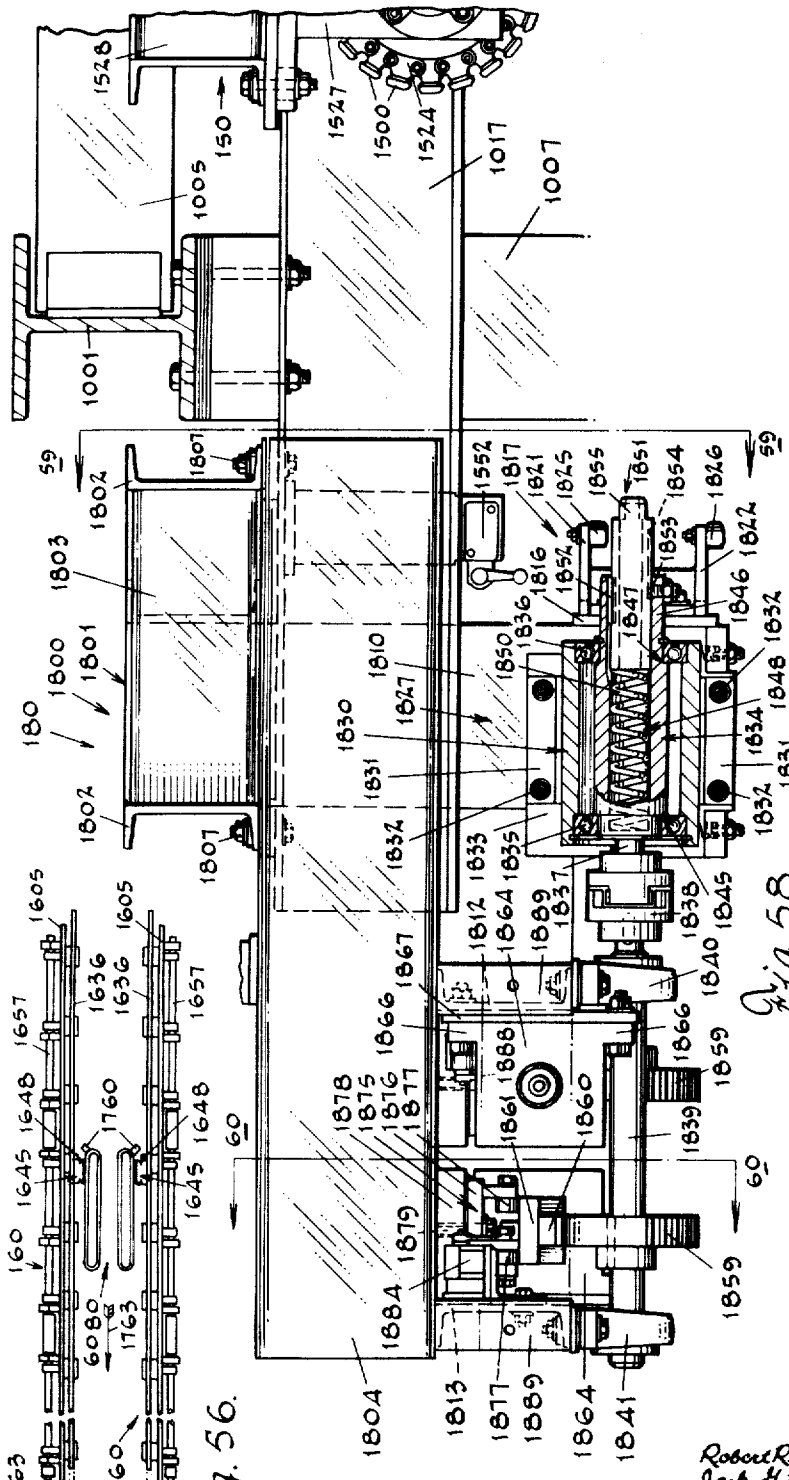

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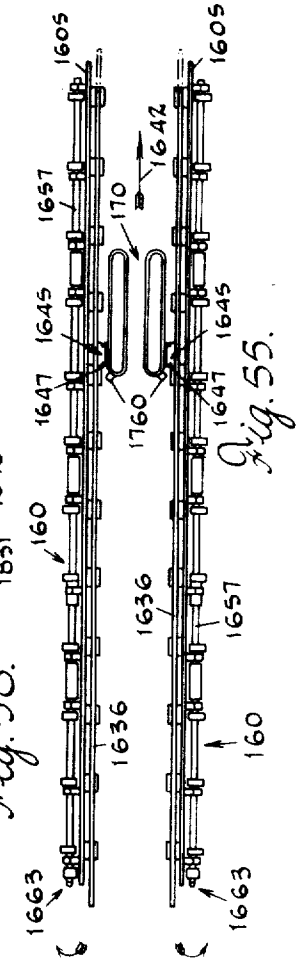

Fig. 58.



Fig. 55.

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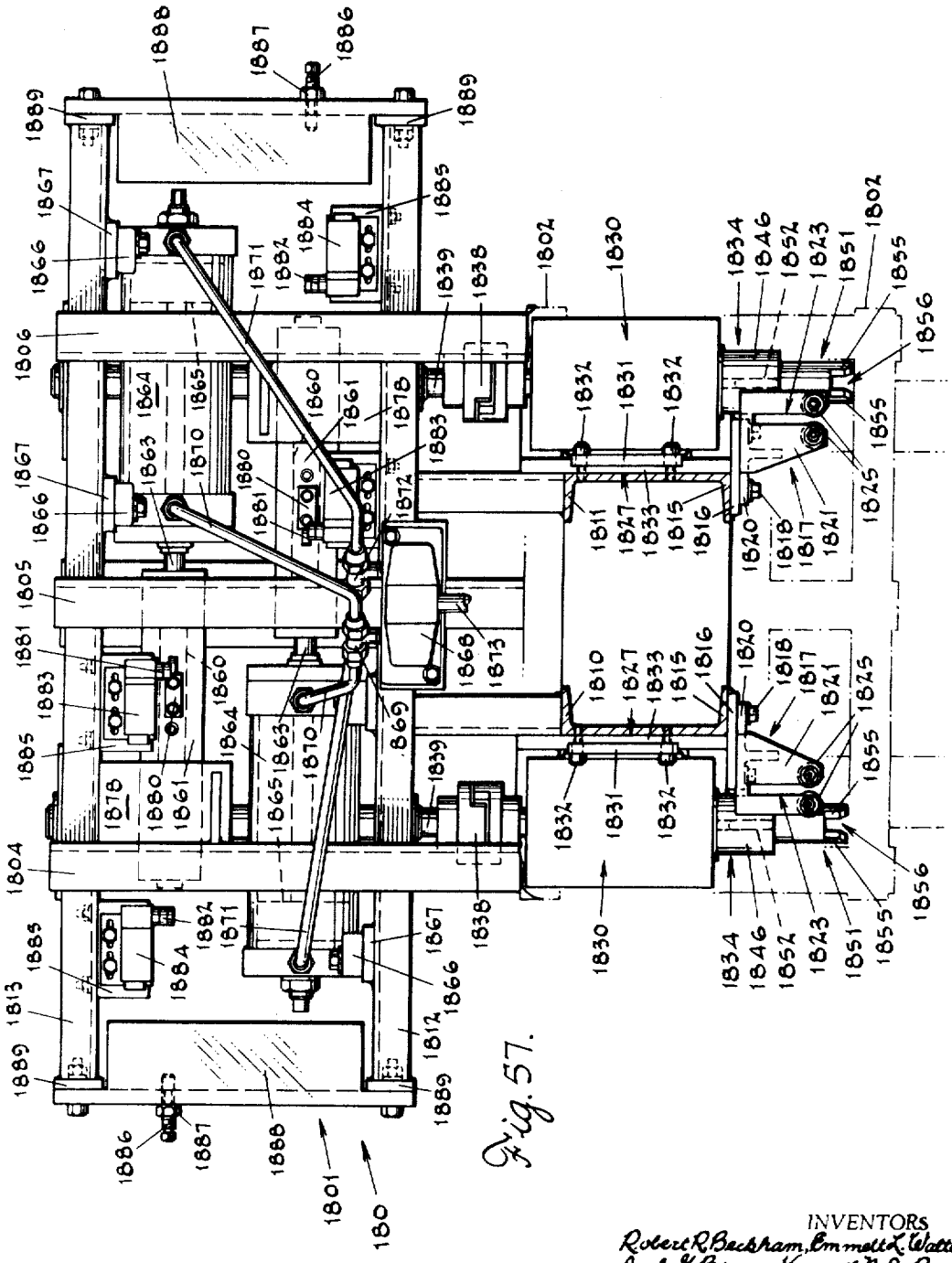

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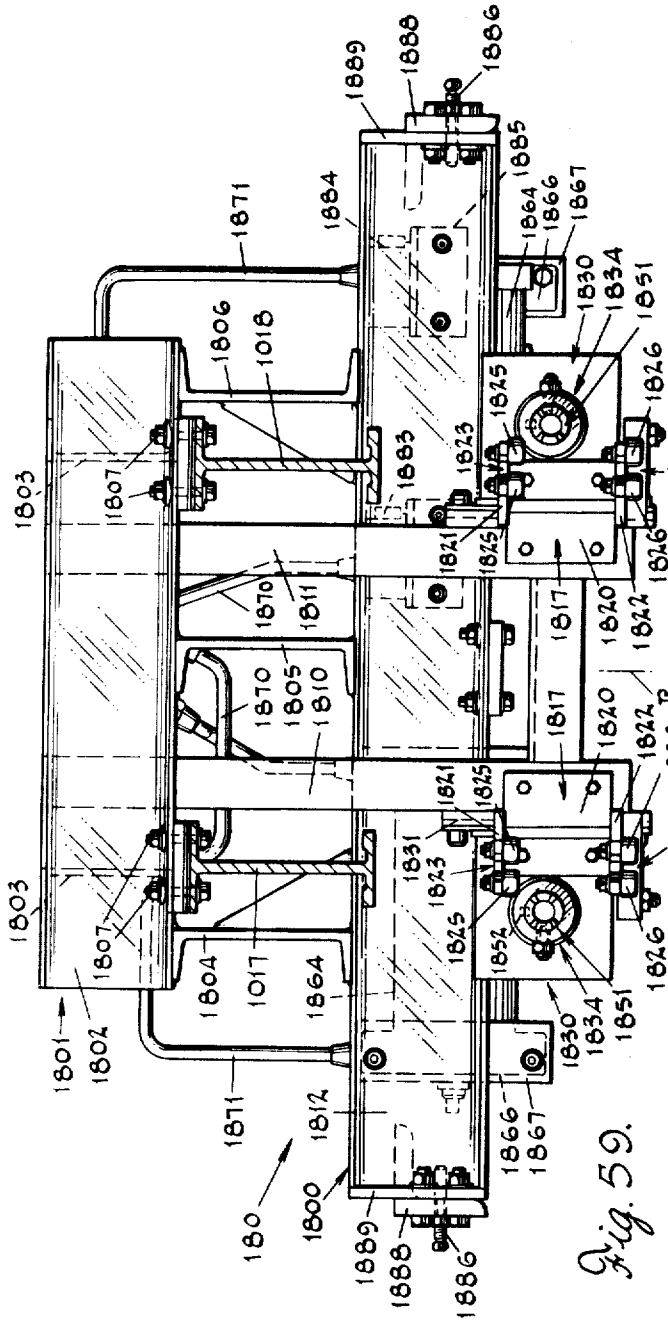

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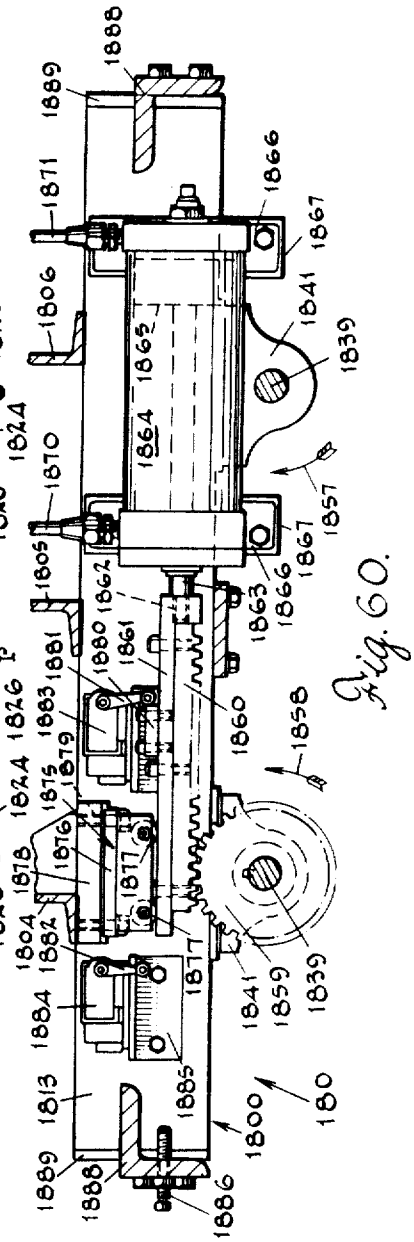

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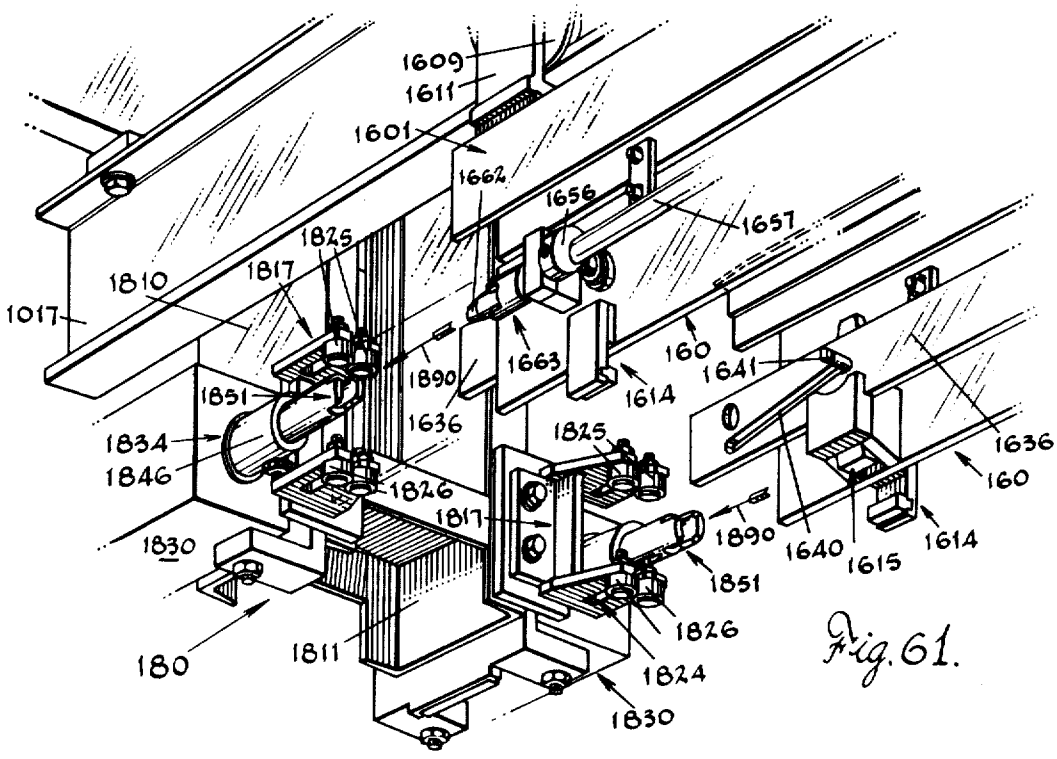


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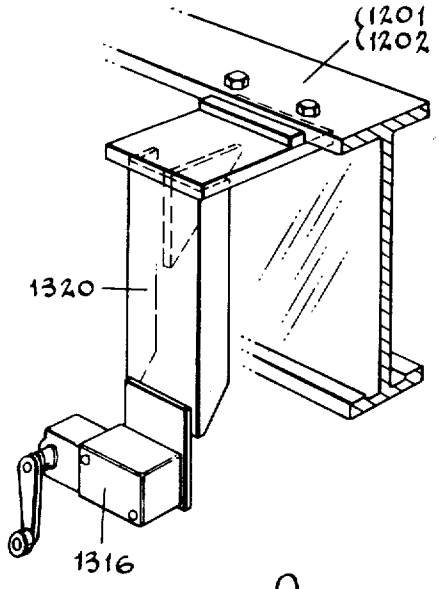


Fig. 62.

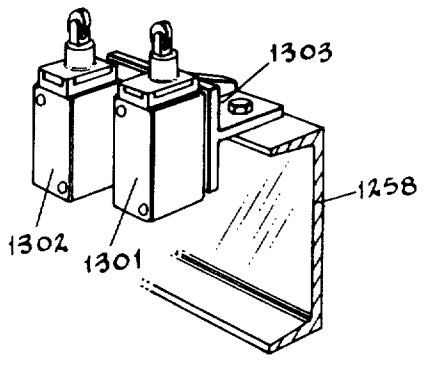


Fig. 63.

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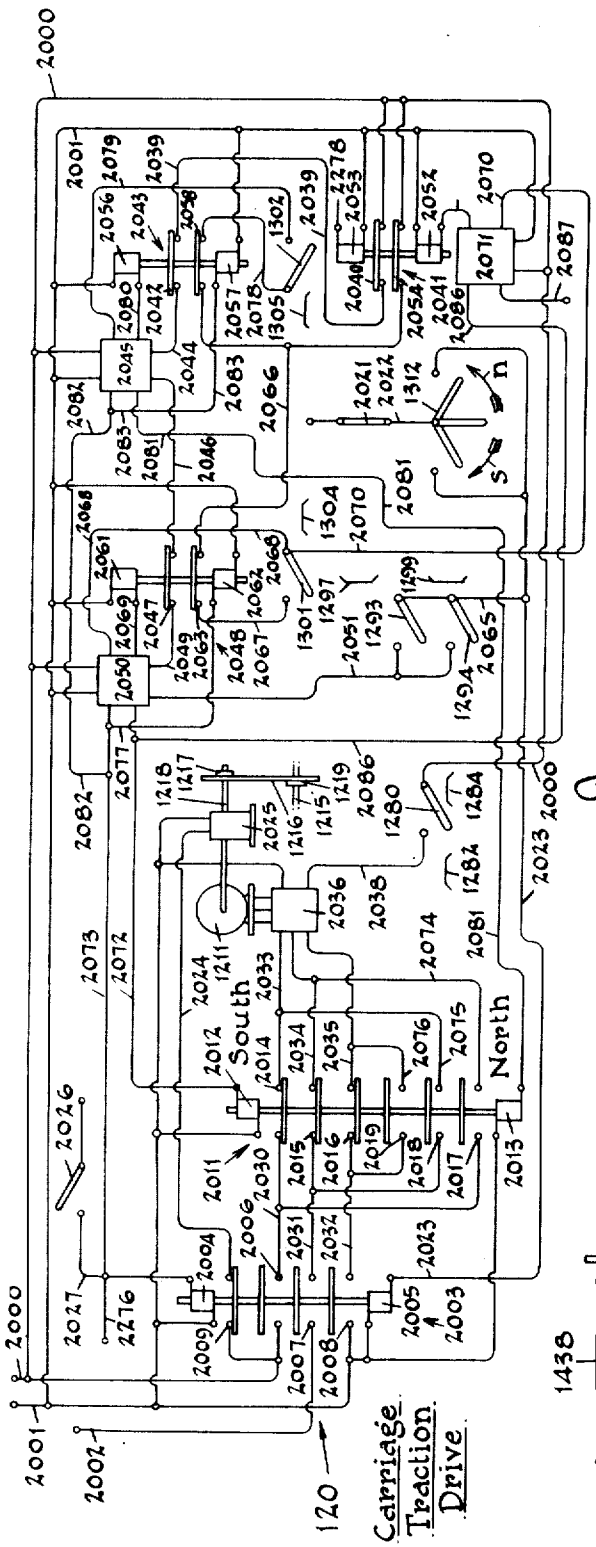


Fig. 64.

Fig. 67.

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Robert R. Beckham, Emmett L. Walters,
Jack E. Brown, Kenneth N. DeRose
and Joseph D. Ryan
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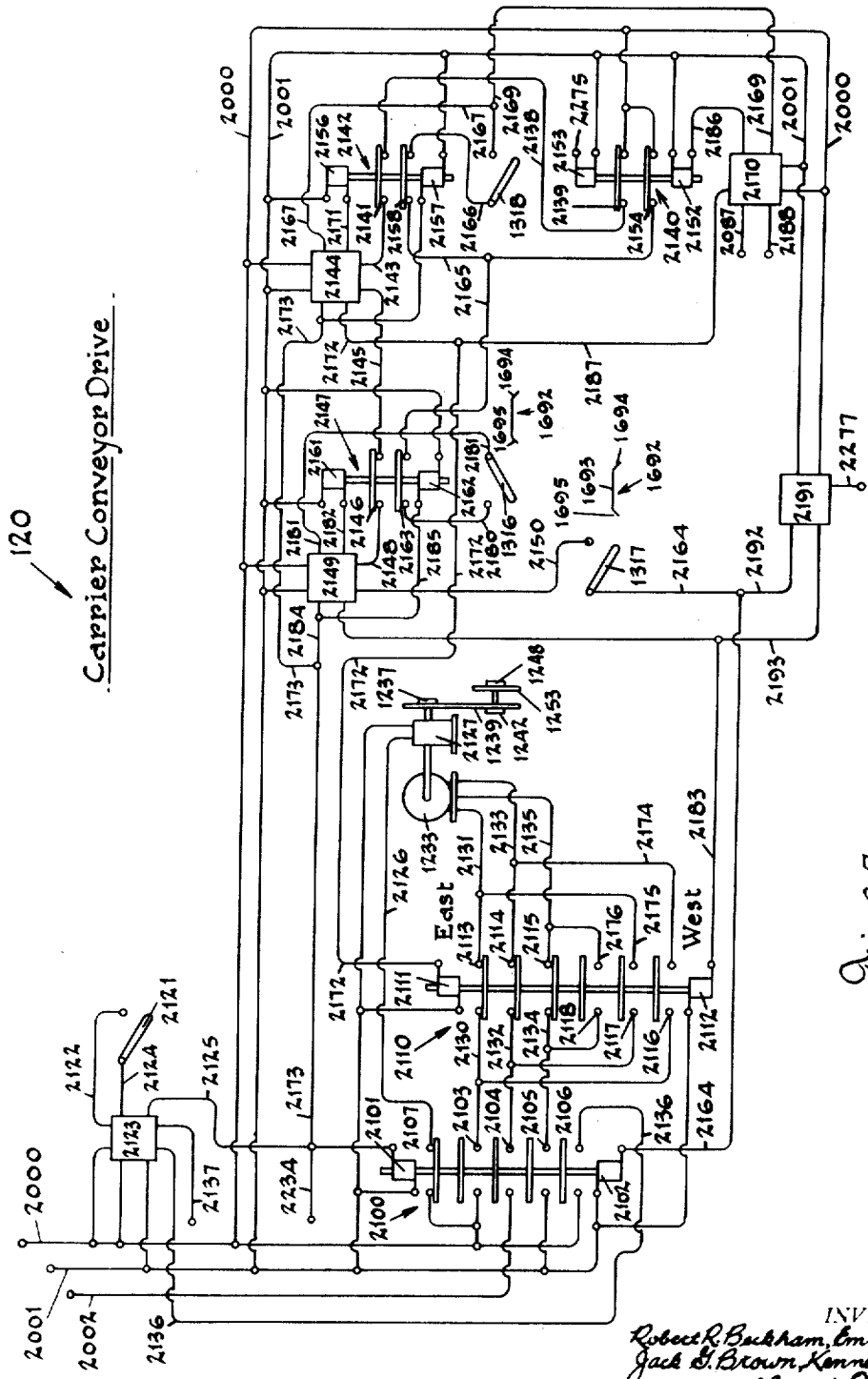


Fig. 65.

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Robert R. Buckham, Emmett L. Watson,
Jack E. Brown, Kenneth N. De Rose
and Joseph D. Ryan
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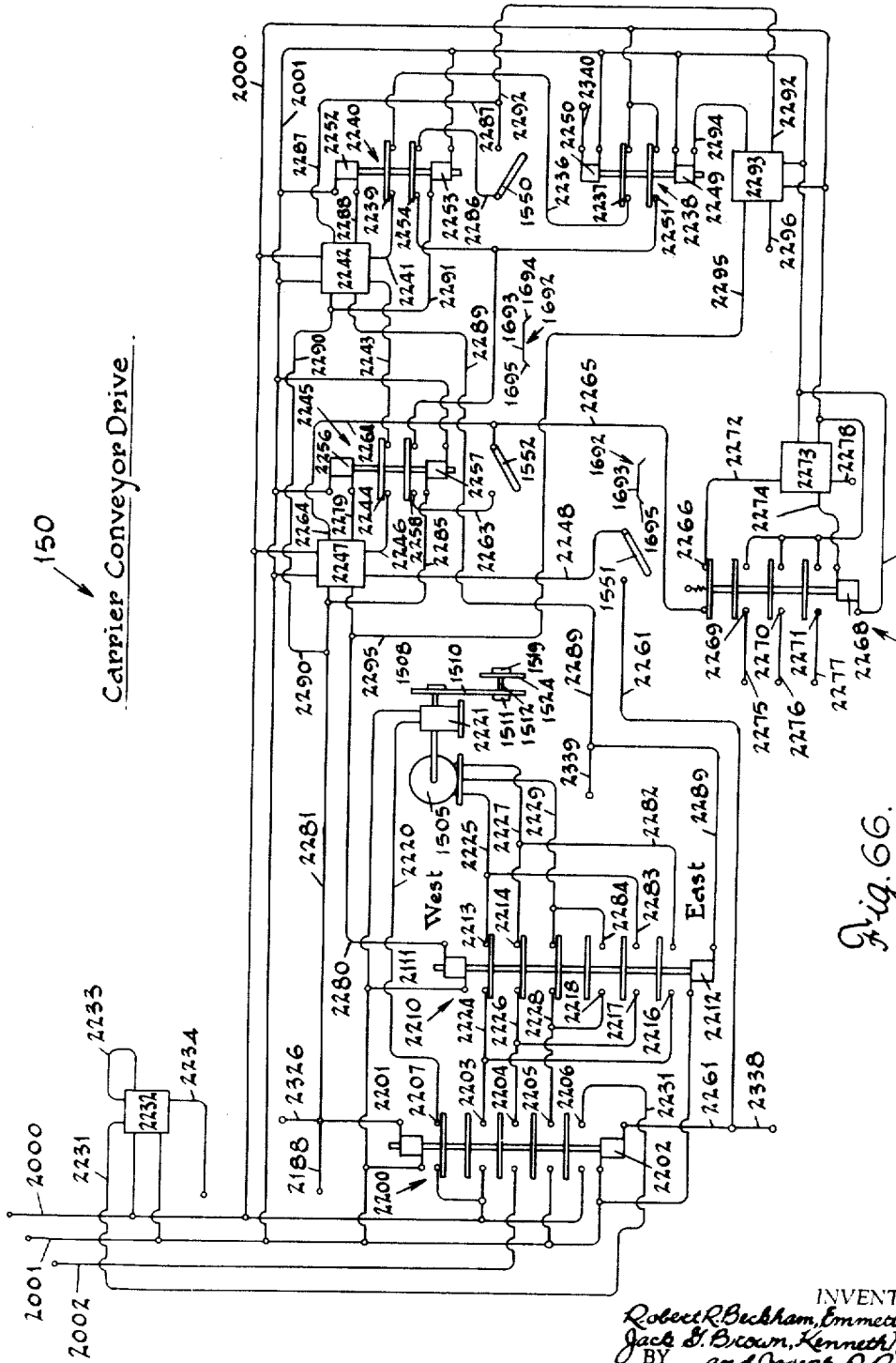


Fig. 66.

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Jack S. Brown, Kenneth N. De Rose
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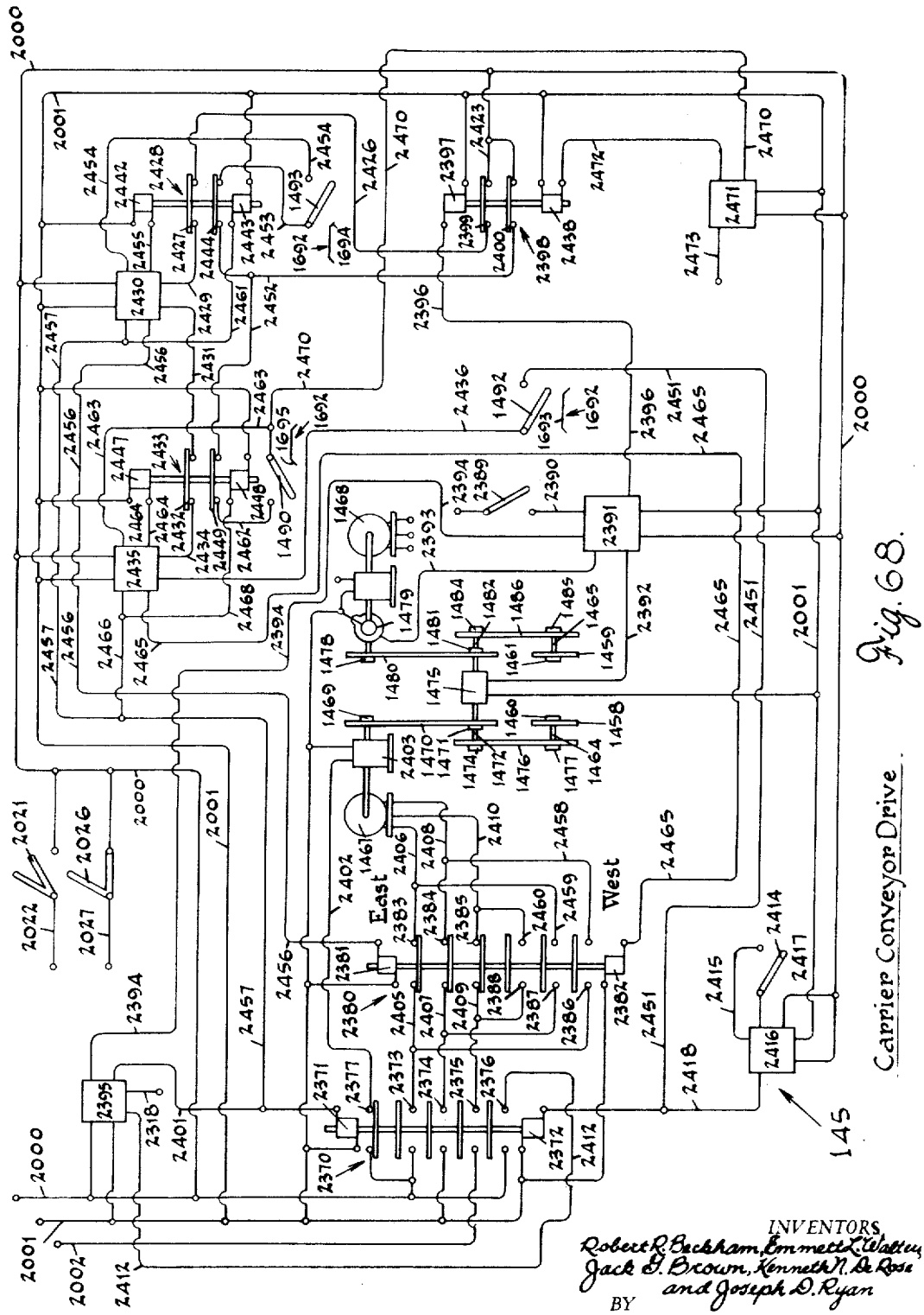


Fig. 68.

Carrier Conveyor Drive

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and Joseph D. Ryan

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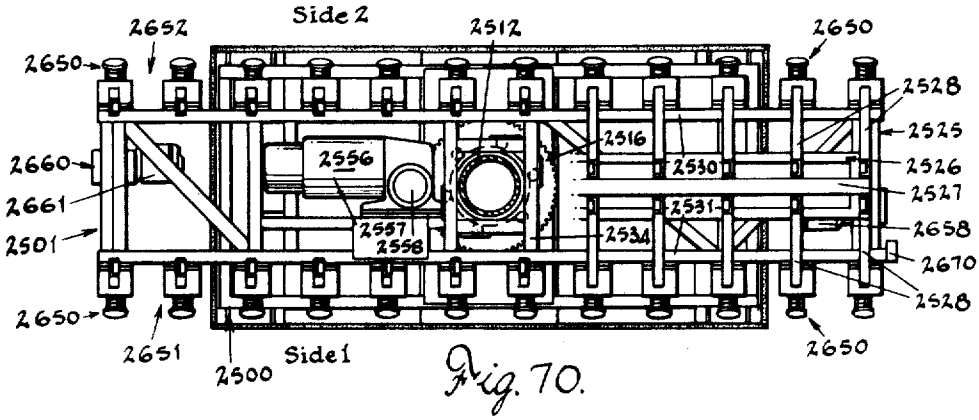


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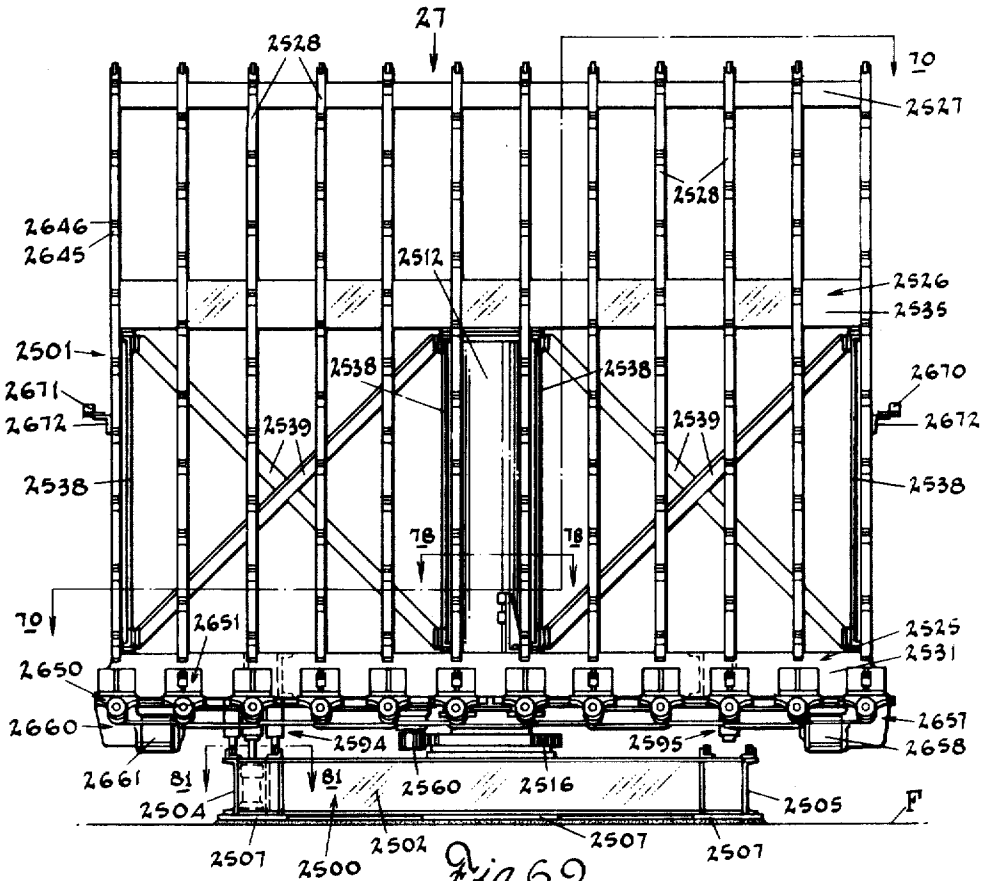


Fig. 69.

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Robert R. Beckham, Emmett L. Weller, Jack G. Brown, Kenneth N. DeRose and Joseph D. Ryan
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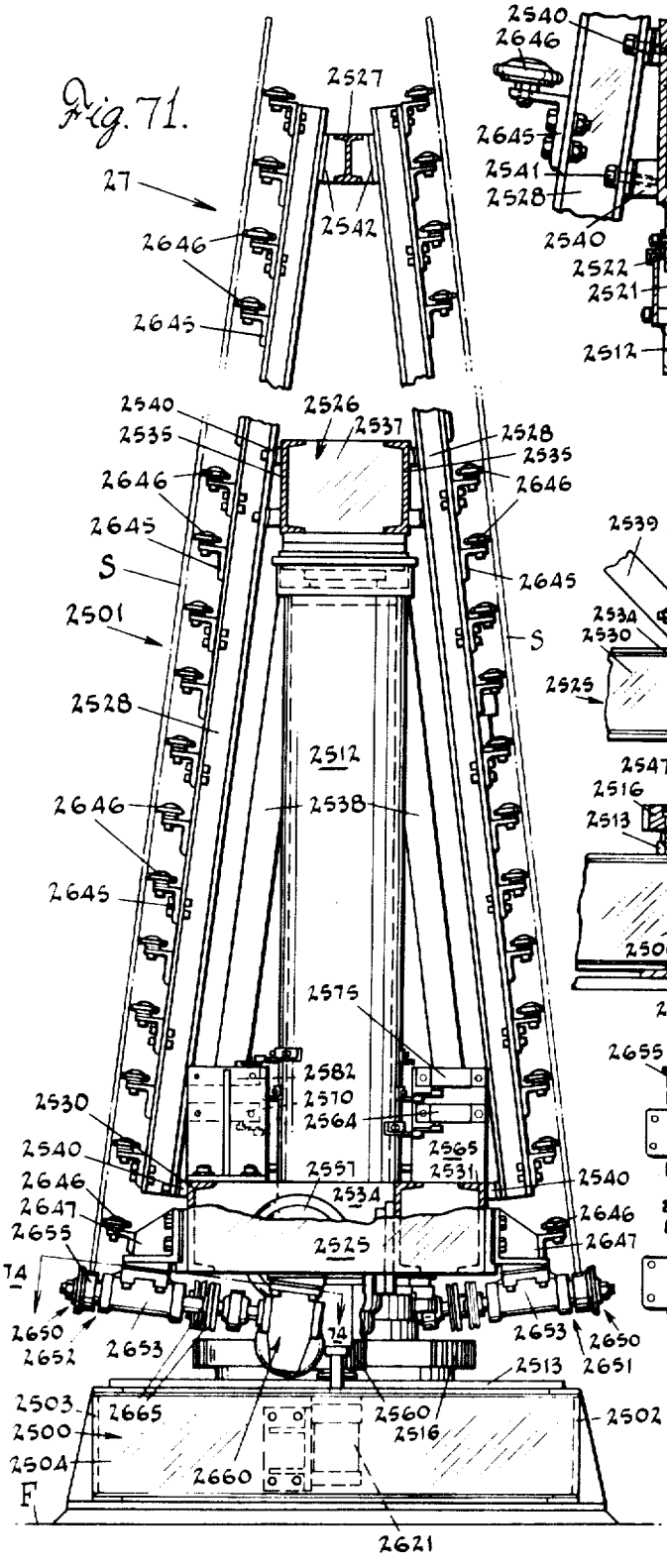
Fig. 71.



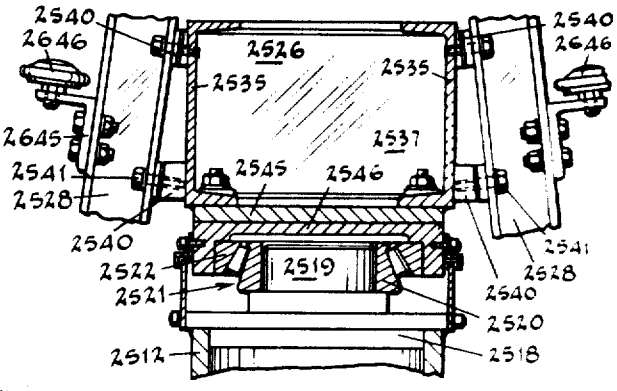
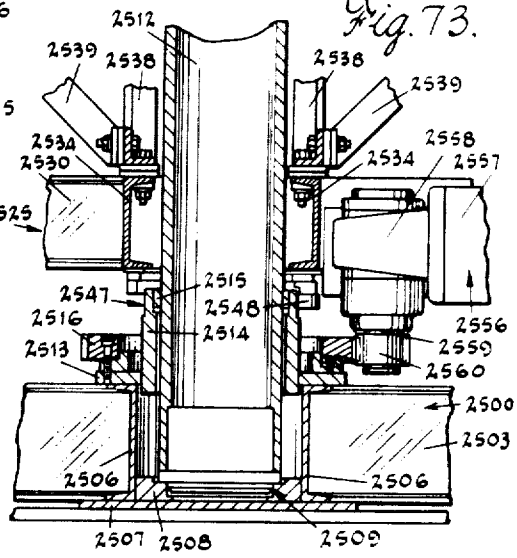




Fig. 72.

Fig. 73.



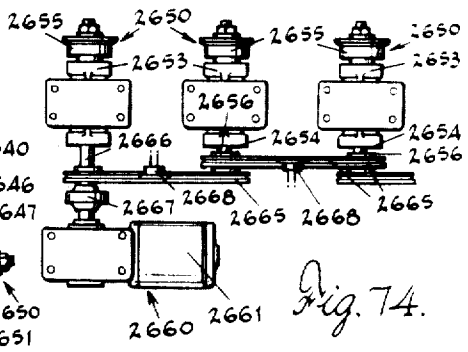




Fig. 74.

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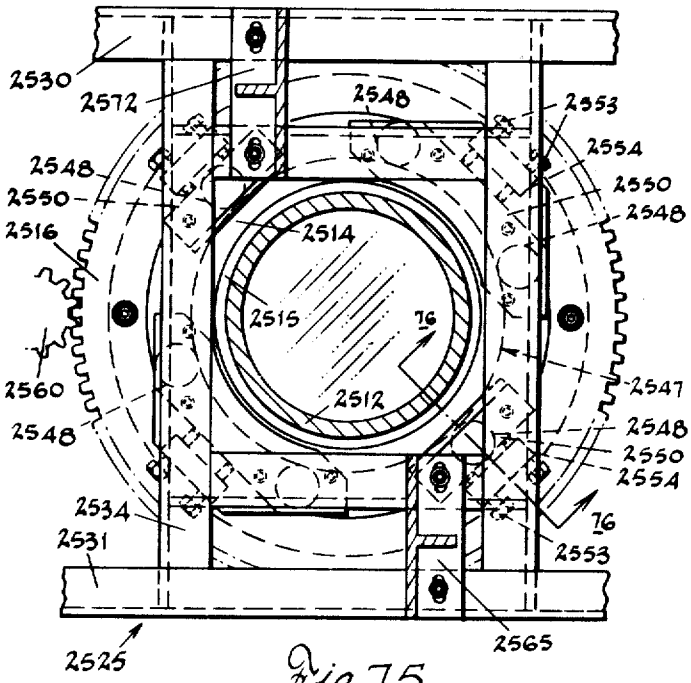


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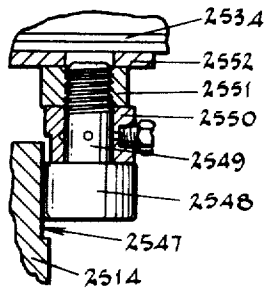


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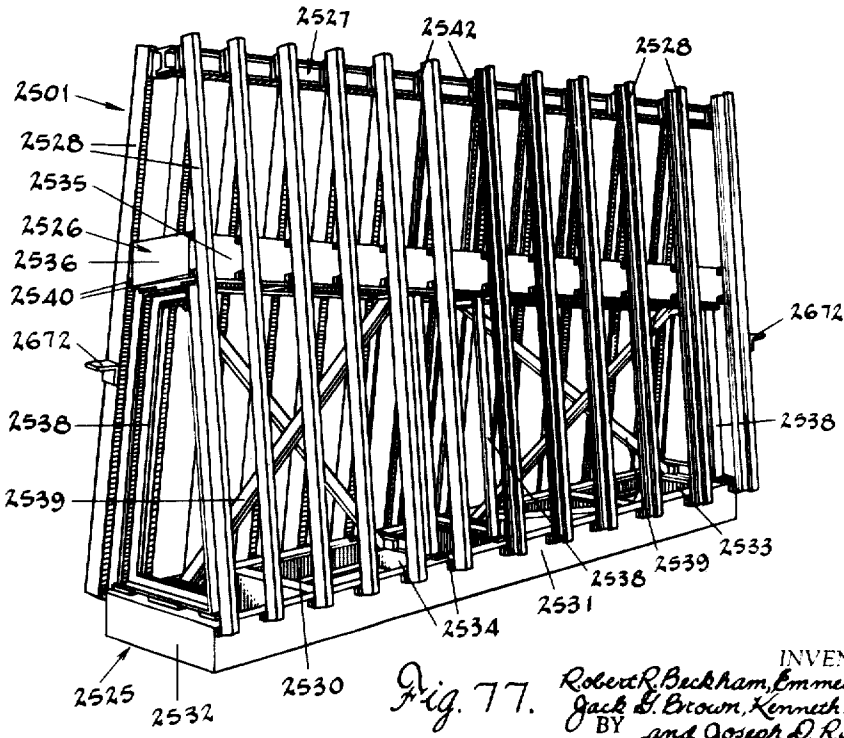


Fig. 77.

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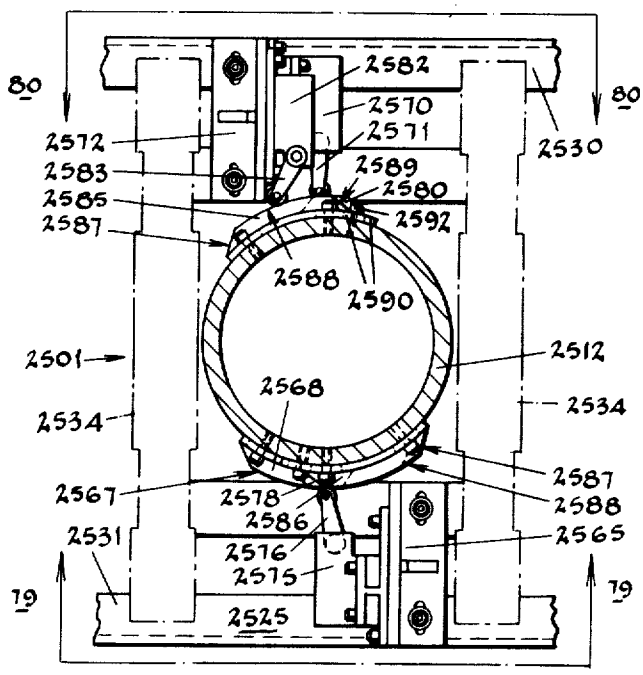
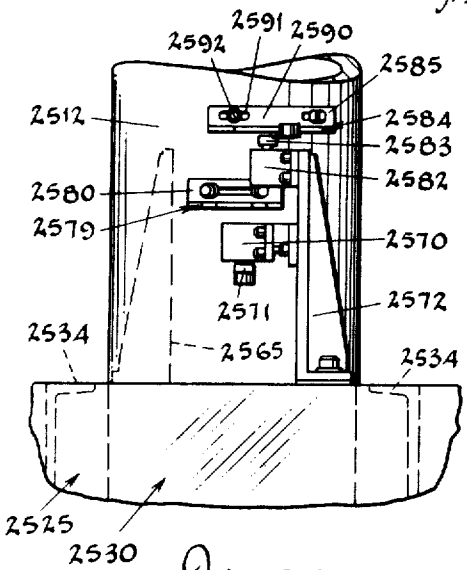



Fig. 78.

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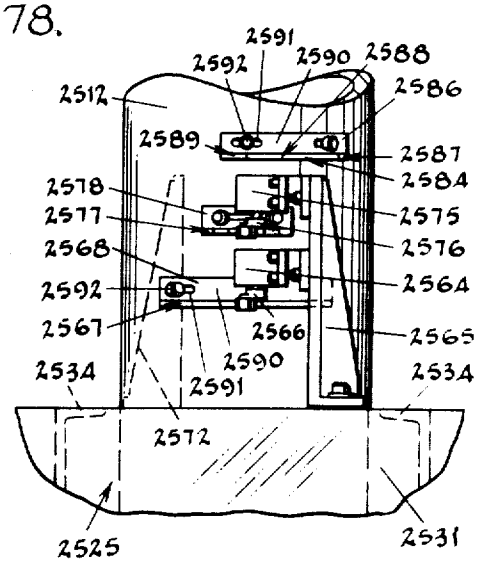


Fig. 79.

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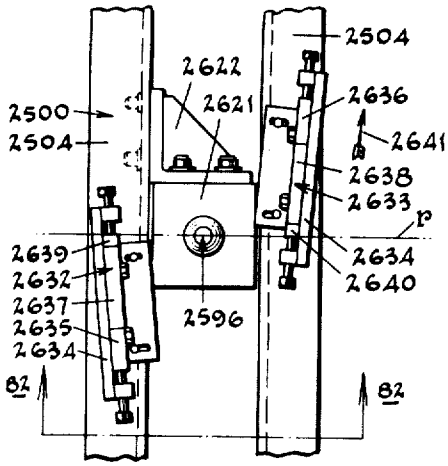



Fig. 81.

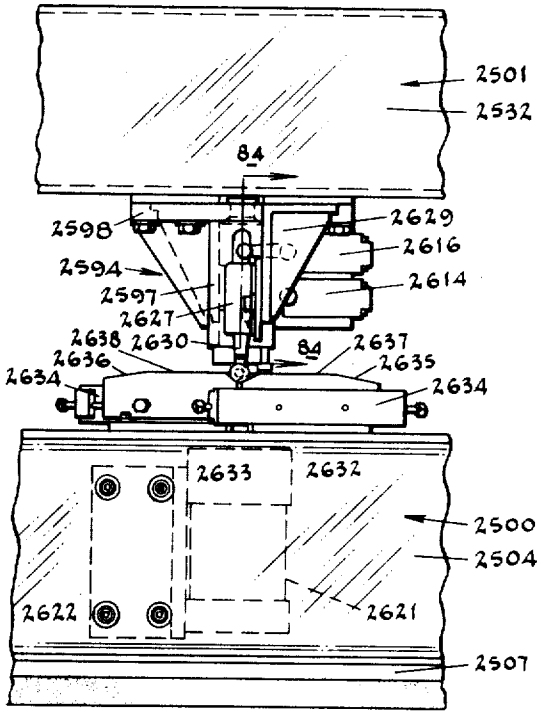
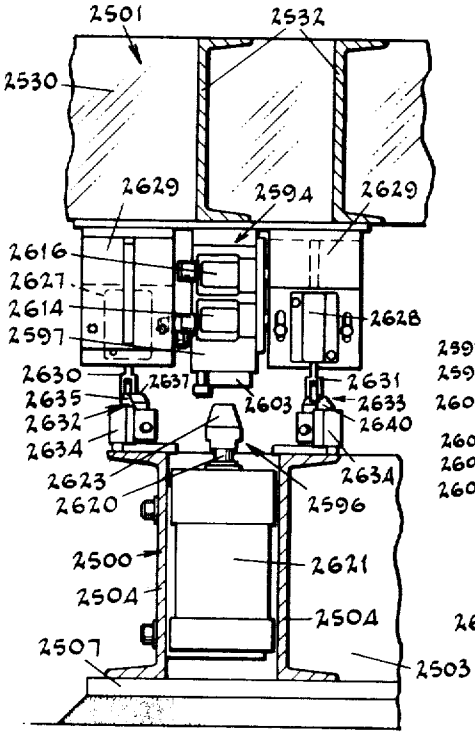



Fig. 83.

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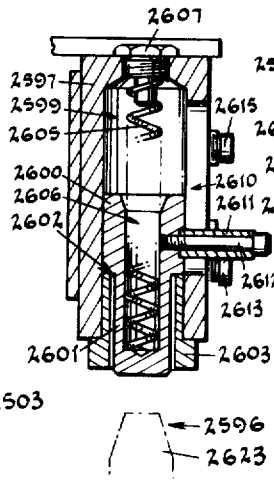


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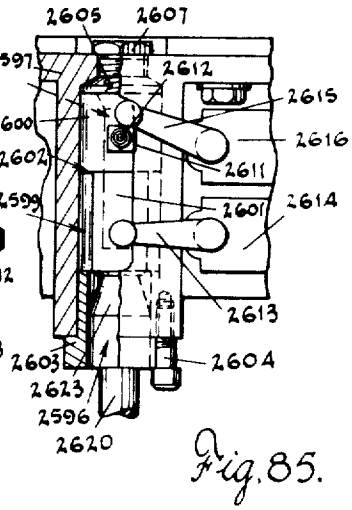


Fig. 85.

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Robert Q. Beckham, Emmett L. Walters,
Jack G. Brown, Kenneth M. DeRose
and Joseph D. Ryan
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Collins & Oberlin
ATTORNEYS

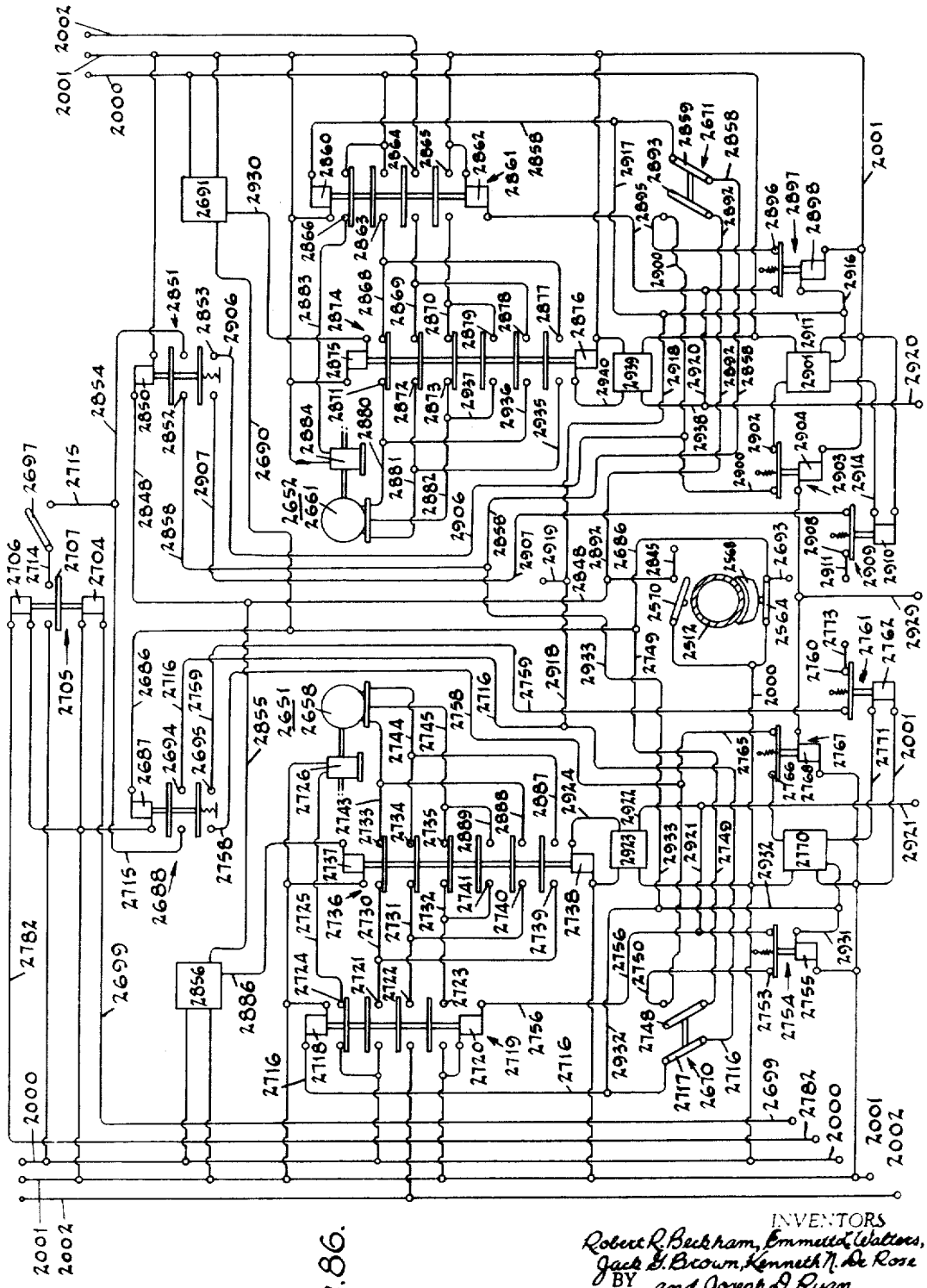

Fig. 86.

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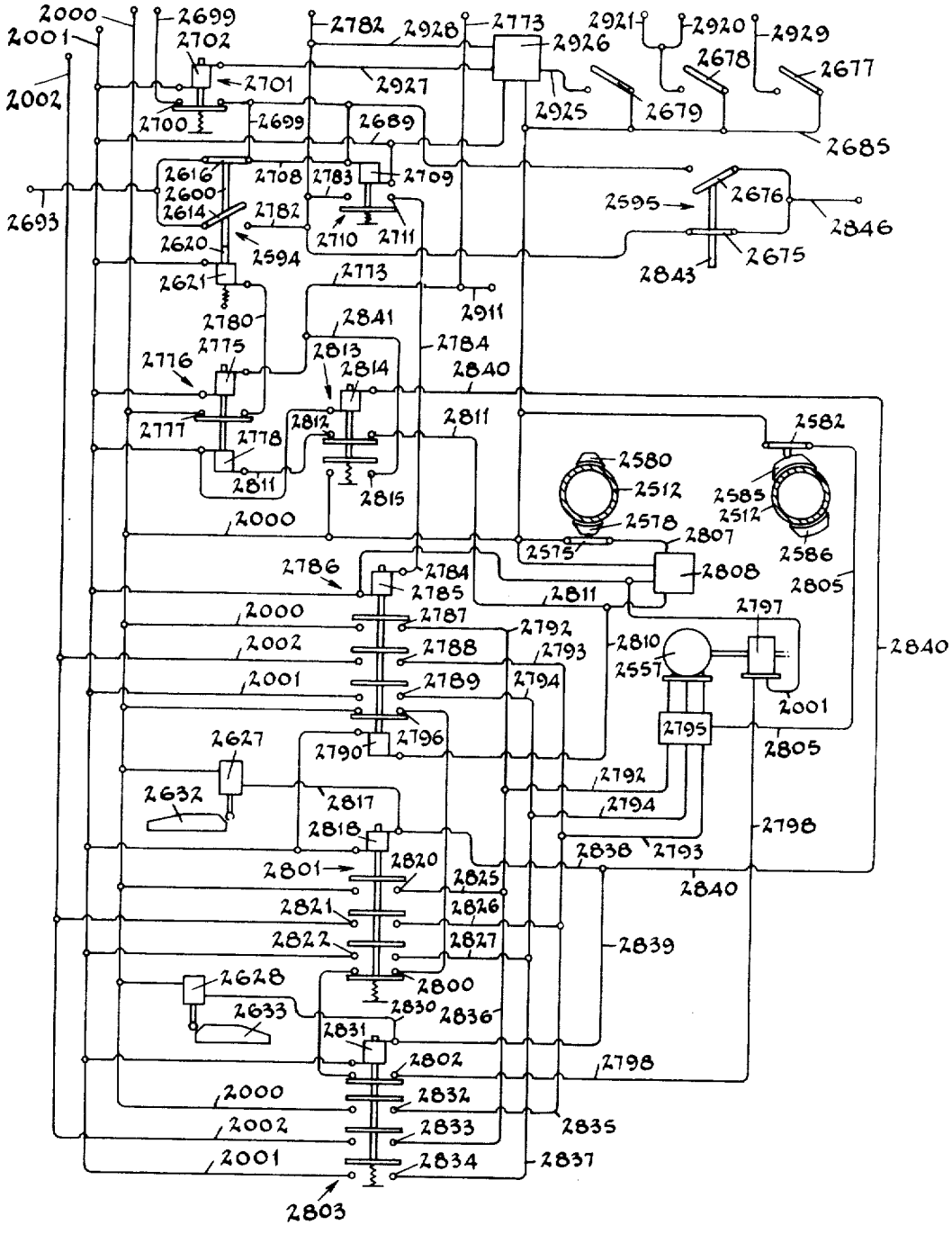


Fig. 87.

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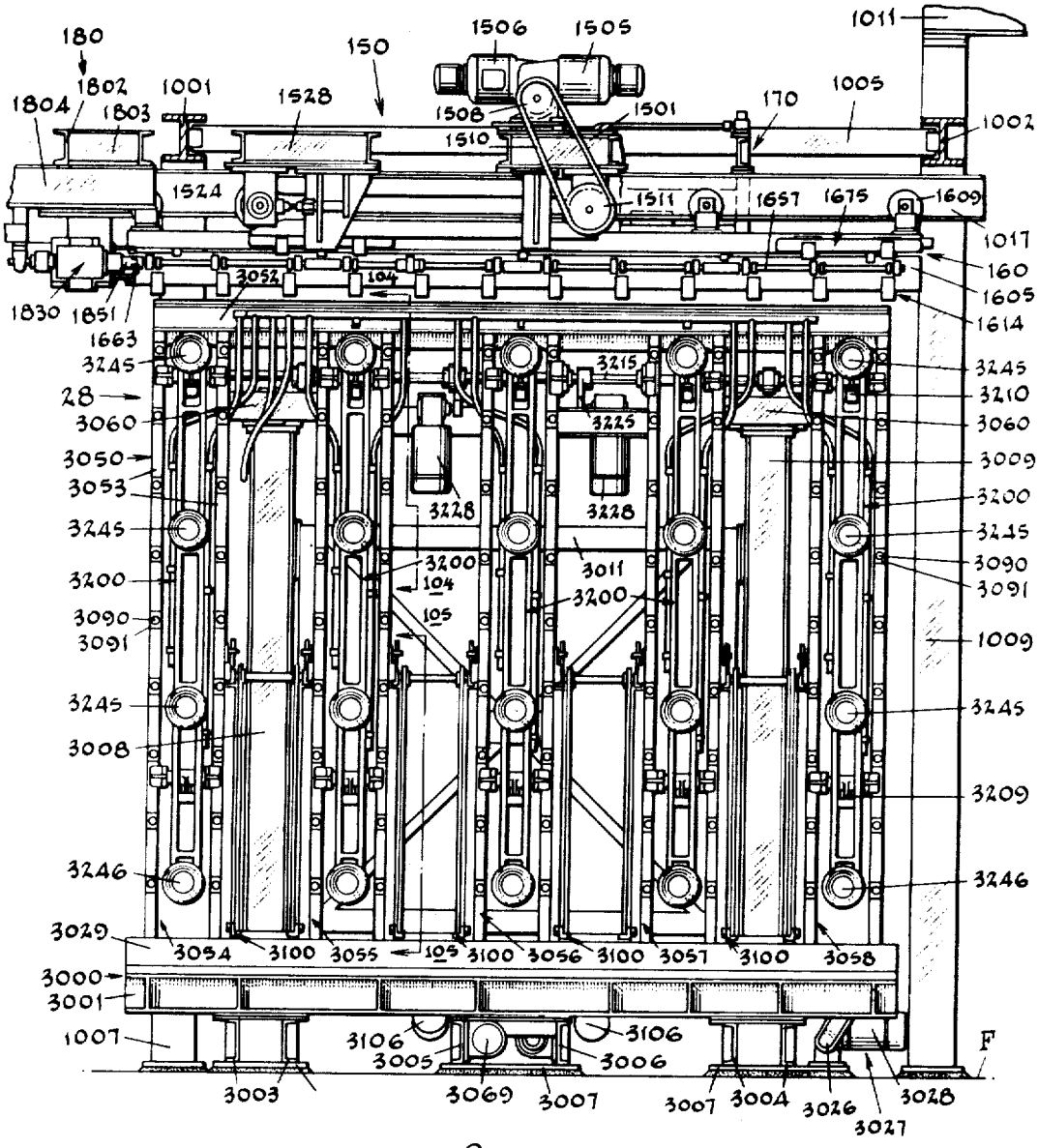


Fig. 88.

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Jack H. Brown, Kenneth N. De Rose
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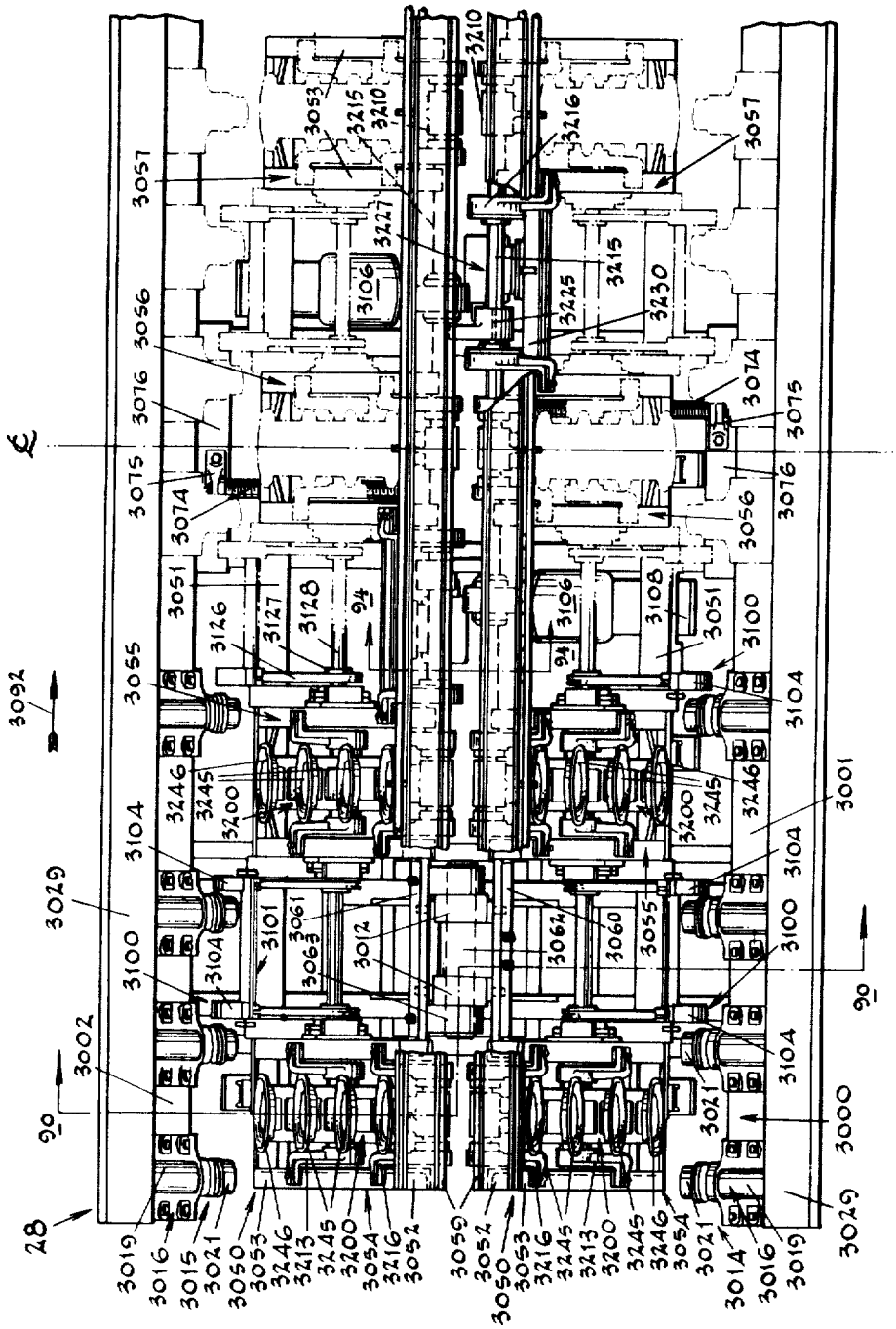

Fig. 89.

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Jack D. Brown, Kenneth N. DeRose
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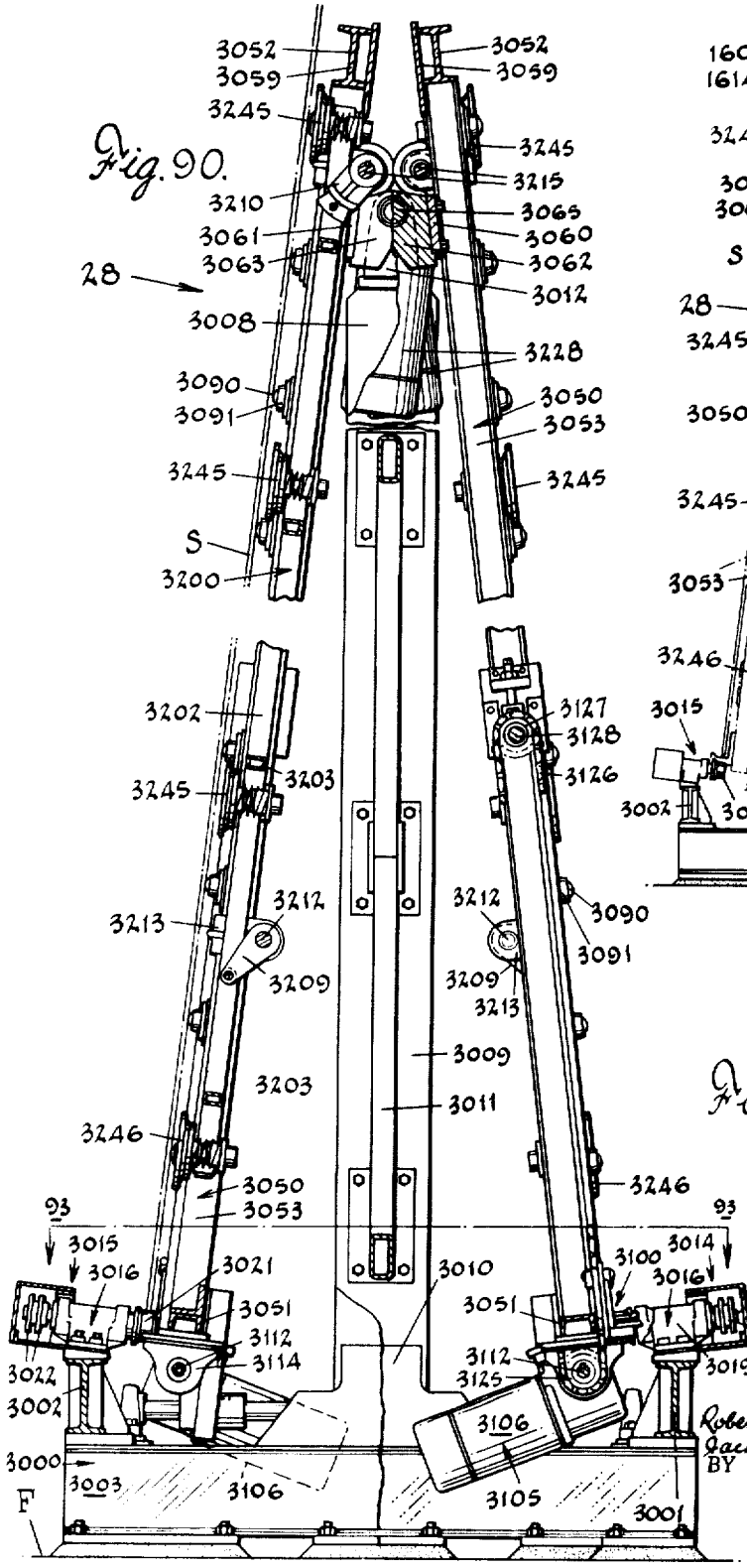
Fig. 90.

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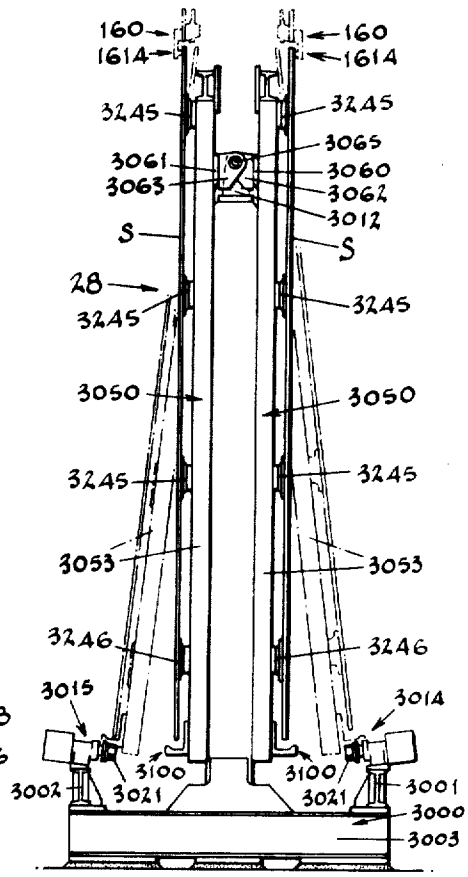


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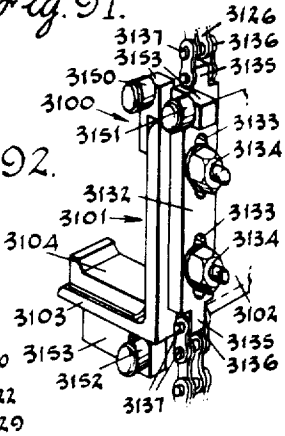


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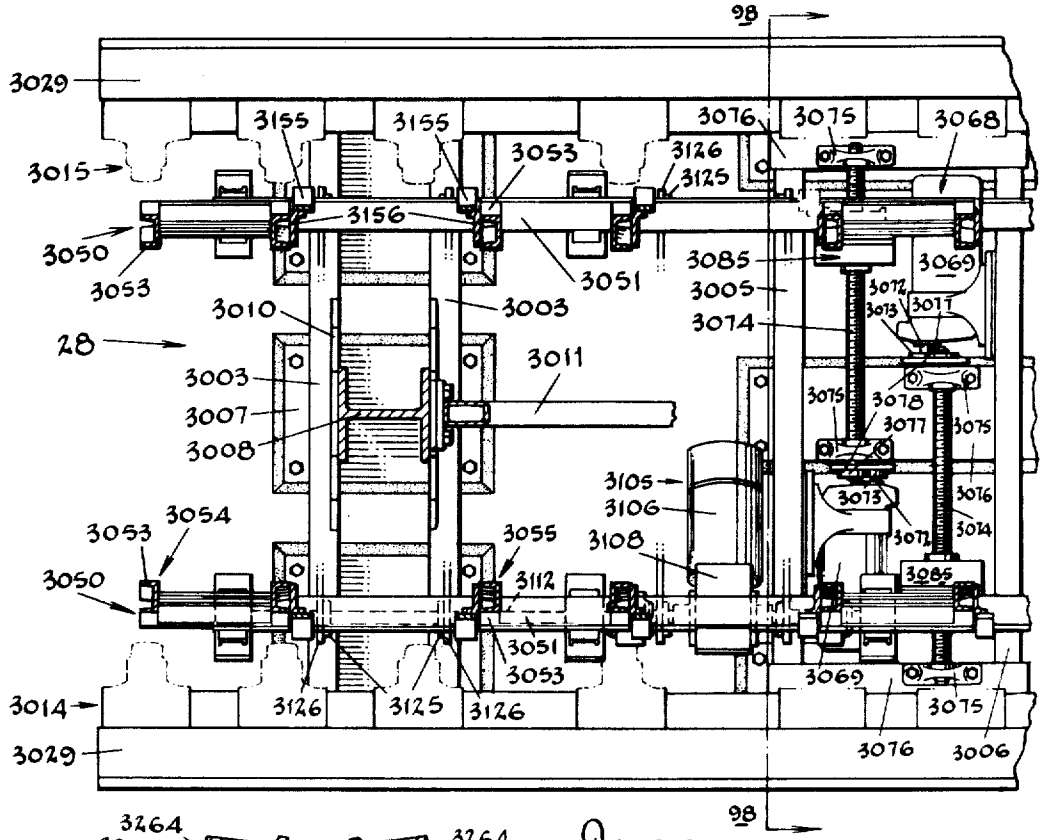


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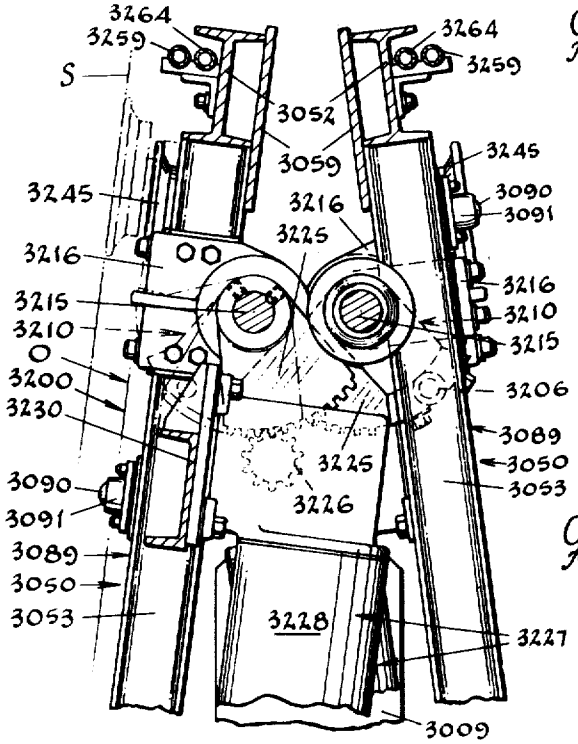


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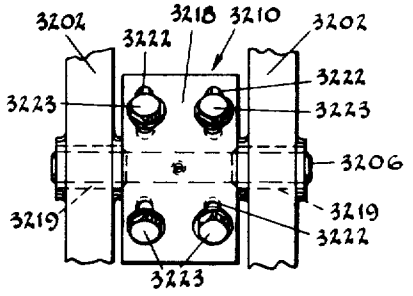


Fig. 95.

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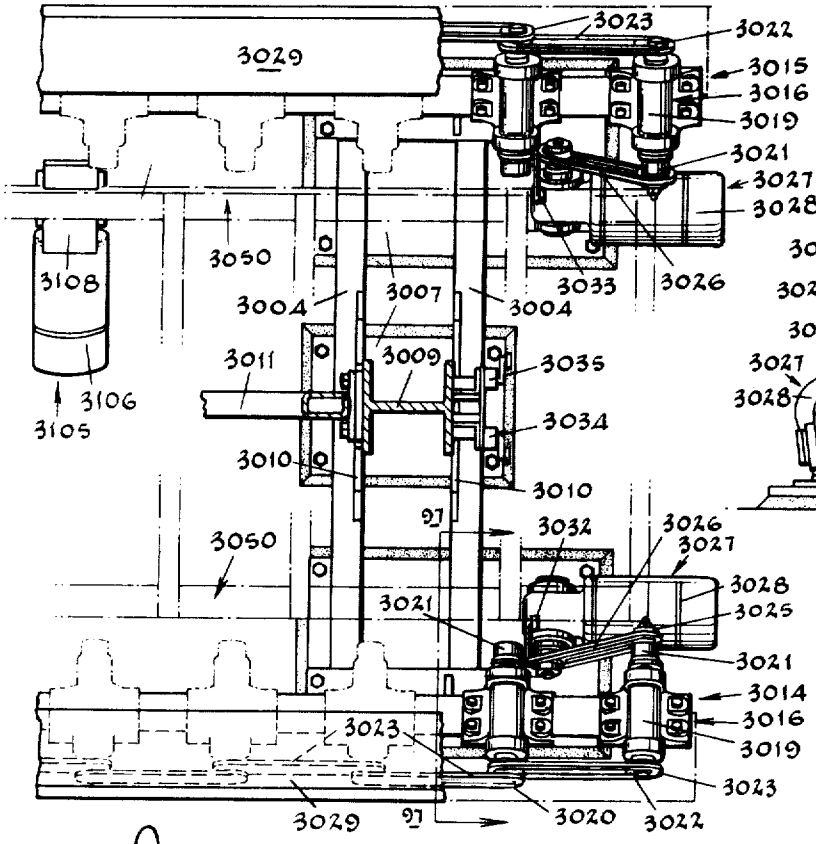


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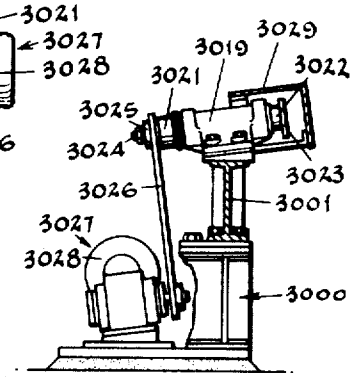


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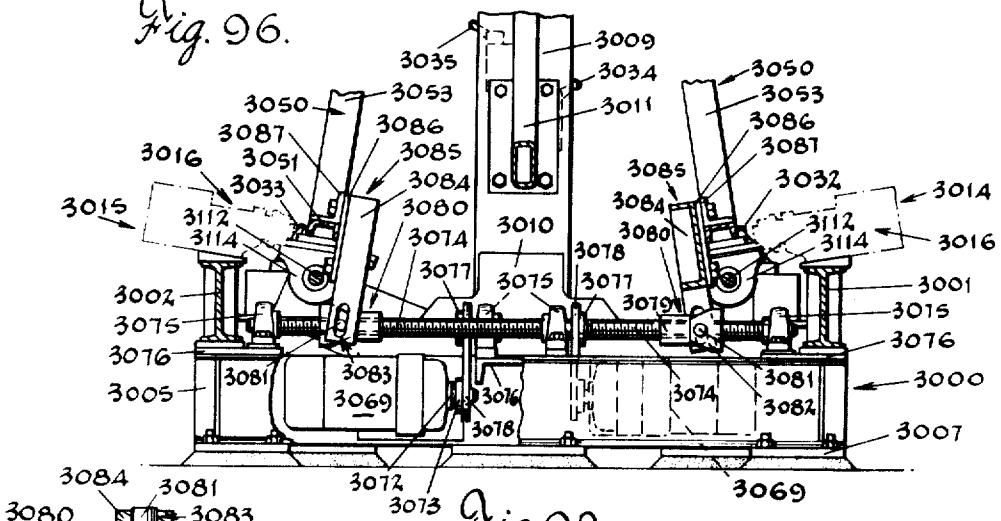


Fig. 98.

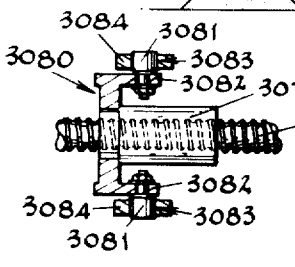


Fig. 99.

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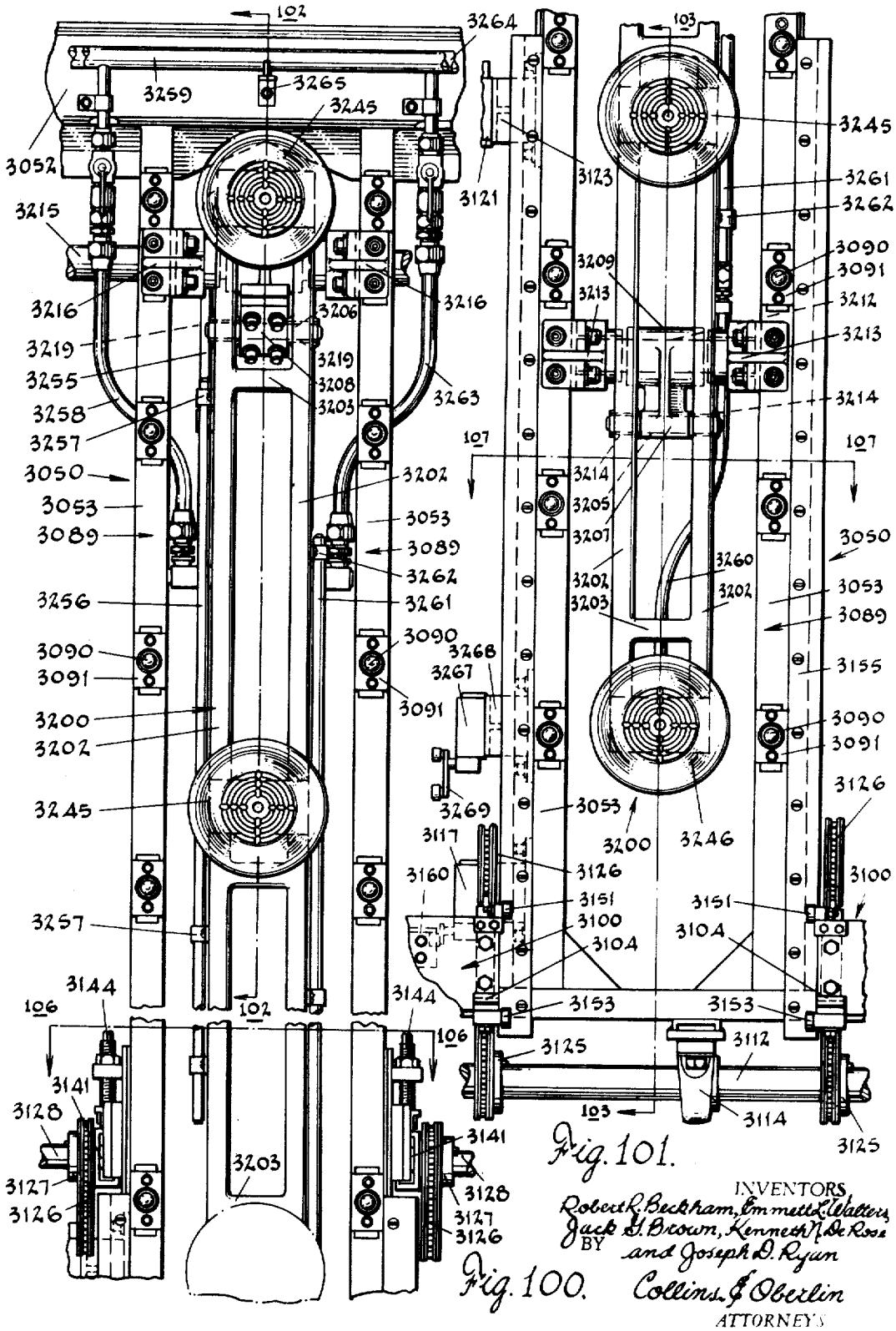


Fig. 101.

Fig. 100.

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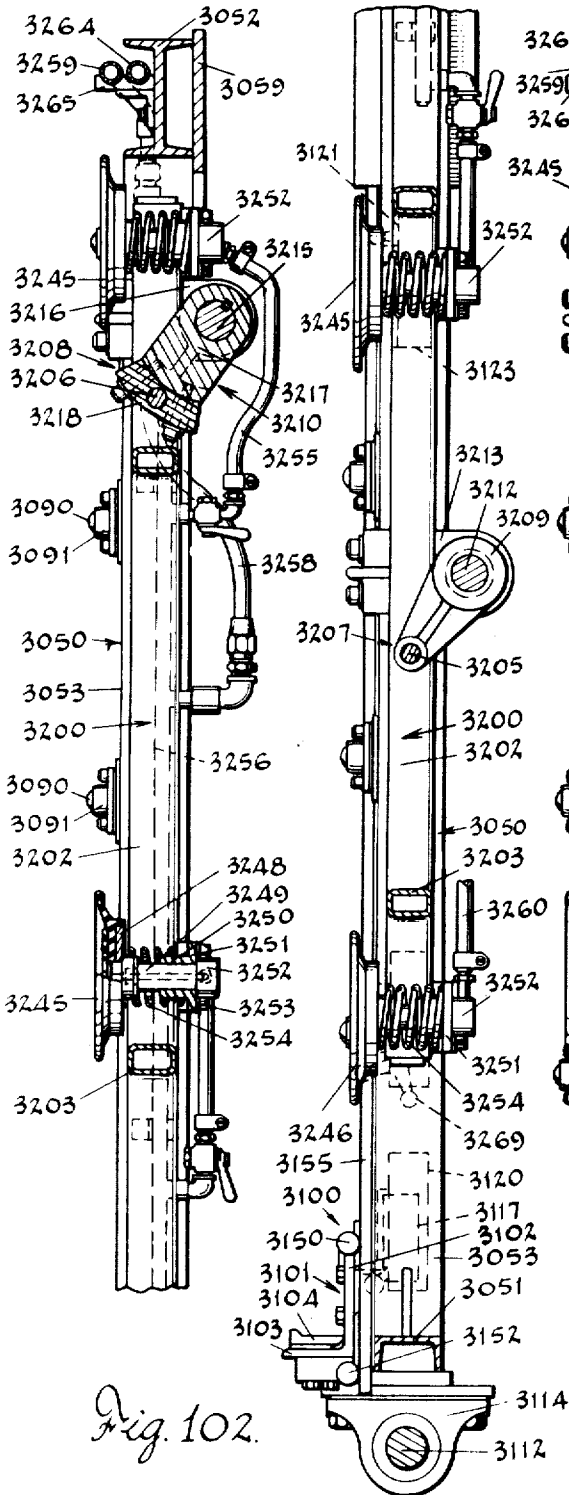
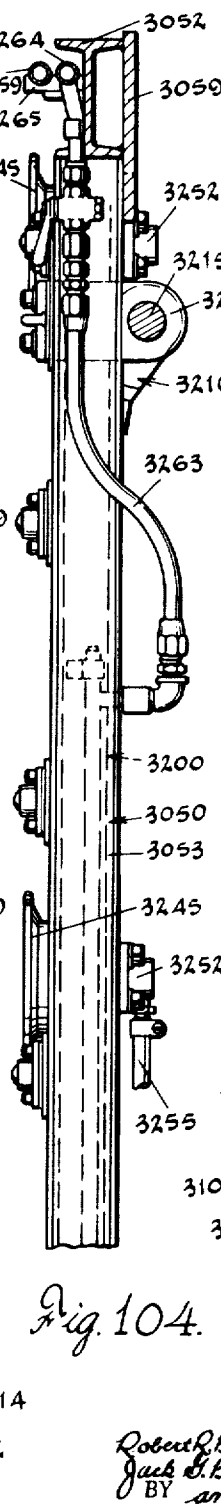



Fig. 102.




Fig. 103.

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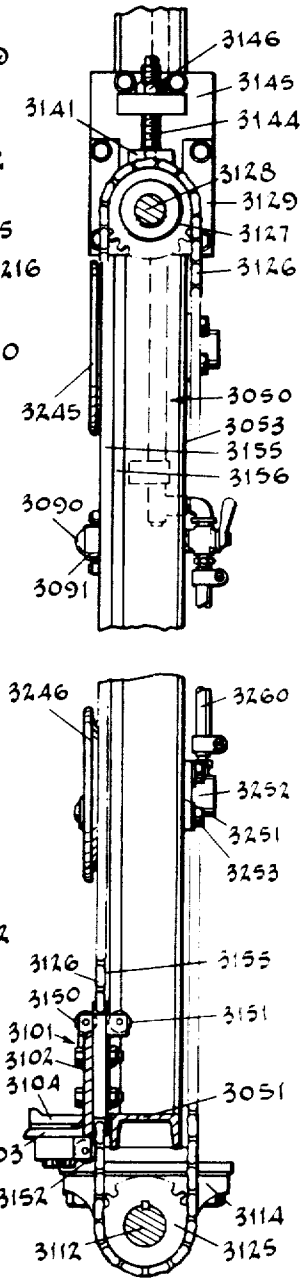


Fig. 105

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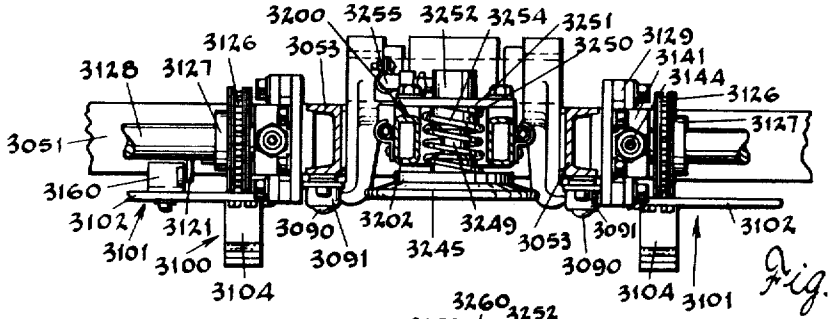


Fig. 106.

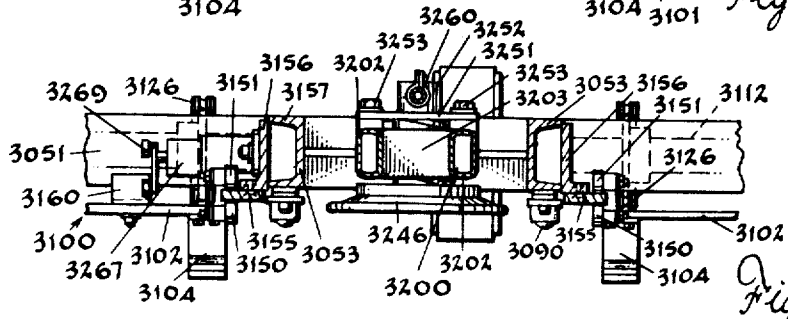


Fig. 107.

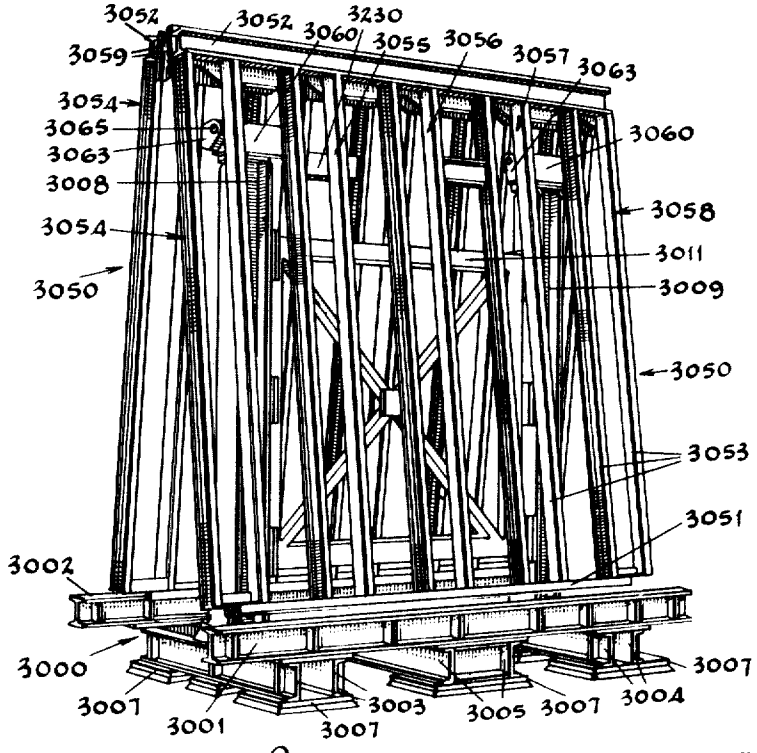


Fig. 108.

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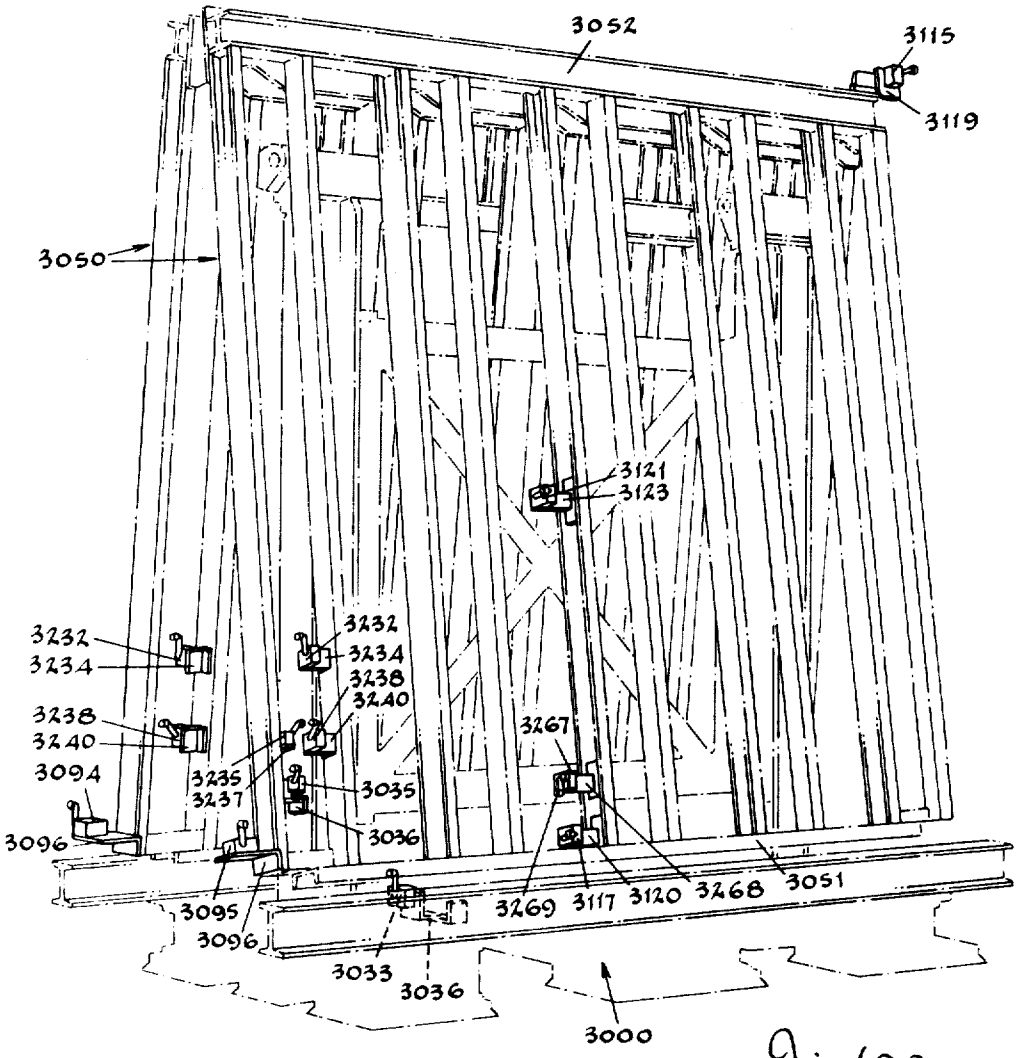


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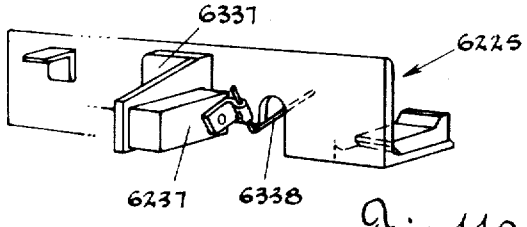


Fig. 110.

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Robert R. Beckham, Emmett L. Walters,
Jack B. Brown, Kenneth N. DeRose
and Joseph D. Ryan
BY
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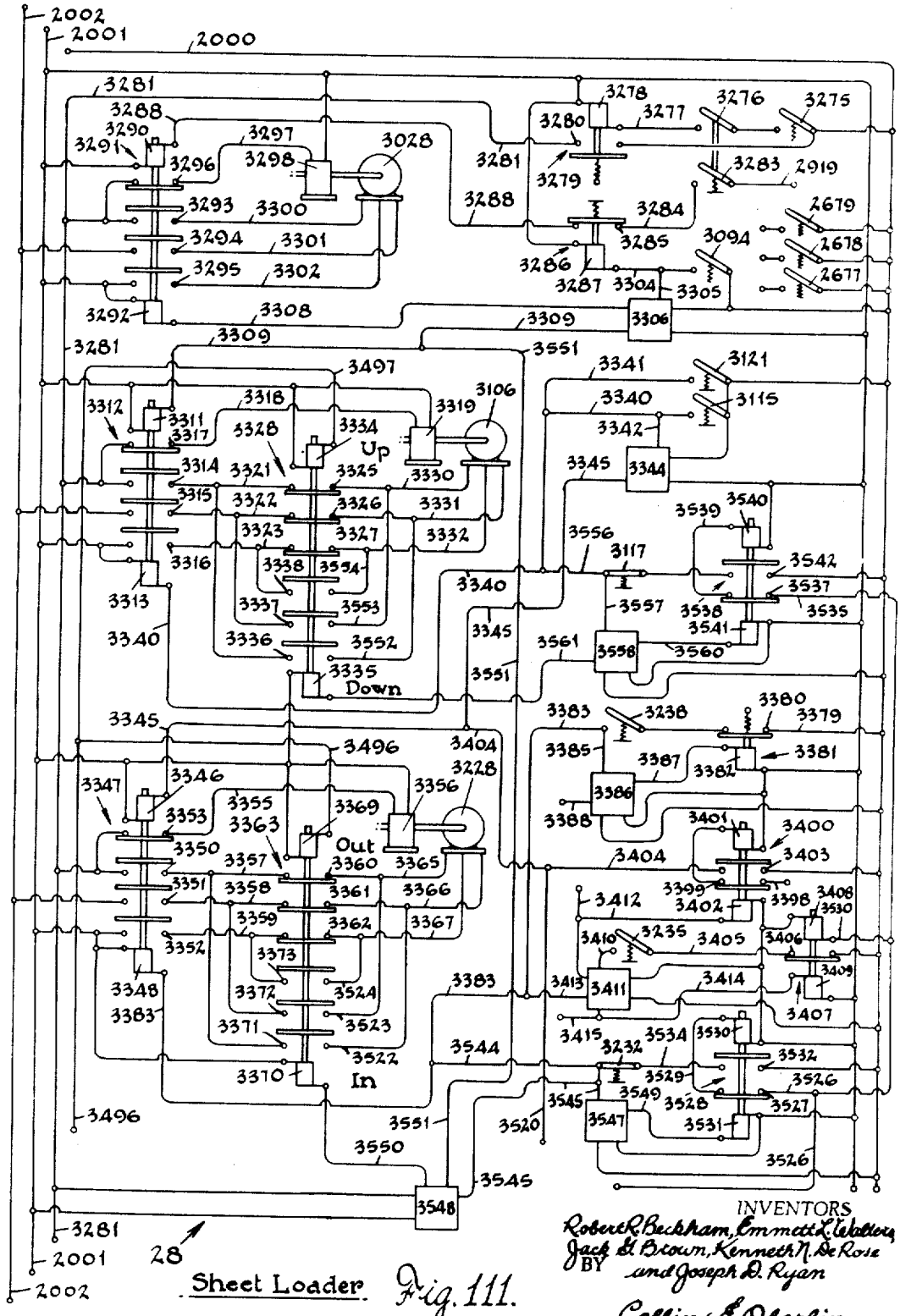


Fig. 111.

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Robert R. Beckham, Emmett L. Webber,
Jack H. Brown, Kenneth N. DeRose
and Joseph D. Ryan
BY
Collins & Oberlin
ATTORNEYS

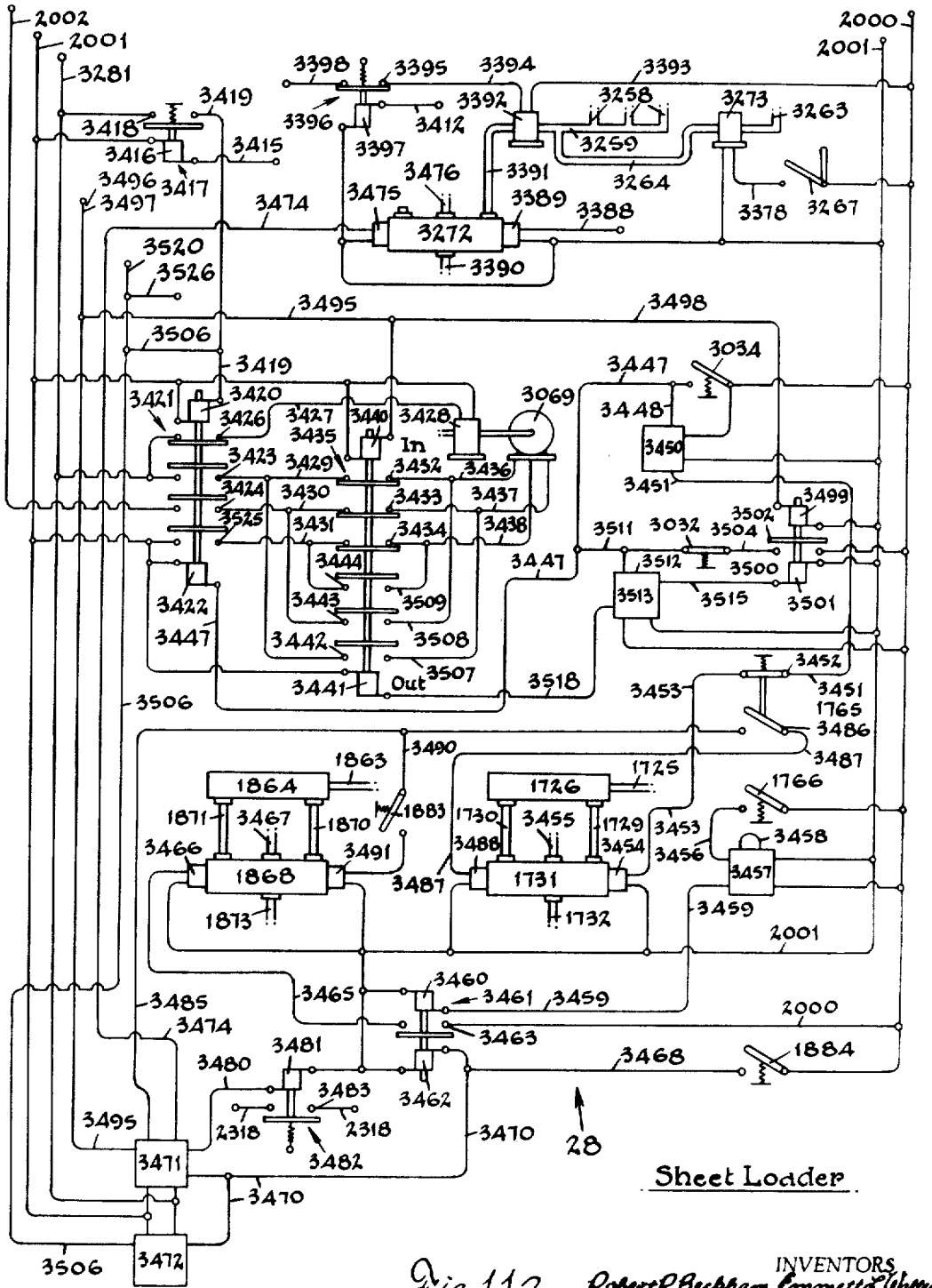
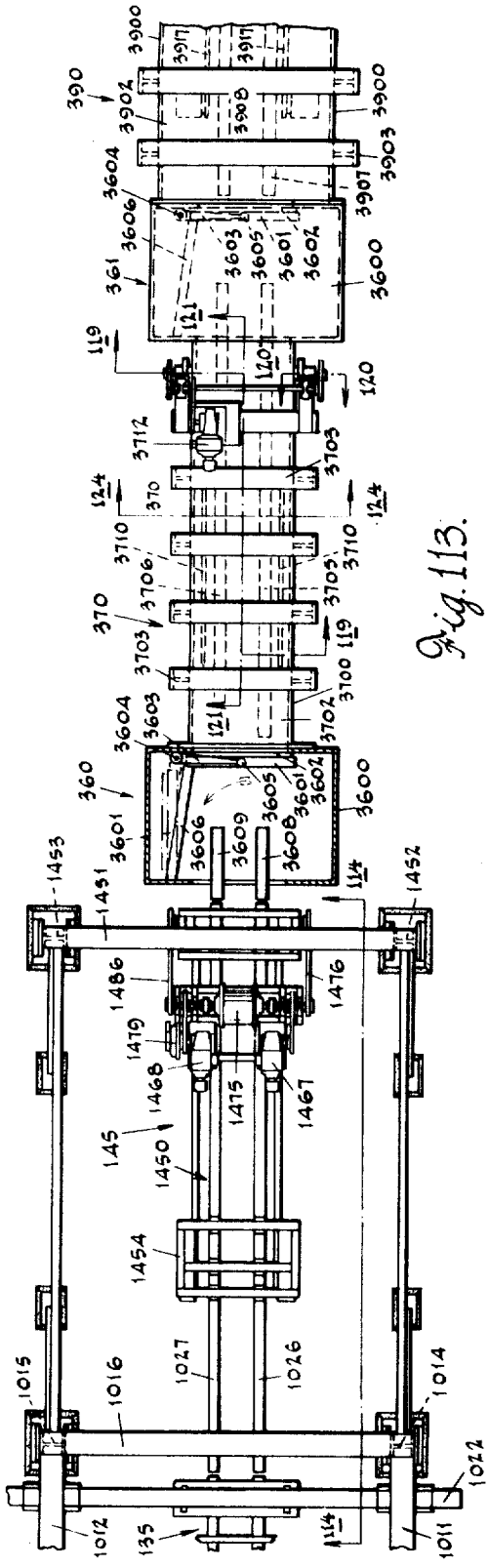



Fig. 112.

INVENTORS
Robert R. Beckham, Emmett L. Lehrer,
Jack D. Brown, Kenneth N. De Rose
BY and Joseph D. Ryan
Collins & Oberlin
ATTORNEYS



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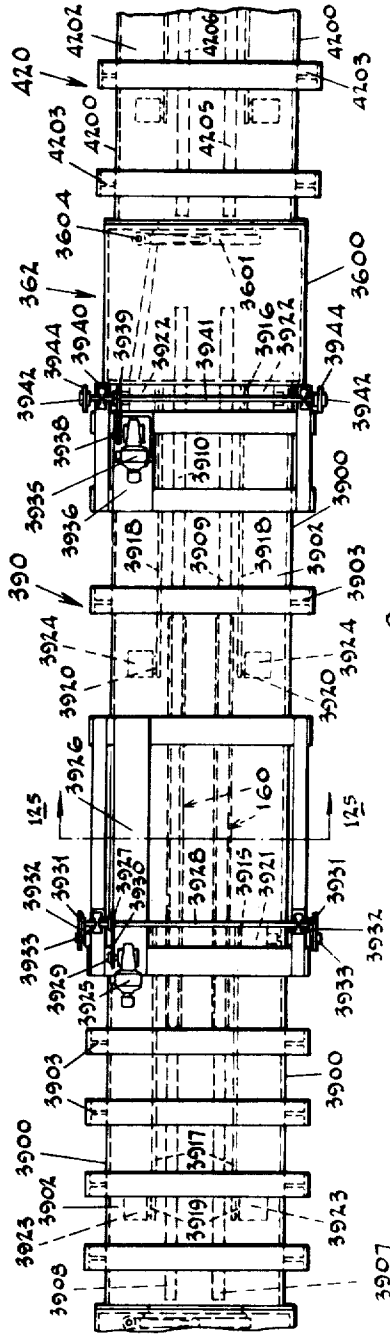

Fig. 123.

INVENTORS
Robert R. Beckham, Emmett L. Collins,
Jack D. Brown, Kenneth N. DeRose
BY and Joseph D. Ryan

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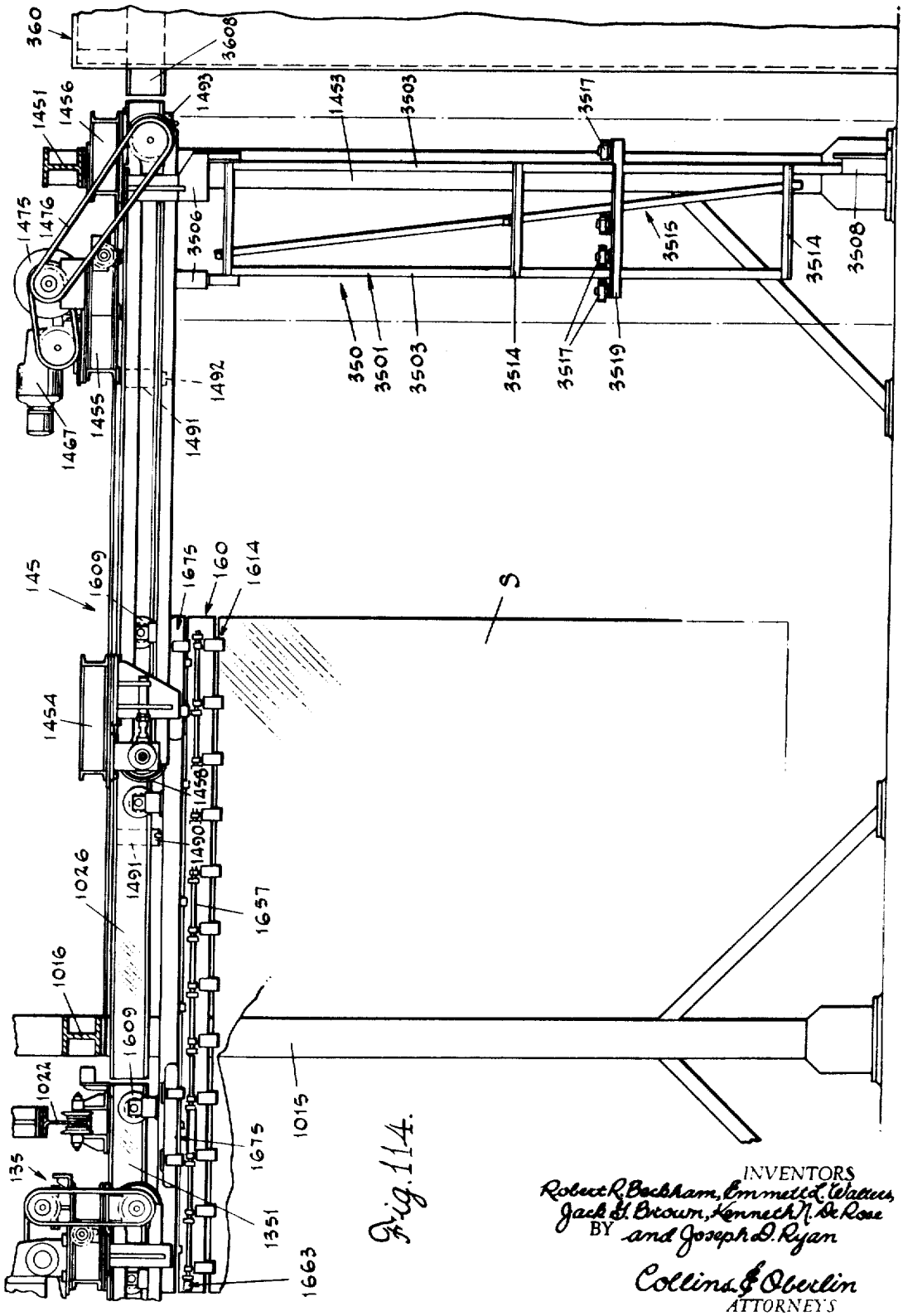


Fig. 114.

INVENTORS
Robert R. Beckham, Emmett L. Wallace,
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ATTORNEYS

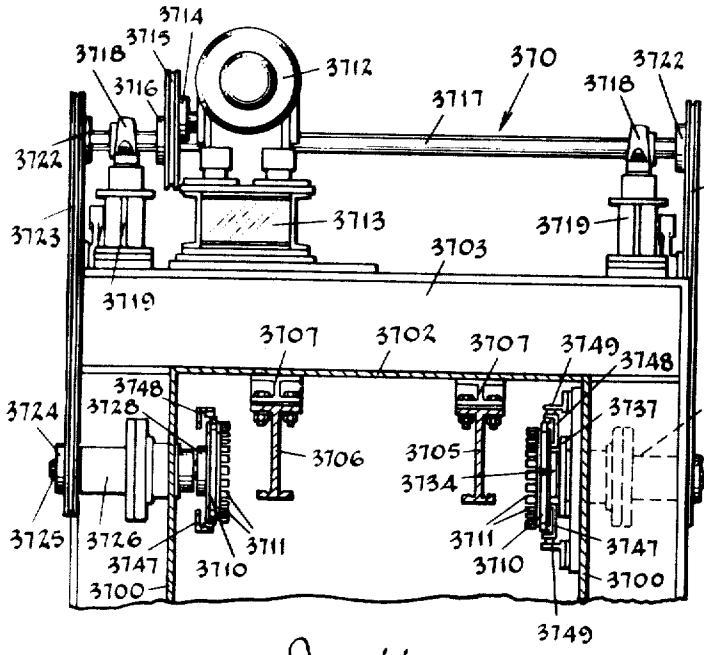
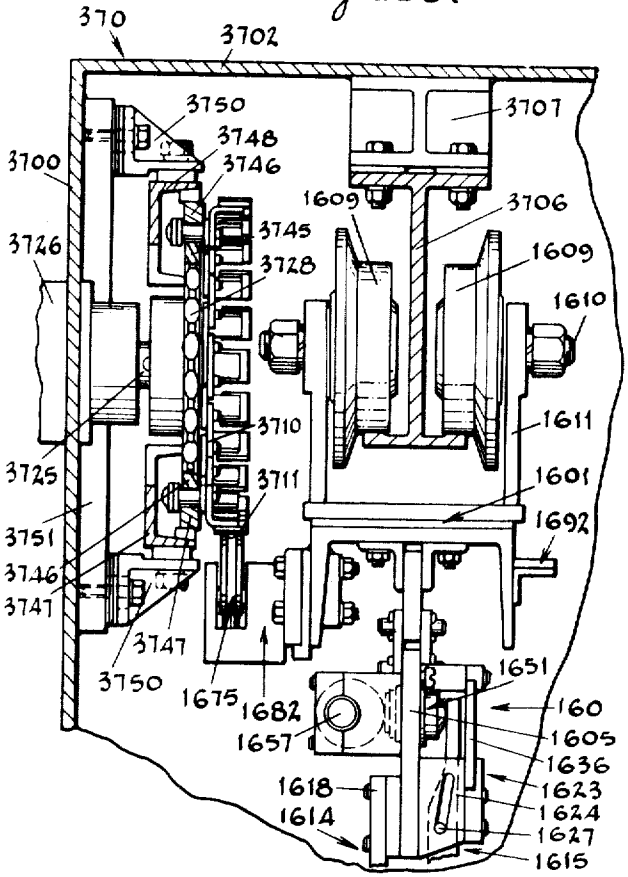



Fig. 119.



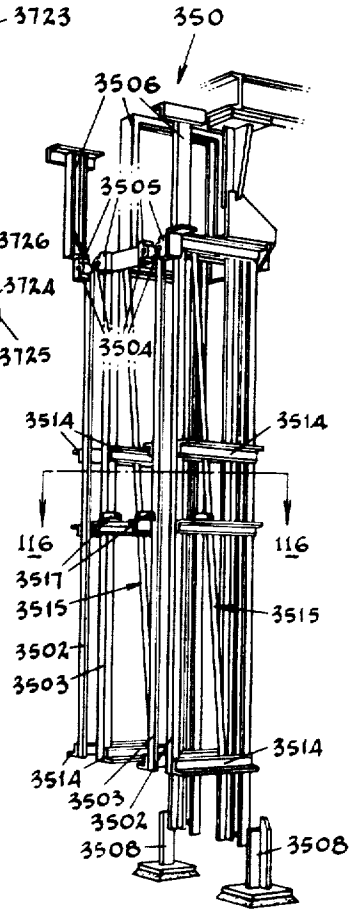




Fig. 115.

Fig. 120.

INVENTORS
Robert R. Beckham, Emmett L. Walters,
Jack F. Brown, Kenneth N. De Rose
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ATTORNEYS

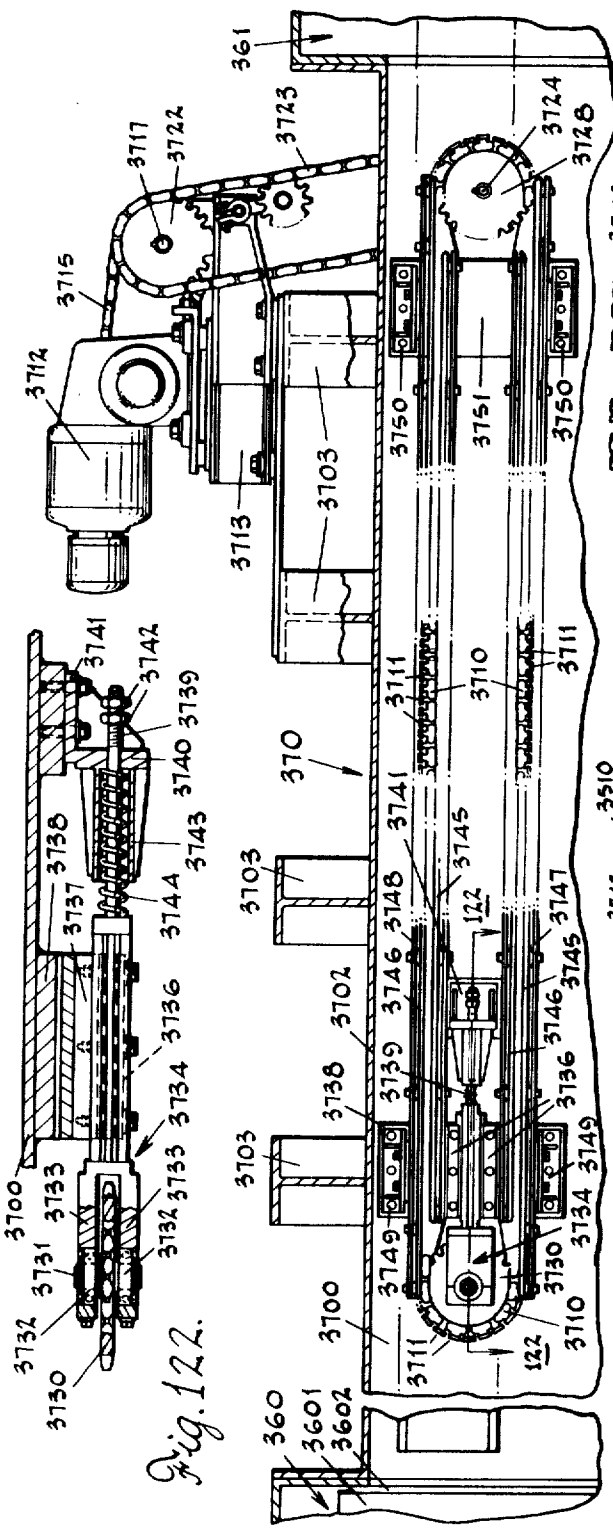

Fig. 122.

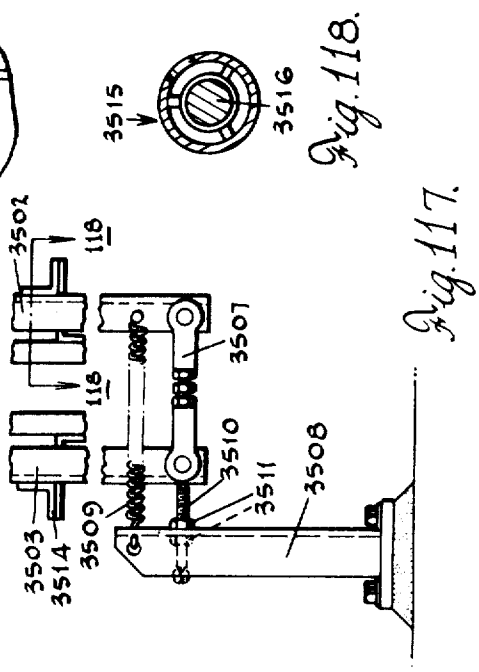

Fig. 117.



Fig. 118.

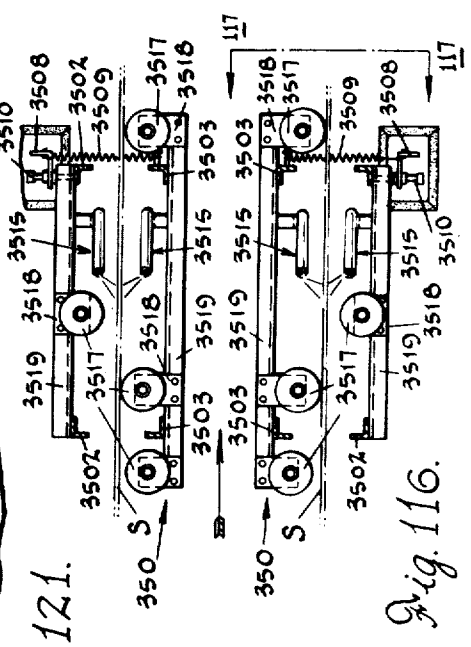

Fig. 116.



Fig. 121.

INVENTORS
Robert R. Beckham, Emmett L. Walters,
Jack D. Brown, Kenneth N. DeRose
and Joseph D. Ryan
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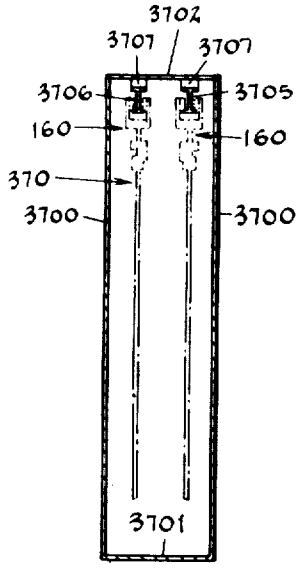


Fig. 124.

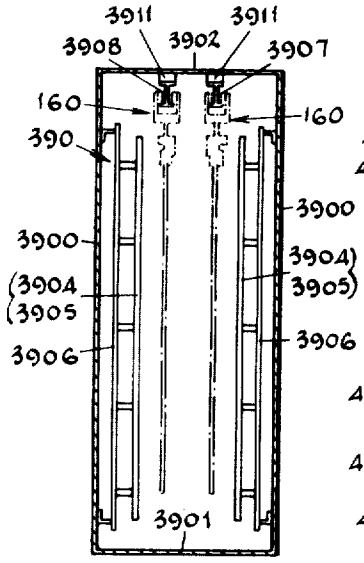


Fig. 125.

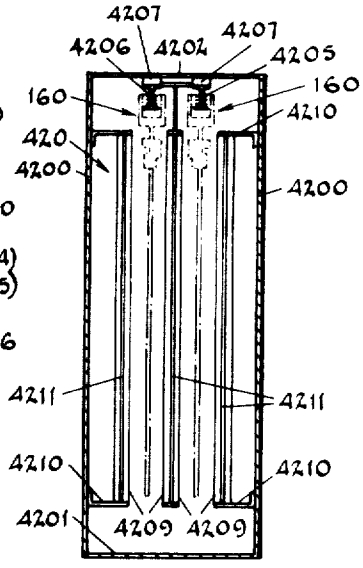


Fig. 128.

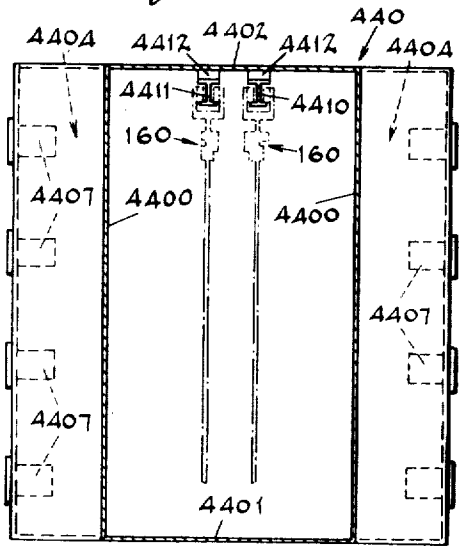


Fig. 129.

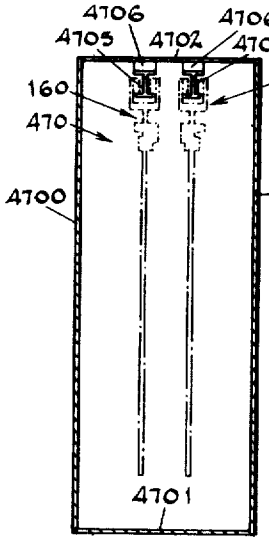


Fig. 131.

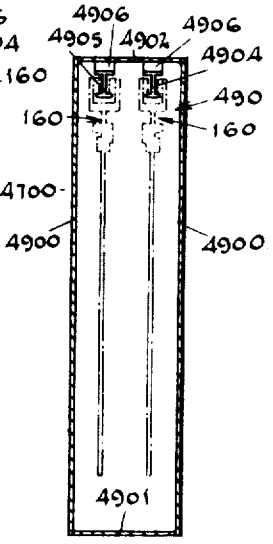


Fig. 132.

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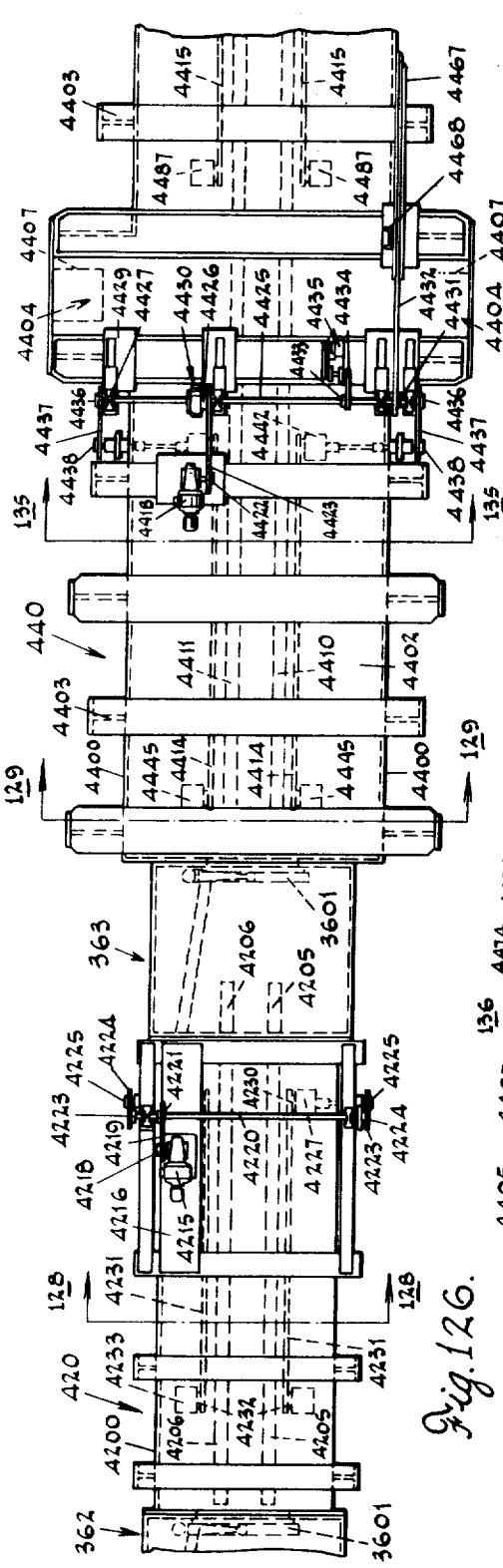

Fig. 126.

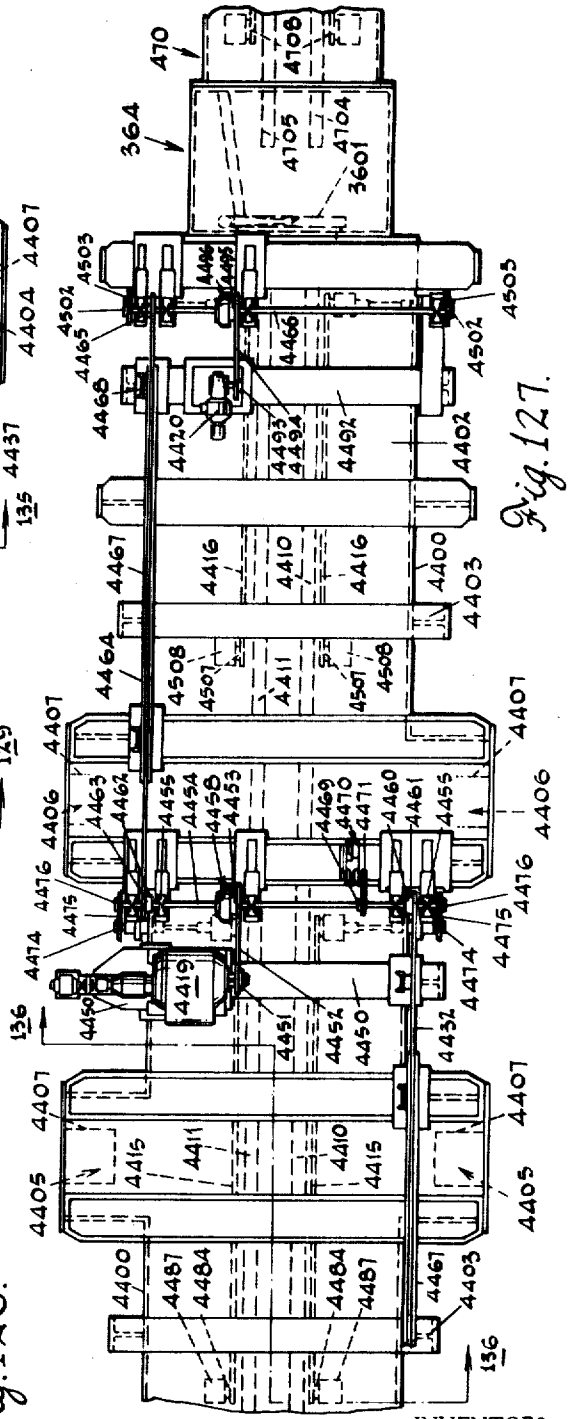

Fig. 127.

INVENTORS
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Jack B. Brown, Kenneth N. De Rose
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ATTORNEYS

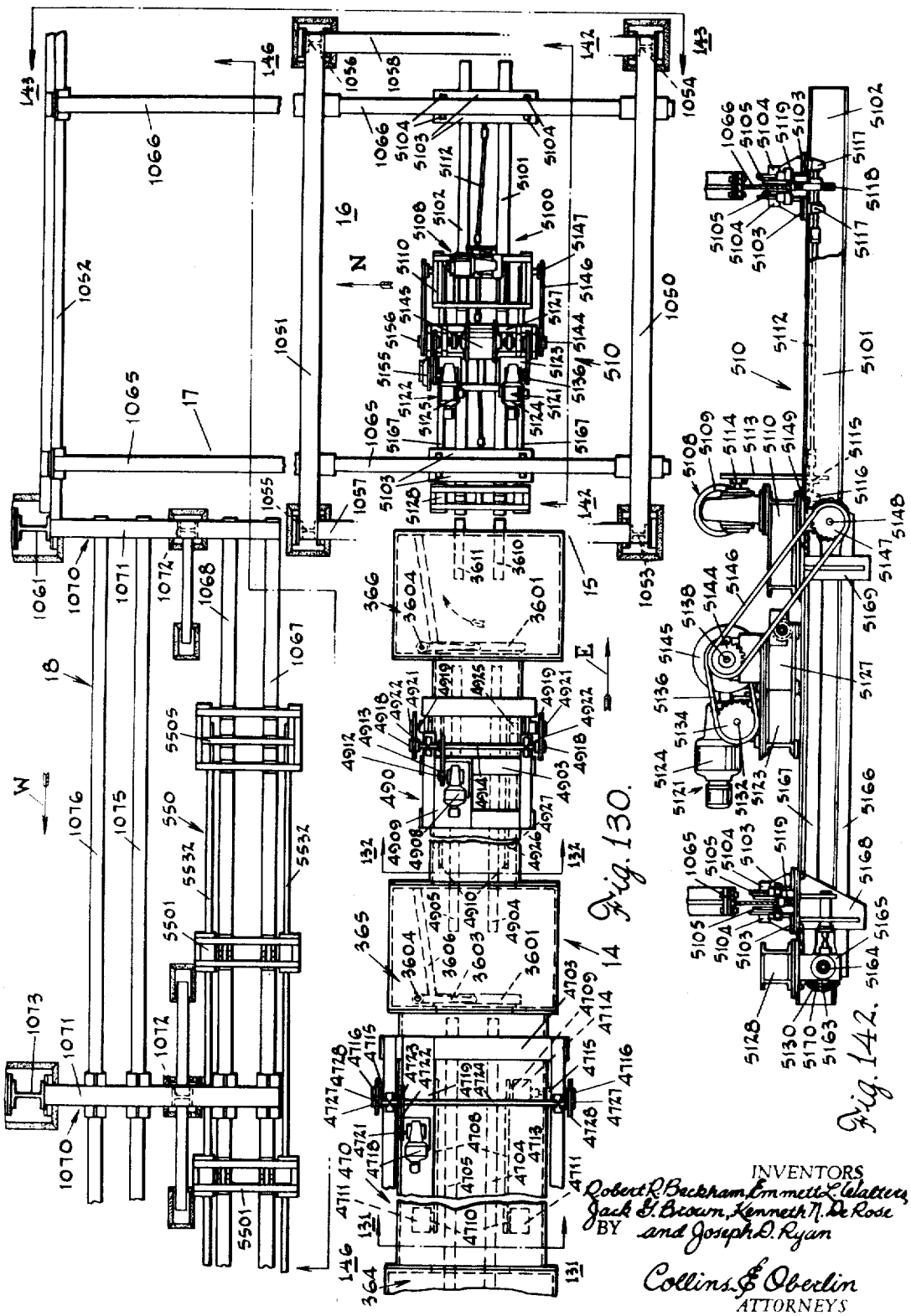

Fig. 130.

Fig. 142.

INVENTORS
Robert R. Beckham, Emmett L. Walters,
Jack G. Brown, Kenneth N. De Rose
and Joseph D. Ryan
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Collins & Oberlin
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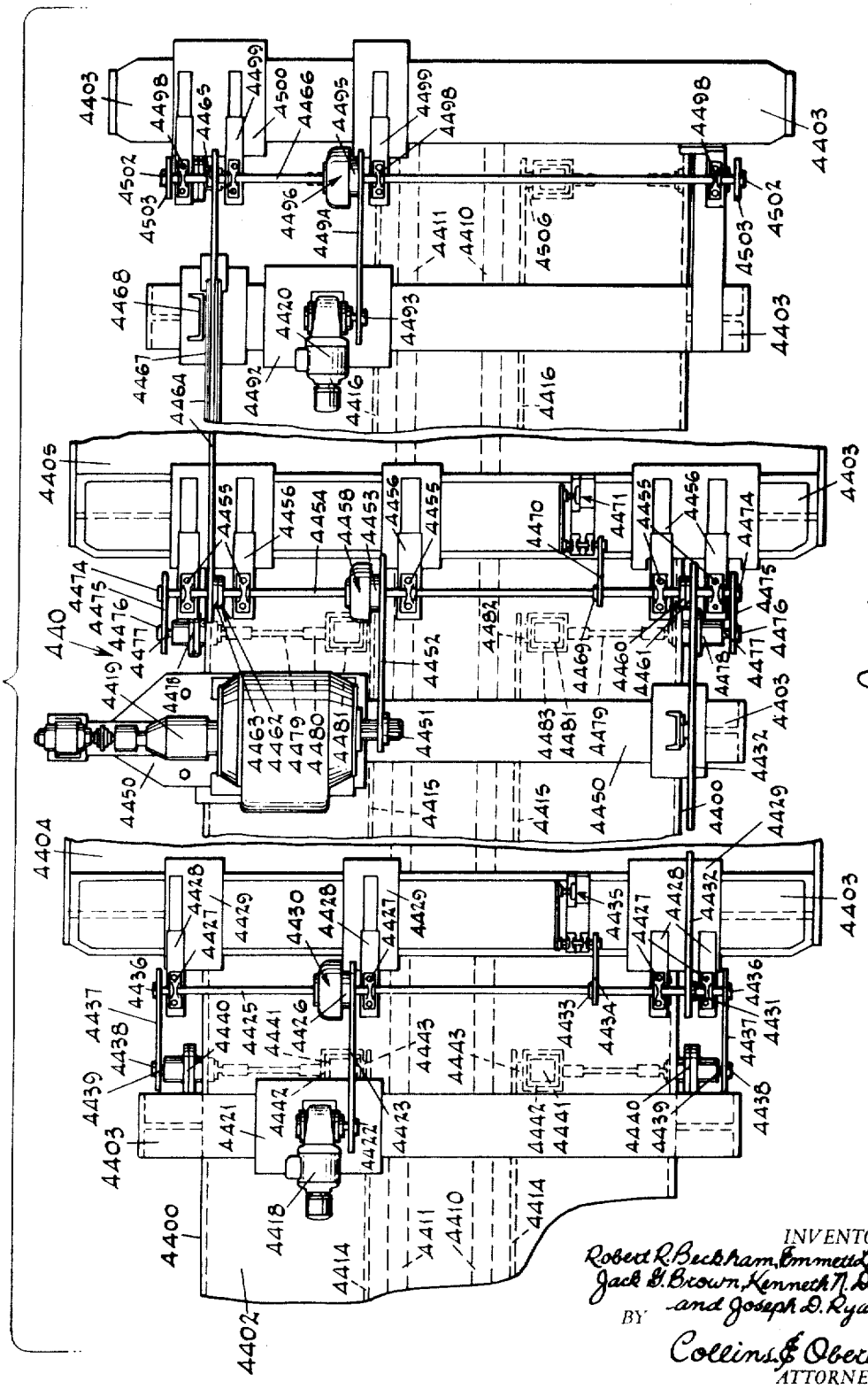

Fig. 133.

INVENTORS
Robert R. Beckham, Emmett L. Walters,
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and Joseph D. Ryan
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Collins & Oberlin
ATTORNEYS

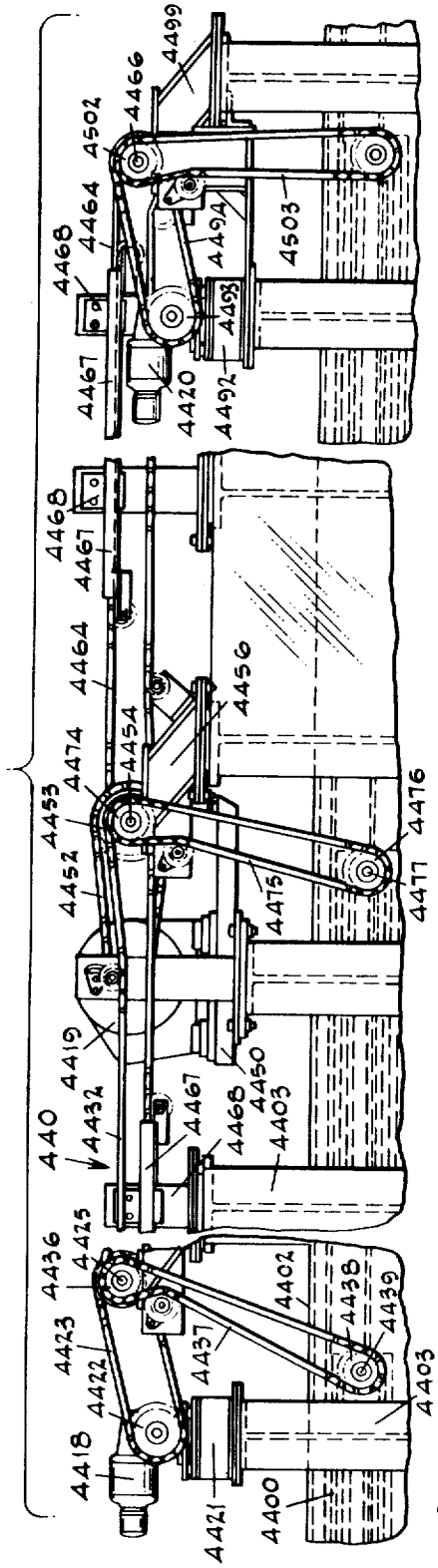

Fig. 134.

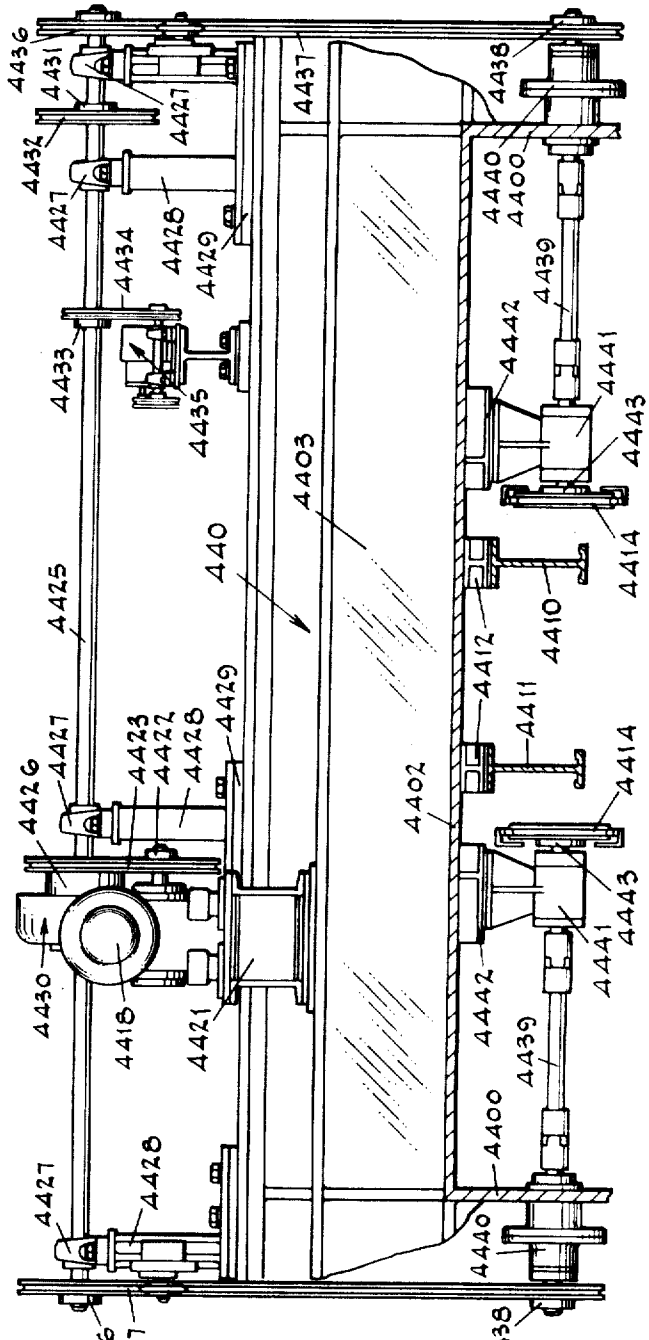

Fig. 135.

INVENTORS
Robert R. Beckham, Emmett L. Walters,
Jack L. Brown, Kenneth N. De Rose
and Joseph D. Ryan
BY
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ATTORNEYS

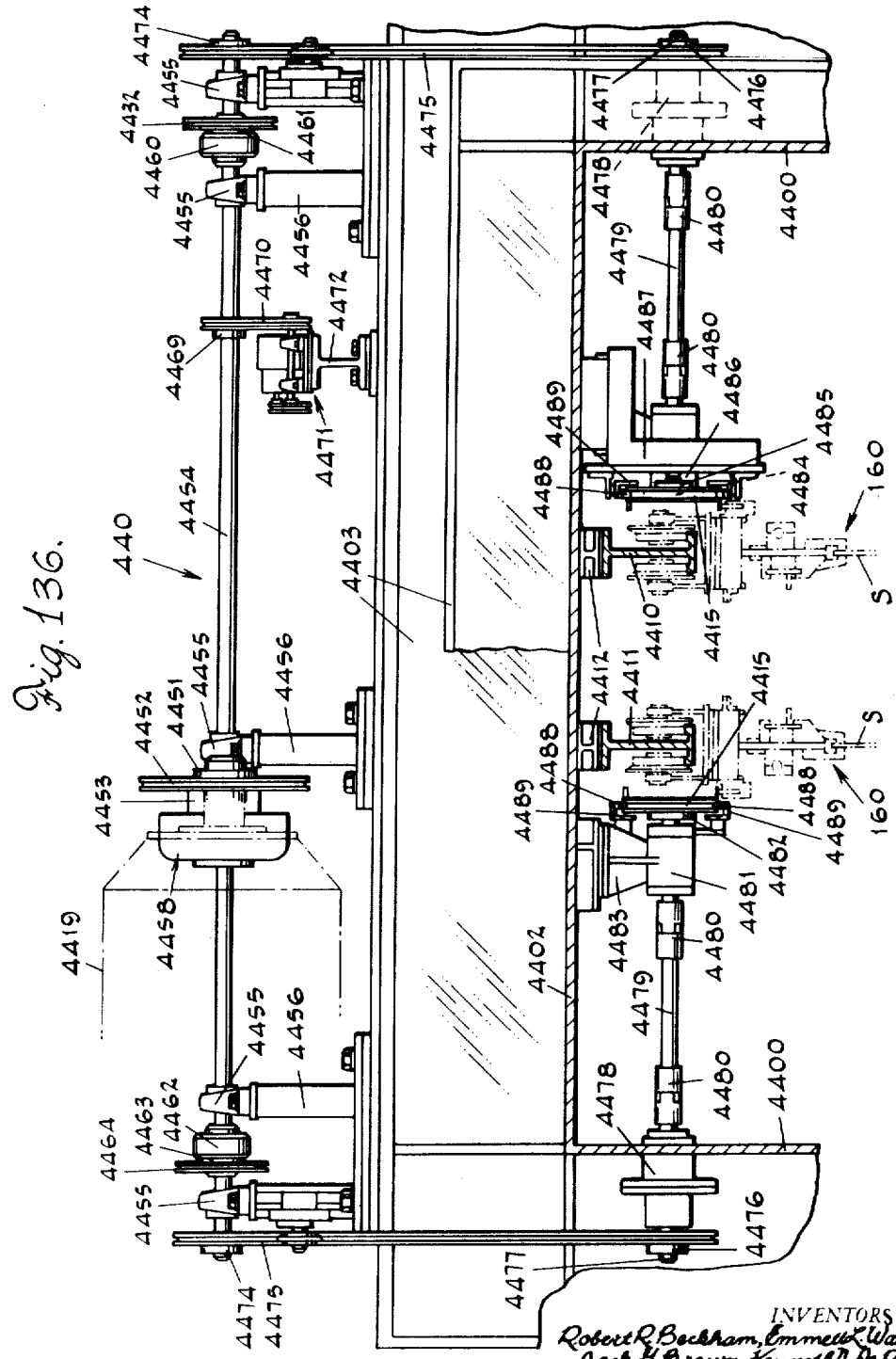


Fig. 136.

INVENTORS
Robert R. Beckham, Emmett K. Walters,
Jack L. Brown, Kenneth N. De Rose
and Joseph D. Ryan
BY
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ATTORNEYS

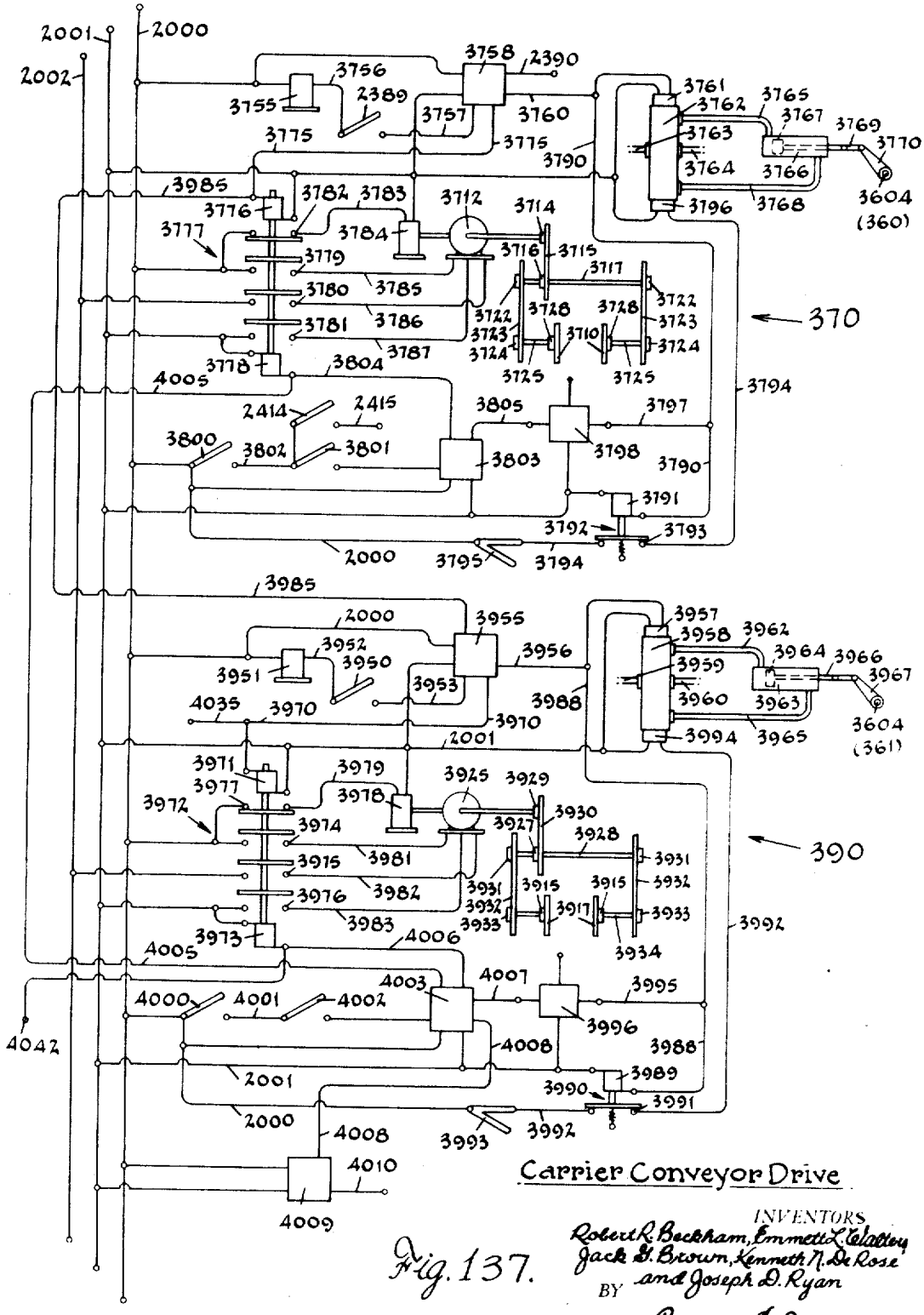


Fig. 137.

INVENTORS
Robert R. Beckham, Emmett L. Caldley
Jack G. Brown, Kenneth N. De Rose
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ATTORNEYS

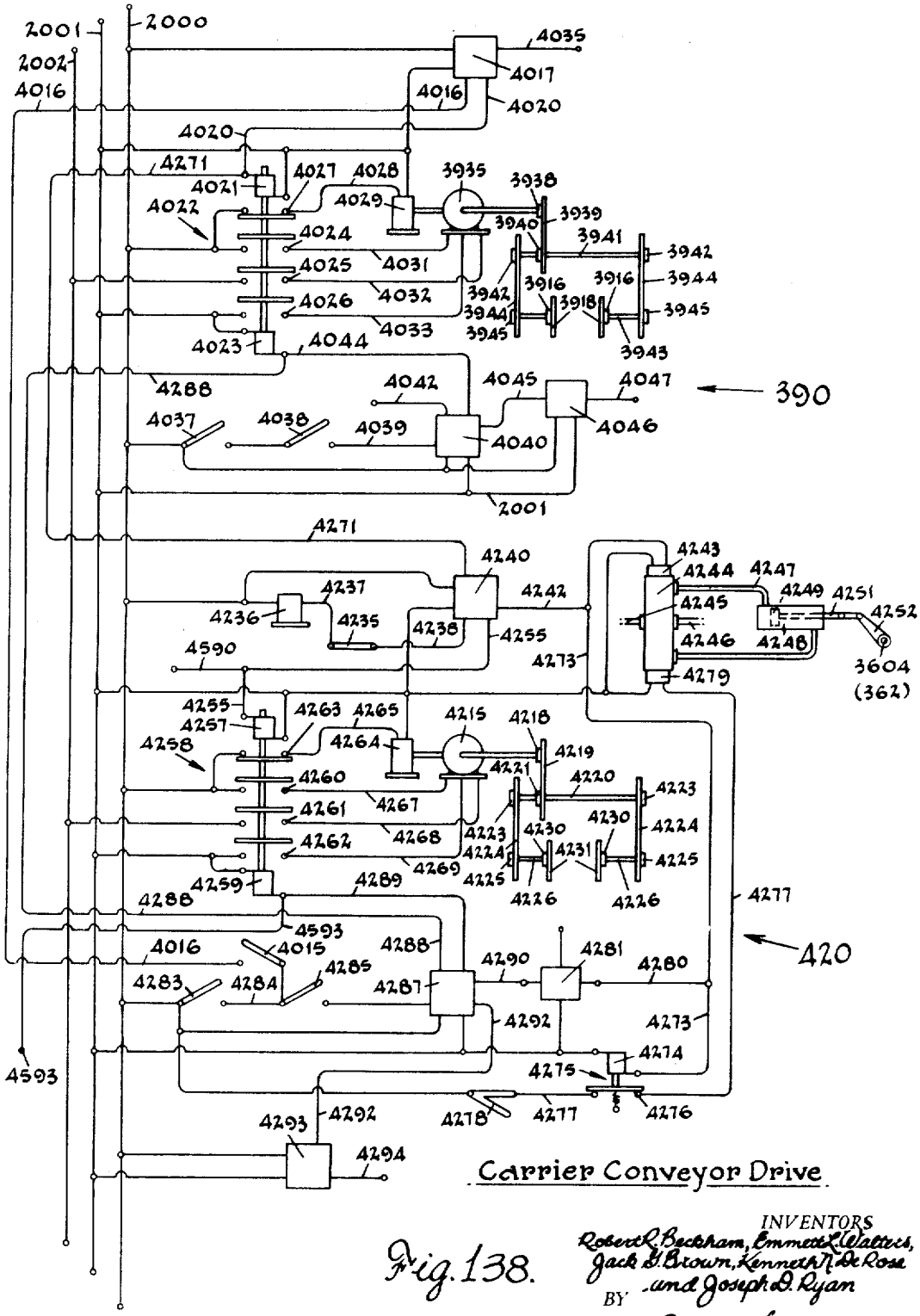


Fig. 138.

INVENTORS
Robert R. Beckham, Emmett L. Walters,
Jack D. Brown, Kenneth N. DeRosa
and Joseph D. Ryan
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ATTORNEYS

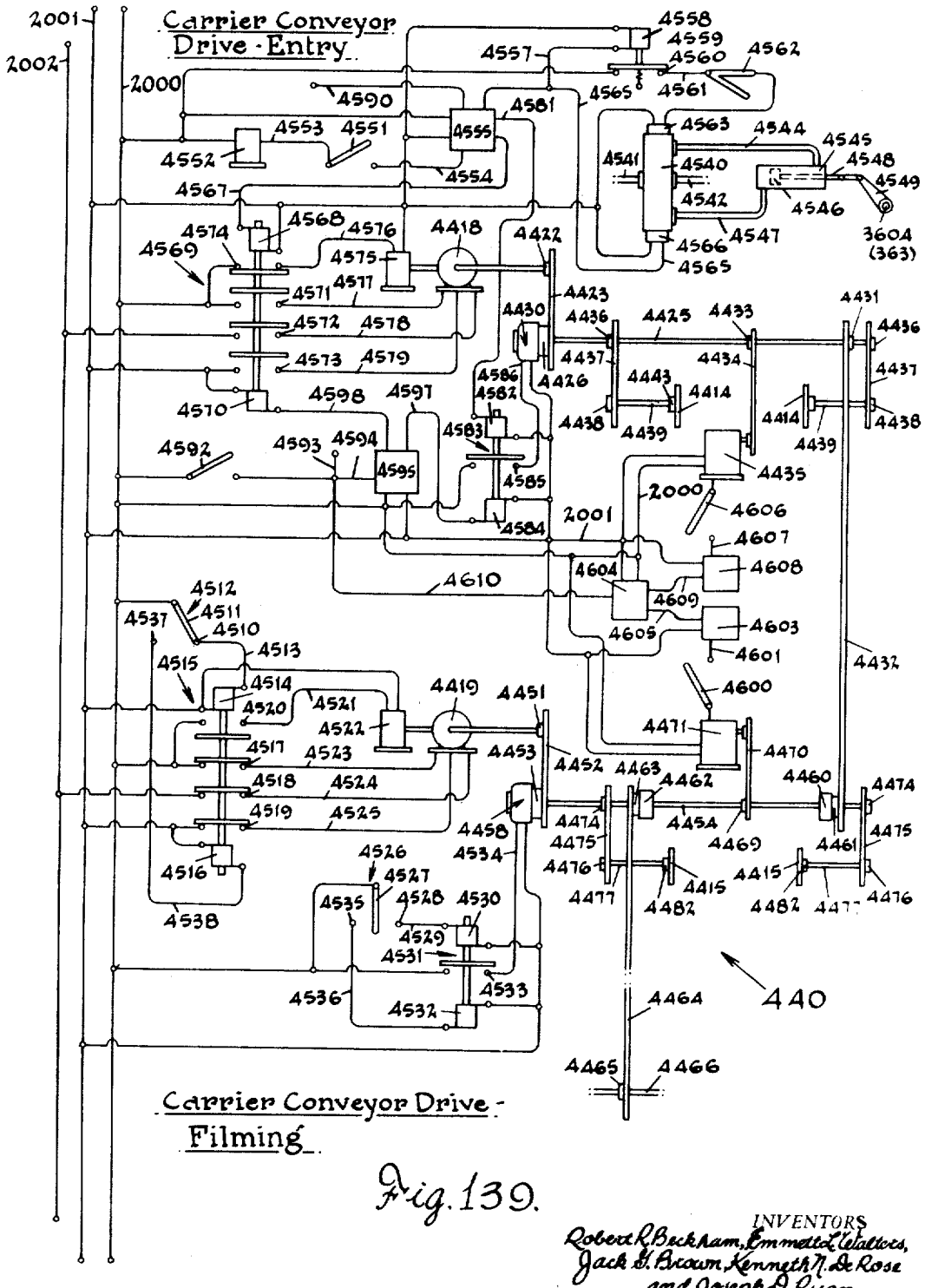
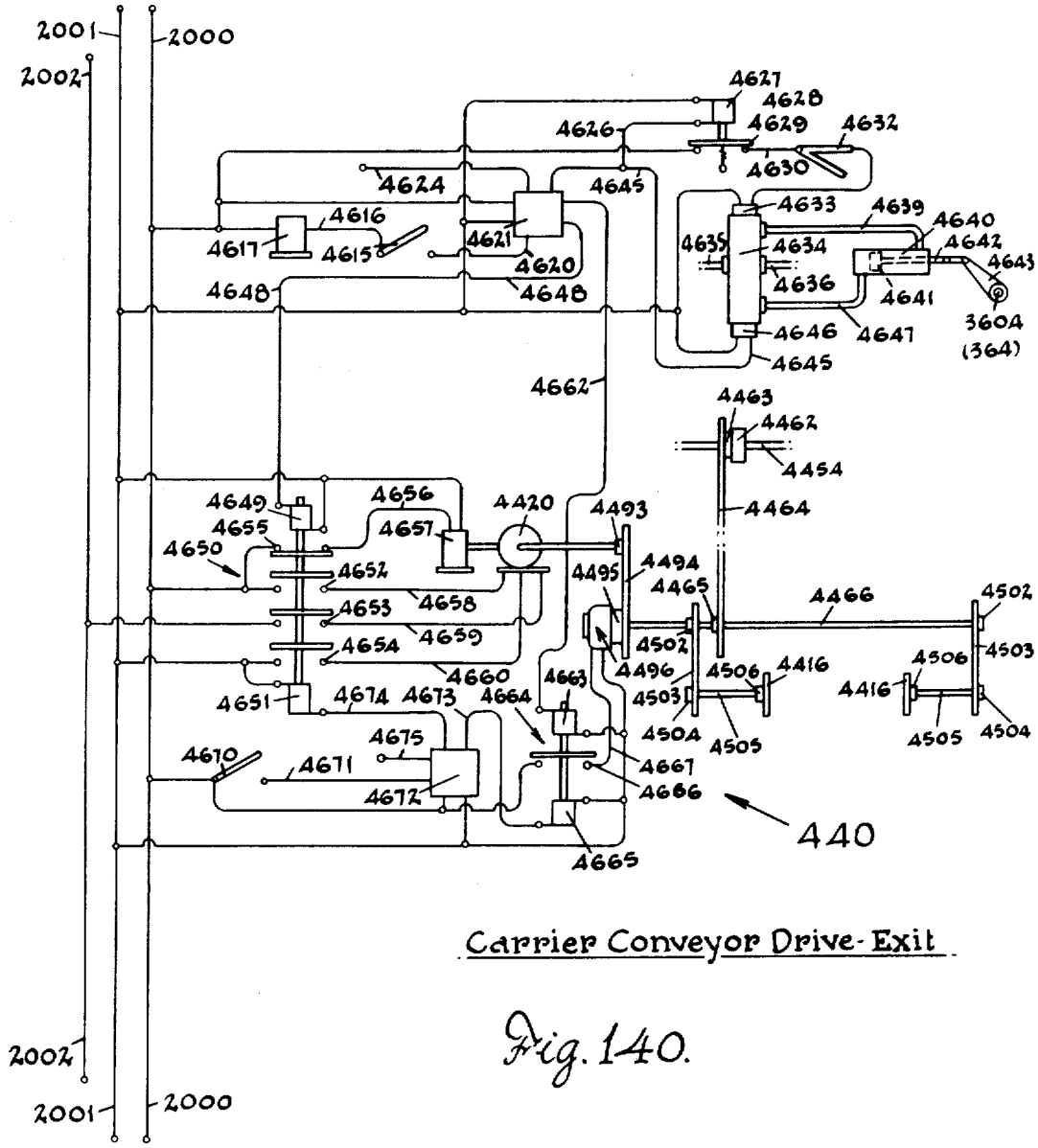



Fig. 139.

INVENTORS
Robert R. Beckham, Emmett L. Walters, Jack B. Brown, Kenneth N. De Rose and Joseph D. Ryan
BY
Collins & Oberlin
ATTORNEYS




Carrier Conveyor Drive-Exit

Fig. 140.

INVENTORS
Robert R. Beckham, Emmett L. Watters,
Jack B. Brown, Kenneth N. DeRose
and Joseph D. Ryan
BY
Collins & Oberlin
ATTORNEYS

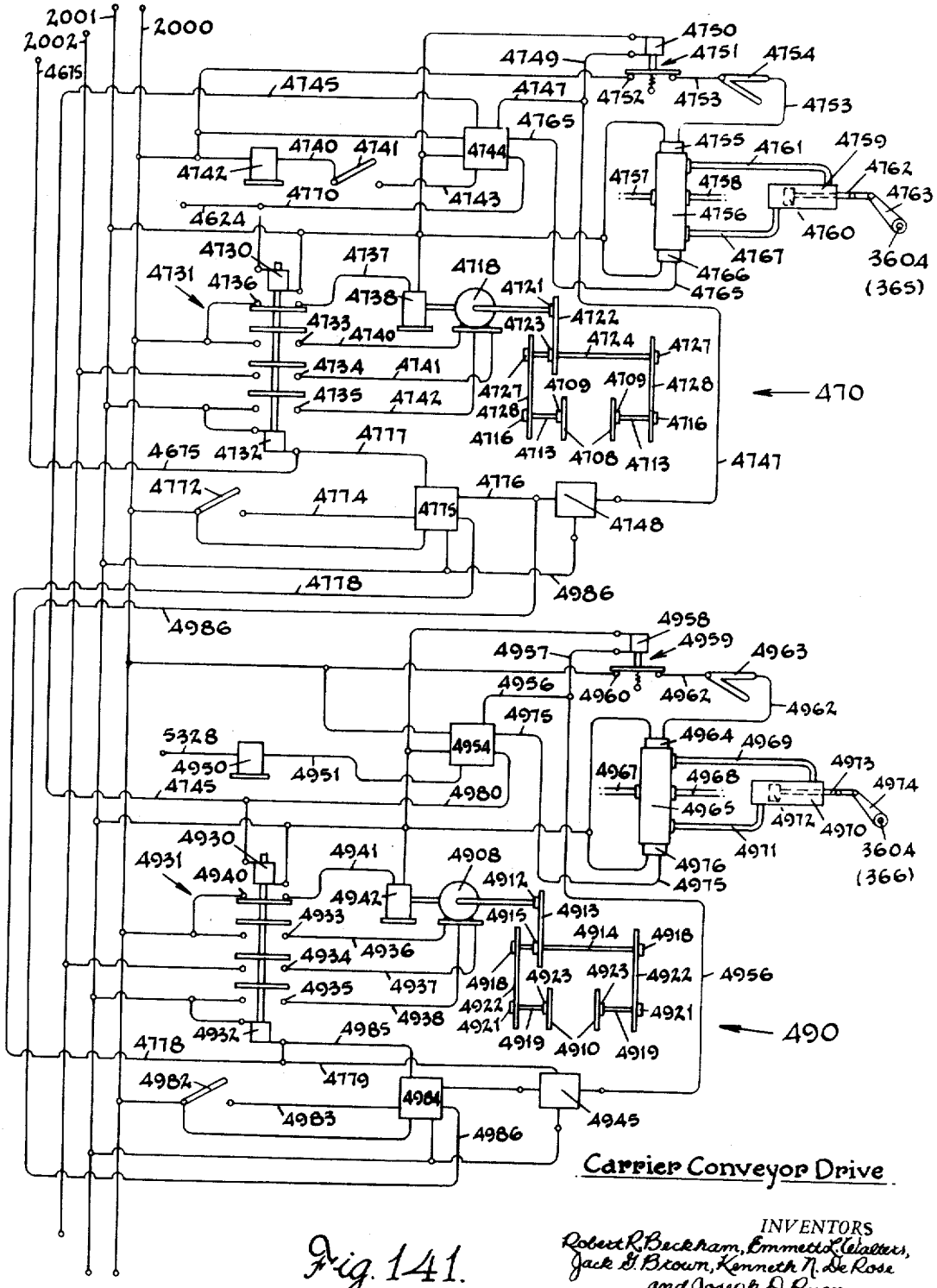



Fig. 141.

Carrier Conveyor Drive

INVENTORS
Robert R. Beckham, Emmett L. Walters,
Jack G. Brown, Kenneth N. De Rose
and Joseph D. Ryan
BY
Collins & Oberlin
ATTORNEYS

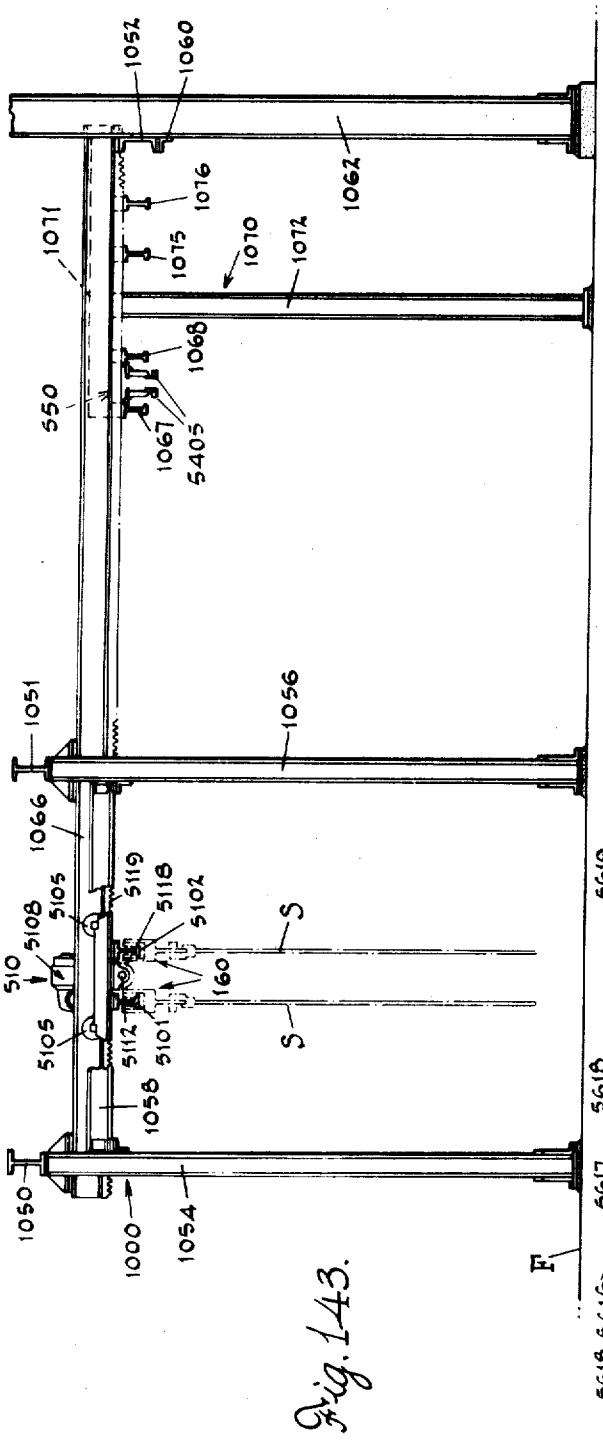


Fig. 143.

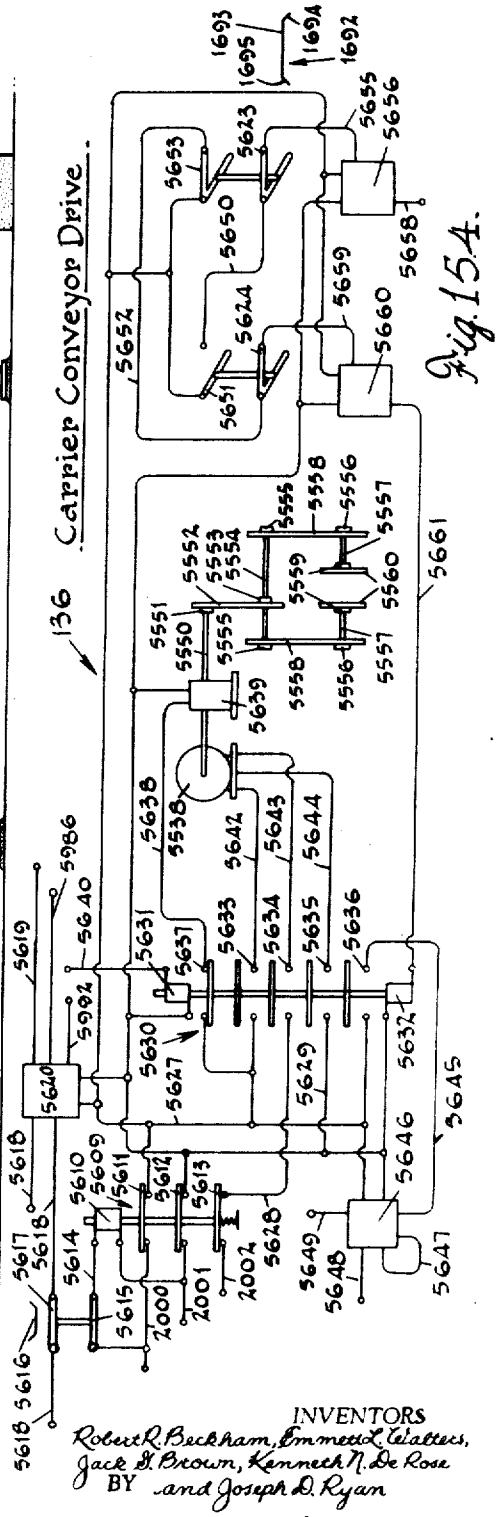


Fig. 154.

INVENTORS
Robert R. Beckham, Emmett L. Walters,
Jack S. Brown, Kenneth N. De Rose
BY and Joseph D. Ryan

Collins & Oberlin
ATTORNEYS

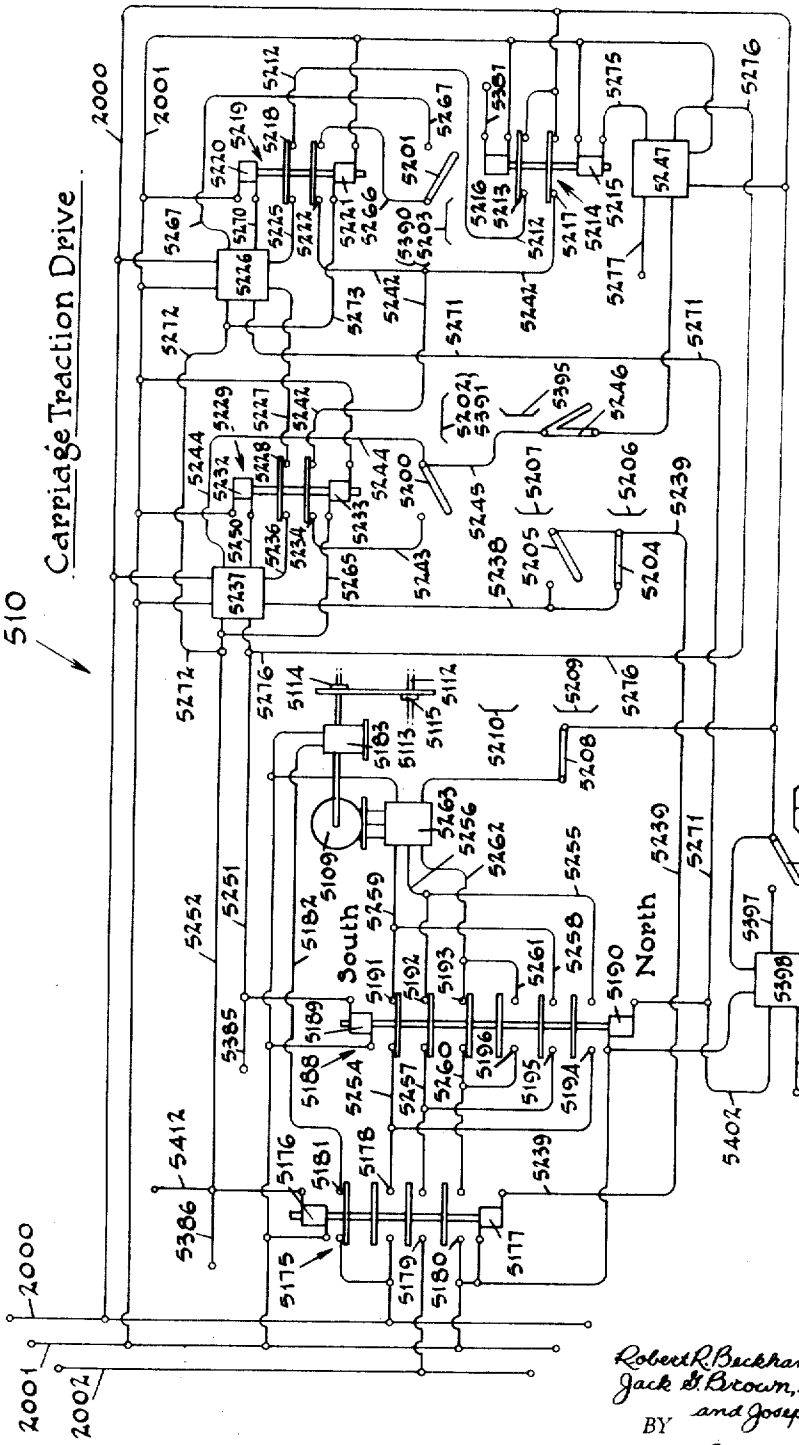



Fig. 144.

INVENTORS
Robert R. Beckham, Emmett L. Walters,
Jack G. Brown, Kenneth N. De Rose
and Joseph D. Ryan
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Collins & Oberlin
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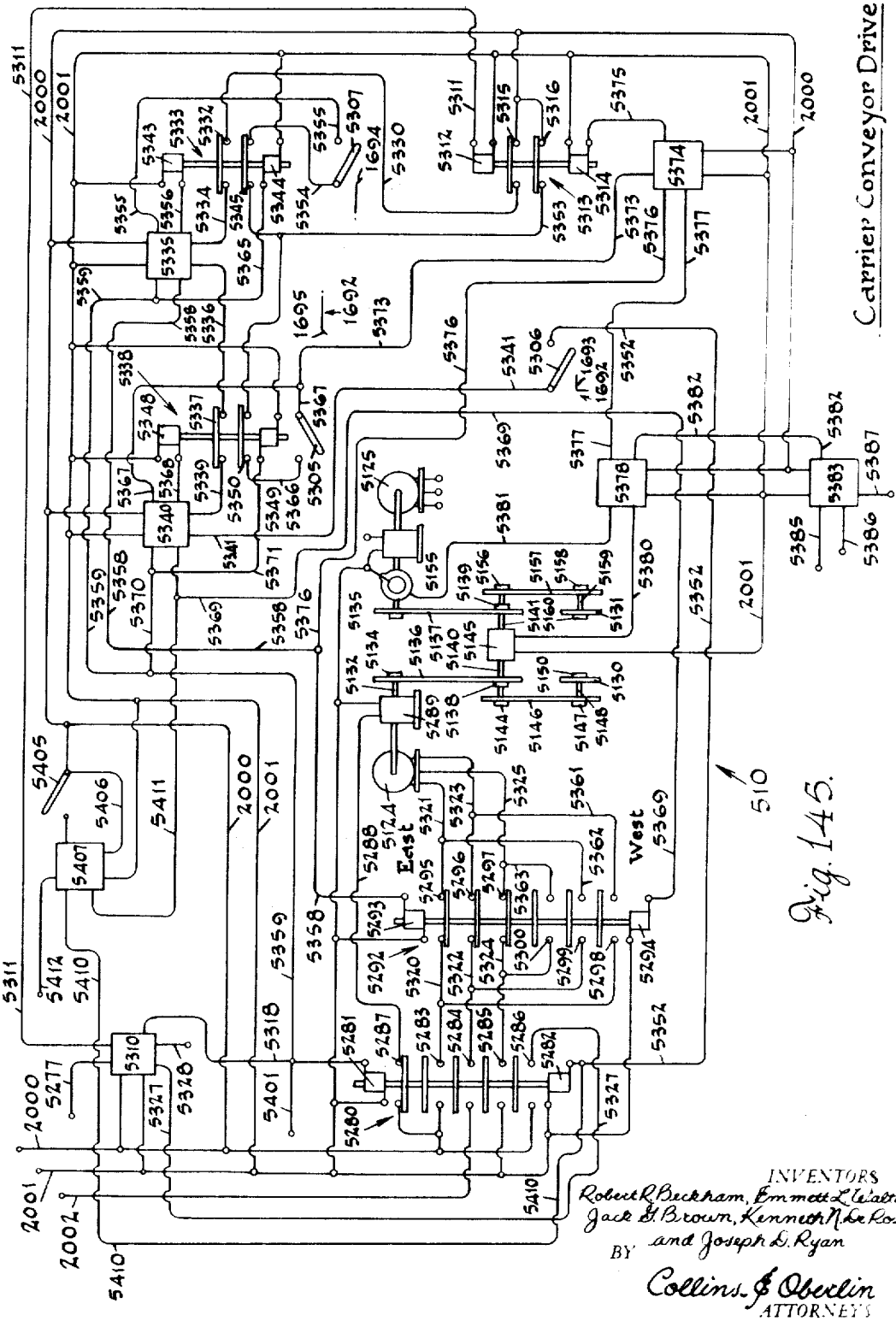


Fig. 145.

INVENTORS
Robert R. Beckham, Emmett L. Waters,
Jack B. Brown, Kenneth N. DeRose
and Joseph D. Ryan
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ATTORNEYS

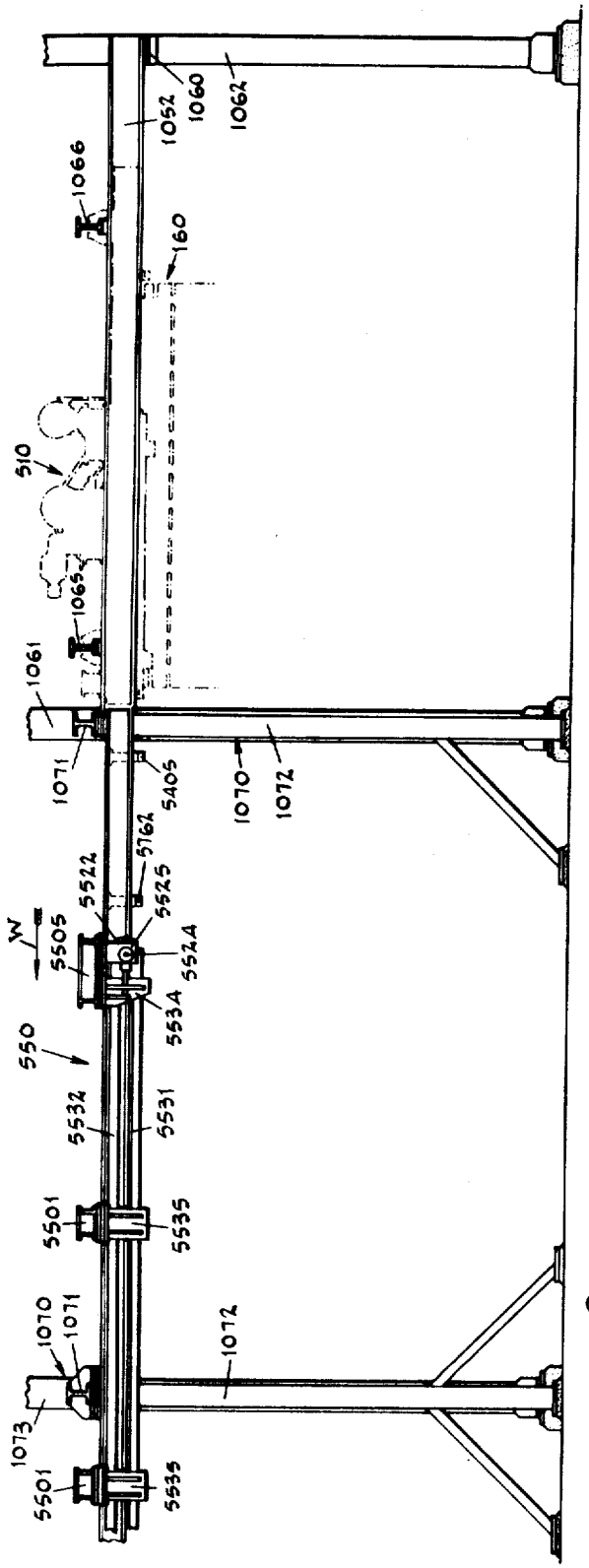


Fig. 146.

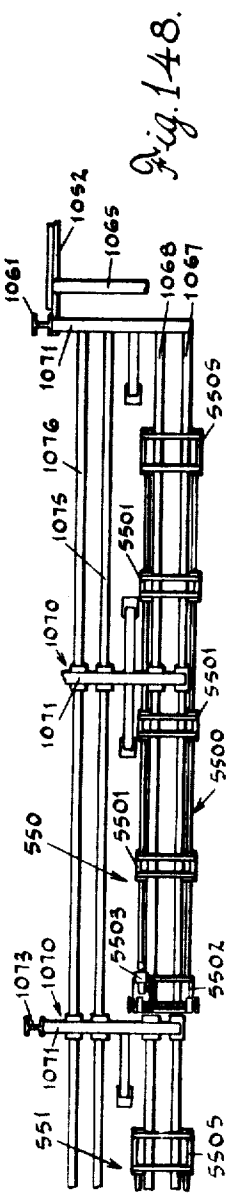


Fig. 148.

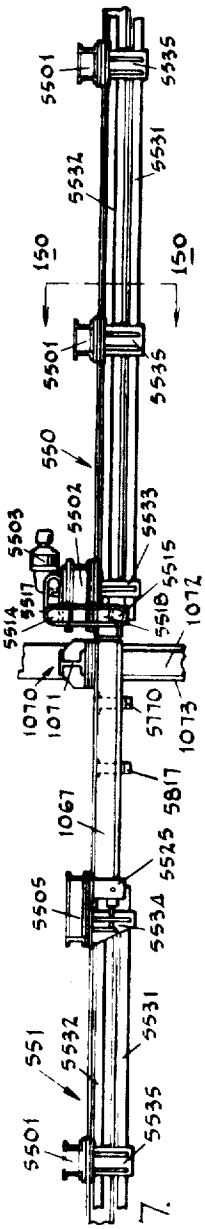


Fig. 147.

INVENTORS
Robert R. Beckham, Emmett C. Walters,
Jack B. Brown, Kenneth N. De Rose
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ATTORNEYS

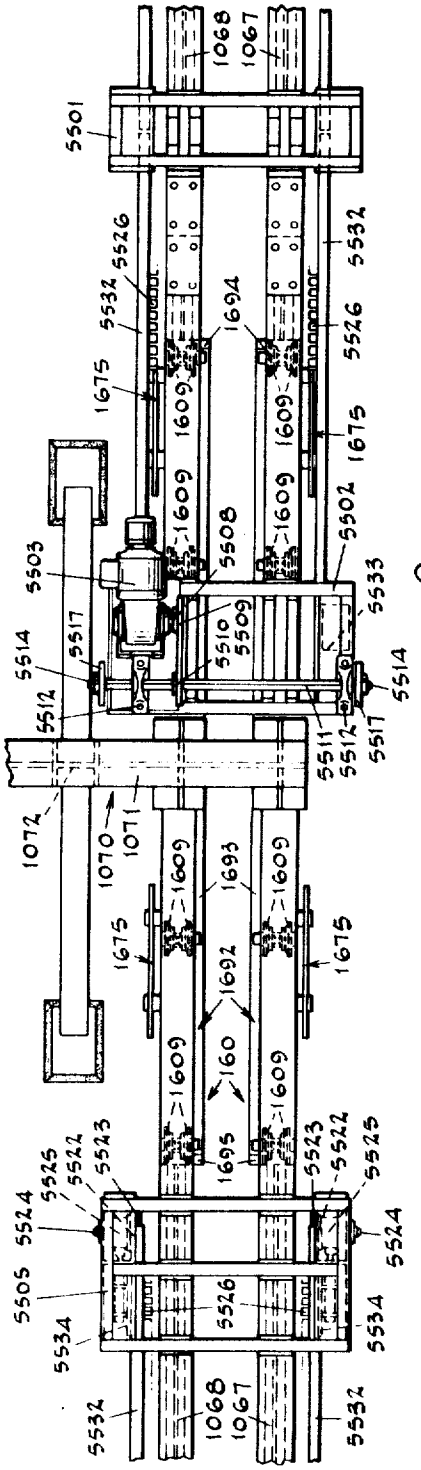

Fig. 149.

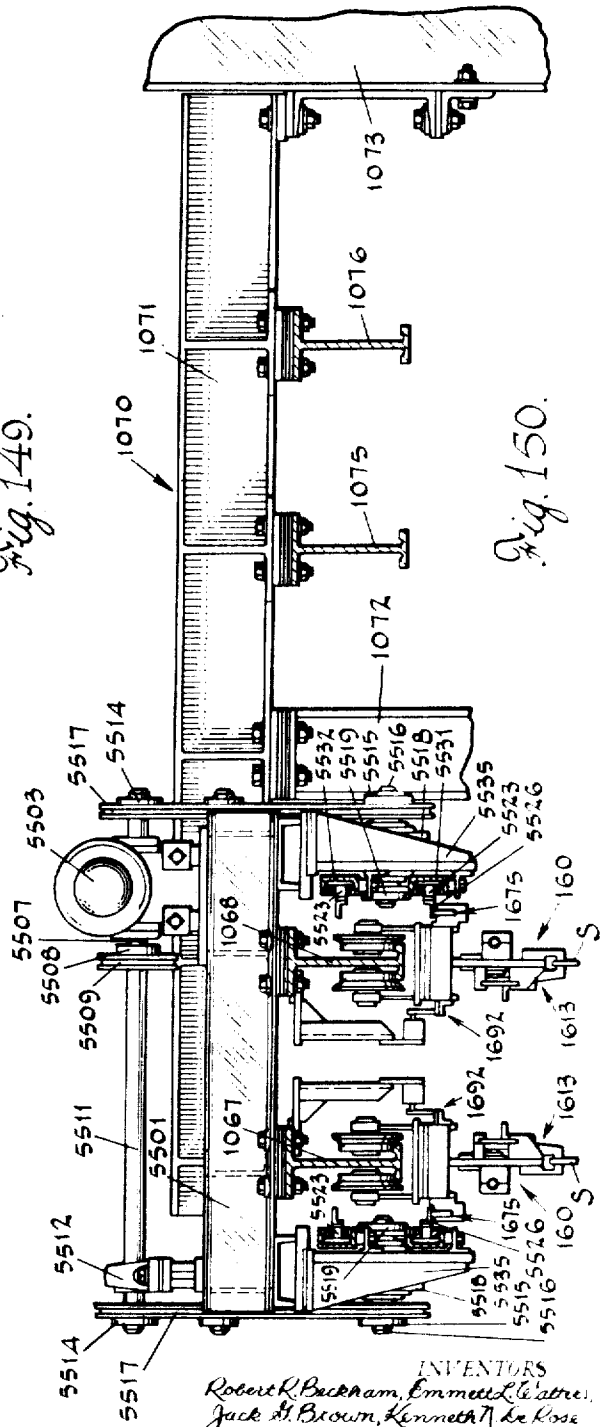

Fig. 150.

INVENTORS
Robert K. Buckham, Emmett L. Chastain,
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and Joseph L. Ryan

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ATTORNEYS

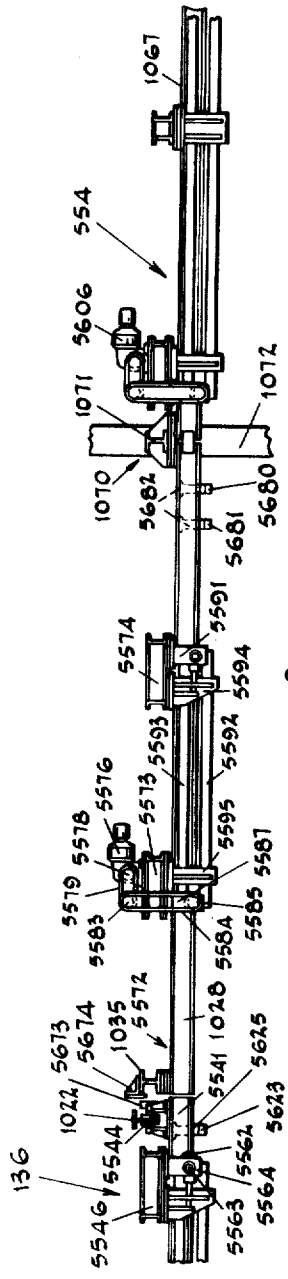


Fig. 151.

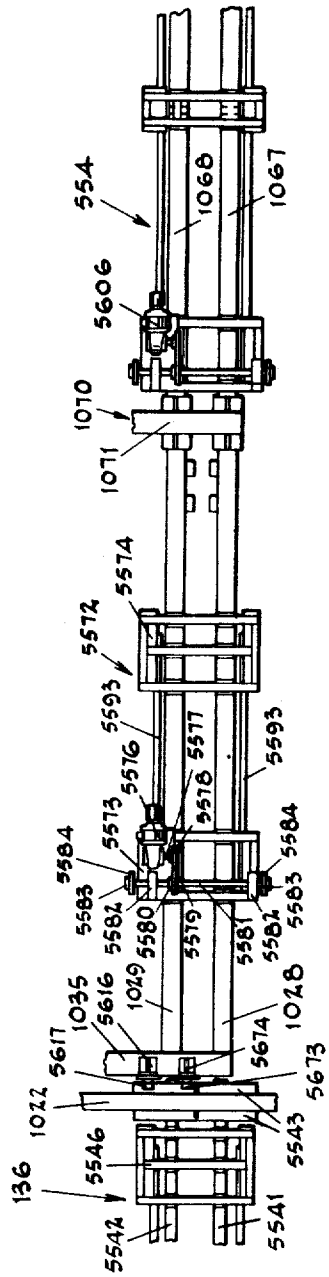


Fig. 153.

INVENTORS
Robert R. Beckham, Emmett L. Watters,
Jack B. Brown, Kenneth N. De Rose
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ATTORNEYS

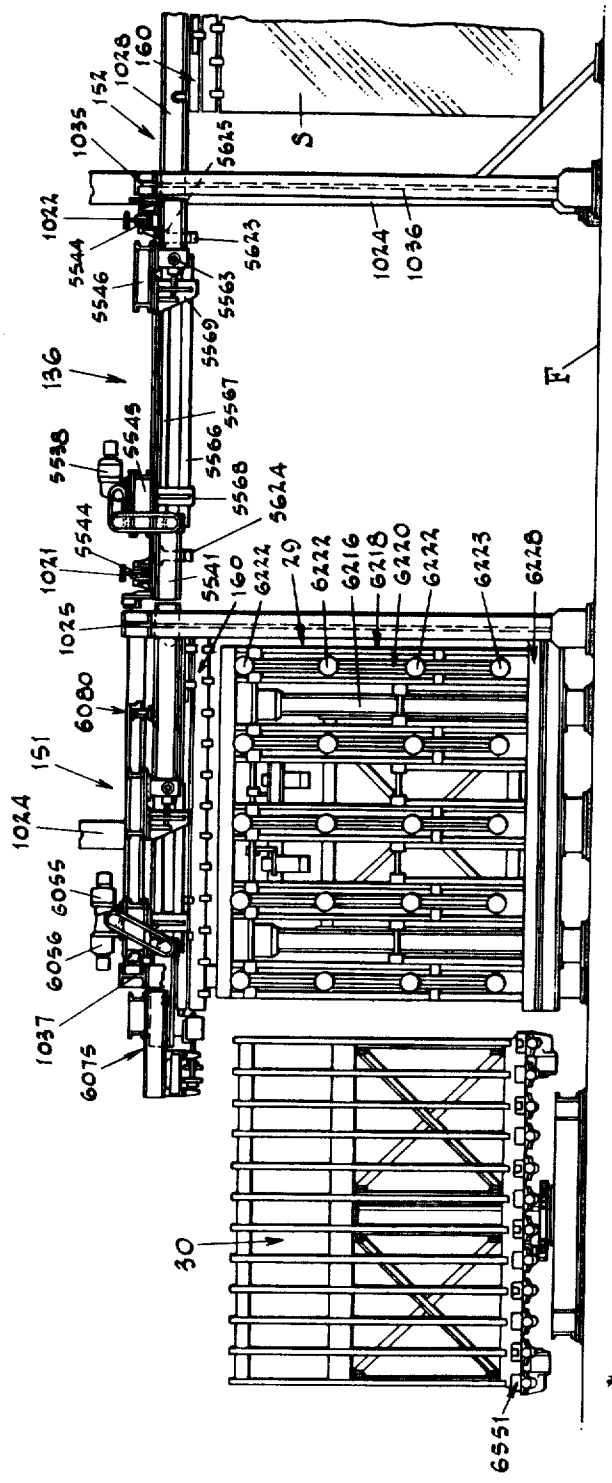


Fig. 152.

INVENTORS
Robert R. Beckham, Emmett L. Walters,
Jack B. Brown, Kenneth M. De Rose
and Joseph D. Ryan
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ATTORNEYS

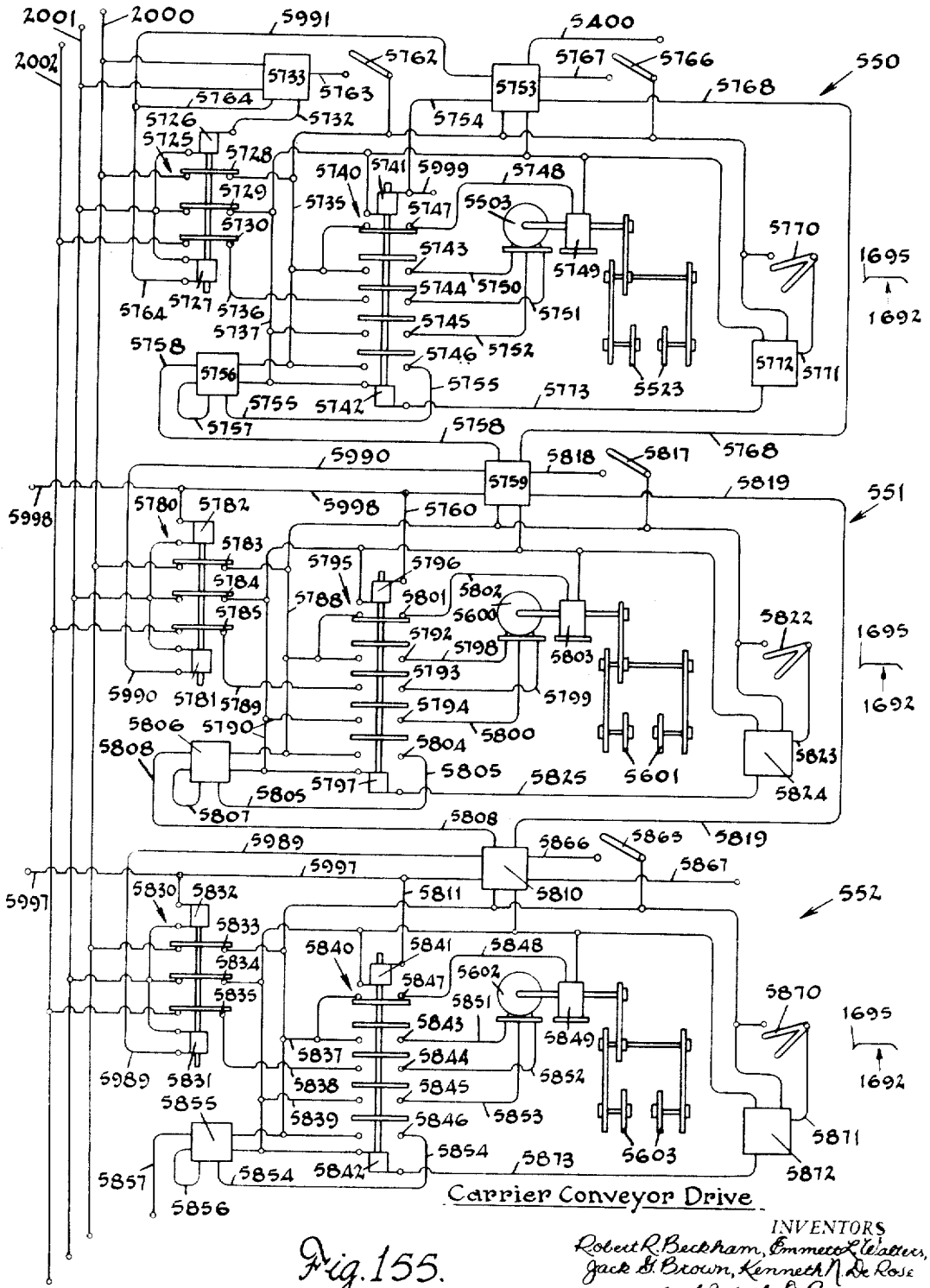


Fig. 155.

INVENTORS
Robert R. Beckham, Emmett L. Walters,
Jack G. Brown, Kenneth N. De Rose
and Joseph D. Ryan
BY
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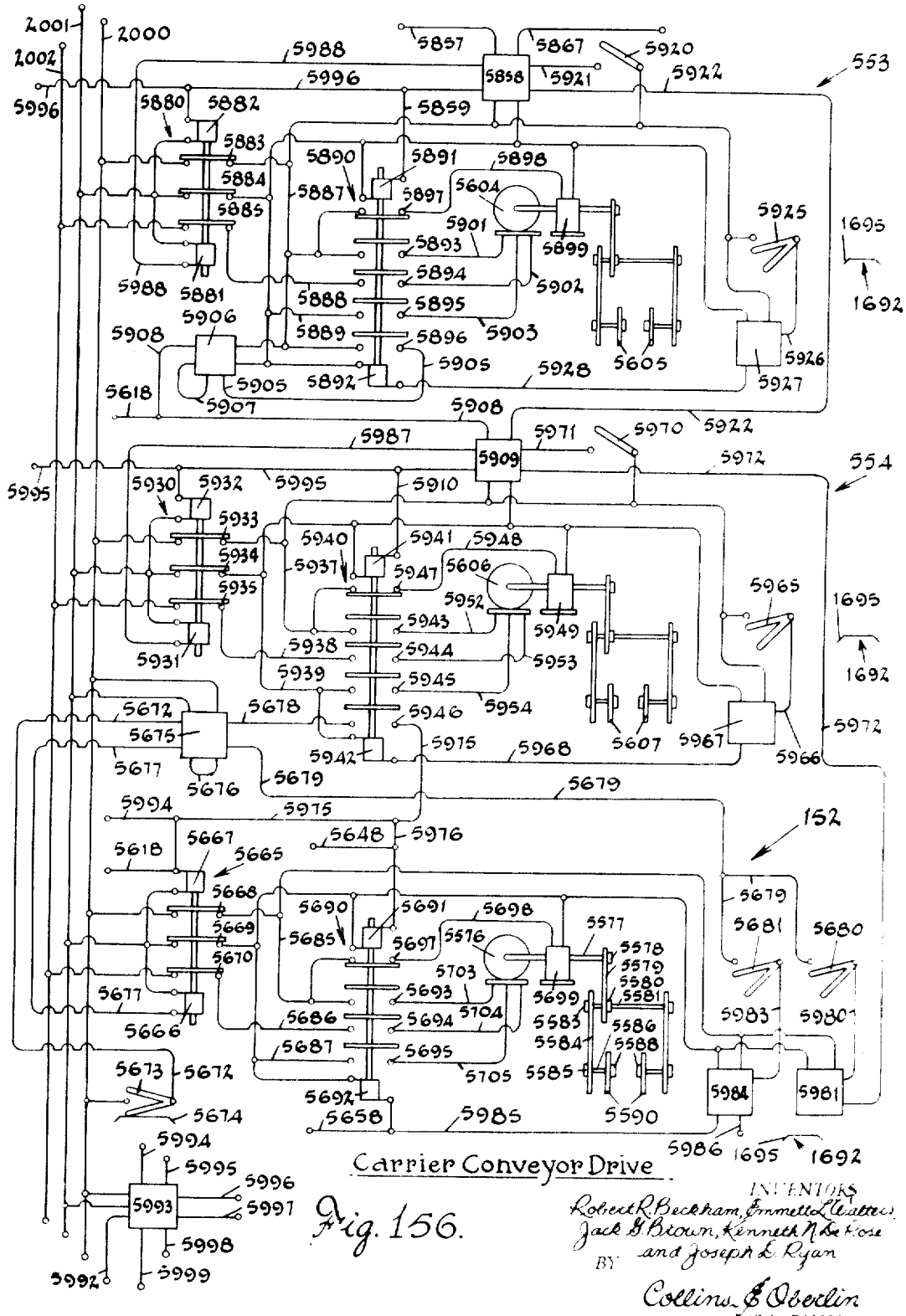
ATTORNEYS




Carrier Conveyor Drive

Fig. 156.

INVENTORS
Robert R. Beckham, Emmett L. Watters
Jack G. Brown, Kenneth N. De Rose
and Joseph L. Ryan
BY
Collins & Oberlin
ATTORNEYS

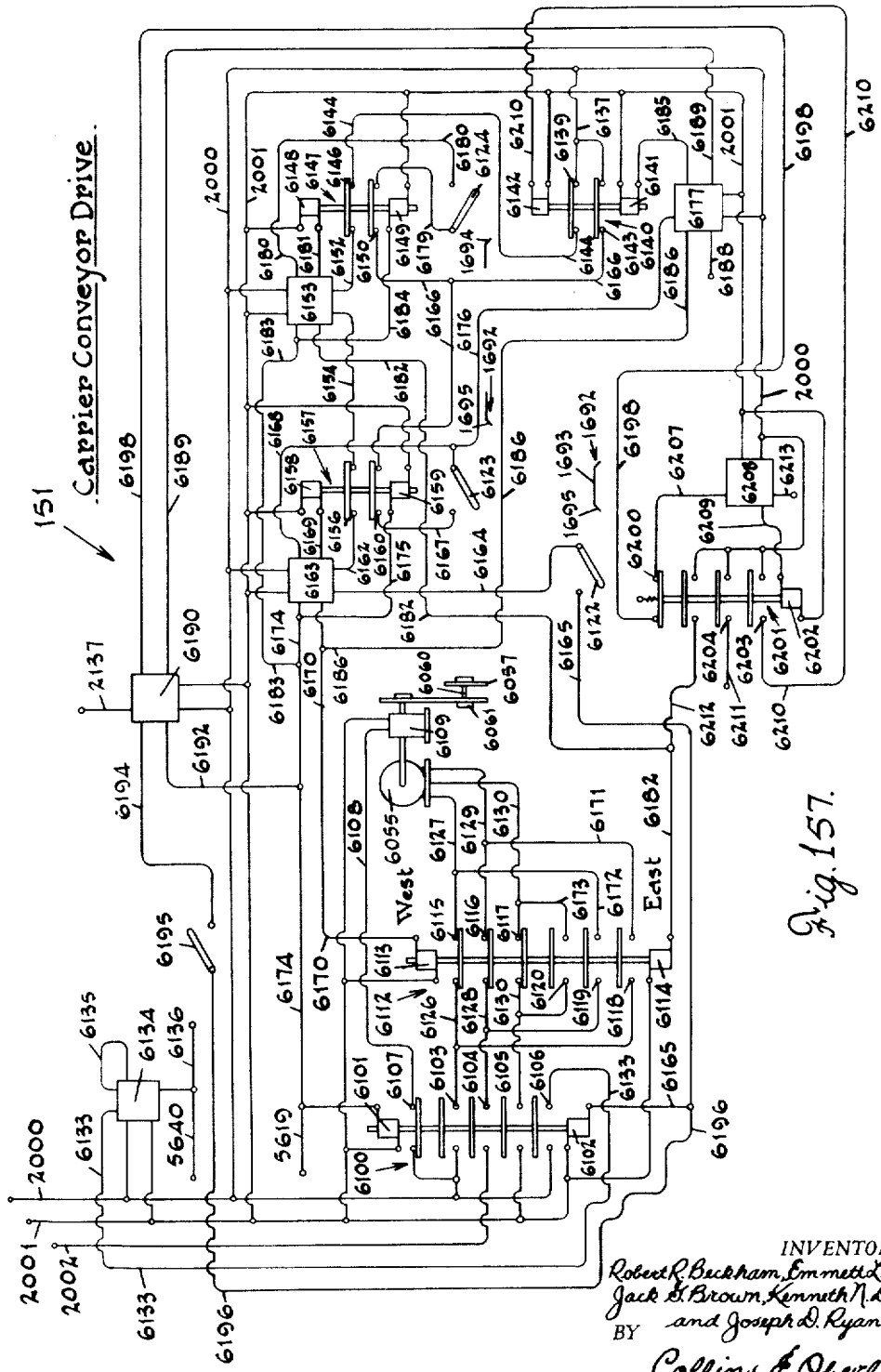



Fig. 157.

INVENTORS
Robert R. Beckham, Emmett L. Walters,
Jack E. Brown, Kenneth N. De Rose
and Joseph D. Ryan
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ATTORNEYS

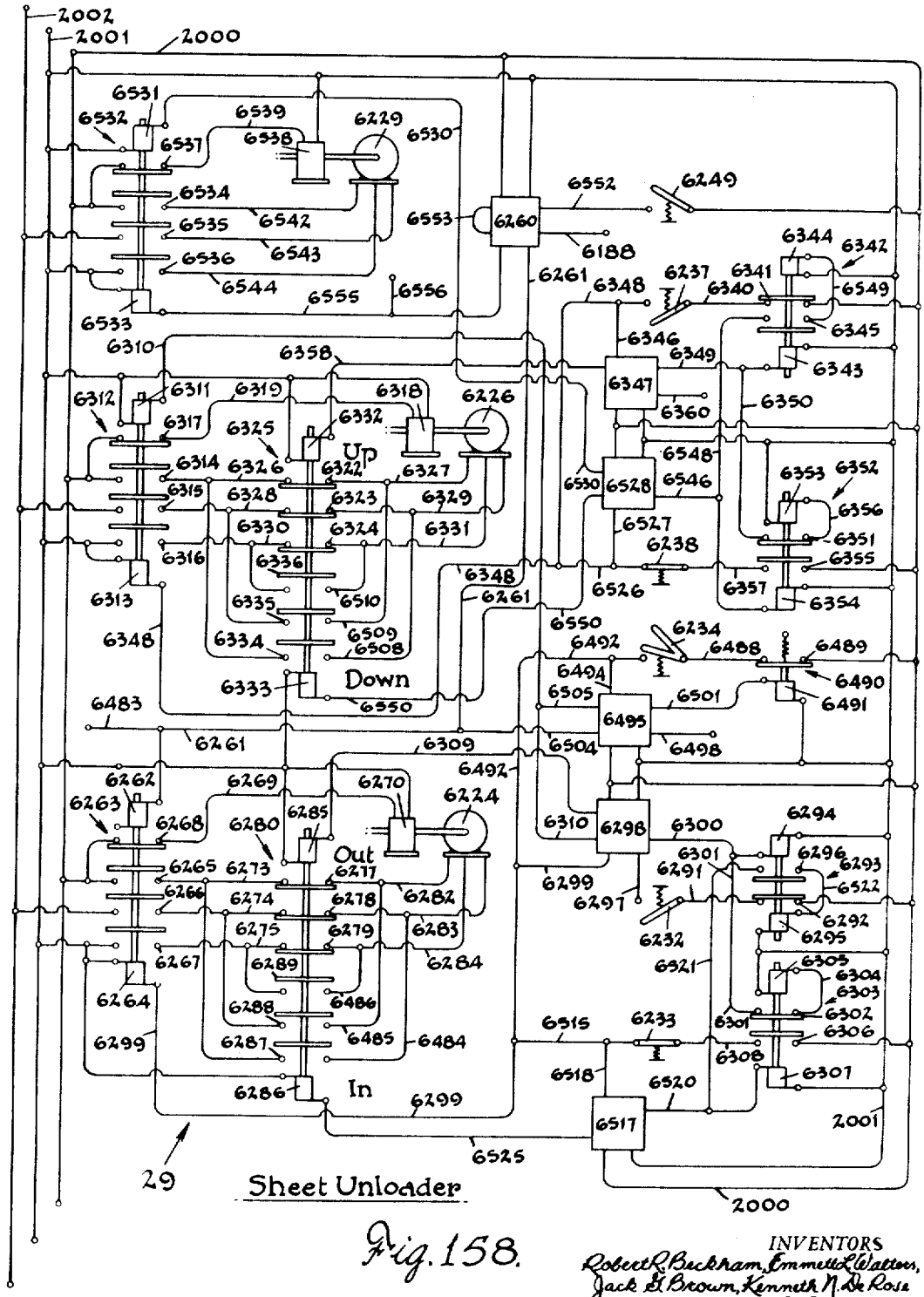


Fig. 158.

INVENTORS
Robert R. Beckham, Emmett L. Walters,
Jack E. Brown, Kenneth N. De Rose
and Joseph D. Ryan
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ATTORNEYS

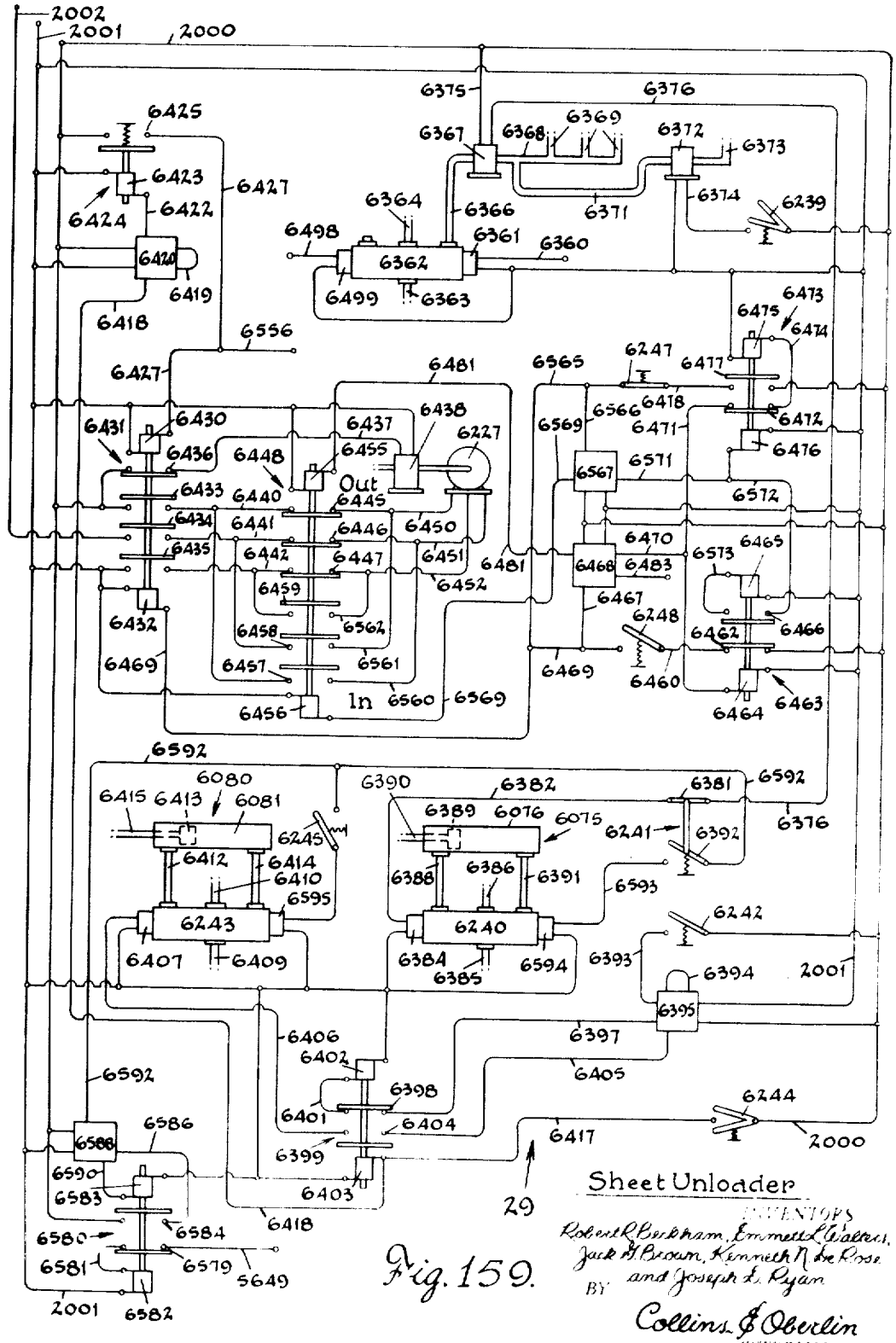


Fig. 159.

Sheet Unloader

INVENTORS
Robert R. Berkham, Emmett L. Walters,
Jack H. Brown, Kenneth N. De Rose
and Joseph L. Ryan
BY
Collins & Oberlin
ATTORNEYS

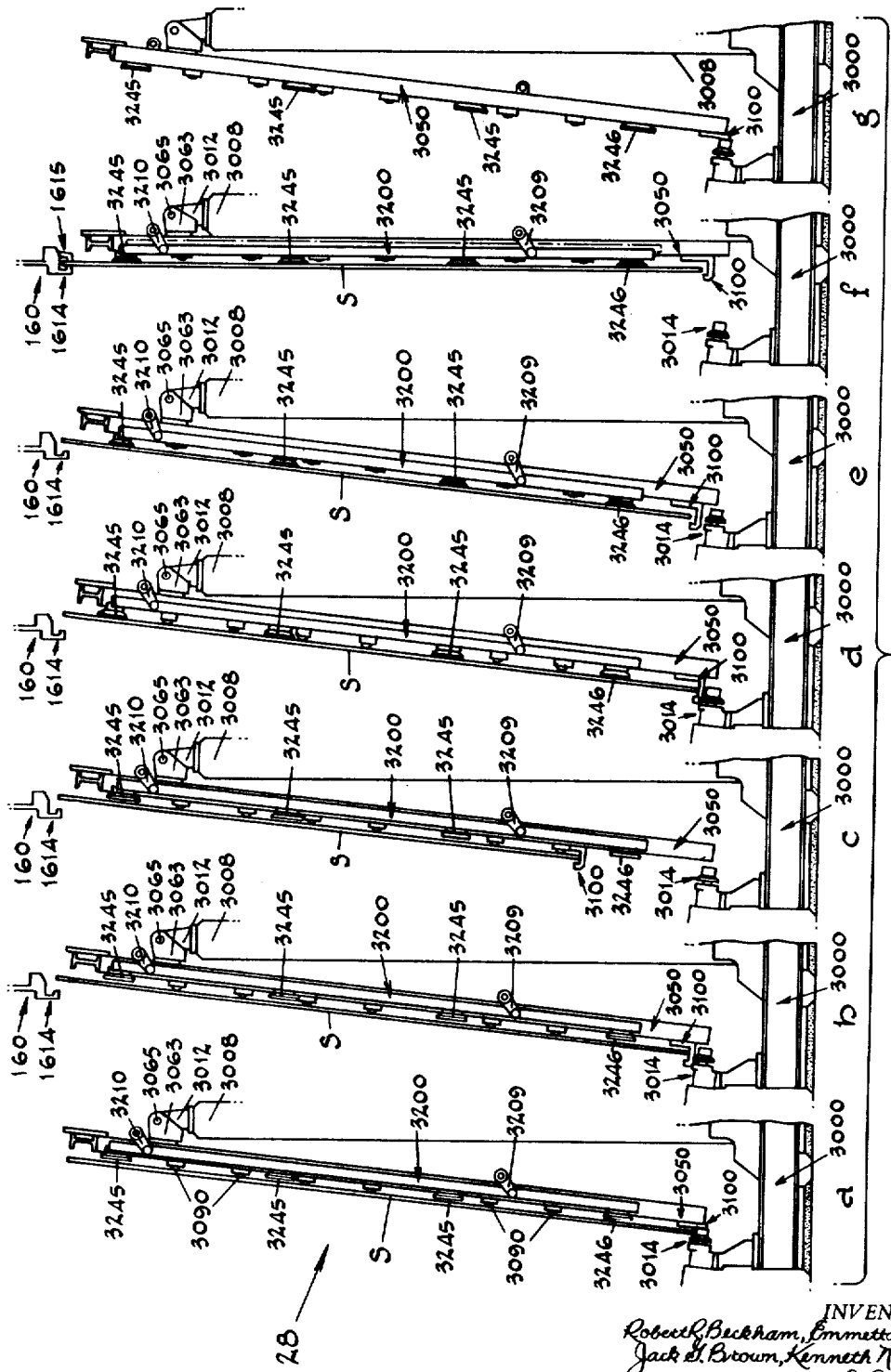


Fig. 160. Sheet Loader

INVENTORS
Robert R. Beckham, Emmett L. Walters,
Jack D. Brown, Kenneth N. DeRose
and Joseph D. Ryan
BY
Collins & Oberlin
ATTORNEYS

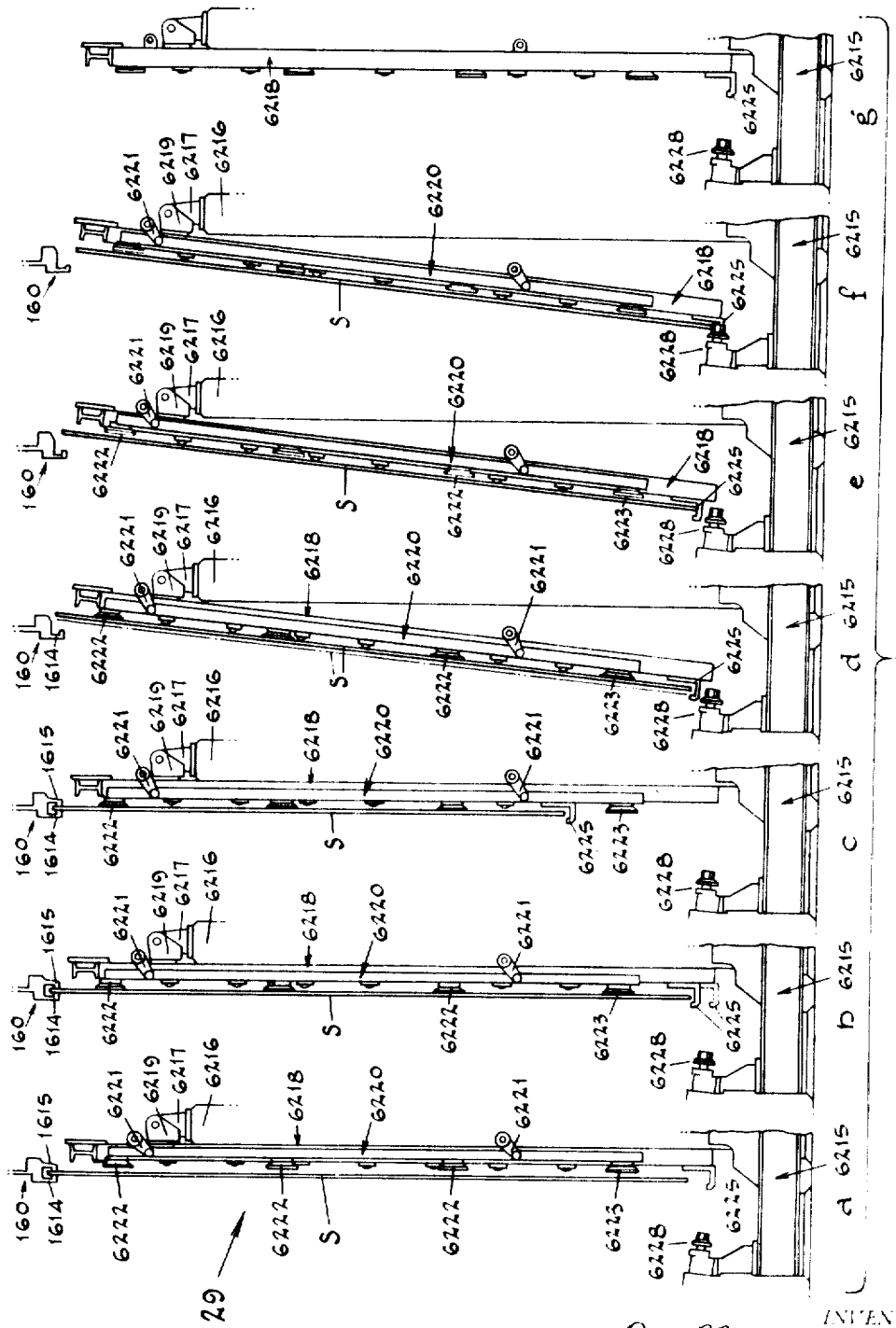


Fig. 161.

Sheet Unloader

INVENTORS
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Jack H. Brown, Kenneth N. De Rose
and Joseph L. Ryan
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ATTORNEYS

# FILMING APPARATUS

This application is a divisional application of application Ser. No. 664,440, filed Aug. 30, 1967 now U.S. Pat. No. 3,495,724, which in turn is a continuation-in-part of application Ser. No. 568,514, filed July 29, 1966 and now abandoned.

The present invention relates in general to the manufacture of filmed or coated articles and, more particularly, is concerned with a new and improved system for the vacuum deposition of thin films on sheet material, which system is adapted for the continuous, rapid and effective handling and processing of such material.

It has heretofore been proposed to provide thin coatings or films on objects by vacuum deposition techniques. However, except where the substrate was a large coil of strip material and an extremely effective vacuum was not necessitated, such processes have been largely confined to batch or intermittant operations. This, in turn, has caused serious production problems in that the coating chamber had to be evacuated each time an article or group of articles to be coated were loaded therein.

The present invention provides an improved system which may be readily and automatically controlled in an expeditious manner with a minimum of manual labor, and which, most importantly, is entirely continuous and uninterrupted in operation, that is, an article may be caused to enter the system at one end thereof and be moved through each individual section thereof including the coating chamber itself wherein it is conveyed continuously without stoppage and subsequently removed from the exit end of the system as a finished product. While the apparatus and method in accordance with this invention are not limited in use to the filming of any specific object or material, they are particularly well adapted for providing films for modifying light, e.g. ultraviolet, visible and infrared, on transparent sheet material such as glass or plastic and will, therefore, be described with reference to such application.

For example, it has long been appreciated that glass windows transmit large amounts of solar radiation and thus have a very definite effect upon the temperature within a building, automobile or other enclosures in which they are placed. If the amount of solar radiation transmitted by the glazing units can be reduced, it is evident that a substantial reduction can be made in the air conditioning and heating load of the particular installation in which they are used.

At the present time, glazings for architectural use wherein it is desired to alter the optical properties of clear glass and particularly wherein it is desired to reduce the transmission of solar radiation into the interior of a building have required the use of special composition glasses having heat absorbing properties. However, while these special glasses have been found to some extent to be effective in decreasing radiation transmittance, the fact remains that since they act to intercept radiation by absorption, their temperature may eventually be increased to a point where they become a radiator with part of the heat going to the inside of the enclosure and part of the heat going to the outside. Moreover, equal distribution of reradiated heat from heat absorbing glass would take place only when the conditions outside and inside the building are the same with respect to air temperatures and convection and conduction losses.

The use of vacuum evaporated heat reflecting metal, metal halide or metal oxide films to provide a coated glass of controlled visible transmittance have been contemplated. Such coated glass would, of course, be highly desirable for architectural use due to the multiplicity of color effects obtainable therewith, the great flexibility in producing glazings having varied light and radiation transmittance properties and the fact itself that such coated glass would eliminate the need for a special composition glass and the significant expense involved with its use. However, up to the present time, the use of such films has remained only visionary due to their fragile nature or their inability to withstand mechanical damage and weathering, and the lack of a system capable of economically producing such filmed glazings. The present invention makes possible the economical mass production of these and other filmed objects.



The filming apparatus or system of this invention may comprise:

a. A washing apparatus capable of removing substantially all surface contaminates from at least one side of the sheet material and leaving it completely dry and not water-spotted;

b. An inspection station wherein the sheet material, for example, a glass sheet arranged in a near vertical position, is visually inspected for cleanliness;

c. A turntable for reversing alternate sheets proceeding from the washing and inspecting station in single file in order to subsequently place the sheets on conveyors in paired, spaced, back-to-back position with the clean side of each sheet facing outwardly for passage through the vacuum chambers. In the event both sides of a single glass sheet are to be coated, this apparatus would not be required;

d. A loading unit having bottom roller supports to initially receive the sheets in an inclined position, i.e. at an angle to the vertical with the upper portion of the surface of the sheet not to be coated resting against suitable idler rolls, from the turntable, and including a mechanism for lifting the sheets until the top edges thereof are at a fixed elevation and for tilting the sheets into a vertical plane;

e. A conveyor system for transporting the sheets through the processing and return sides of the apparatus and including:

1. A number of carriers for gripping the sheets along the upper edges thereof and supporting the sheets in a vertical plane during their travel through the system;

2. A transfer station including a number of carriages for moving empty carriers from the sheet return line to a position adjacent the loading unit;

3. A number of individually powered conveyor sections or motorized units for independently controlling the speed of the carriers throughout the system at the various stations and chambers thereof;

4. A cooling and transfer area whereat the carriers and sheets are removed via a carriage from the coating or processing line to the return line;

f. A de-dusting device for removing dust and other loosely adhered surface contaminates which may have settled on the sheet material after washing;

g. An entrance or pump-down vacuum chamber into which the sheets are conveyed from the atmosphere and which is evacuated during travel of the sheets therethrough to a pressure in the range of from $2 \times 10^{-1}$ to $5 \times 10^{-3}$ torr, and preferably about $5 \times 10^{-2}$ torr;

h. A second vacuum chamber connected to the entrance chamber through a valve means and containing an electric glow discharge cleaning apparatus therein. Oxygen is admitted to this chamber to maintain the pressure at the proper level, e.g. between $1 \times 10^{-2}$ to $1 \times 10^{-3}$ torr and preferably between $5 \times 10^{-2}$ torr to $5 \times 10^{-3}$ torr;

i. A third chamber connected to said second chamber through suitable valve means and in which apparatus for heating the sheet material to the temperature desired thereof when subsequently coated is located. This chamber also communicates with suitable diffusion pumps for lowering the pressure of the chamber during travel of the sheets therethrough from that of the glow discharge chamber to that desired in the coating chamber, e.g. in the range of from $1 \times 10^{-4}$ to $1 \times 10^{-6}$ torr, so that no disruption of the filming process takes place as the valve between this chamber and the coating chamber is opened;

j. A fourth or coating chamber in which the sheet material is provided with one or more films by means of electron beam evaporation sources mounted in the walls of the chamber. The conveyors in this chamber are divided into

three sections. The center section, operating at a constant speed, carries the sheet material in front of the evaporation sources. The first section brings the sheet material up to the filming zone or zones quickly, then slows it down to synchronize its travel with that of the sheets which are already being filmed. Similarly, the third section will accelerate the movement of the sheets for transfer to the following chamber after the trailing edge of the sheets has passed the last filming zone. This chamber is maintained at a pressure in the range of from $1 \times 10^{-4}$ to $1 \times 10^{-7}$ torr, with the preferred coating pressure being $1 \times 10^{-5}$ torr or lower;

k. A fifth chamber connected to the fourth or coating chamber through suitable valve means to which the sheets are conveyed after filming for cooling. During passage of the sheets through this chamber, the pressure will be raised from that of the coating chamber to approximately $2 \times 10^{-4}$ to $5 \times 10^{-3}$ torr;

l. A sixth or up-to-air chamber which communicates with the fifth chamber through suitable valve means and wherein the sheet material is further cooled and the pressure therein changed from approximately $5 \times 10^{-2}$ torr to atmospheric temperature during travel of the sheet material therethrough;

m. A return line comprising a series of conveyor sections disposed so as to move the carriers and coated sheet material carried thereby back adjacent the loading area of the system;

n. An unloader unit which functions to remove the coated sheet material from the carriers transporting same, with the empty carriers then being returned to the aforementioned trans-fer station;

o. A second turntable mechanism adapted to receive both sheets simultaneously from the unloader and then convey them individually in single file into a final inspection, unloading and packaging area; and

p. And means for automatically controlling the above mechanism and apparatus in a coordinated, systematic manner for sequential operation thereof to provide a continuous, un-interrupted filming plant arrangement for the mass production of filmed or coated sheets.

It is, accordingly, a principal object of the present invention to provide a novel and improved system for the vacuum deposition of thin films on sheet material which is capable of effectively and efficiently performing all of the related operations and functions in the production of filmed sheets from the initial washing of the unfilmed sheets to the final inspection of the filmed sheets.

Another object of the invention is to provide a system of the above type which occupies a minimum of floor space and requires a minimum amount of manual labor for operation thereof.

A further object of the invention is to provide an apparatus capable of continuously coating sheet material by thermal evaporation in a vacuum.

Another object of the invention is to provide an apparatus of the type described wherein the coating material is heated and vaporized by electron bombardment.

A still further object of the invention is the provision of a filming or coating system which will substantially reduce the cost of producing filmed sheet material.

Other objects and advantages of the invention will become more apparent during the course of the following description when taken in connection with the accompanying drawings.

In the drawings, wherein like numerals are employed to designate like parts throughout the same:

FIG. **1** is a schematic plan view of the left-hand end of the filming plant or system in accordance with the invention;

FIG. **2** is a schematic plan view similar to FIG. **1** showing the right-hand end of the apparatus;

FIG. **3** is a diagrammatic view illustrating the sheet travel through the system;

FIG. **4** is a diagrammatic view illustrating initial movement of the sheets;

FIG. **5** is a plan view of the conveyor system adjacent the loading, transfer and unloading areas of the apparatus;

FIG. **6** is a perspective of the structural framework for the conveyor in the loading area;

FIG. **7** is a side elevation of the turntable unit, the loading unit and associated conveyor system;

FIG. **8** is a front elevation of the conveyor system as taken on line **8—8** in FIG. **5**;

FIG. **9** is a plan view of the shuttle carriage unit employed in the transfer area;

FIG. **10** is a side elevation of the shuttle carriage with parts thereof being shown in section;

FIG. **11** is an end elevation of the track and shuttle carriage;

FIG. **12** is a transverse vertical section taken on line **12—12** of FIG. **9**;

FIG. **13** is an enlarged, transverse vertical section taken on line **13—13** of FIG. **10**;

FIG. **14** is a perspective view of an improved type of chain belt link employed in the conveyor system;

FIG. **15** is a plan view of a bridging carriage unit employed in the transfer area;

FIG. **16** is a side elevation of the bridging carriage;

FIG. **17** is a transverse vertical section of the carriage taken on line **17—17** of FIG. **15**;

FIG. **18** is an enlarged detail view of a portion of the bridging conveyor;

FIG. **19** is an enlarged, transverse vertical section taken on line **19—19** of FIG. **15**;

FIG. **20** is an enlarged, detail view taken on line **20—20** of FIG. **5**;

FIG. **21** is an enlarged, broken elevational view of certain switch devices and the controllers therefor as taken on line **21—21** of FIG. **5**;

FIG. **22** is a broken plan view of the elements of FIG. **21**;

FIG. **23** is an enlarged, broken elevational view of other switch devices and the controllers therefor as taken on line **23—23** of FIG. **5**;

FIG. **24** is a broken plan view of the elements of FIG. **23**;

FIG. **25** is a side elevation of the conveyor drive unit positioned between the transfer area and the first vacuum chamber;

FIG. **26** is a transverse section of the drive unit as taken on line **26—26** of FIG. **25**;

FIG. **27** is a side elevation of the conveyor drive unit associated with the loader;

FIG. **28** is a plan view of the loader conveyor drive unit;

FIG. **29** is an enlarged, side elevation of the loader conveyor unit;

FIG. **30** is an enlarged, transverse vertical section taken on line **30—30** in FIG. **5**;

FIG. **31** is an enlarged, transverse vertical section taken on line **31—31** in FIG. **5**;

FIG. **32** is an enlarged, longitudinal vertical section taken on line **32—32** in FIG. **31**;

FIG. **33** is a side elevation of the conveyor drive unit associated with the unloader;

FIG. **34** is a plan view of the unloader conveyor drive unit;

FIG. **35** is a broken side elevation of a sheet support carrier;

FIG. **36** is a broken plan view of the support carrier;

FIG. **37** is an enlarged, transverse vertical section taken on line **37—37** in FIG. **35**;

FIG. **38** is a broken elevation of the opposite side of the carrier as taken on line **38—38** in FIG. **37**;

FIG. **39** is a horizontal section taken on line **39—39** in FIG. **38**;

FIG. **40** is a transverse vertical section taken on line **40—40** in FIG. **39**;

FIG. **41** is a transverse vertical section taken on line **41—41** in FIG. **39**;

FIG. **42** is a fragmentary plan view as taken on line **42—42** in FIG. **41**;

FIG. **43** is a horizontal section taken on line **43—43** in FIG. **40**;

FIG. **44** is a side elevation of a connector bar for connecting the carriers to the conveyor system;

FIG. 45 is an enlarged, transverse vertical section of the bar mounting on a carrier as taken on line 45—45 in FIG. 35;

FIG. 46 is a horizontal section taken on line 46—46 in FIG. 45;

FIG. 47 is a fragmentary perspective view of one end of a support carrier as taken in the direction of arrows 47—47 in FIG. 36 and illustrating the pressure applying components;

FIG. 48 is a fragmentary perspective view of the sheet support components of a support carrier in their clamping position;

FIG. 49 is a fragmentary perspective view of a sheet support component in the disengaged position;

FIG. 50 is an enlarged side view of a first clamp activator device of the conveyor unit of FIG. 28 and taken on line 50—50 therein;

FIG. 51 is a transverse vertical section taken on line 51—51 in FIG. 50;

FIG. 52 is a horizontal section taken on line 52—52 in FIG. 50;

FIG. 53 is a horizontal section taken on line 53—53 in FIG. 50;

FIG. 54 is an enlarged fragmentary detail view;

FIG. 55 is a schematic view of a loading operation;

FIG. 56 is a schematic view of an unloading operation;

FIG. 57 is an enlarged plan view of a second activator device of the loader conveyor drive unit, as taken in the direction of arrows 57—57 of FIG. 27;

FIG. 58 is an enlarged side elevation;

FIG. 59 is a transverse vertical section taken on line 59—59 in FIG. 58;

FIG. 60 is a transverse vertical section taken on line 60—60 in FIG. 58;

FIG. 61 is a perspective view of two carriers and a portion of the conveyor system adjacent the loader;

FIG. 62 is a detail view of a typical mounting for certain of the switch devices and associated controllers of the conveyor drive units;

FIG. 63 is a similar detail view;

FIG. 64 is a diagrammatic view of an electrical system adapted to control operation of the traction motor of the shuttle carriage;

FIG. 65 is a diagrammatic view of an electrical control system for the belt motors of the shuttle carriage;

FIG. 66 is a similar diagrammatic view of the electrical control system for the belt motors of the conveyor drive unit associated with the loader;

FIG. 67 is a similar diagrammatic view of the electrical control system for the belt motor of the bridging carriage;

FIG. 68 is a diagrammatic view of the electrical control system for the belt motors of the conveyor drive unit between the loader and the first chamber;

FIG. 69 is a side elevation of the turntable unit;

FIG. 70 is a horizontal section of the turntable unit as taken on line 70—70 of FIG. 69;

FIG. 71 is an end elevation of the turntable, portions thereof being shown in cross-section;

FIG. 72 is a detail view of the upper bearing support;

FIG. 73 is a detail view of the lower bearing support;

FIG. 74 is a plan view of a drive system as taken on line 74—74 of FIG. 71;

FIG. 75 is a detail view of the lower bearing and drive mechanism;

FIG. 76 is an enlarged detail view of an adjustable guide bearing roller as taken on line 76—76 of FIG. 75;

FIG. 77 is a perspective view of the basic structure of the turntable unit;

FIG. 78 is an enlarged horizontal section taken on line 78—78 of FIG. 69 and illustrates the position of several limit switches on the turntable and of control cams on the base column;

FIG. 79 is an elevation taken on line 79—79 of FIG. 78 and illustrates two of the control cams on one side of the base column and the two related switches;

FIG. 80 is a similar elevation taken on line 80—80 of FIG. 78 illustrating the control cams on the opposite side of the base column and the two related switches;

FIG. 81 is an enlarged horizontal section on line 81—81 of FIG. 69 and illustrates the control cams for jogging movement of the turntable and one component of a locking device for the turntable;

FIG. 82 is a vertical transverse section on line 82—82 of FIG. 81 and illustrates the jogging switches and both components of the locking device;

FIG. 83 is a front elevation of the jogging control members and the locking device;

FIG. 84 is an enlarged, longitudinal vertical section taken on line 84—84 of FIG. 83 and shows the lock components in the unlatched condition;

FIG. 85 is a detail view of the locking device with the components in the latched condition;

FIGS. 86 and 87 are diagrammatic views of a control system adapted to produce sequences of operation of the turntable unit;

FIG. 88 is a side elevation of the sheet loading unit;

FIG. 89 is a plan view of the loading unit;

FIG. 90 is a transverse vertical section of the loading unit taken on line 90—90 of FIG. 89;

FIG. 91 is a view graphically illustrating certain operations of the loading unit;

FIG. 92 is a fragmentary perspective view of a sheet elevator device;

FIG. 93 is a horizontal section taken on line 93—93 of FIG. 90;

FIG. 94 is an enlarged detail view;

FIG. 95 is a fragmentary detail view of an adjusting device;

FIG. 96 is a plan view, which, with FIG. 93, comprises a cross-section of the entire unit on the indicated section line 93—93 of FIG. 90;

FIG. 97 is a transverse vertical section taken on line 97—97 of FIG. 96;

FIG. 98 is a transverse vertical section taken on line 98—98 of FIG. 93;

FIG. 99 is a fragmentary detail view;

FIG. 100 is a broken view of the upper end of a vacuum cup support frame;

FIG. 101 is a similar view of the lower end of the support frame;

FIG. 102 is a vertical section taken on line 102—102 of FIG. 100;

FIG. 103 is a similar vertical section taken on line 103—103 of FIG. 101;

FIG. 104 is an enlarged vertical section taken on line 104—104 of FIG. 88;

FIG. 105 is a broken, enlarged vertical section taken on line 105—105 of FIG. 88;

FIG. 106 is a horizontal section taken on line 106—106 of FIG. 100;

FIG. 107 is a similar horizontal section taken on line 107—107 of FIG. 101;

FIG. 108 is a perspective of the basic structure of the sheet loading unit;

FIG. 109 is a perspective view in broken line illustrating the mounted positions of certain switch devices employed in the operation of the loading unit;

FIG. 110 is a perspective view of the mounted position for at least one switch device employed with the unloading unit;

FIGS. 111 and 112 are related diagrammatic views of a control system adapted to produce sequences of operation of the loading unit;

FIG. 113 is a plan view of the entry conveyor unit and first vacuum chamber of the apparatus;

FIG. 114 is a side elevation as taken in the direction of arrows 114—114 in FIG. 113;

FIG. 115 is a perspective view of a sheet surface preparatory unit of the apparatus;

FIG. 116 is a horizontal section taken on line 116—116 of FIG. 115;

FIG. 117 is a fragmentary end elevation as taken in the direction of arrows 117—117 in FIG. 116;

FIG. 118 is an enlarged section taken on line 118—118 of FIG. 117;

FIG. 119 is a transverse vertical section taken on line 119—119 of FIG. 113;

FIG. 120 is an enlarged transverse vertical section taken on line 120—120 of FIG. 113;

FIG. 121 is a longitudinal vertical section taken on line 121—121 of FIG. 113;

FIG. 122 is a horizontal section taken on line 122—122 of FIG. 121;

FIG. 123 is a continuation plan view from FIG. 113 and illustrates the second chamber and the entry area of the third chamber;

FIG. 124 is a schematic cross section through the first chamber as taken on line 124—124 of FIG. 113;

FIG. 125 is a schematic cross section through the second chamber as taken on line 125—125 of FIG. 123;

FIGS. 126 and 127 are related continuation plan views of the third and fourth chambers, and entry area of the fifth chamber;

FIG. 128 is a schematic cross section through the third chamber as taken on line 128—128 of FIG. 126;

FIG. 129 is a schematic cross section through the fourth chamber;

FIG. 130 is a plan view of the fifth and sixth chambers at the exit end of the apparatus, the entry end of the return side of the conveyor systems and the transfer area therebetween;

FIG. 131 is a schematic cross section through the fifth chamber as taken on line 131—131 of FIG. 130,

FIG. 132 is a schematic cross section through the sixth chamber as taken on line 132—132 of FIG. 130;

FIG. 133 is a plan view of the power sources for the conveyor units in the fourth chamber;

FIG. 134 is a side elevation of the power sources;

FIG. 135 is a transverse vertical section taken on line 135—135 of FIG. 126;

FIG. 136 is a transverse vertical section taken on line 136—136 of FIG. 127;

FIGS. 137 and 138 are diagrammatic views of control systems associated with the conveyor units of the first, second and third chambers of the apparatus;

FIGS. 139 and 140 are diagrammatic views of the control systems for the conveyor units of the fourth chamber;

FIG. 141 is a diagrammatic view of the control systems for the conveyor units of the fifth and sixth chambers;

FIG. 142 is a side elevation of the shuttle conveyor carriage in this transfer area and as taken on line 142—142 of FIG. 130;

FIG. 143 is an end elevation of the conveyor carriage support structure as taken in the direction of arrows 143—143 in FIG. 130;

FIGS. 144 and 145 are diagrammatic views of the control systems for the shuttle conveyor carriage of FIG. 142;

FIG. 146 is a side elevation of the return side of the conveyor system as taken on line 146—146 of FIG. 130;

FIG. 147 is a continuation of the side elevation of FIG. 146;

FIG. 148 is a plan view in reduced scale of one conveyor unit employed in the return side of the system;

FIG. 149 is a fragmentary plan view of the adjacent ends of two such conveyor units;

FIG. 150 is a transverse vertical section taken on line 150—150 of FIG. 147;

FIG. 151 is a side elevation of the conveyor units at the exit end of the return side of the system;

FIG. 152 is a side elevation of the return side exit end, the sheet unloading unit and associated turn-table unit, this view being taken on line 152—152 of FIG. 5;

FIG. 153 is a plan view of the conveyor units of FIG. 151;

FIG. 154 is a diagrammatic view of the electrical control system for the belt motor of the bridging carriage at the end of the return side of the system;

FIG. 155 is a diagrammatic view of the electrical control systems for the belt gear-motor of the first series of conveyor drive units of the return side conveyor system;

FIG. 156 is a related diagrammatic view of the electrical control systems for the belt gear-motors of the continuing series of conveyor drive units of the return side and of the exit conveyor drive unit;

FIG. 157 is a diagrammatic view of the electrical control system for the belt gear-motors of the unloading conveyor drive unit;

FIGS. 158 and 159 are related diagrammatic views of the electrical control system for the unloading unit;

FIG. 160 is a schematic illustration of the operation of the loading unit; and

FIG. 161 is a schematic illustration of the operation of the unloading unit.

As illustrated schematically in FIGS. 1, 2 and 3, the conveyor system for transporting pairs of glass sheets sequentially through the filming plant includes a plurality of individually operable carriages that are interrelated through certain controls to advance sheet supporting carriers into the vacuum chambers on the processing side of the apparatus and then transfer the carriers to the return side thereof. Briefly described, the support carriers are advanced, as shown in FIG. 3, from a loading area 10 through the side 11 of a transfer area 12 to the entry end 13 of the processing side 14 or vacuum chambers of the apparatus, from which point the carriers proceed in the direction of the arrow designated by the reference letter E (East). In this respect, to simplify description of the paths traversed by the carriers, reference will hereinafter be made to the known compass points in defining the direction of their movements.

At the exit end 15 of the processing side, the carriers are transported laterally, in the direction of the arrow designated by the letter N (North), across a transfer area 16 to the entry end 17 of the return side 18 of the apparatus, along which they are moved in the direction of the arrow designated by the letter W (West). This return side terminates at the side 19 of the transfer area 12 adjacent an unloading area 20. When the carriers have been emptied, they are removed from the area 20 to the transfer side 19 from which they are carried laterally in the direction of the arrow, designated by the reference letter S (South), to the side 11 of the transfer area 12. The carriers are then moved into the loading area 10 preparatory to receiving subsequent sheets of glass or the like.

Prior to advancing to the loading area, the sheets must be properly prepared for receiving an optical film or coating thereon. In this respect, the sheets are transferred via a portable carrier from a storage area to a position adjacent a washing apparatus 22. One of the sheets is then lifted, for example, by means of a suction lift hoist onto the entry portal of the washing apparatus from which it is conveyed into the latter. It has been found that the best washing action is obtained when the sheets are positioned in a near vertical plane, for example, at an angle of 7 degrees from the vertical, although either a horizontal or a vertical position may be employed. The washing may suitably be conducted with detergent and hot water and preferably includes contacting the surface of the sheet to be cleaned with a roller brush or the like.

The washed sheet is rinsed with clean water and thoroughly dried to leave the surface thereof to be filmed or coated free from water spots. The drying procedure is preferably accomplished by directing streams of filtered, oil-free air against the sheet surface as it is being conveyed out of the washing apparatus, with the reference numeral 23 designating the drying section of the system. The air blast over the sheet surface produces a static charge on the glass which is removed by ionizing the air immediately in contact with the glass surface by means of an AC corona discharge.

The sheet is then conveyed, preferably by roller contact at the lowermost edge thereof and while still in a near vertical plane with the upper portion of the surface of the sheet not to be coated resting against suitable idler rolls, to an inspection

station indicated at **24**. The sheet is here inspected visually for cleanliness and any obvious imperfections in the glass which would have an adverse effect upon the subsequently applied coating, e.g. scratches or the like. In this respect, while such visual inspection is generally satisfactory, other more elaborate inspection systems may be provided at this point if desired and in the event such was not provided at some earlier point in the manufacturing operation. Upon the conclusion of the inspection operation and preferably again by means of roller contact with the lower edge of the sheet, the latter is conveyed while at a slight angle to the vertical (view *a* of FIG. **4**) onto one side of a turntable mechanism schematically shown at **27**.

The turntable is adapted to reverse alternate sheets proceeding from the washing and inspection stations in single file in order to subsequently place these sheets on a loading unit in paired, spaced, back-to-back position with the clean side of each sheet facing outwardly. In the event both sides of a single sheet are to be coated in accordance with the invention instead of only one side, this operation would not be required. The pairing of the sheets may be readily accomplished by conveying a first sheet onto one side of the turntable assembly and rotating the assembly in a counterclockwise direction, as indicated in view *b* of FIG. **4**, 180 degrees. This will position the opposite side of the turntable in alignment with a second sheet proceeding from the inspection station. The second sheet is then fed onto this side of the assembly (view *c*, FIG. **4**) and a conveyor operated so as to advance both sheets forwardly simultaneously from the turntable onto the respective sides of a loading unit schematically illustrated at **28** in view *d* of FIG. **4**. The sheets are thereafter clamped to carrier units of the conveyor system as will more fully hereinafter be described. In this connection, since the loading and unloading operations performed by the apparatus of the invention are in essence just reversals of each other, it will suffice here to merely indicate the unloading unit by the numeral **29**, a second turntable at **30** and a "run-out" conveyor at **31**.

With more specific reference now to FIGS. **5**, **6**, **7** and **8**, the conveyor system M includes a structural framework designated in its entirety by the numeral **100** which, in the loading and transfer areas, comprises structure **1000** having transversely disposed beams **1001** and **1002**, braced by suitable channels **1005** and supported on or adjacent the upper ends of pairs of vertical pedestals or columns **1006**, **1007** and **1008**, **1009**, respectively. As viewed in FIGS. **7** and **8**, horizontally disposed beams **1011** and **1012** bridge the transfer area **12** and, while being supported at one of their respective ends by the columns **1008**, **1009**, are similarly supported at their opposite ends by vertical columns **1014**, **1015** interjoined by a cross-beam **1016** paralleling the beam **1002**. The track of the conveyor system in the loading area is provided by a pair of monorails **1017** and **1018** suspended from the beams **1001** and **1002**. As viewed in FIG. **5**, these rails **1017** and **1018** are equally spaced from and arranged parallel to a reference line, designated by the reference letter *r*, which represents the longitudinal centerline of the processing side of the apparatus. Similar pairs of rails will be found to form various components of the system M in its entirety and will be noted in their order of utility.

Thus, beams **1011** and **1012** support a pair of parallel monorails **1021** and **1022** in the transfer area **12**. Rails **1021** and **1022** are arranged at angles of substantially 90° to the reference line *r* (see FIG. **5**) and bridge the entire distance between the sides **11** and **19** of the area **12**. As seen in FIGS. **5** and **8**, these rails **1021** and **1022** are carried at their respective ends at the side **19** of area **12** by a structural channel **1023** supported by vertical columns **1024**. Also, a parallel beam **1025** is located between column **1009** and the channel **1023**.

Since the structural features and functions of the loading area **10** and unloading area **20** are somewhat similar (see FIGS. **27**, **33** and **34**), it is believed that a description of the manner in which the sheet-supporting carriors (see FIGS. **35–49**) are returned from the unloading area **20**, via the transfer area **12**, and are delivered into the loading area **10** will resolve one of the important phases of conveyor operation. Thus, as shown in FIG. **5**, a so-called "shuttle" conveyor carriage, generally designated by the numeral **120** (FIGS. **9** and **10**), is mounted for movement along the rails **1021**, **1022** to alternatively engage and disengage similar "bridging" conveyor carriages. In this respect, one bridging carriage **135** (FIGS. **15** and **16**) is mounted on the rails **1021**, **1022** and normally located at the side **11** of the transfer area **12** adjacent the powdered conveyor section **150** (FIGS. **28** and **29**) in the loading area **10** to support carriers while they are being moved from the tracks **1017** and **1018** to axially aligned tracks **1026** and **1027** associated with the conveyor drive unit **145** (FIGS. **25** and **26**) at the entry end **13** of the processing side **14** of the apparatus. A bridging carriage **136** of similar but somewhat revised structure is similarly mounted on rails **1021** and **1022** and located in the opposite side **19** of the transfer area **12**. These bridging carriages are located adjacent to, i.e. "eastwardly" of, the respective loading and unloading areas to support the carriers as they are moved, in a first instance, from tracks **1028** and **1029** of a conveyor drive unit **152** at the end of the return side **18** of the conveyor system M onto the tracks **1030** and **1031** associated with the unloading conveyor drive unit **151** (FIGS. **33** and **34**) and, in the second instance, as they are moved from the tracks **1017**, **1018** in the loading area toward and onto the tracks **1026**, **1027** in the entry area of the processing side of the apparatus. Thus, when a pair of carriers are removed from the unloading area to be delivered into the loading area, they are received on the shuttle carriage **120** while the bridging carriage **136** is temporarily displaced from its normal position, as shown in full line in FIG. **5**, to the position shown in phantom.

As herein disclosed, one end of the tracks **1028** and **1029** associated with the conveyor drive unit **152** are carried by a beam **1035** supported at its ends by column **1036** and the adjacent column **1024**. The tracks **1030** and **1031**, on the other hand, are supported by a beam **1025** and a beam **1037**, the latter mounted at its ends on vertically disposed columns **1038** and **1039** and structurally connected to beam **1025** by bracing channels **1040**.

In operation, a pair of carriers each in clamping engagement with a coated glass sheet are moved "west," as indicated by the arrow designated by the numeral **137** in FIG. **5** from the tracks **1028**, **1029** at the terminal end of the return side **18** of the monorail system and across the bridging carriage **136** onto the tracks **1030**, **1031** of the conveyor drive unit **151**. The shuttle conveyor carriage **120** then moves northward, in the direction of the arrow designated by the numeral **138**, until it assumes the normal position of bridging carriage **136** by pushing this unit into the position indicated in phantom in FIG. **5**. When the pair of carriers on the tracks **1030**, **1031** have been unloaded, they are moved eastward by the unit **151** and received on the shuttle conveyor carriage **120** which then transports the carriers south in the direction of the arrow indicated by the reference numeral **139**.

As the carriage **120** approaches the middle of the transfer area, it may be halted due to the presence of a pair of carriers in the loading area. However, if the loading area is free of carriers, the carriage **120** then advances "south" toward the normal position (full line) of the bridging carriage **135** where it engages same and moves it south to the position shown in phantom. The carriers can then be moved west from the shuttle carriage **120** onto the tracks associated with the conveyor drive unit **150** over the loading area, conveyor **120** then returning north to its normal at rest position as shown in full line in FIG. **5** thus permitting the carriage **135** to resume its normal position. A pair of loaded carriers are then moved eastwardly across the bridging carriage **135** and in the direction of the arrow designated by the reference numeral **140**, onto the rails **1026**, **1027** in the entry area **13**.

As will be more fully hereinafter set forth, the bridging carriages **135** and **136** are equipped with one component of a counter-balanced return device generally designated by the

numeral **142** (FIG. **15**). Briefly stated, such devices include a pair of cables attached to suitable weights which are sequentially raised and lowered as the related unit **135** or **136** is moved from and returned to its normal position. This position is ensured by the provisions of suitable stops.

## THE SHUTTLE CARRIAGE

With reference now to FIGS. **9** through **13**, it will be seen that the framework **1200** of the shuttle carriage unit **120** comprises a pair of parallel beams **1201** and **1202** equally spaced from the longitudinal axis of the unit and forming, at their lower extensions, tracks or rails for supporting the carriers. At their opposite ends, the beams **1201** and **1020** support, by bolts **1203**, the horizontal flanges **1204** of similar pairs of angular beams **1205**, the vertical walls **1206** thereof being equipped with blocks **1207** for receiving the shafts of ball-bearing casters **1208**. These casters are adapted to traverse the rails **1021**, **1022** as the carriage **120** is moved by a source of power **1210** including a gear-motor **1211**. The gear-motor **1211** is coupled to a drive shaft **1215** through a chain belt **1216** entrained about a sprocket **1217** on the output shaft **1218** of the motor and a sprocket **1219** on the shaft **1215**. The power source **1210** is supported on the rails **1201**, **1202** by a platform **1222**, while shaft **1215** is carried by pairs of journal bearings **1223** at the platform **1222** and bearings **1224** at the beams **1205**. Between each pair of bearings **1224**, the drive shaft **1215** mounts a spur gear **1225** adapted to mesh with an elongated rack gear **1226** fixed to the lower surfaces of each rail **1021** and **1022**.

To move the carriers in either direction, i.e. onto or off from the carriage **120** along the spaced tracks formed on the beams **1201**, **1202**, the carriage is equipped with a pair of similar power sources indicated generally at **1230** and **1231** that are mounted by a platform **1232** on the upper flanges of the beams **1201**, **1202** and include individual reversible gear-motors **1233** and **1234**. The output shafts **1235** and **1236** of each gear-motor **1233** and **1234** are equipped with sprockets **1237**, **1238**, respectively, which, through related conveyor chain belts **1239**, **1240**, drive sprockets **1242**, **1243** on shafts **1244**, **1245** journaled in bearing brackets **1246**, **1247** carried by the platform **1232** and mounting sprockets **1248**, **1249** inwardly thereof. The sprockets **1248**, **1249** are similarly located with reference to an adjacent track **1201** and **1202**, and each drives a second sprocket **1251**, **1252** (FIGS. **9** and **11**) by means of related carrier-drive, roller chain belts **1253**, **1254**, respectively. Since each of the second sprockets **1251** and **1252** serve as an idler support for the associated chain belt, it is believed that the description of one will suffice for both. Thus, the sprocket in each instance is keyed on shaft **1256** journaled in a bearing bracket **1257** adjustably supported by suitable bolts on a platform **1258** carried by the tracks **1201** and **1202**. Each bracket **1257** is operable by an adjusting device **1259** supported on a bracket **1260** attached to the platform **1258** to increase or decrease the tautness of the related roller chain belt **1253** or **1254**.

As shown in FIG. **14**, the links **1262** of each chain **1253**, **1254** are formed with an outwardly-directed log **1263** on which is fixed a magnetically attractable plate **1264**. As will hereinafter be explained, the plates **1264** constitute the physical connections between the drive chain belts and the sheet supporting carriers. Since it is preferable to halt a support carrier at a predetermined position in transverse relation to the adjacent carrier, it is believed to be readily apparent that each chain belt **1253** or **1254** should be driven individually to thereby move the affected carrier forwardly or rearwardly between the ends of the carriage until the carrier reaches a "-centered" location and, through certain controls, causes the related motor **1233** or **1234** to be halted. In this connection, it should be mentioned that in a contemplated alternative structure the plate **1264** can, if desired, be made of a permanently magnetized metal and insulatingly supported, in one way or another, on the associated link-lug **1263**.

To support the upper and lower flights of the roller chain belts, support rails **1267** and **1268** (FIG. **13**) are mounted by blocks **1269** on the opposed flanges or legs of channel members **1270** and **1271**. These channels are similarly mounted by brackets **1272** on plate brackets **1273** suspended from the platform **1232** and brackets **1272** fixed to the inner surfaces of brackets **1260** attached to the platform **1258**. The plates **1264** associated with the links of each roller chain belt **1253** and **1254** combine to form an articulated surface, the lower flight of which is adapted to be magnetically engaged by elements of the carriers thereby to move the carrier in the direction in which the lower flights of the belts are being driven.

The beams **1205** (FIG. **9**) at the ends of the shuttle carriage **120** are provided with bracket members **1275** having padded surfaces **1276** of a hard, shock-absorbing material by which the unit **120** engages either of the bridging carriages **135** or **136**, as above described.

In connection with the control and power source lines for the gear-motors **1211**, **1233** and **1234** which will hereinafter be discussed in detail, it will be understood that the cables carrying such source lines are mounted adjacent the tracks **1021**, **1022** and connect to said motors through conventional contactor trolley devices. However, as illustrated in FIGS. **9** and **21** through **24**, several switch devices and the actuators therefor are mounted on the conveyor unit and/or the tracks **1021**, **1022** to produce the desired operation of the carriage, or temporarily associated carriers, in the desired sequence of action.

Thus, a switch device LS **1280** is mounted by bracket **1281** on the side of the platform **1232** adjacent track **1022**. This switch device is adapted, when the conveyor unit **120** is moving south toward and into engagement with the bridging carriage **135**, to effect a reduction in the rate of speed at which the motor **1211** is being operated. This control of the motor, as will hereinafter be more fully explained, is produced by LS **1280** when its lever arm is actuated by an elongated cam plate **1282** which is mounted by brackets **1283** on the track **1022**. As seen in FIG. **23**, this cam is effective in the approach area of the carriage **120** toward the bridging carriage **135** and the area in which the tracks **1201**, **1202** of the shuttle carriage **120** must be accurately aligned with the tracks **1017**, **1018** in the loading area. In this same respect, it will also be noted that when the shuttle carriage is moving north toward the side **19** of the transfer area, LS **1280** is carried into engagement with a cam plate **1284**, duplicating cam plate **1282**, to reduce the carriage speed when it approaches the bridging carriage **136** and alignment of the rails **1201**, **1202** with the rails **1030**, **1031**. The arrows, illustrated in FIGS. **21** and **23** and designated by the numeral **1290**, are intended to indicate the south direction of movement of the shuttle carriage when delivering a pair of empty carriers into the side **11** of the transfer area **12** adjoining the loading area **10**.

On the outer side of the oppositely disposed platform **1258** adjacent the rail **1021**, a pair of switch devices LS **1293** and LS **1294** are supported on a common bracket **1295**. Switch **1293**, as viewed in FIGS. **21** and **22**, is adapted to be activated by a cam plate **1297** mounted by bracket **1298** on the track **1021** in the transfer area. LS **1293** becomes instrumental in halting operation of the motor **1211** in the south side **11** of the transfer area. On the other hand, LS **1294** is adapted to be engaged by the cam plate **1299** when the shuttle conveyor enters the north side **19** of the transfer area adjacent to the unloading area. As shown in FIGS. **21** and **22**, cam plate **1299** is mounted by a similar bracket **1298**.

In transversely spaced relation from LS **1293** and **1294**, a pair of switch devices LS **1301** and LS **1302** are mounted by a common bracket **1303** on the platform **1258**. LS **1301** and **1302** are activated, with the carriage **120** in the transfer area, by cam plates **1304** and **1305**, each mounted by a bracket **1306** on the rail **1021**. LS **1301** and **1302** are adapted to produce so-called "jogging" or forward and back movements of the carriage **120** thereby permitting it to seek the exact location whereat its longitudinal axis will be substantially coin-

cident with the reference line *r*. At this time, the actuator arms of the switch devices will be substantially equally spaced from the opposed ends of cam plates **1304** and **1305** and the motor **1211** will cease operation in either direction.

In this connection, it will be noted in FIGS. **21** and **22** that similar cams **1307** and **1308** are located on rail **1021** in the north side of the transfer area to halt motion of the shuttle carriage when the tracks **1201** and **1202** thereof are accurately aligned with the related tracks **1030**, **1031** in the unloading area. In this sequence of operation, the cams **1307** and **1308** will serve to actuate the switch devices LS **1301** or LS **1302**.

Intermediate these pairs of switch devices, a bracket **1310** is fixed on the platform **1258** having an upwardly directed plate **1311** which serves as the actuator for a rocker-type switch device LS **1312** (FIGS. **21** and **22**) that is located by bracket **1313** in the center or idle position of the shuttle carriage **120**. LS **1312** is employed to halt movement of the shuttle carriage beyond the central or rest position thereof when a pair of carriers are being moved westward across the bridging carriage **136** into the unloading area. Also, when the shuttle carriage **120** is moving in a south direction, actuation of LS **1312** by the plate **1311** will halt further movement of this carriage in the event a pair of sheet-supporting carriers are being moved from the loading area and across the bridging carriage **135**.

Additionally, a plurality of switch devices are arranged in the path of each of the sheet-supporting carriers to determine the centered location thereof on the south and north sides of the carriage **120** by producing short forward and rearward motions as the carrier is moved to seek or find the optimum location and to then halt further movement. These switches thereby control operation and direction of operation of the motors **1233** and **1234**.

As shown in FIGS. **10**, **11**, **21** and **23**, these switch devices are identified as LS **1316**, **1317** and **1318** and are similarly mounted by individual brackets **1320** on the respective tracks **1201** or **1202**. LS **1316** in each instance is located at the west end of each track. LS **1317** is located adjacent the west end of the tracks. LS **1318** is located at the opposite or east end of each track. Thus, a carrier entering onto tracks **1201**, **1202** will engage LS **1318**, and then engage LS **1317** to independently control operation of the respective gear-motors **1233**, **1234** until the carrier is centered between LS **1316** and LS **1318**.

## THE BRIDGING CARRIAGES

With reference now to FIGS. **15** to **18**, the bridging carriage **135**, as well as the carriage **136**, has a framework **1350** including parallel beams **1351** and **1352**, which, at their lower extremities, form rails or tracks for supporting the carriers, pairs of angular bases **1353** at each end thereof and platforms **1354** and **1355** located therebetween. The bases and platforms are secured to the beams **1351**, **1352** in any suitable manner, for example, by bolts or like fastenings. In this connection, while only the carriage **135** has been shown in detail in the drawings, it should be understood that carriage **136** is identical in construction therewith, the only difference being a 180° reversal in position as clearly illustrated in FIG. **5**.

A rapid comparison of FIGS. **9** and **10** with FIGS. **15** and **16** could lend apparent truth to a supposition that carriages **120** and **135**, **136** are substantially duplicates one for the other. However, in the instant case and while the carriages **135** and **136** are also adapted to be supported on and to traverse the tracks **1021**, **1022**, they are not equipped with individual sources of power for this purpose. Thus, the vertical wall **1357** of each base **1353** is provided with blocks **1358** for the shafts of ball bearing casters or wheels **1359** which support the bridging carriages on tracks **1021**, **1022**.

To move the sheet-supporting carriers relative to the framework **1350**, a source of power indicated generally at **1362** is mounted to the platform **1354** and includes a gear-motor **1363**. Since the source of power **1362** is employed only for the purpose of either moving a pair of carriers forwardly into the entry end of the processing side of the apparatus, i.e., the power source associated with carriage **135**, or moving the carriers through the side **19** of the transfer area, i.e., the power source associated with the carriage **136**, it will not require reversing controls. Thus, the output shaft **1366** of the motor **1363** fixedly carries a sprocket **1367** which, by means of a chain belt **1368**, drives sprocket **1369** on shaft **1370**. The shaft **1370** is journaled in bearings **1371** mounted on the platform **1354** and sprockets **1372** and **1373** are keyed at the opposite ends of the shaft. The sprockets **1372** and **1373**, through related chain belts **1374** and **1375** (FIG. **17**), drive shafts **1376** and **1377** by means of sprockets **1378** and **1379** keyed thereon. Shafts **1376** and **1377**, in each instance, is journaled in a similar type of bearing bracket **1380** suspended from the platform **1354** and at its opposite end carries a fixed sprocket **1381** and **1382**. These sprockets, by means of the conveyor roller chain belts **1384** and **1385**, drive idler sprockets **1386** which, in each instance, are keyed to a shaft **1388** journaled by bearing brackets **1389** that are adjustably supported by bolts on the platform **1355**. Each bracket **1389** is operable by means of an adjusting device **1390** supported in a bracket **1391** on platform **1355** to increase or decrease the tautness of the associated roller chain belt **1384** or **1385**. These roller chain belts are formed by links of the same structure as the links **1262** of chain belts **1251** and **1252** (FIG. **14**) of the shuttle carriage and similarly carry magnetically attractable plates **1392** for the same purpose.

The upper and lower flights of the roller chain belts are supported on rails **1395** and **1396** mounted by blocks on the opposed flanges of channel members **1398** and **1399**. These channels, adjacent the bearing brackets **1380**, are mounted by brackets **1400** on plate brackets **1401** and at their opposite ends by similar brackets **1400** on the brackets **1391**.

The bases **1353** at the ends of the carriages **135** and **136** are equipped with spring-loaded devices, generally designated by the numeral **1405**, that are engaged by the padded surfaces **1276** of brackets **1275** on the opposite sides of the shuttle carriage unit **120** (FIG. **9**). Each of these devices, as shown in detail in FIG. **18**, comprises a plunger **1406** equipped with a striker head **1407** and reciprocally mounted in a block **1408** secured to the base **1353**. The plunger **1406** has a reduced end section **1410** which is slidably supported in a threaded sleeve **1411** located in a plate **1412** of base **1353** and equipped on each side thereof with a lock-nut **1413**. The outwardly exposed end of rod **1410** is threaded at **1414** to receive a lock-nut **1415**. A coil spring **1416** in located between the main body portion of the plunger **1406** and the opposed end of the sleeve **1411** to resiliently absorb any bumping or jarring that is normally to be expected when structural bodies of the size of the carriages **120**, **135** and **136** are brought into contact. By inward and outward movement of the sleeve **1411** relative to the plate **1412**, the tension of the springs can be adjusted and, by endwise movement of the lock-nut **1415** along the threaded portion **1414** of rod **1410**, the outward projection of the plunger from the unit can be readily selected.

The heretofore mentioned counter-balanced return device **142**, as seen in FIGS. **15**, **16**, **19** and **20**, includes a bracket **1420** mounted at each end of the bridging carriages **135** and **136**. The bracket has a projecting element **1421** to the wall of which is joined a bolt mounted thimble **1422** for attaching one end of either cable **1423** or **1424** (FIGS. **5** and **20**). As viewed in FIG. **20**, the vertical column **1009** or **1015**, as the case may be, is equipped with a mounting bracket **1425** for sheaves **1426** and **1427**. The cables **1423** from unit **135** and **1424** from unit **136**, are trained about their respective sheaves and therebeneath are connected to individual counter-weights **1428** and **1429** (FIG. **7**). The influence of the counter-weights is, of course, overcome by the momentum of the shuttle carriage **120** as it moves either of the bridging carriages from their normal position but becomes effective to produce return movement of the related carriage when the shuttle carriage moves back to its central position.

To ensure halting of either bridging carriage precisely in its normal position, stop members are employed such as the typical one shown by the numeral **1430** (FIGS. **15** and **19**). Such a stop member includes a limiting bolt **1431** adjustably supported in a bracket **1432** mounted on the adjacent end of rail **1018**. The head **1433** of bolt **1431** is adapted to engage the opposed head **1434** of a bolt **1435** similarly mounted for adjustment relative to the bracket element **1421**.

The bridging carriage **135** is equipped with an actuator bracket **1437** mounted on the side of platform **1354** adjacent the track **1022**. As illustrated in FIGS. **23** and **24**, the cam surface of the actuator **1437** is adapted to sequentially engage switch device LS **1438** mounted on the track **1022** by bracket **1439**. While the carriage **135** is normally positioned in the transfer area, LS **1438** is maintained in its closed condition. However, when the unit **135** has been shifted to the phantom line position of FIG. **5** by the shuttle carriage **120**, the actuator **1437** is removed from the switch device.

Tracks **1351** and **1352** of this bridging carriage support switch devices LS **1441** and **1442** by similar brackets **1443**. These switches are located closely adjacent to the parallel paths of carrier movement and in paired arrangement adjacent the ends of the tracks such as LS **1441** at the west ends of the tracks and LS **1442** on the east ends of the tracks. The utility of these switches will hereinafter be discussed in connection with FIG. **67**.

## THE ENTRY CONVEYOR DRIVE UNIT

As illustrated in FIGS. **5**, **7**, **25** and **26**, the entry conveyor drive **145** is a stationary unit of which the framework **1450** includes the rails **1026** and **1027** that are suspended at their west ends from the beam **1016**, between columns **1014** and **1015**. As can also be seen in FIGS. **113** and **114**, these rails are carried at their opposite ends by a beam **1451** mounted at its ends by vertically disposed columns **1452** and **1453**. The rails **1026** and **1027** support a series of platforms **1454**, **1455** and **1456** on which are mounted the driving and supporting elements for the conveyor chain belts **1458** and **1459**. As previously described in connection with the conveyor chain belts of the carriages **120**, **135** and **136**, belts **1458** and **1459** are similarly driven by sprockets **1460** and **1461** from sources of power indicated generally at **1462** and **1463**; the shafts **1464** and **1465**, respectively, of said sprockets being journaled in bearing brackets **1466** secured to the platform **1456**.

The power sources **1462** and **1463** are generally mounted on the platform **1455** and include gear-motors **1467** and **1468**, respectively. In this instance, the output shaft of gear-motor **1467** mounts a sprocket **1469** which through chain belt **1470** drives a sprocket **1471** on shaft **1472**. This shaft, journaled in bearings **1473**, at one end mounts sprocket **1474** and at other end is joined to the driver component of a "tie" or coupler clutch device **1475**. Sprocket **1474** by chain belt **1476** drives sprocket **1477** on the outer end of shaft **1464** to drive related sprocket **1460** and thereby operate the associated conveyor chain belt **1458**.

With regard to power source **1463**, the output shaft of gear-motor **1468** drives a sprocket **1478** (FIG. **68**) by means of a magnetic clutch **1479**, which sprocket **1478** by chain belt **1480** operates a sprocket **1481** on shaft **1482**. Shaft **1482**, journaled in bearings **1483**, is equipped at one end with a sprocket **1484** while the opposite end is joined to the driven component of a coupler device **1475**. Sprocket **1484** is coupled to a sprocket **1485** by chain belt **1486**, the sprocket **1485** being mounted on shaft **1465** opposite to the sprocket **1461**, about which conveyor chain belt **1459** is entrained. Each conveyor chain belt **1458** and **1459** is similarly entrained at its oppositely looped end about an idler sprocket **1488** generally supported by a bearing bracket **1489** on the platform **1454**. It is believed evident that the conveyor chain belts **1458** and **1459** between the respective drive sprockets **1460** and **1461** and idler sprockets **1488** are supported in the same manner as are the conveyor chain belts of the previously described carriages and further description is not deemed necessary. In this connection, reference may be had to FIG. **13** or FIG. **32**.

The rails **1026** and **1027** at their west ends adjacent the transfer area **12** carry similarly located, transversely aligned switch devices LS **1490** secured by mounting brackets **1491** (FIG. **114**). Likewise, adjacent their east ends, the rails are provided with transversely aligned switch devices LS **1492** and at their east ends carry switches LS **1493** on brackets **1491**. LS **1492**, in each instance and similarly to LS **1317**, when actuated by a control element on each of the sheet support carriers **160**, as will later be described, causes halting of the associated belt motor **1467** and **1468**. As will hereinafter be more fully described in connection with the circuitry of FIG. **68**, LS **1490** controls the centered positioning of a carrier as on the south rail **1026** of the entrance conveyor unit **145** by jogging the carrier east while the oppositely disposed LS **1493** will effect westward movement of the carrier in the event that it has over-run the desired position. LS **1492**, on the other hand, is adapted to directly effect halting of the related gear-motor when the carrier is centered. This is also true in connection with similarly employed LS **1490**, LS **1492** and LS **1493** that are adapted to be activated by the presence of a carrier on the north rail **1027** of the conveyor drive unit.

Generally speaking, when the carriers are moved and cross the bridging carriage **135** from the conveyor drive unit **150** and onto the entry conveyor drive unit **145**, it is believed understandable that the related motors may not function instanteously with the result that one carrier will lead the other carrier. This will cause the continued or jogging operation of either gear-motor **1467** or **1468** until the affected carrier is delivered exactly to its centered position. However, when the carriers are to enter the processing side of the apparatus, it is highly important that they be uniformly advanced as a transversely aligned pair. To this end, after the carriers have halted for a suitably timed interval, the clutch **1479** is deenergized and the "tie" or coupler clutch device **1475** is conditioned to drive shaft **1482** when shaft **1472** is driven by gear-motor **1467**. Thus, the conveyor chain belts **1458** and **1459** will be simultaneously driven from a common source of power and consequently will produce uniform forward motion of the carriers.

## THE LOADING CONVEYOR DRIVE UNIT

The conveyor drive unit designated in its entirety by the numeral **150**, is illustrated in FIGS. **5**, **7**, and **27** through **32**, inclusive. Structurally and operatively associated with this drive unit is a first unit **170** (FIGS. **50** to **54**) and a second unit **180** (FIGS. **57** to **61**) which are both adapted to clampingly secure a glass sheet along its top marginal edge in supported relation with a sheet-supporting carrier **160** (FIGS. **35** to **49**).

As hereinbefore noted, the rails **1017** and **1018** are integral parts of the over-all structural framework **100** and are located in the loading area of the system. A sheet support carrier **160** is located on each of the rails **1017**, **1018** and is adapted to be propelled along such rails in the same manner of operation as has been described in connection with the shuttle carriage **120** and bridging carriages **135** and **136**. That is to say, a pair of empty carriers are moved westward onto the rails **1017**, **1018** from the transfer area and ultimately, when loaded, eastward along the rails. In this respect, it is now believed apparent that conveyor roller chain belts equipped with contactor plates **1500**, of the same character as plates **1264** of FIG. **14**, are employed with the carriages **135** and **136** as well as with the drive unit **145** and those to be hereinafter described in the sequences of their utility.

In the present instance, the rails **1017**, **1018** support a platform **1501** on which reversibly operable sources of power indicated generally at **1502** and **1503** are mounted.

Thus, each power source **1502** and **1503** includes a "belt" gear-motor **1505** and **1506**, respectively. Each motor mounts a sprocket **1508** or **1509** keyed on the related output shaft. Through chain belt **1510**, sprocket **1508**, associated with gear-

motor **1505**, drives a sprocket **1511** fixed on shaft **1512** journaled in a bearing bracket **1513** suspended from platform **1501** (FIG. **30**). Similarly, the sprocket **1509** on the output shaft of gear-motor **1506** drives sprocket **1515** mounted on shaft **1516** through the chain belt **1517**, shaft **1516** being journaled in a bearing bracket **1518**. Shafts **1512** and **1516**, at their opposite or inner ends, mount sprockets **1519** and **1520** which, with related sprockets **1522** and **1523** (FIGS. **31** and **32**), support and drive roller chain belts **1524** and **1525**, respectively, Sprockets **1522** and **1523** are keyed on shafts **1526** journaled in a bearing bracket **1527** adjustably suspended on a plate attached to a platform **1528**, said platform being mounted on rails **1017**, **1018**. The spaced distance between each of the pair of shafts **1512** and **1526** or **1516** and **1526** is controlled, to maintain the required tautness in the roller chain belts **1524** and **1525**, by means of an adjusting device **1530** (FIG. **29**) mounted on a plate bracket **1531** suspended on the platform **1528**.

With reference now to FIG. **32**, it will be noted that the rollers of the upper and lower flights of the roller chain belt **1524** are supported between rails **1535** and **1536** which, as in the case of rails **1267** and **1268** of the shuttle carriage **120**, are mounted by blocks **1537** on the opposed legs **1538** and **1539** of channels **1540** and **1541**. The ends of channels **1540** and **1541**, adjacent the bearing brackets **1513** and **1518**, are secured by brackets **1542** to similar plate brackets **1543** suspended from the platform **1501** (FIG. **29**). The opposite end of each channel is mounted by a bracket **1542** on the plate bracket **1531**. As shown in FIG. **32**, the individual links **1544** of the chain belt **1524**, as well as those of the chain belt **1525**, are conventionally formed with outwardly directed lugs **1545** on which the plates **1500** are attached. In this respect, the upper and lower flights of roller chain belt **1525** are supported in the identical manner above described in connection with belt **1524**.

Adjacent the opposite ends of each rail or track **1017** and **1018**, switch devices, mounted by brackets **1549**, are provided to halt operation of the related gear-motor **1505** or **1506** and to produce rearward (east) and forward (west) motion of affected carrier **160** until the same is automatically and accurately centered above the loading unit and, more particularly, in the desired operative relation with regard to the securing unit **170**. Thus, switch devices LS **1550** are located near the east end of tracks **1017** and **1018**, LS **1551** adjacent the west ends of the tracks and LS **1552** at the west ends of tracks **1017** and **1018**. In each instance, LS **1550** is not actuated by a part of the carrier **160**, later to be described, as the carrier is moved from the tracks **1201**, **1202** of the shuttle carriage **120** onto the aligned tracks **1017** and **1018**. However, LS **1551** is activated by this carrier to stop the respective belt gear-motor **1505** or **1506**. LS **1552**, at the west ends of the tracks, may then be actuated if the momentum of the carriers will carry them slightly beyond the intended load position. Thus, LS **1552** will reverse the polarity of motors **1505** and **1506** to provide slight rearward or east jogging movement of the carrier on tracks **1017** and **1018**. In the event that this rearward movement by either carrier overruns the centered or load position, LS **1550** will halt and again reverse the polarity of the related motor to slightly advance the affected carrier. In the optimum location, both switch devices LS **1550** and **1552** are disengaged. Due to interlocking features of the electrical control systems, to hereinafter be more fully described, a pair of glass sheets can be raised from the loading unit toward the carriers and clamped thereto along their top edges by the units **170** and **180** as will shortly be described in connection with FIGS. **50** to **61**.

## THE SHEET SUPPORTING CARRIER

As viewed in FIG. **7**, a support carrier is shown in mounted position on the rail or track **1017** to receive a sheet from the loading unit therebeneath. These carriers, designated in their entirety by the numeral **160** in FIGS. **35** to **49**, are constructed either as a so-called "south" unit adapted for travel on the track **1017**, or a "north" unit adapted for travel on track **1018**, with the only difference in structure between the units being the particular side thereof on which certain members are located. The reasons for these distinctions will become more apparent in connection with FIGS. **55** and **56**. The carrier **160** of FIG. **35** therefore will be understood to be adapted for mounting on the south track **1017**.

Each support carrier **160** includes a main body portion indicated generally at **1600** including an inverted channel member or U-shaped base **1601** comprised of a web **1602**, legs **1603** and **1604** and a mounting panel **1605**, supported by pairs of links **1606** from said panel and clips **1607** secured to the undersurface web **1602** (FIGS. **37** and **48**). Ball bearing casters or wheels **1609**, for supporting the carriers on their respective tracks, are mounted in transversely aligned pairs by means of axles **1610** supported in brackets **1611** on the upper surface of the web **1602**.

The panel **1605** along its lower margin carries a plurality of regularly spaced, sheet-clamping members generally designated by the numeral **1613** and including stationary elements **1614** and movable components **1615**. Since these component clamping members are located with reference to one side or the other of panel **1605**, the sides thereof will be designated, for convenience of reference, as side **1616** (FIG. **35**) and side **1617** (FIG. **38**). Thus, the stationary elements **1614** are fixedly mounted by brackets **1618** on side **1616**, as in FIGS. **35**, **40** and **43**, and include a bar **1619**, attached by bolts **1620**, having a facing, non-abrasive layer or pad **1621** as of cork material.

On the panel side **1617**, the movable components **1615** are generally mounted by U-shaped brackets **1623** having side walls **1624** and a web or end wall **1625**. A lever **1626** is received within each bracket **1623** on a rod **1627**. The lever is adapted to move upwardly and downwardly along an inclined path defined by slots **1628** in side walls **1624**. The lower end of the lever is formed with notches **1630** (FIG. **43**) in which the lugs **1631** of a bar **1632** are swingably supported by a pin **1633**. As in the case of bar **1619**, the active face of bar **1632** is provided with a layer or pad of cork material **1634** thereby to positively grip the opposite surfaces of a glass sheet without scratching or otherwise marring same. The swingable mounting of the bar **1632** permits the layer **1634** to come angularly into contact with the surface of the glass sheet and to then gently rock thereon into full engaging contact as downward movement of the lever **1626** is completed.

The several levers **1626** are moved in common and downwardly from their upper, open positions, as in FIGS. **37** and **49**, to lower, clamping positions as in FIGS. **40** and **48**. These motions are produced by an elongated plate **1636** that is slidably supported along its lower margin in recessed corners or notches **1637** provided in the end walls **1625** of brackets **1623** (FIGS. **41**, **42** and **48**). As seen in FIGS. **40** and **41**, the upper margin of the panel **1605** is engaged by keeper blocks **1638** to sustain it in a vertical plane while permitting relatively free end-wise movement, The plate **1636** is formed with slots **1640** that are so inclined to the horizontal (FIG. **38**) that the vertical distance between the upper and lower terminus of each slot will substantially equal the upward and downward limits of travel of the related levers **1626**. For this purpose, each lever **1626** is provided with an outwardly directed finger **1641** associated with a slot **1640** so that when the plate **1636** is moved in the direction of the arrow, designated by the reference numeral **1642** in FIG. **38**, the fingers **1641** will simultaneously move downwardly to lower the levers **1626** into clamping position with reference to stationary bars **1619**.

In the above connection, it will be understood that the lower ends of bars **1626** move both downwardly and inwardly as the ends of support rods **1627** traverse the slots **1628** in the side walls **1624** of brackets **1623** to move the bars **1632** into clamping position with reference to stationary bars **1619**. The slide-plate **1636** is first urged in the direction of arrow **1642**

during a loading or clamping operation, and eventually in the opposite direction during the unloading operation while the carriers are located on the conveyor drive unit **151** associated with the unloader. To this end, the plate **1636** (FIGS. **38** and **39**) is provided with a bracket **1645** of which the outwardly directed leg **1646** is provided in its ends with notches **1647** and **1648**, about which more will be said later.

Now, when the levers **1626** are located in their lower clamping positions, the upper ends **1650** thereof are adapted to be engaged by resilient clamping devices generally designated by the numeral **1651**. As in FIGS. **40** and **42**, each of these devices includes a cup-shaped plug **1652** that is telescopically supported on a cup-shaped plug **1653** which in turn is slidably mounted by a bushing **1654** in the body of panel **1605**. A spring **1655** is contained within the cupped plugs **1652** and **1653** to resiliently urge the plug **1652** outwardly from the related plug **1653** and against the adjacent end **1650** of the associated lever **1626**. Each cupped plug **1653** is acted upon to produce the clamp securing action by an individual cam roller **1656** mounted with reference to the axis of a so-called "eccentric" shaft **1657** and fixed thereon by set-screw **1658**.

With reference to FIG. **39**, the shaft **1657**, which can be formed, although not necessarily, of axially aligned portions united by couplings **1660**, is supported on side **1616** of the panel **1605** by bearing blocks **1661**. One end of the shaft **1657** is tapered as at **1662** (FIGS. **35** and **47**) and inwardly thereof is equipped with a component chuck member **1663** having diametrically aligned notches **1664** to provide bayonet-type jaws **1665** (FIG. **47**). Obviously, when the carriers enter the area of the conveyor drive unit **150**, the levers **1626** are in the upper position and the cam rollers **1656** are inactively positioned as in FIG. **37**.

The shaft **1657** is also equipped with a fixed lock-collar **1667** having diametrically opposed sockets **1668** in the peripheral surface thereof (FIGS. **41** and **42**). Rotation of the shaft, although produced and controlled by rotation of chuck member **1663**, is thus restricted to an arc of substantially 180° by a dog **1669** formed on the end of threaded plug **1670** mounted in the panel **1605** and adjustably secured by lock-nut **1671**.

Each carrier **160** is propelled along the conveyor system in its entirety including the previously described carriages **120**, **135** and **136** and drive unit **150** through a connector device **1675** having permanent magnet characteristics. As shown in FIGS. **35**, **37** and **44** to **46**, the carrier mounts two of these devices or bars **1675** adjacent the respective ends thereof. For this purpose, the device (FIG. **46**) comprises a pair of plates **1676** and **1677** separated by a plurality of magnetic elements **1678** having a protective layer **1679** located along their upper and lower surfaces; the assembly being secured together by screws **1680** and provided with mounting slots **1681**. Each device or magnetic bar **1675** is carried on the leg **1603** of the carrier frame **1600** by a pair of brackets **1682** secured by bolt fastenings **1683**. The brackets are formed with an outwardly directed boss or block **1684** having a longitudinal, vertically open groove **1685**.

Preparatory to mounting a bracket **1682** on the leg **1603** of channel **1601**, a bar **1675** is placed in the groove **1685** and loosely held therein by a screw **1686** passed through the slots **1681** and threaded in the outer leg **1687** of the block **1684** (FIGS. **45** and **46**). The bar is urged upwardly within groove **1685** by a spring-loaded plug **1688** received in a wall or socket **1689** in the floor **1690** of the groove **1685**.

With reference to FIGS. **11** and **30**, it will be seen that the upper edges of the bars **1675** magnetically contact the several plates **1264**, **1392** or **1500** of the chain belts of the carriages and drive units and, as the belts are operated, the plugs **1688** will urge the bars upwardly against a plurality of such plates carried in the lower flight of the belt to thereby propel the carrier in the direction of belt movement. In the event that plates, such as plates **1264**, are as hereinabove described made of a permanently magnetized metal, the bars **1675** would alternatively be made up of solid or laminated metal plate.

Each carrier **160** is adapted to produce actuation of the several switch devices on the carriages or motor drive units; such as LS **1316** through LS **1318** on the shuttle carriage **120**; LS **1441** and LS **1442** on the bridging carriage **135**; LS **1490**, LS **1492** and LS **1493** on the conveyor drive unit **145** as well as LS **1550**, LS **1551** and LS **1552** on the conveyor drive unit **150**. Thus, as will be seen in FIGS. **36** and **37**, the inwardly disposed leg **1604** of each carrier channel member **1601** is provided with an angle iron element **1692** which by its horizontally disposed leg **1693** affords a switch actuating surface and with the leg being formed at its ends with downwardly inclined surfaces **1694** and **1695**. In the case of the switch devices associated with the shuttle carriage **120** and the entrance and loading conveyor drive units **145** and **150**, when these surfaces **1694** and **1695** are disengaged from adjacent switch devices the carrier will be suitably located in a centered position on the unit.

## THE SHEET CLAMPING UNIT

This aforementioned first unit **170** is located on the conveyor drive unit **150** and has functioning components, generally located between the tracks **1017** and **1018** (FIG. **28**), that are adapted to bring about clamping of the sheets along their top marginal edges to the carriers **160**. A framework **1700** for supporting these functioning components, as viewed in FIGS. **28** and **50** through **54**, consists of a channel **1701** bridging the tracks **1017** and **1018** and a channel **1702** of the platform **1501**. Longitudinally spaced, vertically disposed pairs of parallel channels **1703**, **1704** and **1705**, **1706** are equipped at their upper ends with mounting plates **1707** by which they are secured in any suitable manner to the channels **1701** and **1702**, respectively. Immediately beneath the mounting plates **1707**, the longitudinally opposed channels **1703**, **1705** and channels **1704**, **1706** are interconnected by bracing channels **1708**, **1709**. Structurally spaced beneath channels **1708**, **1709**, these pairs of channels are connected, in pairs **1703**, **1704** and **1705**, **1706**, by transverse braces **1710**, **1711** and in longitudinally opposed relation, **1703**, **1705** and **1704**, **1706**, by channel members **1712**, **1713**. Thus, channels **1710**, **1711** and **1712**, **1713** serve to re-enforce the lower extremities of the vertically disposed pairs of channels **1703–1705**, **1704–1706** while additionally providing mounting surfaces for the functioning components of the unit **170**. As well, the pairs of channels **1703**, **1704** and **1705**, **1706** have mounting plates **1715**, **1716**, respectively, secured to the outwardly directed surfaces of their lower ends, with each plate carrying a locator plate **1717**, **1718**, respectively, adjustably mounted by means of bolts **1719** and **1720**.

The locator plates **1717**, **1718** support vertically parallel, horizontally disposed annular rods **1722** and **1723** on which a slide-block **1724** is adapted to be moved by a piston rod **1725** of a cylinder **1726** located on the locator plate **1718** by a mounting base **1727**. The plates **1717**, **1718** are therefore adapted to be shifted vertically with reference to their associated plates **1715**, **1716** to locate the axes of rods **1722**, **1723** and piston rod **1725** in substantially horizontal and parallel planes. The cylinder **1726**, having contained piston **1728**, is connected by pipes **1729** and **1730** to an electrically controlled valve **1731** (FIGS. **28** and **29**) having suitable connection by pipe **1732** to a source of pressure.

The slide-block **1724** is formed with vertically disposed end blocks **1735**, **1736** secured together at their upper and lower ends by cap plates **1737**, **1738** and being equipped with sleeve bushings **1739** in which rods **1722** and **1723** are received. The block **1735** is provided on its outwardly directed face with a clevis part **1740** to which the free end of piston rod **1725** is connected by pin **1741**.

The aligned side surfaces of the blocks **1735**, **1736** are equipped with mounting plates **1743**, **1744** to which the opposite ends of chain belts **1745**, **1746** are attached. These chain belts are entrained about spaced pairs of idler sprockets **1748**, **1749**, respectively, of the ball bearing supported type

(FIG. 54) with the mounting spindle 1750 for each sprocket being fixed by set screws 1751 in blocks 1752 fixedly mounted on the inwardly disposed surfaces of channels 1703, 1706 and forming integral parts of the framework 1700.

The rollers of interconnecting pins of the links of each chain belt, between the respective pairs of sprockets 1748, 1749, engage the edges of respectively related guide plates 1755 and 1756 that are supported by similar structural angles 1757 having mounting bars 1758 that are attached to bracing channels 1712, 1713. The guide plates 1755, 1756 ensure that the chain bolts 1745 and 1746 will move in a flat plane whereby a pin 1760 carried by lugs 1761 of special belt links 1762 (FIG. 54) will perform a function contributing to clamping of the glass sheets. With reference to FIG. 55, and during the sheet clamping phase of a loading action, the slide-block 1724 will be moved west (or in a leftward direction in FIG. 53) whereupon the pins 1760 will be moved east to enter the notches 1647 of the bracket 1645 associated with each of the carriers 160. This will cause the brackets to move the slide-plates 1636 eastwardly in the direction of the arrow designated by the reference numeral 1642, with consequent downward movement of the movable clamping elements 1615 formed by the levers 1626. The top edge of the sheet is thereby clampingly gripped between the cork pad 1634 on bar 1632 of the lever 1626 and the similar pad 1621 of the bar 1619 of the stationary clamping element 1614.

On the other hand, during unloading of the sheets at the conveyor drive unit 151, the unit 170 associated therewith is located, and the chain belts are operable, as in FIG. 56, to cause the related pins 1760 to enter the notches 1648 of brackets 1645 thereby to move the plates 1636 west in the direction of the arrow, indicated by the reference numeral 1763, and raise the several levers 1626. This will, of course, remove the movable clamping elements 1615 from positive engagement with the glass sheet.

The limits of movement of the slide-block 1724 are controlled by certain switch devices, two of which, LS 1765 and LS 1766, are shown in FIG. 52 as being mounted by brackets 1767 on the bracing channels 1712 and 1713. To activate the lever arms 1768 and 1769 of these switch devices, the slide-block 1724 carries an actuator plate 1770 on the upper cap plate 1737 thereof to alternatively engage the actuating levers of the respective switch devices. The sequentially occurring functions of LS 1765 and LS 1766 will be more fully described in connection with the overall operation of the loading unit 28.

## THE ECCENTRIC SHAFT ACTUATOR UNIT

The function of the unit 180 is to partially ensure clamping of the top edge of a glass sheet by the members 1614 and 1615 of each carrier 160 and carried into effect, as previously described, by the unit 170. As viewed in FIGS. 27 and 57 to 60, this unit 180 includes a superstructure framework indicated generally at 1800 carried by the tracks 1017 and 1018 and including a platform 1801 formed with transversely disposed channels 1802 and longitudinally arranged channels 1803. Longitudinally located channels 1804, 1805 and 1806 are secured to channels 1802 at their opposite ends and medially therebetween. As viewed in FIG. 59, the extreme ends of track beams 1017 and 1018 are suitably fixed to the lower surfaces of channels 1802 by bolts 1807.

The functioning elements of the eccentric shaft actuator unit 180 are operatively mounted on a pair of vertically disposed channels 1810, 1811, located between the spaced channels 1802 and on a pair of transverse channels 1812, 1813 fixed to the lower surfaces of the channels 1804, 1805 and 1806.

On the outer surface of flanges 1815 of channels 1810 and 1811, a plate 1816 is provided (FIGS. 57, 58 and 59) for the mounting of guide fixtures 1817 by bolts 1818. Each of these guide fixtures, although oppositely formed, includes a rear vertical wall 1820 and horizontally disposed plate 1821 and 1822 that are integrally secured to the upper and lower ends of such rear wall, with the plates having vertically disposed slotted openings 1823, 1824 formed therein. Each plate, adjacent the outwardly opening ends of the related slots, is provided with pairs of guide rolls 1825 and 1826, respectively, that are adapted to guide the leading ends of panels 1605 of the support carriers 160.

The outwardly facing surfaces of the webs 1827 of channels 1810 and 1811 support bearing boxes 1830 having flanges 1831 which, by bolts 1832, are located against mounting panels 1833 on the channel webs. Each box 1830 (FIG. 57) rotatably supports a tubular driven member 1834 by means of thrust bearings 1835 and 1836. One end of the member 1834 has a shank 1837 of reduced diameter that is connected by a coupling 1838 to a drive shaft 1839 journaled in pillow bearings 1840, 1841 secured to the framework channels 1812, 1813.

The tubular member 1834, adjacent the shank 1837, is formed with a shoulder 1845 for receiving the inner race of bearing 1835, and with an outwardly directed reduced shank or barrel portion 1846 to form an oppositely disposed shoulder 1847 for the inner race of bearing 1836. This affords freedom of rotation for the member 1834 without any occasional displacement due to endwise thrusts. The inner chamber 1848 of each tubular member 1834 receives a coil spring 1850 to bear against the inwardly disposed end of a tubular, bayonet type chuck member 1851. This member is slidably received in the annular chamber 1848 and is fitted with a key 1852 and set screw to revolve with such member. A locking screw 1853 in the wall of the shank 1846 is received in a groove 1854 in the wall of the chuck member 1851 to resist ejection of the chuck by the spring 1850. The outwardly disposed end of the chuck member 1851 is formed to provide jaw portions 1855 and diametrically disposed slots 1856, each substantially equaling half of the circumference of the member. As seen in FIG. 59, the chuck members 1851 are equally spaced from a reference line, designated by the letter *r*, representing the longitudinal axis of the conveyor drive unit 150, which is also true with regard to the guide fixtures 1817.

With reference now to FIGS. 57, 58 and 60, the drive shaft 1839 for each driven member 1834 is generally rotated from a source of power, such as fluid pressure, through a gear and rack combination. In this respect, the arrows of FIG. 60, designated by the reference numerals 1857 (clockwise) and 1858 (counterclockwise), indicate the reverse directions of rotation of the similar shafts 1839 to achieve the same purpose. Thus, each shaft is equipped with a fixed spur gear 1859 that is meshed with a gear rack 1860 carried by a support plate 1861. This plate has a threaded connection 1862 with the piston rod 1863 of cylinder 1864 having contained piston 1865. In each instance, the bases 1866 of the ends of each cylinder is mounted by plates 1867 on channel 1812 or 1813 as the case may be. Also the rod ends of the cylinders are supplied from an electrically controlled valve 1868 mounted on channel 1812 by a tee fitting 1869 and similar conduits 1870 therefrom. Likewise, the head or opposite end of each cylinder is supplied by conduits 1871 through a tee fitting 1872 at the opposite side of valve 1868 which is connected to a source of fluid pressure by pipe 1873.

Each support plate 1861 (FIG. 60) maintains the engaged relation of the rack 1860 with gear 1859 by means of a pressure member 1875 including a U-shaped block 1876 for rollers 1877, such block being attached to a channel 1804 or 1806 through a mounting plate 1878 and bolts 1879.

Each plate 1861 is also provided with an actuator block 1880 which alternately engages the lever arms 1881 and 1882 of switch devices LS 1883 and 1884, respectively; such switch devices being located by similar brackets 1885 on either channel 1812 or 1813. Each LS 1883 is actuated by the associated block 1880 to open the electrical circuit to one side of the control valve 1868 for the cylinder 1864, as will be hereinafter more fully described, to halt retraction of the piston rods 1863 when the shafts 1839 and related chuck members 1851 are

returned to the position, as in FIG. **60**, from which the chuck members **1663** of the carriers **160** are to be operated. Similarly, each LS **1884** is engaged by the block **1880** upon projection of the rods **1863** from the cylinders **1864** and completed rotation of the eccentric shafts **1657**. LS **1884**, in each instance, thereby opens the electrical circuit to the opposite side of the aforementioned control valve **1868** and by a series circuit therethrough can establish a circuit which will permit the loaded carriers to be removed from the conveyor drive unit **150**. Generally speaking, such a circuit is originated in the control system of the entry conveyor drive unit **145** as will later be explained.

Overrunning of each support plate **1861** is an outward direction of the piston rod **1863** is limited by a set screw **1886** provided with a lock-nut **1887** and threadedly mounted in a support member **1888** mounted by plates **1889** at the ends of channels **1812** and **1813**.

As is thus believed apparent, as a pair of carriers **160** are received on the tracks **1017** and **1018** of the conveyor drive unit **150**, the associated magnetic bars **1675** are connected to the plates **1500** of conveyor chain belts **1524** and **1525** to advance the carriers in the direction of the arrows indicated by the reference numerals **1890** as in FIG. **61**. The chuck member **1663**, is each instance, will thus couple with the component chuck member **1851** as the tapered end **1662** of shaft **1657** enters the bore of the member **1851**. Also, the leading ends of the panels **1605** of the carriers will be received between the pairs of guide rollers **1825** and **1826** while entering the slots **1823** and **1824**. As the chuck members **1663** and **1851** are united, it is believed reasonable to anticipate that momentum of the carriers will produce a physical bumping or jarring as the carriers are suddenly halted. This is materially relieved and absorbed by the springs **1850** in the chamber **1848** of each tubular driven member **1834**. As explained in connection with the switch devices LS **1552**, when they are engaged by the inclined surface **1695** of the member **1692**, the resulting action produces reversing of the motors **1505** and **1506** to move the respective carrier slightly rearwardly. As one or both of the carriers are caused to move slightly rearwardly, the related chuck members **1663** will of course retract sufficiently for the affected coil springs **1850** to move the chuck members **1851** forwardly to the position of normal operation as in FIG. **58**. In the event the opposite inclined surfaces **1694** and **1695** do not engage LS **1550** or LS **1552**, it is assumed that the carriers have arrived at the desired centered position on the conveyor drive unit **150** as will hereinafter be more fully described in connection with FIG. **66**.

Referring again to FIG. **5**, the automated and interrelated functions of the shuttle carriage **120** are believed to have been fully set forth with reference to the bridging carriages **135** and **136**, the entry conveyor drive unit **145** and the loading conveyor drive unit **150**. Also, the structural embodiments of the carriage **120** have been described in connection with FIGS. **9** to **13** with details of the bridging carriages being similarly shown in FIGS. **15** to **18**. The structure of the conveyor drive unit **145** has been disclosed in FIGS. **25** and **26** while the embodiment of the conveyor drive unit **150** with the associated sheet clamping unit **170** and the eccentric shaft actuator unit **180** were shown in FIGS. **28** to **32**; FIGS. **50** to **54** and FIGS. **57** to **61**, respectively. These devices are instrumental in the automatic handling of the sheet carriers **160**, shown in FIGS. **35** to **49**, inclusive.

The sequential movements of a pair of carriers, each support a glass sheet, have been related to the progress of the carriers into the conveyor drive unit **151** associated with the unloader at the north transfer area, their removal when empty into the south transfer area and reception on the conveyor drive unit **150** and their eventual movement, when loaded with an uncoated pair of sheets, onto the entry conveyor drive unit **145** preparatory to further movement automatically into the processing apparatus or chambers according to the demands of production sequencing.

Now, to adequately describe the controlled programming of the above-noted carrier movements, reference is made to FIGS. **64** through **68** wherein circuit systems are illustrated as exemplary means for causing each of the units to be automatically operated and, in one way or another, produced related operation of an associated unit or units. Thus, FIG. **64** discloses an electric control system for the traction gear-motor **1211**, of reversible polarity, for causing movement of the shuttle conveyor carriage **120** alternately between the north and south transfer areas. Similarly, FIG. **65** reveals the electrical control system for operation of the belt gear-motors **1233** and **1234**, attention being directed particularly to the motor **1233**. Each of these gear-motors are of the reversible polarity type in order that a pair of carriers **160** can be moved onto and off from the tracks **1201** and **1202**. FIG. **66**, on the other hand, illustrates the related system for operation of the belt gear-motors **1505**, **1506**, gear-motor **1505** being described, with each of these gear-motors being of reversible polarity to receive a pair of empty carriers from the carriage **120** and to ultimately remove a pair of then-loaded carriers onto the bridging conveyor carriage **135**. The control system for this carriage is set forth in FIG. **67** wherein it will be noted that one belt gear-motor **1363** is provided for moving the carriers in one or an eastward direction toward the entry conveyor drive unit **145**. As viewed in FIG. **68**, the control system for this conveyor unit includes the circuitry for belt gear-motors **1467** and **1468**, which are of reversible polarity, and further illustrates the provision of clutch devices **1475** and **1479** whereby gear-motor **1467** serves to accurately move the pair of carriers in transverse tandem association into the processing apparatus. Understandably, cross reference is made where necessary between these figures for interrelated operation of the carriages and/or drive units according to the sequences of carrier movement.

The power circuits for the traction gear-motor **1211** of the shuttle carriage **120**, as in FIG. **64**, are completed from source lines **2000**, **2001** and **2002** by relay switch **2003** equipped with opposed solenoids **2004** and **2005**, presently disengaged pairs of contacts **2006**, **2007** and **2008** and presently engaged contact pair **2009**. Likewise, the means for reversing the polarity of gear-motor **1211** is herein provided by a relay switch **2011** equipped with opposed solenoids **2012** and **2013**, presently engaged pairs of contacts **2014**, **2015** and **2016** (which produce southward travel) and with presently disengaged pairs of contacts **2017**, **2018** and **2019** (which are adapted to produce northward travel).

As described in connection with FIG. **5**, normal operation of the shuttle carriage **120** is to move into the north transfer area or side **19** thereof and displace the bridging carriage **136** until the tracks **1201** and **1202** are aligned with the tracks **1030** and **1031** of the conveyor unit **151**. A pair of empty carriers **160** are then removed from the unit **151** and received on the carriage **120**. After being halted in a centered position on the carriage **120**, the carriers are instrumental in producing operation of the traction gear-motor **1211** to move the shuttle carriage south toward the side **11** of the transfer area **12**.

In the event that a pair of loaded carriers **160** are located on the conveyor drive unit **150** (a pair of loaded conveyors may or may not be similarly located on the entrance conveyor drive unit **145**), movement of the shuttle carriage **120** will be halted, during its southward travel from the side **19** of transfer area, at a center position (shown in full line in FIG. **5**) before it is permitted to deliver the pair of empty carriers **160** into the side **11** of the transfer area. For this purpose, a switch device, LS **2021**, later to be described in connection with FIG. **68**, is adapted to complete the circuit of a line **2022** to one side of the rocker-type switch device LS **1312**, which, when engaged and pivotally moved by the striker plate **1310** in the direction of the arrow designated by the letter *s*, will have continued line **2022** by line **2023** through solenoid **2005** of RS **2003** to source line **2001** to thereby disengage pairs of contacts **2006**, **2007** and **2008**, as shown, while reclosing contact pair **2009** to restore a circuit by line **2024** through magnetic brake **2025**, associated with the gear-motor **1211**.

Now, when a pair of loaded carriers have been moved into and halted on the entry conveyor drive unit **145**, the aforementioned LS **2021** will be caused to open and a switch device LS **2026** will have been engaged in the area of the entry conveyor unit. This switch (also in FIG. **68**) is adapted to establish a circuit from source line **2000** by line **2027** through solenoid **2004** of RS **2003** to source line **2001**. Contacts **2009** are thereby opened to deenergize brake **2025** while engaged contact pairs **2006**, **2007** and **2008** will be adapted to complete source lines **2000**, **2001** and **2002** via lines **2030**, **2031** and **2032** and engaged pairs of contacts **2014**, **2015** and **2016** to lines **2033**, **2034** and **2035** which through a resistance **2036** connect to motor **1211**. This will operate by output shaft **1218** and sprockets **1217** and **1219** to drive shaft **1215** through chain belt **1216**. Shaft **1215**, of course, produces motion of the unit **120** as the spur gears **1225** are driven to traverse rack gears **1226** on the tracks **1021** and **1022**.

As the shuttle carriage proceeds southward, the stationary cam **1282** (FIGS. **23** and **24**) is engaged by LS **1280** which becomes effective to reduce the speed at which the carriage is traveling as it approaches the bridging carriage **135**, to engage and move the same into the position indicated in phantom in FIG. **5**. LS **1280** will thus be caused to complete a circuit from source line **2000** by way of line **2038** through resistance **2036** thereby adjusting the same to reduce the motor speed.

Upon the approaching the desired position for the tracks **1201** and **1202** of carriage **120** to align with tracks **1017**, **1018** of the conveyor drive unit **150**, LS **1293** (FIGS. **21** and **22**) will be engaged with cam **1297** and thereby complete a circuit from source line **2000** by line **2039** through the engaged pair of contacts **2040** of relay switch RS **2041**, presently engaged pair of contacts **2042** of relay switch RS **2043**, line **2044** through timing relay TR **2045**, line **2046** and engaged pair of contacts **2047** of relay switch RS **2048**, line **2049** through timing relay TR **2050** and to line **2051**.

RS **2041** is additionally provided with opposed solenoids **2052** and **2053** and engaged pair of contacts **2054** as well as contact pair **2040**. Similarly, RS **2043** is equipped with opposed solenoids **2056** and **2057** and presently engaged pair of contacts **2058** as well as contact pair **2042**. Likewise, RS **2048** is provided with opposed solenoids **2061** and **2062** and presently engaged pair of contacts **2063** as well as contact pair **2047**. In this connection, it will be noted that LS **1294** is connected in parallel with LS **1293** to line **2051**; however, LS **1294** is employed to serve the same function of stopping motor **1211** when the shuttle carriage enters the side **19** of the transfer area and is engaged by cam **1297** (FIGS. **21** and **22**).

LS **1293** thus completes the circuit of line **2051** to line **2065** which connects with line **2023** to extend its circuit through the solenoid **2005** of RS **2003** to source line **2001**. This will disengage contact pairs **2006**, **2007** and **2008** to break the motor circuits while setting brake **2025** upon reclosure of contact pair **2009**.

After the halting of motor **1211**, it is very possible that momentum of the carriage **120** will cause it to come to a halt either slightly south or north of the required position of alignment of the tracks **1201**, **1202** with tracks **1017**, **1018**. Thus, LS **1301** or **1302** are employed, in conjunction with stationary cams **1304** and **1305** (FIGS. **21** and **22**), to "seek" the required position and in so doing "jog" the motor to momentarily produce the desired direction of motion. Of course, the carriage arrives at the optimum position when the actuator arms of the switch devices are located substantially midway between the opposed ends of the cams.

Thus, LS **1301** is adapted to produce northerly motion of the carriage **120** and, while in contact with cam **1304**, to complete a circuit from source line **2000** through line **2066** from contacts **2054** of RS **2041**, and, by way of line **2067**, via contacts **2063** of RS **2048**, and line **2068** to TR **2050**, in series with source lines **2000** and **2001**. At this time, the circuit of line **2039** is closed by line **2046** from TR **2045** and line **2051** from TR **2050** so that line **2065** can be completed by LS **1293**, to energize solenoid **2005** of RS **2003** thereby halting gear-motor **1211**. TR **2050** then completes a circuit by line **2069** through the solenoid **2061** of RS **2048** to disengage contact pairs **2047**, **2063** thereof. The circuit of line **2068** from LS **1301** is also extended by line **2070** to complete a circuit to a timing relay TR **2071**, in series with source lines **2000** and **2001**. This timer device is adjusted to monitor an interval of time of sufficient duration to permit LS **1302** to be engaged, if necessary, to produce any required southward movement and to permit the motor **1211** to halt with the carriage **120** in the rest position. The circuitry controlled by TR **2071** will shortly hereinafter be explained.

Initially, TR **2050** sets up a time interval, during which the motor **1211** is halted, to interrupt the service of lines **2049** and **2051** to render LS **1293** inoperable. It will, of course, be understood that while the carriage is located in the south transfer area the cam plate **1297** will maintain LS **1293** closed which is also true with regard to LS **1294** when engaged by the cam plate **1299** in the north side **19** of the transfer area.

The timer then completes a circuit by line **2072** through solenoid **2012** of RS **2011** to source line **2001** thereby disengaging contact pairs **2014**, **2015** and **2016** and engaging contact pairs **2017**, **2018** and **2019** to reverse the polarity of gear-motor **1211**.

Finally, TR **2050** opens line **2072** and closes line **2073** through the solenoid **2004** of RS **2003** to source line **2001**. This causes engagement of contact pairs **2006** and **2007** and **2008** while de-energizing brake **2025** at contacts **2009**. The power circuits to motor **1211** will now be made through line **2030**, contact pair **2017** and line **2074** to line **2034**; line **2031**, contact pair **2018** and line **2075** to line **2033** and line **2030**, contact pair **2019** and line **2076** to line **2035**. This causes motor **1211** to move the carriage **120** northward. By branch line **2077** from line **2073**, a circuit is made through solenoid **2062** of RS **2048**; this acting to re-engage contact pair **2046** of RS **2048** although lines **2049**, **2051** are disconnected at TR **2050** as well as to re-engage contacts **2063** although lines **2067**, **2068** are presently broken at LS **1301**.

In the event that the ensuing slight northward jogging motion of the carriage overruns the position of alignment and LS **1302** is engaged by cam **1305**, line **2066** at engaged contact pair **2058** of RS **2043** completes a circuit by line **2078** through LS **1302** and line **2079** to TR **2045**, in circuit with source lines **2000** and **2001**.

Initially, TR **2045** sets up a time interval, during which the gear-motor **1211** is halted, to interrupt the service of lines **2044**, **2046** and again render LS **1293** inoperable. The timer completes a circuit by line **2080** through the solenoid **2056** of RS **2043** to disengage contact pairs **2042**, **2058** thereof. TR **2045** then completes a circuit by line **2081** through the solenoid **2013** and RS **2011** to source line **2001** thereby disengaging pairs of contacts **2017**, **2018** and **2019** and re-engaging contact pairs **2014**, **2015** and **2016** to reverse the polarity of motor **1211**. Finally, TR **2045** opens line **2081** and closes line **2082** connecting by line **2073** through solenoid **2004** of RS **2003** to source line **2001**. This again causes engagement of contact pairs **2006**, **2007** and **2008** of RS **2003** while de-energizing brake **2025** at disengaged contact pair **2009**. The power circuits will thus be made through line **2030**, contacts **2014** and line **2033**; line **2031**, contacts **2015** and line **2034**, and line **2032**, contacts **2016** and line **2035** through resistance **2036** to gear-motor **1211**. Since LS **1280** is still held engaged by the cam **1282**, motor **1211** will operate at the slower rate of speed to move the shuttle conveyor carriage **120** southward until it reaches the desired aligned position of tracks **1201**, **1202** with tracks **1017**, **1018**. By branch line **2083** from line **2082**, a circuit is made through solenoid **2057** of RS **2043** to source line **2001**, this operating to re-engage contact pair **2042** although lines **2044**, **2046** are open at TR **2045** and also to re-engage contact pairs **2058** although lines **2078** and **2079** are presently open at LS **1302**.

Now, when the shuttle carriage **120** arrives at the position of track alignment, TR **2071** becomes active to complete a circuit by line **2085** through the solenoid **2052** of RS **2041** to source **2001**. This acts to disengage contact pairs **2040** and

2054 to thereby open the circuit lines generally to the switch devices LS 1293, 1301 and 1302, thereby rendering them inoperable until they have been removed from the control of cams 1297, 1304 and 1305 by northward travel of the shuttle carriage 120.

During this interval of time, TR 2070 establishes a circuit by line 2086, connecting by line 2072, through the solenoid 2012 of RS 2011 to source line 2001. This will reverse the polarity of motor 1211 preparatory to subsequent returning northward movement of the carriage 120 from the south transfer area. This northward movement, as will later be described in connection with FIG. 66, is attributable to the action of switch devices that are actuated when a pair of carriers 160 have been moved from the tracks 1201 and 1202 and their ends have cleared the entry ends of the tracks 1017 and 1018.

Finally, TR 2071 makes a circuit by line 2087 to create the required power lines for operation of the belt motors 1233 and 1234 of the carriage 120 to drive the associated conveyor chain belts 1253 and 1254. However, in the preferred sequence of operation, the circuit of line 2087, as described and illustrated in connection with FIGS. 65 and 66, actually produces initial operation of motors 1505 and 1506 of the loading conveyor drive unit 150. This acts as a precautionary measure since the associated chain belts 1524 and 1525 must be operating to magnetically contact the bars 1675 on the carriers 160 before the chain belts 1253, 1254 are put into operation to move the carriers west by their related magnetic bars.

Operation of the traction gear-motor 1211 (FIG. 64) to move the shuttle carriage 120 northward is conditioned upon complete removal of the carriers from the carriage 120 and their positions on the conveyor drive unit 150 as will later be described in connection with FIG. 66 and, eventual movement of the carriage 120 permits the bridging carriage 135 to return to its normal position (full line in FIG. 5) whereby the tracks 1351 and 1352 will again be aligned with tracks 1017, 1018 of the loading conveyor drive unit 150 and tracks 1026, 1027 of the entry conveyor drive unit 145.

In the event that there are no carriers 160 in the area of the conveyor drive unit 151 associated with the unloader, or that a pair of loaded carriers are being transferred from the exit end of the return side of the system across the bridging carriage 136, a circuit will be completed, by control devices not shown, but such as LS 2021 (FIG. 64), to one side of LS 1312 by line 2022. In the present circumstance, the northward movement of the shuttle carriage will cause the plate to swing the arm of LS 1312 in the direction of the arrow designated by letter *n*. This will establish the circuit of lines 2022, 2023 through solenoid 2005 of RS 2003 to source line 2001 thereby halting northward movement of the carriage 120 at the midway point as shown in FIG. 5.

On the other hand, if a pair of carriers are situated on the conveyor drive unit 151, the circuit of line 2022 will not be completed so that the traction motor 1211 will continue to move the carriage 120 into the north transfer area to engage and displace the bridging carriage 136 into the position thereof shown in phantom in FIG. 5. As this area is approached, LS 1280 engages cam plate 1284 to reduce the rate of travel. As the tracks 1201, 1202 are moved into alignment with tracks 1030, 1031, LS 1294 will be engaged by cam plate 1299 to halt operation of traction gear-motor 1211, this act of course being encompassed by engagement of LS 1301 or LS 1302 with the respective cam plates 1307 and 1308 as previously described.

In consequence, the shuttle conveyor carriage 120 will be positioned to receive a subsequent pair of empty carriers 160 from the conveyor drive unit 151 and repeat the sequence of its operation.

As disclosed in FIG. 65, the power circuits for the belt gear-motors 1233 and 1234 of the shuttle carriage 120 are completed from source lines 2000, 2001 and 2002 through associated switch devices as will hereinafter be described. Since these motors are operable for the same purpose, to drive the related chain belts 1253 and 1254, it is believed that the description of a typical electrical circuit for one gear-motor, such as the motor 1233, will suffice for both. Thus, the service circuits for belt gear-motor 1233 are made by a relay switch 2100 equipped with opposed solenoids 2101 and 2102, presently disengaged pairs of contacts 2103, 2104, 2105 and 2106 and presently engaged contact pairs 2107. Likewise, the means for reversing the polarity of gear-motor 1233 is herein provided by a relay switch 2110 equipped with opposed solenoids 2111 and 2112, presently engaged pairs of contacts 2113, 2114, and 2115 (which produce eastward travel of a carrier) and with presently disengaged pairs of contacts 2116, 2117 and 2118 (which produce westward travel).

As described in connection with FIG. 5, when a pair of unloaded carriers 160 are located on the unloading conveyor drive unit 151 and the shuttle carriage 120, presently void of carriers, approaches the north terminus 19 of its travel across the transfer area 12, it causes outward movement of the bridging carriage 136 (to the position shown in phantom in FIG. 5) until the carriage tracks 1201 and 1202 are correctly aligned with the tracks 1030 and 1031. At this time, a cam 2120 (FIG. 5) on the bridging carriage 136 will engage a switch device LS 2121 (FIGS. 21 and 22) that is adapted to cause operation of the belt gear-motors 1233 and 1234. As above mentioned, the power lines to gear-motor 1233 are completed through the pairs of contacts of RS 2100. Thus, when the belt gear-motors, such as gear-motor 1233, are started to operatively drive the related chain belts 1253, 1254, a circuit (not shown) is completed to similar gear-motors associated with the conveyor drive unit 151, this being to ensure that the chain belts 1253, 1254 are being driven to receive the bars 1675 of the carriers before the power sources for the chain belts associated with the conveyor drive unit 151 are started to move the carriers eastwardly.

LS 2121 is thus adapted to complete a circuit from source line 2000 by line 2122 through one side of a timing relay TR 2123 to activate the same by line 2124, said TR being in series with source lines 2000 and 2001. While functioning, TR 2123 acts to open line 2122 thereby rendering LS 2121 inoperable since it will be held closed by cam 2120 while the bridging carriage 136 remains in its outwardly disposed position. TR 2123 then completes a circuit by line 2125 through solenoid 2101 of RS 2100 thereby causing engagement of contact pairs 2103, 2104 and 2105 while disengaging contact pair 2107 to open line 2126 through brake 2127 of gear-motor 1233. Contacts 2103 now complete a circuit from source line 2000, line 2130, contacts 2113 of RS 2110 and line 2131 to gear-motor 1233; contact 2104 from source line 2001, line 2132, contacts 2114 and line 2133 to the motor while contact pair 2105 complete a motor circuit from source line 2002 via line 2134, contacts 2115 of RS 2110 and line 2135. The gear-motor will thereby cause sprocket 1237 to drive sprocket 1242 by means of chain belt 1239, sprocket 1242 acting to operatively drive the chain belt 1253 through sprocket 1248 thereby to move the related carrier in an eastward direction.

When similarly engaged, contact pair 2106 will be understood to complete a circuit to a relay switch (not shown) associated with the gear-motors of the conveyor drive unit 151 to start the same. This starting circuit can be established by a line 2136 through TR 2123 to line 2137. Since it desirable, for reasons to shortly be explained, to subsequently bring about the completion of circuits through contact pairs 2103, 2104 and 2105 without simultaneously recreating a circuit through contact pair 2106, TR 2123 will open lines 2136, 2137 after having produced operation of the unloading conveyor unit 151.

Upon approaching the desired centered position for the carrier 160 on the track 1201, the leading end portion 1695 of actuator bar 1692 will engage LS 1317 to complete a circuit from source lines 2000 by line 2138 through the engaged pair of contacts 2139 of relay switch RS 2140, presently engaged pair of contacts 2141 of relay switch RS 2142, line 2143 through timing relay TR 2144, line 2145, engaged pair of contacts 2146 of relay switch RS 2147, line 2148 through timing relay TR 2149 to line 2150.

RS 2140 is additionally provided with opposed solenoids 2152 and 2153 and engaged pair of contacts 2154 as well as contact pair 2140. Similarly, RS 2142 is equipped with opposed solenoids 2156 and 2157 and presently engaged pair of contacts 2158 as well as contact pair 2141. Likewise, RS 2147 is provided with opposed solenoids 2161 and 2162 and presently engaged pair of contacts 2163 as well as contact pair 2146.

LS 1317 thus completes the circuit of line 2150 to line 2164 which makes a circuit through the solenoid 2102 of RS 2100 to source line 2001. This will disengage contact pairs 2103, 2104 and 2105 to break the motor circuits while setting brake 2127 upon reclosure of contact pair 2107.

While LS 1317 acts to open the circuits of motor 1233, it can be expected that momentum of the carrier 160 will cause it to come to a halt either slightly east or west of the required centered position on the carriage 120 when the gear-motor 1233 ceases to operate. Thus, LS 1316 or 1318 are employed, in conjunction with the end portions 1694 and 1695 of actuator bar 1692, to cause the carrier to seek the required position and in so doing jog the motor to momentarily produce the desired direction of motion. Of course, the optimum position is reached when the actuator arms of the switch devices are located substantially equally spaced from the opposed end portions of the bar 1692. LS 1318 is adapted to produce westerly directed motion and while in contact with end portion 1694 complete a circuit from source line 2000 via line 2165 through contacts 2154 of RS 2140. By way of line 2166 through contacts 2158 of RS 2142, LS 1318 is then adapted to complete a circuit by line 2167 to TR 2144, in series with source lines 2000 and 2001. At this time, the circuit of line 2138 is closed by line 2145 from TR 2144 and line 2150 from TR 2149 so that line 2164 can be completed by LS 1317, to energize solenoid 2102 of RS 2100 thereby halting gear-motor 1233. TR 1244 initially functions to open the lines 2143, 2145 to line 2150 and LS 1317.

The circuit of line 2167 is also extended by line 2169 to complete a circuit to a timing relay TR 2170, in series with source lines 2000 and 2001. This timer device is adjusted to monitor an interval of time of sufficient duration to permit LS 1316 to be engaged, if necessary, by the bar end 1695 to produce any required eastward movement and to then permit the motor 1233 to halt with the carrier in the centered position. The circuitry controlled by TR 2170 will shortly hereinafter be explained.

Initially, TR 2144 sets up a time interval, during which the motor 1233 is halted, to interrupt the service of lines 2143 and 2145 which renders LS 1317 inoperable. It will, of course, be understood that with a carrier bodily supported, as on the rail 1201, the actuator bar 1692 by its horizontal leg 1693 will maintain LS 1317 closed. The timer TR 2144 then completes a circuit by line 2171 through the solenoid 2156 of RS 2142 to disengage contact pairs 2141, 2158 thereof. The timer then completes a circuit by line 2172 through solenoid 2111 of RS 2110 to source line 2001 thereby disengaging contact pairs 2113, 2114 and 2115 and engaging contact pairs 2116, 2117 and 2118 to reverse the polarity of gear-motor 1233. Finally, TR 2144 opens line 2172 and closes line 2173 through the solenoid 2101 of RS 2100 to source line 2001.

This action causes completion of circuits at particularly contact pairs 2103, 2104 and 2105, since the circuit of line 2136 of contact pair 2106 is open at TR 2123, while de-energizing brake 2127 at contacts 2107. The power circuit to motor 1233 will now be made through line 2130, contact pair 2116 of RS 2110 and line 2174 to line 2133; line 2132, contact pair 2117 and line 2175 to line 2131 and line 2134, contact pair 2118 and line 2176 to line 2135. This causes motor 1233 to operate chain belt 1253 to move the carrier 160 westward. By branch line 2177 from line 2173, a circuit is made through solenoid 2157 of RS 2142, this acting to re-engage contact pair 2141 of RS 2142 although lines 2143, 2145 are disconnected at TR 2144 as well as to re-engage contacts 2158 although lines 2166, 2167 are presently broken at LS 1318.

In the event that the ensuing slight jogging westward motion of the carrier slightly overruns the centered position and LS 1316 is engaged by end portion 1695, a circuit is made by line 2180, via line 2165 from source line 2000, at engaged contact pair 2163 of RS 2147 completes a circuit by LS 1316 and line 2181 to TR 2149, in circuit with source lines 2000 and 2001.

Initially, TR 2149 sets up a time interval, during which the gear-motor 1233 is halted, to interrupt the service of lines 2145, 2148 and again render LS 1317 inoperable. The timer then completes a circuit by line 2182 through the solenoid 2161 of RS 2147 to disengage contact pairs 2146, 2163 thereof. TR 2149 then completes a circuit by line 2183 through the solenoid 2112 of RS 2110 to source line 2001 thereby disengaging pairs of contacts 2116, 2117 and 2118 and re-engaging contact pairs 2113, 2114 and 2115 to reverse the polarity of motor 2133. Finally, TR 2149 opens line 2183 and closes line 2184 connecting by line 2173 through solenoid 2101 of RS 2100 to source line 2001. This again causes engagement of contact pairs 2103, 2104 and 2105 of RS 2100 while de-energizing brake 2127 at disengaged contact pair 2107. The power circuit will thus be made through line 2130, contacts 2113 and line 2131; line 2132 contacts 2114 and line 2133 and line 2134, contacts 2115 and line 2135 to the gear-motor 1233 to produce the required distance of eastward movement of the carrier. By branch line 2185 from line 2184, a circuit is made through solenoid 2162 of RS 2147 to source line 2001, this operating to re-engage contact pair 2146 although lines 2148, 2150 are open at TR 2149 and also re-engage contact pair 2163 although lines 2180, 2181 are presently open at LS 1316.

Now, when the carrier arrives at the centered position, TR 2170 becomes active to complete a circuit by line 2186 through the solenoid 2152 of RS 2141 to source 2001. This acts to disengage contact pairs 2139 and 2154 to thereby open the circuit lines generally to the switch devices LS 1316, LS 1317 and LS 1318 thereby rendering them inoperable until the actuator bar 1692 on the related carrier 160 has been removed from their vicinity by westward travel of the carrier from the shuttle carriage 120 onto the loading conveyor drive unit 150.

During this lapse of time, TR 2170 establishes a circuit by line 2187, connecting by line 2172, through the solenoid 2111 of RS 2110 to source line 2001. This will reverse the polarity of motor 1233 preparatory to westward movement of the carrier 160 from the shuttle carriage 120. This westward movement, as will later be described in connection with FIG. 66, is attributable to the action of switch devices that are actuated when a pair of carriers, centered on the tracks 1201 and 1202, can be moved onto the tracks 1017 and 1018 so that the related magnetic bars 1675 will actively engage the plates 1500 of the chain belts 1524 and 1525 to move the carrier thereby. Before becoming inactive, TR 2170 functions to complete a circuit from the line 2087 to line 2188 connecting to solenoid 2201 of RS 2200 shown in FIG. 66.

As will shortly be described and when the respective carriers have been moved to the west ends of the tracks 1017 and 1018, they will be bodily carried by these tracks so that the shuttle carriage 120 can be moved northward from the position normally occupied by the bridging carriage 135. Thus, at this time the closure of switch devices LS 1522 (FIG. 66), can be employed to complete the circuit of a line to activate timer relay TR 2191, in series with source lines 2000 and 2001.

Initially, TR 2191 is adapted by line 2192 to complete a circuit via line 2164 through solenoid 2102 of TR 2100 thereby to disengage contact pairs 2103, 2104 and 2105 to open the service lines to gear-motor 1233 while reenergizing the brake 2127 upon closure of contact pair 2107. While active and after halting of motor 1233, TR 2191 establishes a circuit by line 2193 (via line 2183) through the solenoid 2112 of RS 2110 to reengage pairs of contacts 2113, 2114 and 2115 so that when the carriage is again located in the northern transfer area, the polarity of the belt gear-motors 1233 and 1234 will be conditioned to subsequently move the next pair of unloaded carriers 160 eastwardly from conveyor drive unit 151.

With reference now to FIG. 66, the power circuits for the belt gear-motors 1505 and 1506 of the conveyor unit drive 150 are also completed from source lines 2000, 2001 and 2002. Since these motors are operable for the same purpose, to drive the related chain belts 1524 and 1525, it is believed that the description of a typical electrical circuit for one gear-motor, such as the motor 1505, will suffice for both. Thus, the service circuits for belt gear-motor 1505 are made by a relay switch 2200 equipped with opposed solenoids 2201 and 2202, presently disengaged pairs of contacts 2203, 2204, 2205 and 2206 and presently engaged contact pairs 2207. Likewise, the means for reversing the polarity of gear-motor 1505 is herein provided by a relay switch 2210 equipped with opposed solenoids 2211 and 2212, presently engaged pairs of contacts 2213, 2214 and 2215 (which produce westward travel of a carrier) and with presently disengaged pairs of contacts 2216, 2217 and 2218 (which produce eastward travel).

As described in connection with FIG. 5, when a pair of loaded carriers 160 are located on the shuttle carriage 120 and are thereby positioned in the south transfer area, the carriage tracks 1201 and 1202 are correctly aligned with the tracks 1017 and 1018 for transfer of the carriers therebetween. As above mentioned in connection with the diagram of FIG. 65, the actuating circuit line to RS 2200 for completing the power lines to gear-motor 1505 is completed through line 2087 originating in TR 2070 and continued by way of line 2188 from TR 2170 in FIG. 65. Thus, when the belt gear-motors, such as gear-motor 1233 or 1234 are conditioned to operatively drive the related chain belts 1253, 1254, a preparatory circuit is completed to the similar gear-motors associated with the conveyor drive unit 150, this being to ensure that the chain belts 1524, 1525 are driven to accept the carriers before the power sources for the chain belts 1253, 1254 associated with the shuttle carriage 120 are started to move the carriers.

Lines 2087 and 2188 thus complete a circuit through solenoid 2201 of RS 2200 thereby causing engagement of contact pairs 2203, 2204 and 2205 while disengaging contact pair 2207 to open line 2220 through brake 2221 of gear-motor 1505. Contacts 2203 now complete a circuit from source line 2000, line 2224, contacts 2213 of RS 2210 and line 2225 to gear-motor 1505; contact 2204 from source line 2002, line 2226, contacts 2214 and line 2227 to the motor while contact pair 2205 complete a motor circuit from source line 2001 via line 2228, contacts 2215 of RS 2210 and line 2229. This will permit the gear-motor to operatively drive the chain belt 1524 to continue movement of the related carrier in a westward direction. As hereinabove described, sprocket 1508 on the output shaft of gear-motor 1505 drives sprocket 1511 on shaft 1512 by chain belt 1510, while sprocket 1519 also on shaft 1512 operates chain belt 1524 by the looped end trained thereabout.

While similarly engaged, contact pair 2206 of RS 2200 will complete a circuit to the relay switch 2100 (FIG. 65) associated with belt gear-motor 1233 of the shuttle carriage 120. Contact pair 2206 initiates a circuit line 2231 through a timing relay TR 2232 in series with source lines 2000 and 2001 to line 2233, which initially functions to open line 2231 to line 2233 for a time interval of sufficient length for desired transfer of the carriers. TR 2232 then completes the circuit of line 2234 through the solenoid 2101 of RS 2100 (FIG. 65) to produce operation of gear-motor 1233 to move the associated carrier in the westward direction. Since it is desirable to subsequently bring about the completion of circuits through contact pairs 2203, 2204 and 2205 without simultaneously creating an effective circuit for the above purpose through contact pair 2206, lines 2231 are open at TR 2232 until it is re-activated during subsequent operation of the loading conveyor drive unit 150 and shuttle carriage 120 to move the carriers westward.

Upon approaching the desired centered position for a carrier 160 as on the track 1017, the leading end portion 1695 of bar 1692 will engage LS 1551 to complete a circuit from source lines 2000 by line 2236 through the engaged pair of contacts 2237 of relay switch RS 2238, presently engaged pair of contacts 2239 of relay switch 2240, line 2241 through timing relay TR 2242 to line 2243, engaged pair of contacts 2244 or relay switch RS 2245, line 2246 through timing relay TR 2247 to line 2248.

RS 2238 is additionally provided with opposed solenoids 2249 and 2250 and engaged pair of contacts 2251 as well as contact pair 2237. While the utility of solenoid 2249 will shortly be described, the opposed solenoid 2250 is not intended to be energized until the carriers, when loaded with sheets of glass, have been moved eastwardly and the associated bars 1692 have been carried from the vicinity of RS 1550, 1551 and 1552 and consequently will be discussed hereinbelow. Similarly, RS 2240 is equipped with opposed solenoids 2252 and 2253 and presently engaged pair of contacts 2254 as well as contact pair 2240. Likewise, RS 2245 is provided with opposed solenoids 2256 and 2257 and presently engaged pair of contacts 2258 as well as contact pair 2244.

LS 1551 completes the circuit of line 2248 to line 2261 which makes a circuit through the solenoid 2202 of RS 2200 to source line 2001. This will disengage contact pairs 2203, 2204 and 2205 to break the motor circuits while setting brake 2221 upon reclosure of contact pair 2207.

In actual practice, it can be expected that momentum of the carrier 160 will cause it to come to a halt either slightly east or west of the required centered position on the track 1017 of unit 150 when the gear-motor 1505 ceases to operate. More importantly, during this particular phase of carrier movement, when the end portion 1695 of the actuator bar 1692 on the carrier is moved into engagement with LS 1552 at a point beyond or slightly west of the desired centered position of the carrier above the loading unit, this momentum causes the chuck member 1663, in its coupling action with the chuck member 1851 of the eccentric shaft actuator unit 180 (FIG. 61), to thrust the same into the chamber 1848 of the driven member 1834 against the influence of contained spring 1850. Thus, LS 1550 or 1552 are employed, in conjunction with the end portions 1694 and 1695 of an actuator bar 1692, to seek the required position and in so doing jog the motor to momentarily produce the desired direction of motion. Of course, the optimum position is reached when the actuator arms of the switch devices are located substantially midway between the opposed end portions of the bar 1692. At this time, the desired "chucked" relation of members 1663 and 1851 will be realized with the member 1851 in its normally outward disposed relation with reference to the driven member 1834 (see FIG. 57).

LS 1552 is thus adapted to produce eastwardly directed motion and, while in contact with end portion 1695, completes a circuit from source line 2000 via line 2262 through contacts 2251 of RS 2238. By way of line 2263 through contacts 2258 or RS 2245, LS 1552 is then adapted to complete a circuit by line 2264 to TR 2247, in series with source lines 2000 and 2001. At this time, the circuit of line 2236 is closed by line 2243 from TR 2242 and line 2248 from TR 2247 so that line 2261 can be completed by LS 1551, to energize solenoid 2202 of RS 2200 thereby halting gear-motor 1505.

Since the carriers 160 at this time are bodily located on the rails 1017 and 1018, LS 1552 is substantially simultaneously adapted to complete a circuit by line 2265 through the presently engaged contact pair 2266 of spring-biased relay switch RS 2267, equipped with solenoid 2268 and presently disengaged pairs of contacts 2269, 2270 and 2271. Line 2272 through contacts 2266 completes this circuit from line 2265 to timing relay TR 2273, in series with source lines 2000 and 2001.

TR 2273 is initially active to complete a circuit by line 2274 through solenoid 2268 to source line 2001 thereby disengaging contact pair 2266 to open lines 2265 and 2272 while engaging contact pairs 2269, 2270 and 2271. Contacts 2269 complete a circuit from source line 2000 by line 2275 through the solenoid 2153 of RS 2141 (FIG. 65) to thereby reengage the contact pairs 2140 and 2154 thereof. Similarly, the circuit

of line **2276** through contact pair **2270** is completed through solenoid **2004** of RS **2005** (FIG. **64**) to source line **2001**. This operates to reengage the related pairs of contacts **2006**, **2007** and **2008**, while releasing brake **2025** at opened contact pair **2009**, to cause operation of gear-motor **1211** and resulting northward movement of the shuttle carriage **120**. Contacts **2271** make a circuit by line **2277** to TR **2191** (FIG. **65**) which, as previously described functions to halt the belt gear-motor **1233** and to then reverse the polarity thereof. TR **2273** monitors a time interval while the carriage **120** is removed from the south transfer area and then establishes a circuit by line **2278** through the solenoid **2053** of RS **2041** (FIG. **64**) to reengage contact pairs **2040** and **2054** for subsequent use.

Initially, TR **2247** sets up a time interval, during which the motor **1505** is halted, to interrupt the service of lines **2246** and **2248** to render LS **1551** inoperable. It will, of course, be understood that with a carrier bodily supported, as on the rail **1017**, the actuator bar **1692** by its horizontal leg **1693** will maintain LS **1552** closed. The timer then completes a circuit by line **2279** through the solenoid **2256** of RS **2245** to disengage contact pairs **2244**, **2258** thereof. TR **2247** further completes a circuit by line **2280** through solenoid **2211** of RS **2210** to source line **2001** thereby disengaging contact pairs **2213**, **2214** and **2215** and engaging contact pairs **2216**, **2217** and **2218** to to reverse the polarity of gear-motor **1505**. Finally, TR **2247** opens line **2280** and closes line **2281** through the solenoid **2201** of RS **2200** to source line **2001**. This causes engagement of contact pairs **2203**, **2204** and **2205**, since the circuit of line **2231** of contact pair **2206** is open at TR **2232**, while deenergizing brake **2221** at contacts **2207**. The power circuits to motor **1505** will now be made through line **2224**, contact pair **2216** of RS **2210** and line **2282** to line **2227**; line **2226**, contact pair **2217** and line **2283** to line **2225** and line **2228**, contact pair **2218** and line **2284** to line **2229**. This causes motor **1505** to operate chain belt **1524** to move the carrier **160** eastward. By branch line **2285** from line **2281**, a circuit is made through solenoid **2257** of RS **2245**; this acting to reengage contact pair **2244** although lines **2243–2246** are disconnected at TR **2247** as well as to reengage contacts **2258** although lines **2263–2264** are presently broken at LS **1552**.

In the event that the ensuing slight jogging eastward motion of the carrier slightly overruns the centered position and LS **1550** is engaged by end portion **1694**, line **2262** at engaged contact pair **2254** of RS **2240** completes a circuit by line **2286** through LS **1550** and line **2287** to TR **2242**, in circuit with source lines **2000** and **2001**.

Initially, TR **2242** sets up a time interval, during which the gear-motor **1505** is halted, to interrupt the service of lines **2241** and **2243** and again render LS **1551** inoperable. The timer then completes a circuit by line **2288** through the solenoid **2252** of RS **2240** to disengage contact pairs **2239**, **2254** thereof. This timing relay then completes a circuit by line **2289** through the solenoid **2212** of RS **2210** to source line **2001** thereby disengaging pairs of contacts **2216**, **2217** and **2218** and reengaging contact pairs **2213**, **2214** and **2215** to reverse the polarity of motor **1505** for westward movement of the carrier. Finally, TR **2242** opens line **2289** and closes line **2290** connecting by line **2281** through solenoid **2201** of RS **2200** to source line **2001**. This again causes engagement of contact pairs **2203**, **2204**, **2205** of RS **2200** while deenergizing brake **2221** at disengaged contact pair **2207**. The power circuits will thus be made through line **2224**, contacts **2213** and line **2225**; line **2226**, contacts **2214** and line **2227** and line **2228**, contacts **2215** and line **2229** to the gear-motor **1505** to produce westward movement of the carrier. By branch line **2291** from line **2290**, a circuit is made through solenoid **2253** of RS **2240** to source line **2001**; this operating to reengage contact pair **2239** although lines **2241** and **2243** are open at TR **2242** and also reengage contact pair **2254** although lines **2286–2287** are presently open at LS **1550**.

The circuit of line **2287** from LS **1550** is also adapted by line **2292** to complete a circuit through timing relay TR **2293**, the same being in series with source lines **2000** and **2001**. Timer device TR **2293** is adjusted to monitor a time interval of sufficient duration to permit the motor **1505** to halt and thereby the related carrier **160** to come to rest position and to then complete a circuit by line **2294** through the solenoid **2249** of RS **2238** to source **2001**. This acts to disengage contact pairs **2237** and **2251** to thereby open the circuit lines generally to the switch devices LS **1550**, **1551** and **1552** thereby rendering them inoperable until the actuator bar **1692** has been removed from their vicinity by eastward travel of the carrier from the loading unit **150** and onto the bridging carriage **135**.

During this lapse of time, TR **2293** establishes a circuit by line **2295**, connecting by line **2280**, through the solenoid **2211** of RS **2210** to source line **2001**. This will reverse the polarity of motor **1505** preparatory to subsequent eastward movement of the sheet-supporting carrier **160** from the loading conveyor unit **150**. This subsequent eastward movement, as will later be described in connection with FIG. **68**, is attributable to the action of switch devices that are actuated when a pair of glass sheets have been clamped along their top edges by the clamping members **1614** and **1615** (FIG. **40**) and are to be removed from the loading area and the tracks **1017** and **1018**. The instant of this removing action is of course determined by the demands of production and movement of a pair of sheet-supporting carriers **160** from the entry conveyor unit **145** into the processing apparatus.

Thus, when the belt gear-motors **1505** and **1506**, such a the gear-motor **1505**, are halted and the foregoing switch functions have been carried out, TR **2293** is adapted to complete a circuit by line **2296** to produce operation of the loading apparatus, the structure and operation of which will hereinafter be explained in connection with FIGS. **88** to **112**, inclusive. Preparatory, however, to an actual loading operation, a pair of washed and carefully inspected sheets must be received on the turntable unit **27** and thence delivered to the loading unit **28**.

With regard to the belt gear-motor **1363** of the bridging carriage **135** shown in FIG. **67** as well as FIGS. **15** and **16**, it has been stated that the output shaft **1366** thereof is equipped with sprocket **1367** to drive chain belt **1368**. This chain belt, by sprocket **1369** on shaft **1370**, is adapted to drive fixed sprockets **1372** and **1373**. These sprockets, by chain belts **1374**, and **1375**, are adapted to drive shafts **1376** and **1377** through sprockets **1378** and **1379**, respectively, and thereby drive the carrier chain belts **1384** and **1385** by sprockets **1381** and **1382**. From portions of the foregoing description, it is evident that utility of the carriage **135** resides mainly in its use as a "bridging" unit to support a pair of loaded carriers **160** as they are being moved eastwardly from the loading unit **150** until they are bodily located and supported on the tracks **1026** and **1027** of the entry drive unit **145**. This situation is of course the same, although reversed, with regard to the bridging carriage **136** in the north transfer area. In either instance, the single gear-motor is sufficient to operatively move a pair of carriers by a chain belt drive as described above.

With reference now to FIG. **67**, the service circuits for belt gear-motor **1363** are completed through a spring biased relay switch RS **2300** having a solenoid **2301** and presently engaged pairs of contacts **2302**, **2303** and **2304**. The solenoid **2301** is energized by a circuit of line **2305** from LS **1438** (FIGS. **23** and **24**) which is held in closed position by cam plate **1437** with the carriage **135** aligned with the loading and entry drive units **150** and **145**, respectively. The circuits from source lines **2000**, **2001** and **2002** are therefore opened when the carriage **135** is displaced from its aligned position by the shuttle carriage, as has been described, and moved southward to the phantom line position of FIG. **5**.

Normally these service circuits are completed through RS **2300** to a double-action relay switch RS **2307** equipped with opposed solenoids **2308** and **2309**, presently disengaged pairs of contacts **2310**, **2311**, **2312** and **2313** and presently engaged pair of contacts **2314** which by line **2315** complete a circuit through the brake **2316** of gear-motor **1363** to source line **2001**.

As herein provided, RS **2307** is adapted to be activated to engage contact pairs **2310**, **2311** and **2312** upon completion of a circuit originating in the electrical control system (FIG. **68**) of the entry drive unit **145**, which circuit is dependent on the entrance of a pair of carriers **160** into the first chamber of the processing apparatus and the completed loading of a pair of glass sheets on carriers on the drive unit **150** associated with the loader. Assuming that each of these conditions have been met and the gear-motors of the unit **145** are in operation, the completion of line **2318** (FIG. **68**) through solenoid **2308** to source line **2001** will effect engagement of contact pairs **2310**, **2311** and **2313** to extend the service of source lines **2000**, **2001** and **2002** by way of lines **2319**, **2320** and **2321** to gear-motor **1363** to start the same while opening contact pair **2314** to break the circuit of line **2315** to brake **2316**. Engagement of contact pair **2313** establishes a line **2323** through a timing relay **2324**, in series with source lines **2000** and **2001**, to activate the same via line **2325**. While functioning, TR **2324** interrupts the circuit of lines **2323** and **2325** and, after the gear-motor **1363** is operating to drive the chain belts **1384** and **1385**, creates a line circuit **2326** extended to the solenoid **2201** of RS **2200** (FIG. **66**) to thereby cause operation of the belt gear-motors **1505** and **1506** of the drive unit **150**. This will ensure that the chain belts **1384** and **1385** are being driven before motors **1505** and **1506** are started to move the carriers eastwardly by the associated chain belts **1524** and **1525**.

In the above respect, it will be noted that the circuit of line **2326** (FIG. **66**) coincides with line **2188**. This line **2188**, however, is only effective, as previously described, during the delivery of a pair of empty carriers from the shuttle carriage **120** to the loading drive unit **150** and to create the circuitry whereby gear-motors **1505** and **1506** will be started before the gear-motors **1233** and **1234** are operated. In the present instance, of course, the gear-motor **1363** is put into operation and the gear-motors **1505** and **1506** are then activated by the circuit of line **2326** when the loaded carriers are to be removed from the drive unit **150** to the bridging carriage **135**.

As the leading end portion **1694** of the actuator bar **1692** of each carrier is moved onto the bridging carriage, it engages previously described switch devices LS **1441** and LS **1442** associated with rail **1351**. LS **1441**, which is normally closed, is intended to produce halting of gear-motor **1505** (FIG. **66**) when the associated carrier is bodily, though temporarily, supported on the rail **1351** and for this purpose is connected by line **2328** to presently open LS **2329**, actuated simultaneously with LS **1442** at the opposite end of carriage **135**. As herein contemplated, although in no way restrictive to other uses of the switch devices LS **1441** and LS **1442**, while LS **1441** is supported in the open position by the horizontal leg **1693** of actuator bar **1692**, the circuit of line **2328** will also be open at LS **2329** to source line **2000**.

Likewise, a circuit of a line **2331** through presently closed LS **1442** is open as LS **2332** which is opened simultaneously with LS **1441**. In consequence, when the trailing end portion **1695** of the actuator bar **1692** clears LS **1441** and LS **2332**, the same will be permitted to close. In the first instance, when the leading end **1694** of the bar **1692** engages LS **1442** to open the same, it also actuates LS **2329** to the closed position thereby completing a circuit from source line **2000** and line **2328** to LS **1441**. A circuit is now made by line **2335** from LS **1441** to a timer device TR **2336**, in series with source lines **2000** and **2001**, to, in a first instance, establish a circuit by line **2338** through the opposed solenoid **2202** of RS **2200** (FIG. **66**) to halt the gear-motor **1505**. TR **2336** then makes a circuit by line **2339** connecting by line **2289** through the solenoid **2212** of RS **2210** thereby reversing the polarity of said motor to subsequently move a carrier in a westward direction. If desired, TR **2336** can also be made effective through line **2340** to complete a circuit through solenoid **2250** of RS **2238** which will cause re-engagement of contact pairs **2237** and **2251** for subsequent use in the proper order.

LS **2332** when reclosed completes a circuit from source line **2000** by the line **2331** to the presently open LS **1442**. When the carrier **160** is moved from track **1351** and is bodily supported on track **1026** of the entry conveyor drive unit **145**, the trailing end portion **1695** of actuator bar **1692** releases LS **1442** whereupon the circuit of line **2331** will be completed via line **2341** to a timing device TR **2342**, in series with source lines **2000** and **2001**. This timer monitors an interval of time to ensure that the carriers **160** have moved from the tracks **1351** and **1352** and then completes a circuit by line **2343** through solenoid **2309** of RS **2307** which will open the service of lines **2319**, **2320** and **2321** to halt the gear-motor **1363** while restored line **2315** will again energize the brake **2316**.

In considering a control system for use with the entry conveyor drive unit **145**, it will be recalled that the associated belt gear-motors **1467** and **1468** are adapted to operate individually and simultaneously when a pair of loaded carriers **160** are to be received and moved onto the tracks **1026** and **1027**. The control system for each gear-motor is equipped with switch devices located at the respective ends of tracks to produce the required jogging motions and thereby bring the related carrier into the centered position. More importantly, in this area, the carriers must be transversely aligned to enter the processing apparatus in a common transverse plane. The gear-motor **1467** thus drives a shaft **1472** by sprockets **1469** and **1471** by the chain belt **1470** trained thereabout and with shaft **1472** mounting at one or the other end the sprocket **1474** while being coupled to the tie clutch **1475** at its inner end. Sprocket **1474** by chain belt **1476** drives sprocket **1477** on shaft **1464** which also mounts sprocket **1460** about which chain belt **1458** is entrained.

Gear-motor **1468** drives sprocket **1478** through the electromagnetic clutch **1479**. Sprocket **1478** through chain belt **1480** drives shaft **1482** by sprocket **1481**. Now, while the shaft **1482** carries fixed sprocket **1484** at its outer end, its inner end is also associated with the clutch unit **1475**. When clutch **1479** is energized, sprocket **1484** through chain belt **1486** drives shaft **1465** on which sprockets **1485** and **1461** are mounted, with sprocket **1461** being adapted to drive chain belt **1459**. When clutch **1479** is de-energized, as will shortly be explained, tie clutch **1475** is energized so that by the power directed to shaft **1472** the shaft **1482** will be driven. Consequently, the chain belts **1458** and **1459** will be operated from one source of power, i.e., the gear-motor **1467**, and the carriers will be moved eastwardly from a common source.

With further reference to FIG. **68**, the power circuits for the belt gear-motors **1467** and **1468** of the conveyor drive unit **145** are completed from source lines **2000**, **2001** and **2002** through associated switch devices about to be described. Since in one phase of operation, these motors are operable for the same purpose to drive the related chain belts **1458** and **1459**, it is believed that the description of a typical electrical circuit for one gear-motor, such as the motor **1467**, will suffice for both. Thus, the service circuits for belt gear-motor **1467** are made by a relay switch **2370** equipped with opposed solenoids **2371** and **2372**, presently disengaged pairs of contacts **2373**, **2374**, **2375** and **2376** and presently engaged contact pairs **2377**. Likewise, the means for reversing the polarity of gear-motor **1467** is herein provided by a relay switch **2380** equipped with opposed solenoids **2381** and **2382**, presently engaged pairs of contacts **2383**, **2384** and **2385** (which produce eastward travel of a carrier) and with presently disengaged pairs of contacts **2386**, **2387** and **2388** (which produce westward travel).

When a pair of loaded carriers **160** are located on the tracks **1026** and **1027** of the entry conveyor drive unit **145** and are to be advanced into the first chamber of the processing apparatus, the power lines, such as to the gear-motor **1467**, are completed through a circuit originating in the first processing area or chamber to ensure that the chain belts in said area are in motion before the power sources for chain belts **1458** and **1459** are started to advance the carriers.

As herein contemplated and before the belt gear-motor in the said first chamber is started, a switch device **2389** is permitted to close when a preceding pair of carriers have been advanced into a second chamber of the apparatus. LS **2389** completes a circuit by line **2390** to a timing device TR **2391**, in series with source lines **2000** and **2001**. This timer completes a circuit by line **2392** through the tie or coupler clutch **1475** to source line **2001** and then acts to open the circuit of line **2393** through the electromagnetic clutch **1479**. As noted above, the chain belt **1470** is thus made effective to drive shafts **1472** and **1482** in common.

In the above connection, it should be noted that an electric service circuit cannot be made to LS **2389** unless the pressure within the first chamber closely approximates that of the outside ambient atmospheric. This is a necessary factor of operation since the pressure to which the first chamber is evacuated must be relieved and the pressure raised before the entry valve compartment can be opened to admit the carriers. This will be more fully described in connection with the control system schematically shown in FIG. **137**.

As presently described and with the above-noted conditions having been satisfied, LS **2389** completes the circuit of line **2390**. Thus, TR **2391** monitors a first interval of time sufficient for a pair of loaded carriers **160** to be removed bodily from the tracks **1026** and **1027** and, after effecting the above circuits, makes a circuit by line **2394** to a timing device TR **2395**, in series with source lines **2000** and **2001**. After a second monitored interval of time, TR **2391** completes a circuit by line **2396** through the solenoid **2397** of relay switch RS **2398** to source line **2001**. RS **2398** is equipped with contact pairs **2399** and **2400** which are moved to closed position. When the action of timing device TR **2391** terminates, the circuit of line **2392** to clutch **1475** is opened and the circuit of line **2393** to clutch **1479** is reclosed.

While functioning, TR **2395** first completes a circuit by line **2401** through the solenoid **2371** of RS **2370** to source lines **2001** thereby producing engagement of contact pairs **2373**, **2374** and **2375** while disengaging contact pair **2377** to open line **2402** through brake **2403** of gear-motor **1467**. Contacts **2373** now complete a circuit from source line **2000**, line **2405**, contacts **2383** of RS **2380** and line **2406** to gear-motor **1467**; contacts **2374** from source line **2001**, line **2407**, contacts **2384** and line **2408** to the motor while contact pair **2375** completes a motor circuit from source line **2002** via line **2409**, contacts **2385** of RS **2380** and line **2410**. This will cause the gear-motor **1467** to drive the associated chain belt **1458** to thereby receive and continue movement of a related carrier **160** in an eastward direction.

Engaged contact pair **2376** of RS **2370** complete the circuit of line **2318** to solenoid **2308** by a relay switch **2307** associated with the gear-motor **1363** of the transfer conveyor carriage **135**. As earlier pointed out, the circuit of line **2318** is preferably completed upon actuation of LS **1886** of the eccentric shaft actuator device **180** to ensure that the pair of glass sheet have been properly clamped to the respective carriers before the motor **1363** of the bridging carriage **135** can operate. Thus motor **1363** is started in response to the initiation of a transfer cycle whereby a pair of loaded carriers are transferred from the loading conveyor drive unit **150** via the carriage **135** to the entry conveyor drive unit **145**. This starting circuit is established by line **2412** from contact pair **2376** through timing relay TR **2395** to line **2318** during a second phase of its functioning. Since it will be desirable to subsequently bring about the completion of circuits through contact pairs **2373**, **2374** and **2375** without simultaneously recreating a circuit through contact pair **2376**, TR **2395** will maintain lines **2412–2318** open until it is activated during subsequent operation of the entry conveyor drive unit **145**.

As the carrier **160** is bodily transferred from the track **1026** onto the aligned rail in the first chamber of the processing apparatus, a switch device LS **2414** is closed to make a circuit by line **2415** through one side of timing relay TR **2416**, in series with source lines **2000** and **2001**, to activate the same by way of line **2417**. TR **2416** initially opens the circuit of line **2415** to render LS **2414** and line **2417** inoperable and then completes a circuit by line **2418** through solenoid **2372** of RS **2370** to disengage particularly pairs of contacts **2373**, **2374** and **2375** to stop motor **1467** while setting brake **2403** upon re-engagement of contact pair **2377**. Substantially simultaneously, TR **2391** times out whereupon the circuit of line **2392** to coupler clutch **1475** will be opened while the resumption of line circuit **2393** will reenergize clutch **1479**. Thus, when loaded carriers are to be subsequently delivered form the tracks **1351** and **1352** to the aligned tracks **1026** and **1027** of the conveyor drive unit **145**, the gear-motor **1467** by chain belt **1470** will drive chain belt **1458** while gear-motor **1468** by chain belt **1480** will similarly drive chain belt **1459**.

The empty situation of the conveyor drive unit **145** makes it possible for the shuttle carriage **120** to proceed from or through the midway location in which it is depicted in FIG. **5**. Accordingly, LS **2021** and LS **2026** (FIG. **64**) will be released so that LS **2021** will open the circuit of line **2022** to LS **1312** which otherwise is effective in halting operation of the traction gear-motor **1211**. LS **2026**, on the other hand, will reclose the circuit of line **2027** to solenoid **2004** of RS **2003** (FIG. **64**). For this reason, these switch devices are also shown in FIG. **68**.

When line **2401** from TR **2395** is completed through the solenoid **2371** of RS **2370** to cause operation of gear-motor **1467**, as described above, engaged pair of contacts **2376** will complete a circuit of line **2412** through TR **2397** to line **2318**. This line (FIG. **67**) is effective to produce actuation of RS **2307** and operation of gear-motor **1363** while also causing TR **2324** by line **2326** to establish the circuit which at solenoid **2201** of RS **2200** (FIG. **66**) is instrumental in starting the belt gear-motor, such as gear-motor **1505**, of the conveyor drive unit associated with the loader. In this way, it will be understood that the related gear-motors of the conveyor drive unit **150**, the bridging carriage **135** and the entry conveyor drive unit **145** are simultaneously operating.

Upon approaching a substantially centered position for the carrier **160** on the track **1026**, the leading end portion **1694** of the bar **1692** will engage LS **1492** to complete a circuit from source line **2000** by line **2423** through the engaged pair of contacts **2399** of relay switch RS **2398**, line **2426**, presently engaged pair of contacts **2427** of relay switch RS **2428**, line **2429** through timing relay TR **2430**, line **2431**, engaged pair of contacts **2432** of relay switch **2433**, line **2434** through timing relay TR **2435** and line **2436**.

RS **2398** is provided with opposed solenoids **2397** and **2438** and engaged pair of contacts **2400** as well as contact pair **2399**. Similarly, RS **2428** is equipped with opposed solenoids **2442** and **2443** and presently engaged pair of contacts **2444** as well as contact pair **2427**. Likewise, RS **2433** is provided with opposed solenoids **2447** and **2448** and presently engaged pair of contacts **2449** as well as contact pair **2432**.

LS **1492** is thus adapted to complete the circuit of line **2436** to line **2451** which makes a circuit via line **2418** through the solenoid **2372** of RS **2370** to source line **2001**. This will disengage contact pairs **2373**, **2374** and **2375** to break the circuits of gear-motor **1467** while setting brake **2403** thereof upon reclosure of contact pair **2377**.

Usually, residual momentum of the carrier **160** will cause it to come to a halt either slightly east or west of the required centered position on the track **1026** of unit **145** when the gear-motor **1467** ceases to operate. More importantly, during this particular phase of carrier movement, the end portion **1694** of the actuator bar **1692** on the carrier is moved into engagement with LS **1493** at a point beyond or slightly east of the desired centered position of the carrier on the entry conveyor drive unit. Thus, LS **1490** or LS **1493** is employed, in conjunction with the end portions **1694** and **1695** of actuator bar **1692**, to "seek" the required position for the carrier and in so doing "jog" the affected motor to momentarily produce the desired direction of motion. Of course, the optimum position is reached when the carriers are located substantially midway

between the actuator arms of the switch devices LS **1490** or LS **1493**. At this time, the actuator bars **1692** by their horizontal leg portions **1693** will maintain the respective LS **1492** in closed condition.

LS **1493** is thus adapted to produce westward directed motion of the related carrier and while in contact with end portion **1694** complete a circuit from source line **2000** via line **2452** through contacts **2400** of RS **2398**. By way of line **2453** through contacts **2444** of RS **2428**, LS **1493** is then adapted to complete a circuit by line **2454** to TR **2430**, in circuit with source lines **2000** and **2001**. At this time, the circuit of line **2426** is closed to line **2431** from TR **2430** and line **2436** from TR **2435** and line **2451** can be completed by LS **1492**, to energize solenoid **2372** of RS **2370** thereby halting gear-motor **1467**. TR **2430** initially functions to open the lines **2429**, **2431** to line **2436** and LS **1492**. The timer then completes a circuit by line **2455** through the solenoid **2442** of RS **2428** to disengage contact pairs **2427**, **2444** thereof. The timer then completes a circuit by line **2456** through solenoid **2381** of RS **2380** to source line **2001** thereby disengaging contact pairs **2382**, **2384** and **2385** and engaging contact pairs **2386**, **2387** and **2388** to reverse the polarity of gear-motor **1467**. Finally, TR **2430** opens line **2456** and closes line **2457** through the solenoid **2371** of RS **2370** to source line **2001**. This causes engagement of particularly contact pairs **2373**, **2374** and **2375**, since the circuit of line **2412** of contact pair **2376** is open at TR **2397**, while de-energizing brake **2403** at contacts **2377**. The power circuits to motor **1467** will now be made through line **2405**, contact pair **2386** of RS **2380** and line **2458** to line **2408**; line **2407**, contact pair **2387** and line **2459** to line **2406** and line **2409**, contact pair **2388**, and line **2460** to line **2410**. This causes motor **1467** to operate associated chain belt **1458** to move the carrier **160** westward. By branch line **2461** from line **2457**, a circuit is made through solenoid **2443** of RS **2428**; this acting to re-engage contact pair **2427** although lines **2429-2431** are disconnected at TR **2430** as well as to re-engage contacts **2444** although lines **2452-2453** are presently broken at LS **1493**. When TR **2430** becomes inactive, line **2431** is completed through RS **2433** and TR **2435** to line **2436** and thereby LS **1492**.

If the ensuing jogging westward motion of the carrier slightly overruns the centered position and LS **1490** is engaged by end portion **1695**, line **2452** at engaged contact pair **2449** of RS **2433** completes a circuit by line **2462** through LS **1490** and line **2463** to TR **2435**, in circuit with source lines **2000** and **2001**. Presently, the circuit of line **2426** is closed by line **2431** from TR **2430** and line **2436** from TR **2435** so that line **2451** can be completed by LS **1492**, to energize solenoid **2372** of RS **2370** thereby halting gear-motor **1467**.

Initially, TR **2435** sets up a time interval, during which the gear-motor **1467** is halted, to interrupt the service of lines **2434** and **2436** and again render LS **1492** inoperable. The timer then completes a circuit by line **2464** through the solenoid **2447** of RS **2433** to disengage contact pairs **2434**, **2449** thereof. This timing relay then completes a circuit by line **2465** through the solenoid **2382** of RS **2380** to source line **2001** thereby disengaging pairs of contacts **2386**, **2387** and **2388** and re-engaging contact pairs **2383**, **2384** and **2385** to reverse the polarity of motor **1467**. Finally, TR **2435** opens line **2465** and closes line **2466** connecting by line **2457** through solenoid **2371** of RS **2370** to source line **2001**. This again causes engagement of contact pairs **2373**, **2374** and **2375** while de-energizing brake **2403** at disengaged contact pair **2377**. The power circuits will thus again be made through line **2405**, contacts **2383** and line **2406**; line **2407**, contacts **2384** and line **2408** and line **2409**, contacts **2385** and line **2410** to the gear-motor **1467** to produce eastward movement of the carrier. By branch line **2468** from line **2466**, a circuit is made through solenoid **2448** of RS **2433** to source line **2001**; this operating to re-engage contact pair **2432** although lines **2434–2436** are open at TR **2435** and also re-engaging contact pair **2449** although lines **2462–2463** are presently open at LS **1490**. When TR **2435** ceases to function, line **2436** will be completed to LS **1492** to halt the gear-motor **1467** by line **2451**.

The circuit of line **2463** from LS **1490** is also adapted, by line **2470**, to complete a circuit through timing relay TR **2471**, the same being in series with source lines **2000** and **2001**. Timer device TR **2471** is adjusted to monitor a time interval of sufficient duration to permit the motor **1467** to halt and thereby the related carrier **160** to come to a rest position and to then complete a circuit by line **2472** through the solenoid **2438** of RS **2398** to source **2001**. This acts to disengage contact pairs **2399** and **2400** to thereby open the circuit lines generally to the switch devices LS **1490**, **1492** and **1493**, thereby rendering them inoperable until the control surfaces of the actuator bar **1692** have been removed from the area of the switch devices by eastward travel of the carrier from the conveyor drive unit **145** and into the processing apparatus. As previously described, when the carriers are to be advanced, the action of TR **2391** is effective to complete a circuit through the clutch **1475**, to open the circuit through the clutch **1479** and then complete a circuit through the solenoid **2371** of RS **2370** to start operation of gear-motor **1467**. After an interval of sufficient time for the carriers to be removed from the tracks **1026** and **1027**, TR **2391** completes the circuit of line **2396** through solenoid **2397** of RS **2398** to restore the circuit lines to LS **1490**, **1492** and **1493**.

The pair of sheet-supporting carriers **160** have now been removed from the loading conveyor drive unit **150** and received on the entry conveyor drive unit **145** and in consequence the functions of the sheet loading unit **28** can be reversed preparatory to subsequent reception of a pair of sheets from the turntable unit. To this end, TR **2471** also establishes a circuit by line **2473** that will later be described in connection with the control system of the loading unit as illustrated in FIGS. **111** and **112**. Generally speaking, line **2473** initiates a series of operations that are reversals of the operations of the loading unit to locate a pair of glass sheets adjacent a pair of carriers and to then bring about the clamping actions for supporting the sheets on the carriers.

It is realized that the preceding portions of this specification have been directed to the structural embodiments and operations of the component units at the loading and unloading (west) end of the conveyor system M and to thus describe the sequential phases of movement necessary to automatically deliver a pair of empty carriers **160** into the loading area **10**. This area in FIG. **1** has been generally described as including a washing station **22**, inspection area **24**, a turntable unit **27** and a loading unit **28**. These units **27** and **28** are more clearly illustrated in FIG. **7** wherein the turntable unit **27** is arranged on the "west" side of the loading unit or apparatus **28** which is situated in vertically centered relation beneath the conveyor drive unit **150** on which at least the track **1017** is shown as supporting an empty carrier **160**. It is therefore believed apparent that the structure, operation and the inter-related functioning of the turntable unit **27** and the loading unit **28** will be more readily understood with the structure and automated handling of the sheet-supporting carriers **160** having been described.

## THE TURNTABLE UNIT

As hereinbefore briefly mentioned and as illustrated in FIGS. **1** and **2**, after glass sheets, in succession, have been passed through the washing apparatus **22**, they are received at the inspection station **24**. At this point, further movement of each sheet is dependent upon the progress of preceding sheets through the vacuum chambers and other units of the system. In other words, each sheet is permitted to proceed from the station **24** in response to the functioning of automatically actuated controls that become active during the sequentially occurring phases of the overall operation and create a "demand" for a further supply of glass sheets by instituting a rearwardly occurring train of signals. Each individual control signal is intended to cause step-wise advance of a pair of sheets which are then automatically replaced by a following pair of sheets.

This "permission" system of advancing according to the demands of the operation, proceeds rearwardly to the inspection station **24** and consequently one sheet is advanced onto one side of the so-called turntable apparatus or unit **27** which can then be rotated to receive another sheet on its second side. These sheets, or pairs of sheets, are then permitted to advance onto the sides of the loading apparatus or unit **28**. This sequence of action is graphically depicted in FIG. **4** wherein at view *a* the sheet S is positioned on one side of reference line *r* or the longitudinal path of sheet movement. At view *b*, the position of sheet S has been rotated through an arc of **180°** to the opposite side of line *r*. As indicated at view *c*, a following sheet S' is moved to a position transversely parallel with sheet S. This pair of sheets P are then advanced to the loading unit **28** as in view *d* where they are adapted to be engaged by the carriers which then support the sheets during their movement through the system. As previously set forth in connection with FIG. **3**, this path of movement includes the first longitudinal and forward section, the transverse section and the second longitudinal and rearward or return section. Thus, upon completion of their movement along the second longitudinal section the sheets are delivered to the unloading unit **29**, which as viewed in FIG. **1**, is located in transversely spaced relation to the loading unit **28**. Adjoining the unloading unit **29** is the turntable unit **30** on the sides of which the pair of sheets are received and in sequence are trans-ferred to the run-out conveyor **31**. Consequently, while the following description will be directed to the structural and operational features of the first turntable unit to be employed, it will be understood that the description is equally applicable to the second turntable unit, as will be more fully described.

With reference now to FIGS. **69** to **83** inclusive, there is shown the structural embodiments of the turntable unit **27** and the controlling or controlled instrumentalities which produce the sequences of its operation. Thus, this unit generally includes the base framework, designated generally by the numeral **2500** and the carriage **2501** that is rotatably supported thereon.

Generally stated, the base framework is formed by longitudinally disposed beams **2502** and **2503** and transverse pairs of channels **2504** and **2505**, arranged at the opposite ends of the beams, and similar channels **2506** arranged in parallel relation in the medial area of the beams. A footing plate **2507** is located beneath each of the pairs of channels and serves to support the framework on the floor F of the working area. A base plate **2508** (FIG. **73**), located between the channels **2506**, is centrally formed with a socket **2509** in which is supported the lower end of a tubular pedestal **2512** that is additionally more or less rigidly connected to a plate **2513** carried on the upper surfaces of the channels. The socket **2509** is located so that the axis of the pedestal **2512** is initially placed at substantially the intersection of vertical planes through the longitudinal and transverse axes of the base framework. The mounting plate **2513** for the pedestal includes a sleeve **2514** integrally secured at its lower edge to the plate and to the pedestal **2512** at its upper edge by an interposed ring **2515**. A stationary ring gear **2516** is also fixedly mounted on the plate **2513** for purposes to be hereinafter more fully described.

At the upper end of the pedestal **2512** (FIG. **72**), a cap **2518** is secured, said cap being provided in its medial area with a positioning base or plug **2519** for the mounting of one or the inner race **2520** of a taper-roller bearing member **2521**, such bearing conventionally including the outer race **2522** of the bearing member **2521**. This bearing is considered the major rotary support element for the turntable carriage **2501**.

As seen in FIGS. **70**, **71** and **77**, the structure of this turntable carriage **2501** closely approximates the "A-frame" formation of conventionally employed storage bucks on the sides of which sheets of material, such as glass, are placed at a slight angle inwardly inclined to a vertical plane. Herein the turntable carriage is formed by a lower rectangular base frame indicated generally at **2525**, an upwardly disposed intermediate frame indicated generally at **2526**, a top beam **2527** and a plurality of channels **2528** supported thereon.

The base frame **2525** includes longitudinally extending side channels **2530** and **2531** and transversely disposed channels arranged therebetween at the end and central areas of the frame, such transverse channels being designated in pairs by the numerals **2532**, **2533** and **2534**. The intermediate frame **2526** is similarly formed by side channels **2535**, transversely disposed end channels **2536** and a pair of channel members **2537** in the medial area of the frame. With reference to FIG. **77**, it will be noted that the base frame **2525** structurally supports the intermediate frame **2526** by suitably spaced substantially triangular support members **2538** and braces **2539**.

As viewed in FIGS. **70** and **71**, the channels **2528** will be seen as being arranged in substantially equally spaced, perpendicular relation with the lower ends adjacent the base frame **2525** and the upper ends convergently located with reference to the top beam **2527**. The inwardly disposed surfaces of the channels **2528** and the outwardly disposed surfaces of the pairs of side channels **2530**, **2531** and **2535** are equipped with matching components of locator pads or blocks **2540** which are joined by bolts **2541** to mount the channels. The upper end of each channel **2528** is fixedly connected to the beam **2527** by individual integral plates **2542**. In this structural arrangement, the channels **2528** are located in similar, inwardly inclined planes at a so-called "back" angle of substantially 7° to the vertical longitudinal plane of the turntable unit.

As viewed in FIG. **72**, the lower surfaces of the side channels **2535** of the frame **2526** are provided with a plate **2545** and recessed block **2546** in which the outer race **2522** of the bearing **2521** is located. While the weight of the carriage **2501** is more or less fully supported on this bearing to thereby permit entirely free rotation thereabout, it is equally imperative that the turntable be maintained with exactitude to rotate about a true vertical axis. This is necessary to support a glass sheet on one or both sides of the table in equilibrium.

For this purpose as shown in FIG. **73**, the sleeve **2514** is formed at its upper peripheral edge with an accurately finished circular bearing surface **2547** (FIG. **75**). A plurality of roller-bearing wheels **2548** are supported by associated shafts **2549** (FIG. **76**) in blocks **2550** affixed to bars **2551**. These bars are structurally suspended by plates **2552** on the lower surfaces of channels **2534** transversely located between the side elements **2530** and **2531** of the base frame **2525** of the carriage. By means of pairs of adjusting screws **2553** in mounting blocks **2554** secured on the plates **2552**, the blocks **2550** for the several bearing wheels **2548** can be shifted until the axis of equilibrium of the base frame **2525** is coincident with the vertical axial line through the axis of the upwardly disposed bearing **2521**.

Upon reference to FIGS. **70** and **73**, it will be noted that a power source indicated generally at **2556**, including motor **2557** and a gear reduction unit **2558**, is mounted on the base frame **2525**. The output shaft **2559** of the unit **2558** is equipped with a drive pinion gear **2560** adapted to mesh with the stationary ring gear **2516** on the plate **2513** of the base framework. As herein disclosed, the pinion functions in the well known manner to "walk" the carriage in its circular path of movement.

By way of brief explanation, when both sides of the turntable are empty, operation of the motor **2557** is initiated after a first sheet has been received on one side of the turntable to rotate the same for reception of a second sheet on the opposite side. And, while starting of the motor **2557** is controlled by switch devices to be hereinafter described, certain related switch devices are actuated during each half cycle of rotation of the turntable carriage **2501** with reference to the base framework **2500**. These switches, as will be seen in FIGS. **71**, **78**, **79** and **80**, are mounted on the turntable carriage **2501** and are actuated by control elements located on the framework **2500**.

Thus, a switch device, LS **2564**, in FIG. **79**, is secured on a vertically disposed bracket **2565** that is supported on the base frame **2525** adjacent the side channel **2531** thereof. The lever arm **2566** of this switch device is adapted to be engaged by a

surface **2567** of an arcuately formed cam plate **2568** mounted on the pedestal **2512**. A switch device, LS **2570**, having an actuator arm **2571**, is similarly mounted on a bracket **2572** supported on the frame **2525** adjacent the side channel **2530** and in substantially diametric relation to the switch device **2564**. While the carriage remains stationary during the loading of a sheet on one side, the switch device LS **2564**, by way of example, will be engaged with the arm **2566** contacting the cam surface **2567** and, after a half cycle of rotation, the table will be turned to release switch device LS **2564** and eventually carry the arm **2571** of switch LS **2570** into contact with the cam surface **2567**. For reasons that will shortly become more apparent, the alternate actuations of the switch devices LS **2564** and LS **2570** serve to automatically control certain functions of the turntable.

Likewise, a switch device LS **2575**, mounted above LS **2564** on the bracket **2565**, has an actuator arm **2576** adapted to engage the surface **2577** of a cam plate **2578** arranged above the cam plate **2568** on the pedestal **2512**. Switch device LS **2575** effects the opening of electrical circuits to the motor **2557** when one half cycle of rotation has been completed. The surface **2579** of a diametrically located cam plate **2580** functions for the same purpose upon completion of a second or alternate half cycle. Of course, when the turntable carriage has been turned through a full cycle the actuator arm **2576** will again be engaged by the cam surface **2577**.

A switch device LS **2582**, mounted on the bracket **2572** above switch device **2570**, is equipped with a lever arm **2583** that is adapted to alternately engage the surfaces **2584** of diametrically located cam plates **2585** and **2586** on the pedestal **2512**. This switch device is influential in causing the motor **2557** to start rotation of the carriage slowly, to accelerate such rotation and then decelerate the turning motion as each half circle is completed. To this end, the surface **2584** of each cam **2585** or **2586** includes a rising or upwardly inclined entry surface sector **2587**, a central plateau **2588** and a descending or downwardly inclined exit surface sector **2589**, the length of the central plateau surface **2588** being substantially equal to an arc of 40° whereby the arm **2583** will be retained on said surface during the initial 20° turning motion and becoming re-engaged during the final 20° movement. In each instance, the associated switch device will be actuated to control operation of the power source **2556** thereby ensuring relatively smooth starting and stopping action of the table.

The cam plates **2568**, **2578**, **2580**, **2585** and **2586** are similarly constructed with a vertical wall **2590** wherein slots **2591** are provided to permit adjusted shifting of the respective cam plate to properly locate the cam surface thereof prior to securing the plates by screws **2592**.

To position the carriage **2501** with its longitudinal axis in exact alignment with the general longitudinal axis or plane through an inspection fixture or the like in the area **24** adjacent the entry end of the turntable unit as well as through the longitudinal axis of the loading unit **28** adjacent the exit end of the turntable, the table at each of its ends carries a locator device generally designated by the numerals **2594** and **2595** in FIG. **69** and illustrated in FIGS. **82–85** inclusive. Each of these devices is adapted to receive a vertically reciprocal lock plunger **2596**. Briefly stated, each locator device **2594** and **2595** includes a tubular casing **2597** having a horizontally disposed mounting flange **2598** that is suitably secured, as by bolts, to channels **2532** and **2533**, respectively, transversely disposed between the side channels **2530** and **2531** at or adjacent to the ends of the carriage base frame **2525**.

The bore **2599** of the casing **2597**, as in FIGS. **84** and **85**, slidably receives a cup-type piston **2600** having a lower end portion **2601** of reduced outer diameter. The shoulder **2602** formed by this reduced end portion is adapted to retain the piston **2600** in bore **2599** by normally resting on the upper end of a tubular retaining and bearing sleeve **2603** secured to the open lower end of the casing **2597** by a screw **2604**. The piston is urged downwardly by a contained coil spring **2605** received at its lower end in the cup portion **2606** of the piston, with the upper end of the spring being held by a threaded plug **2607**. Otherwise the piston is urged upwardly by the lock plunger **2596**, as will shortly be described.

The casing **2597** in the wall thereof is additionally formed with a vertically disposed slot **2610** in which an actuator bar **2611** is adapted to move, said bar being carried by the piston **2600** by means of screw **2612**. For reasons to be more fully described in connection with the diagrammatic disclosures of FIGS. **86** and **87**, the bar **2611** is instrumental in engaging switch arm **2613** to activate a switch device, LS **2614**, at the lower limit of piston movement and, as in FIG. **85**, to similarly engage the switch arm **2615** of a switch device, LS **2616**, to actuate the same at the upper limit of movement (as shown).

The aforementioned lock plunger **2596** includes the armature element **2620** of a solenoid unit **2621** that is mounted by bracket **2622** in the longitudinal axis of the base framework **2500** (see reference line *r* in FIG. **81**) and more particularly on and/or between the channels **2504** thereof. The outer end of the armature **2620** is equipped with a tapered plug **2623** adapted to slidably interfit with inner wall of the bearing sleeve **2603** when the plunger is in the "up" or locking position in FIG. **85**. Also when so located, the tapered end of the plug **2623** engages the adjacent end of the piston **2600** to raise the same against the influence of spring **2605** and thereby lifting the bar **2611** from engagement with switch arm **2613** and then actuating the switch device **2616** upon engagement and upward movement with the arm **2615** thereof.

The lock plunger **2596** during rotation of the carriage **2501** is of course in a lowered position and it is not intended to be raised into the locking position until the vertical longitudinal planes of the carriage and the base framework **2500** are brought into substantially exact alignment. To automatically achieve this aim, there are provided two "jogging" or "inching" switch devices, LS **2627** and LS **2628**, carried by identical brackets **2629** on the base frame **2501** as in FIGS. **69**, **82** and **83**. The plunger-type actuator arms **2630** and **2631**, respectively, of these switch devices are adapted to rise and fall to actuate the related switches and as influenced by cam plates **2632** and **2633**, the same being mounted for adjustment in identical brackets **2634** on the channels **2504** of the base framework **2500**. The upper surfaces of the cam plates are each formed with an upwardly inclined "entry" surface **2635** and **2636**, respectively, interim flat plateau area **2637** and **2638** and a downwardly inclined "exit" surface **2639** and **2640**. Thus, when the turntable carriage is rotated in the normal, clockwise direction, as indicated by the arrow designated by the numeral **2641** in FIG. **81**, and approaches completion of a half cycle rotation, the arm **2630** of switch device LS **2627** will traverse the surfaces of cam **2632** and will drop from exit surface **2639** as the axis of the carriage reaches "dead-center" and, coinciding with axial reference line *r*, is halted. If, however, momentum of the carriage should inadvertently carry the same past this point, the arm **2631** will be engaged on the entry surface **2636** of cam plate **2633** to actuate switch device LS **2628** thereby causing temporary reversal of operation of the power source **2556** to move the carriage in a counterclockwise direction, as will shortly be more fully described.

The previously noted channels **2528** of the carriage are adapted to provide supporting surfaces on each side of the turntable for the reception of a glass sheet. As shown in FIG. **71**, each channel **2528** is equipped with brackets **2645** which, as more clearly shown in FIG. **72**, support roller casters **2646** having suitably non-abrasive, glass contacting surfaces. Additional lower rows of these casters can be provided and mounted on brackets **2647** carried by the side channels **2530** and **2531** of the base frame member **2500**.

A glass sheet, when delivered from the conveyor system in the inspection area, is received on the several support units **2650** of roller conveyor systems **2651** and **2652** by which the sheet is moved forwardly until it is substantially "centered" on one or the other of the sides of the turntable. Each unit **2650** includes a bearing casing **2653** for a support shaft **2654** which

at one or its outer end mounts a glass supporting roller **2655** and at its inner end carries at least one sprocket **2656**.

To simplify discussion of turntable carriage operation, the roller conveyor system **2651** will be described as being associated with Side **1** and is driven by a reversibly operable power source **2657** including a gear-motor **2658**. Conveyor system **2652** on the other hand, associated with Side **2**, is driven by a power source **2660** having a gear-motor **2661**. In this connection, the shafts **2654** of the several units **2650**, as in FIG. **74**, are provided with one or more sprockets **2656** about which a plurality of chain belts **2665** are entrained. Also, as herein shown the endmost shaft **2666** of each conveyor system is coupled as at **2667** to the output shaft of the respective source of power. If desired, suitably mounted tensioning idler sprockets **2668** can be provided for each of the chain belts **2665**.

While it may be generally stated that either or both of the power sources **2657** or **2660** are controlled in accordance with production demand for pairs of glass sheets as hereinabove set forth, means in the form of switch devices, LS **2670** and LS **2671** for halting the respective power sources are located at the "far" end of the sides of the turntable where they are thus situated in diametrically opposite corners, switch device, LS **2670** being mounted by bracket **2672** on an endmost channel **2528** and the switch device LS **2671** being similarly mounted on a bracket **2672**. Consequently, when a sheet is moved onto the Side **1**, its leading end will actuate the arm of LS **2670** thereby halting the power source **2657**. The electric service to power source **2657** is controlled by the previously noted switch device LS **2616** while the same is engaged by bar **2611** of a locking device **2594** while the service to LS **2670** is governed by the closure of LS **2564** by cam plate **2568**. In this respect, the bar **2611**, while lowered and engaged with arm **2613** of LS **2614**, also places the electrical service to motor **2557** in operable condition.

The circuitry, controlled in one way or another by the switch device LS **2670**, lowers the plunger **2596** to release the locking device, either **2594** or **2595**, thereby opening switch device **2616** and then causes the operation of power source **2556** upon closure of switch device **2614** to rotate the turntable through an arcuate path of substantially 180° to locate Side **2** in the position formerly occupied by Side **1** to receive a sheet thereon. Now, when switch device LS **2570** is engaged by cam plate **2568** to supply electrical service to switch device LS **2671**, the locking device **2595** will be then positioned above the plunger **2596** to be engaged thereby. This will reopen LS **2614** while then closing LS **2616**. During this sequence of events, the circuitry controlled now by LS **2570** produces reversal of the source lines to the power source **2657** for the reason that when the sheet on the conveyor system **2651** is to be removed to the loader unit, it must be carried in the direction opposite to the direction in which it was received on to the rollers **2655** of said system.

The complete operation of the turntable unit **27** will now be made in connection with the electrical circuits of FIG. **86** and FIG. **87** to which reference is now directed. Thus, it will be recalled that LS **2564** (FIGS. **78**, **79** and **86**) is closed by the surface **2567** of cam plate **2568** while oppositely disposed LS **2570** (FIGS. **78**, **80**, and **86**) is presently disengaged. Also, LS **2575** (FIGS. **79** and **87**) is presently held closed by surface **2577** of cam plate **2578**. In sequence, LS **2575** will be again closed upon engagement with the surface **2579** of cam plate **2580** (FIGS. **80** and **87**). LS **2575** functions to cause halting of the motor **2557**. LS **2582** (FIGS. **80** and **87**) is engaged at the midpoint of cam plate **2585** and will in sequence be similarly engaged at the midpoint of diametrically located cam plate **2586** (FIGS. **79** and **87**). LS **2585** serves to reduce the speed of motor **2557** during the first and last 20° of each half cycle rotation of the turntable.

The jogging or "inching" switches LS **2627** and LS **2628** (FIGS. **82** and **87**) are disengaged from the respective cam plates **2632** and **2633**. LS **2616** (FIGS. **85** and **87**) is engaged while the presently located locking device **2594** is engaged by the raised plunger **2596** while solenoid **2621** is engaged to move and hold armature **2620** upwardly (FIG. **87**).

A source for electrical energy to LS **2614** and LS **2616** is supplied from a circuit originating at engaged LS **2564** while the same is closed by cam plate **2568**. Thus, when LS **2614** is allowed to close, preparatory to rotation of the turntable, it is adapted to activate the completion of circuits to the motor **2557** and at the same time prevent inadvertent movement of a subsequent sheet from the inspection area **24**. Upon opening of LS **2614** and closure of LS **2616** by the bar **2611**, the circuitry of motor **2557** will be opened while circuits that can be achieved by a sheet in the inspection area will be reconditioned for use.

Now, when the turntable carriage has been turned to position the Side **2** thereof to receive a sheet thereupon, the locking device **2595** will be positioned to receive the plunger **2596**. The cam plate **2568** at this time will also have engaged LS **2570** to complete a supply of electrical energy essentially to LS **2675**, duplicate of LS **2614**, and LS **2676** (FIG. **87**). In consequence, LS **2675** will open to prevent rotation of the carriage **2501** while LS **2676** will be adapted to restore the necessary circuits to permit the movement of a subsequent glass sheet from the inspection area.

In this connection, LS **2677**, **2678** and **2679** are illustrated in FIG. **87**, these limit switches being located on the loading unit **28**. LS **2677** controls the removal of a pair of sheets from the turntable unit and consequently until a pair of sheets are removed from the loading unit, activity of the turntable unit will be interrupted, as will hereinafter be more fully explained. Similarly, LS **2678** is adapted, when engaged, to halt operation of the motors **2658** and **2661** associated with the roller conveyor systems **2651** and **2652**. As a precautionary measure, LS **2679** is employed, while pairs of sheets are on both the turntable unit and loading unit, to open the service circuits controlling movement of a sheet from the inspection area.

Thus, when solenoid **2621** is de-energized, the plunger **2596** is lowered by the action of spring **2605** to engage and close switch devices LS **2614** (or **2675**) (FIGS. **85** and **87**) by bar **2111** while causing LS **2616** (or **2676**) to open. This prevents alternate operation of motors **2658** and **2661** for the roller conveyor systems **2651** and **2652** and permits operation of the rotation motor **2557**.

Now, when Side **1** is positioned, as in FIG. **79**, to receive a sheet of glass from the inspection area, LS **2564** has completed a circuit from source **2000** by line **2686** through solenoid **2687** of spring-biased relay switch **2688** to source **2001**. Simultaneously, the circuit of line **2686** is extended by branch line **2690** to a timing relay TR **2691** in series with source lines **2000** and **2001**. The circuit of LS **2564** also creates a source line **2693** for LS **2614** and **2616** (FIG. **87**). Energization of solenoid **2687** engages normally open contacts **2694** and **2695** of RS **2688**, the circuits through which will shortly be completed. The position or movement of the sheet in or through the inspection area **24** causes the closure of LS **2697**. Normally, LS **2697** can complete a circuit to alternately initiate operation of conveyor motors **2658** and **2661**. However, conditions at the loading unit which possibly prevented movement of two previous sheets from the turntable unit can also serve to render LS **2697** ineffectual thereby holding a sheet in the inspection area from further movement.

However, presently engaged LS **2616** will have completed a circuit by line **2699** (FIGS. **86** and **87**) from source **2000** through the engaged contacts **2700** of spring-biased RS **2701**, having solenoid **2702**, and through solenoid **2704** of RS **2705** (equipped with opposed solenoid **2706** and normally open contacts **2707**) to source **2001**. Simultaneously, line **2708** from LS **2616** completes a circuit through the solenoid **2709** of spring-biased RS **2710** to source line **2001**, RS **2709** having normally open contacts **2711**.

Closure of contacts **2707** of RS **2705** permits LS **2697**, when closed by the presence of a sheet in the inspection area, to complete a circuit from source **2000** by line **2714** to line **2715** through the closed pair of contacts **2694** of RS **2688** and

line 2716 through closed pair of contacts 2717 of LS 2670 and through solenoid 2718 of RS 2719 to source 2001. RS 2719 is equipped with opposed solenoid 2720, normally open pairs of contacts 2721, 2722 and 2723 and closed pair of contacts 2724. When solenoid 2718 is energized, contacts 2721, 2722 and 2723 will be engaged to complete the circuitry of motor 2658 for the roller conveyor system 2651 (associated with Side 1) while opened contacts 2724 will break the circuit of line 2725 from source 2000 through motor brake 2726 to source 2001. Since motor 2658 must be controlled to operate reversibly, its circuits are presently made by lines 2730, 2731 and 2732 through engaged pairs of contacts 2733, 2734 and 2735 of a polarity reversing RS 2736, RS 2736 is equipped with solenoids 2737 and 2738 and open pairs of contacts 2739, 2740 and 2741. Contacts 2733, 2734 and 2735 complete circuits of lines 2730, 2731 and 2732 from sources 2000, 2001 and 2002 through presently closed contacts 2721, 2722 and 2723 of RS 2719 to lines 2743, 2744 and 2745 to motor 2158. Contacts 2724 of RS 2719 are simultaneously opened to deenergize brake 2726 of said motor.

When the sheet S is properly located on the conveyor rolls of Side 1, the leading end thereof contacts LS 2670 to disengage contacts 2717 and close associated contacts 2748 to complete a circuit by branch line 2749 from LS 2564 by way of line 2686 and line 2750 through presently closed pair of contacts 2753 of spring-biased RS 2754, having solenoid 2755, and thence by line 2756 through solenoid 2720 of RS 2719 to source 2001. This will produce opening of contacts 2721, 2722 and 2723 to halt motor 2658 and set brake 2726 by the circuit of line 2725 from reclosed contacts 2724. Of course, when the circuit of line 2716 through contacts 2717 of LS 2670 is broken, solenoid 2718 of RS 2719 becomes de-energized.

Contacts 2748 also create a circuit by line 2758 through presently closed contacts 2695 of RS 2688 and by line 2759 to normally closed pair of contacts 2760 of spring-biased RS 2761 having a solenoid 2762. Branch 2765 from line 2758 through the normally closed pair of contacts 2766 of spring-biased RS 2767, having solenoid 2768, completes a circuit to activate a timer relay TR 2770 in circuit with sources 2000 and 2001. Initially, TR 2770 establishes a circuit by line 2771 through solenoid 2762 of RS 2761 to source 2689, thereby disengaging contacts 2760 to break the circuit of line 2759 to provide a normal "idle" interval while the sheet S is stopped while supported on the plurality of rollers 2655 of the conveyor system 2651 associated with Side 1. After this interval and reclosure of contacts 2760, line 2759 by line 2773 from reclosed contacts 2760 can be completed (see FIG. 87) through solenoid 2775 of RS 2776 to source 2001, RS 2776 being equipped with closed pair of contacts 2777 and opposed solenoid 2778.

Normally, contacts 2777 maintain the circuit of a line 2780 from source 2000 through solenoid 2621 to source 2001 to cause the armature 2620 and lock plunger 2596 to support the piston 2600 of locking device 2594 in its upper position. This will hold the contacts of LS 2616 engaged. Upon energization of solenoid 2775, however, contacts 2777 are opened which breaks the circuit of line 2780 from source 2685 through solenoid 2621 to permit the spring 2605 to lower the piston 2600 and consequently permitting the locking plunger 2596 thereby to open LS 2616. With the opening of the circuit via LS 2616, line 2699 de-energizes solenoid 2704 of RS 2705 to open contacts 2707. This opening action of LS 2616 also breaks the circuit of line 2708 through solenoid 2209 of spring-biased RS 2710 to source 2001 thereby permitting contacts 2711 to close.

When arm 2613 of LS 2614 is engaged by arm 2611 during descent of piston 2600, LS 2614 is closed and a circuit is made by line 2782 through solenoid 2706 of RS 2705 to source 2001 (FIG. 86) to open contacts 2707 thereby removing the possibility of a completed circuit from source line 2000 to line 2714 and preventing operation of either conveyor motor 2658 (or 2661 for Side 2) preparatory to rotation of turntable carriage.

The circuit, see FIG. 87, of a line 2783, originating with line 2782, is now completed by presently closed contacts 2711 of RS 2710 and line 2784 through solenoid 2785 of RS 2786 to source 2001. RS 2786 is instrumental in completing the lines of power circuits to the motor 2557 and, since the lock device 2594 has been released, the circuits will produce clockwise turning of the carriage 2501 through an arc of substantially 180°. This will align the Side 2 with the conveyor in the inspection area and one side of the loading apparatus 28. To this end, RS 2786 is equipped with pairs of normally open contacts 2787, 2788 and 2789 and an opposed solenoid 2290. Contacts 2787 serve to connect source 2000 and line 2792 to motor 2557, contacts 2788 connect source 2002 and line 2793 to the motor, and contacts 2789 connect source 2001 and line 2794 to the motor. As indicated, the electrical service via one or more of lines 2792, 2793 and 2794 is controlled by a variable resistance unit 2795. While the above pairs of contacts complete their described circuits, contacts 2796 will be opened to release the brake 2797 of motor 2557 upon opening of the line 2798 which is further extended through presently closed contacts 2800 of RS 2801 and presently closed contacts 2802 of RS 2803. As will shortly be further explained, RS 2801 is activated by jogging LS 2627 while RS 2803 is similarly activated by LS 2628.

During the first 20° of rotation, LS 2582 (FIG. 87) while engaged with cam plate 2585 will complete a circuit by line 2805 from source 2685 through the rheostat unit 2795 to source 2001. When cam plate 2585 releases LS 2582, normal speed of rotation of the turntable carriage is developed. Also, when LS 2582 engages cam plate 2586, the circuit of line 2805 is again made to device 2795 to reduce carriage speed during the last 20° rotation.

Cam 2580 then closes LS 2575 to complete a circuit from source 2000 and line 2807 to timing relay 2808, in circuit with sources 2000 and 2001. While active, TR 2808 completes a circuit from 2000, by line 2810 through the solenoid 2790 of RS 2786 to produce opening of circuits of lines 2792, 2793 and 2794 at contacts 2787, 2788 and 2789 of RS 2786 and reclosure of line 2798 at contacts 2796. Branch line 2811 completes a circuit from TR 2808 through presently closed contacts 2812 of spring-biased RS 2813 and thus through solenoid 2778 of RS 2776 to source 2001, RS 2813 also being provided with solenoid 2814 and a pair of presently open contacts 2815, for reasons to be shortly explained. Optimum operation assumes that when the turntable carriage has completed the half cycle of rotation and is stopped, it will be accurately aligned with the inspection and loading apparatus. If this situation does not exist and even though LS 2575 has been engaged by cam plate 2580, then LS 2627 and LS 2628 will be alternately engaged to "inch" the carriage in the required clockwise or counterclockwise direction depending upon the phase of engagement with related cams 2632 and 2633.

In one instance, LS 2627 makes a circuit from source 2000 by line 2817 through solenoid 2818 of spring-biased RS 2801 to source 2001 and thus close contacts 2820, 2821 and 2822 of RS 2801 which will complete the circuits of lines 2792, 2793 and 2794 by way of lines 2825, 2826 and 2827 to motor 2557, while disengaging contacts 2800 to open the circuit of line 2798 to brake 2797. This will produce slight rotary movement of the carriage 2501 in the normal clockwise direction. In second instance, LS 2628 will complete circuit from source 2000 by line 2830 through solenoid 2831 of spring-biased RS 2803 to source 2001 to engage related contacts 2832, 2833 and 2834 to make circuits from source lines 2000, 2001 and 2002 to lines 2793 and 2826, 2792 and 2825 and 2794 and 2827 by lines 2835, 2836 and 2837 to reverse the polarity of motor 2557. Opening of contacts 2802 of RS 2803 will also temporarily break the circuit of line 2798 to brake 2797. During closure of LS 2628 by cam 2633, the turntable will be "inched" in the counterclockwise direction.

When either LS 2627 or LS 2628 is engaged, a circuit by branch 2838 from line 2817 or line 2839 from line 2830 to line 2840 will complete a circuit through solenoid 2814 of RS 2813 to source 2001. This will disengage contacts 2812 and

engage contacts **2815** to complete a circuit from source **2000** by line **2841** and line **2773** through solenoid **2775** of RS **2776** thereby holding contacts **2777** open to de-energize lock solenoid **2621**. Normally, when LS **2575** is closed with the carriage aligned and motor **2557** halted, line **2807** through TR **2808** and line **2811** through contacts **2812** of RS **2813** will again activate solenoid **2778** of RS **2776** to engage contacts **2777** since when LS **2627**, or LS **2628**, is released from its respective cam **2632** or **2633**, the circuit by line **2840** through solenoid **2814** will be broken. This restoration of line **2780** via reclosed contacts **2777** of RS **2776** will re-energize solenoid **2621** which, however, at this time will cause the lock plunger **2596** to function with the locking device **2595**, which in all respects is a duplicate of device **2594** (FIGS. **83-85**). In the present instance (FIG. **87**), device **2595** has associated switch devices, closed LS **2675** and open LS **2676**, that are alternatively operated by a cup piston indicated by the numeral **2843**. When the carriage **2501** has completed the half cycle of rotation, the locking device **2594** will be disposed at the opposite end of the base framework **2500** which will open the described circuits of lines **2699**, **2782** and **2783** emanating from the associated LS **2616** and LS **2614** respectively. Generally speaking, the circuit of line **2782**, when broken, will de-energize solenoid **2706** of RS **2705** while the line **2783** will be open to one side of contacts **2711** of RS **2710**.

Now with LS **2570** (FIG. **86**) engaging cam plate **2568** and closure of LS **2676** by upward movement of member **2843** by plunger **2596**, the circuit of line **2845** to line **2846** will restore the circuit of line **2699** through contacts **2700** of RS **2701** to solenoid **2704** of RS **2705** to engage contacts **2707** and restore the circuit of line **2714** to LS **2697** in the inspection area **24**. This will "permit" a subsequent sheet to be moved forwardly for reception on the Side **2** of the turntable. Since LS **2568** is open and LS **2570** is presently closed, lines **2000** and **2001** are open while the source line **2000** will be presently completed by LS **2570** to make a circuit for line **2848** through solenoid **2850** of spring-biased RS **2851** to source **2001**, RS **2851** having presently open pairs of contacts **2852** and **2853**. Thus, lines **2714** and **2715** will now be extended by line **2854** to now engaged contacts **2852** of RS **2851**. The circuit of line **2848** is also extended by branch line **2855** to timing relay TR **2856**, in circuit with source lines **2000** and **2001**.

When the circuit of line **2854** is made through contacts **2852** of RS **2851**, a circuit by line **2858** is completed through closed contacts **2859** of LS **2671** and through solenoid **2860** of RS **2861** to source **2001**, said RS also being equipped with opposed solenoid **2862**. This will close related pairs of contacts **2863**, **2864**, and **2865** and open pair of contacts **2866** to complete circuits from lines **2000**, **2001** and **2002** to lines **2868**, **2869** and **2870** to presently engaged contacts **2871**, **2872** and **2873** of RS **2874**, having opposed solenoids **2875** and **2876** and presently open pairs of contacts **2877**, **2878** and **2879**, and line **2880**, **2881** and **2882** to conveyor motor **2661** for the roller conveyor system **2652** associated with Side **2** of the turntable carriage. Opening of contacts **2866** will break the circuit of line **2883** from source **2000** through brake **2884** for motor **2661** to source **2001**. This will serve to advance a sheet S onto side **2** of the turntable after the aforementioned LS **2697** has been closed. Also when LS **2570** is closed, the previously noted circuit by line **2855** is completed to TR **2856**, in circuit with sources **2000** and **2001**, which is then activated to complete line circuit **2886** through solenoid **2737** of RS **2736** to source **2001**. This will act to open contacts **2733**, **2734** and **2735** while then closing pairs of contacts **2739**, **2740** and **2741** to connect lines **2730**, **2731** and **2732** by lines **2887**, **2888** and **2889** to lines **2744**, **2743** and **2745**, respectively, while motor **2658** is idle thereby reversing the polarity thereof and contacts **2721**, **2722** and **2723** of RS **2719** are disengaged.

When LS **2570** is closed, as above-described, a branch line circuit **2892** is extended from line **2848** to one side of contacts **2893** of LS **2671**. Thus, when the leading end of the sheet, advancing on the roller conveyor system **2652**, actuates LS **2671** while breaking the circuit of line **2858** at opened contacts **2859**, it also engages contacts **2893** to complete the circuit of line **2895** through solenoid **2862** to RS **2861** to source **2001**. This will open contacts **2863**, **2864** and **2865** and reclose contacts **2866** to open circuits of lines **2868**, **2869** and **2870** to halt motor **2661** and re-energize brake **2884**. Since the sheet S on Side **2** of the turntable carriage, preparatory to and during removal onto the loading apparatus, will maintain contact with LS **2671**, means is herein provided for rendering the circuit through contacts **2893** temporarily inoperable. For this purpose, the circuit of line **2895** is completed through the normally closed contacts **2896** of spring-biased RS **2897**, having solenoid **2898**.

The delivery of the two, or a pair of, sheets simultaneously from the turntable unit to the loading unit can be effected immediately or it may be delayed pending clearance of a preceding pair of sheets from the loading apparatus, about which more will be said later. This, of course, is the "permitted" sequence of operation originating with the step-wise progress of the carrier-supported pair of sheets from above the loading apparatus and eventual entry of a preceding pair of sheets into the vacuum chambers. Therefore, suitably located switch devices, such as LS **2677**, such as may be located on the loader, can be employed to control simultaneous removal of the sheets from both Sides **1** and **2** of the turntable. Thus, while LS **2671** is engaged and effective to halt motor **2661**, it also creates a circuit by line **2900** to a timer relay TR **2901**, in circuit with source lines **2000** and **2001**, through engaged contacts **2902** of spring-biased RS **2903**, equipped with solenoid **2904**. Line **2900** by branch line **2906** creates a circuit through presently engaged contacts **2853** of RS **2851** to line **2907** connecting through the presently closed contacts **2908** of spring-biased RS **2909**, having solenoid **2910**, to line **2911**. Initially, however, TR **2901** establishes a circuit by line **2914** through the solenoid **2910** of RS **2909** to source **2001**, this serving to open the circuit of lines **2907** and **2911** at contacts **2908** thereby preventing operation of solenoid **2621**. Upon reference to FIG. **87**, it will be noted that line **2911** is extended through line **2773** to solenoid **2775** of RS **2776** to open contacts **2777** thereof. TR **2901** then initiates a circuit by line **2916** through solenoid **2898** of RS **2897** to source **2001** thereby opening contacts **2896** in the circuit of line **2895**. By line **2917**, a circuit is made to line **2858** and thus through solenoid **2860** of RS **2861** thereby serving to reclose contacts **2863**, **2864** and **2865** and opening contacts **2866** of RS **2861**. This will cause motor **2661** to operate the related roller conveyor system **2652** for Side **2** and deliver the sheet thereon toward the loading unit.

Simultaneously, branch line **2918** from line **2917** will extend via line **2716** through solenoid **2718** of RS **2719** to source **2001** thereby engaging contacts **2721**, **2722** and **2723** thus completing lines **2730**, **2731** and **2732**. However, since the solenoid **2737** of RS **2736** has been energized during activity of TR **2856**, reversed circuits will be made to motor **2658** for the roller conveyor system **2651** associated with Side **1** of the turntable carriage by way of presently closed contacts **2739**, **2740** and **2741** of RS **2736** whereby line **2730** will connect by line **2887** to line **2744**, line **2731** by line **2888** to line **2743** and line **2732** by line **2889** to line **2745**. The reversed polarity of motor **2658** will thereby operate to remove the related sheet on the conveyor system **2651** of Side **1** onto the opposite side of the loading unit. Line **2919** from line **2918** (FIG. **86**) may be employed to start operation of conveyor systems of the loading unit to receive the sheets as they are passed from the turntable.

By means of a limit switch on the loader, such as LS **2678** in FIG. **87**, when the sheets are properly located on the loading unit, a circuit by line **2920** from source **2000** is completed via line **2895** through solenoid **2862** of RS **2861** to source **2001**. This will cause the contacts **2863**, **2864** and **2865** to open the circuits to motor **2661** by lines **2868**, **2869** and **2870** and by contacts **2866** and line **2883** to energize the brake **2884**. Similarly, line **2921** will connect with line **2756** to become effective in energizing solenoid **2720** to disengage contacts

2721, 2722 and 2723 of RS 2719. This also engages contacts 2724 which will energize brake 2726 when motor 2658 is stopped. The circuit of line 2921 can be extended by line 2922 to activate TR 2923 which, after a short interval, will complete a circuit by line 2924 through the opposed solenoid 2738 of RS 2736 to restore the original polarity of motor 2658.

Sides 1 and 2 of the turntable carriage 2501 are now empty and conditioned to receive a subsequent pair of sheets from the inspection area. As noted earlier, RS 2701 (FIG. 87) is opened during the presence of sheets on the sides of the loader unit by means of LS 2679 and creation of line circuit 2925 to a timing relay TR 2926, in series with source lines 2000 and 2001. This timing relay completes a circuit by line 2927 through the solenoid 2702 of RS 2701 to source line 2001 which disengages contact pair 2700 to break the circuit of line 2699 presently maintaining solenoid 2704 of RS 2705 energized. TR 2926 then completes a circuit by line 2928, via line 2782, through the opposed solenoid 2706 of RS 2705 (FIG. 86) to source line 2001 which will result in opening of the circuit of lines 2000 and 2714 at separated contact pair 2707. This will prevent completion of the circuit of lines 2714 and 2715 when LS 2697 is closed by a sheet arriving at the exit end of the inspection area 24.

LS 2677, which has also been engaged by the presence of sheets on the loader unit, will complete the circuit of line 2929 (FIGS. 86 and 87) through both solenoid 2768 of RS 2767 and solenoid 2904 of RS 2903 to source 2001. This serves as a precautionary measure in that the contacts 2766 of RS 2767 will be separated to break the circuit of line 2765 to TR 2770 and the contacts 2902 of RS 2903 will break the circuit of line 2900 to TR 2901 while similarly disengaged.

However, in normal occurring stages of operation and with contacts 2707 engaged, the circuit of line 2714 will be maintained to LS 2697 in the inspection area and, since LS 2570 is closed by the cam 2568 (FIG. 86), subsequent engagement of LS 2697 will again complete a circuit by the lines 2715 and 2854 through contacts 2852 of RS 2851, and line 2858 through solenoid 2860 of RS 2861 via contacts 2859 of RS 2671. As earlier described, motor 2661 will operate to move a first advancing sheet of a second pair of sheets onto the roller conveyor system 2652 of Side 2 of the turntable carriage. Likewise, when the sheet engages LS 2671, contacts 2859 will be opened to de-energize solenoid 2860 while closed contacts 2893 will complete the circuit of line 2895 (contacts 2896 of RS 2897 being presently engaged) through opposed solenoid 2862 of RS 2861. This will open contacts 2863, 2864 and 2865 to halt motor 2661 while energizing brake 2884 by contacts 2866 and line 2883.

Now, engaged contacts 2853 of RS 2851 will complete the circuit of lines 2906 and 2907 from closed contacts 2893 and by line 2911 (FIGS. 86 and 87) from contacts 2908 of RS 2909 connect to line 2773 thereby causing solenoid 2775 of RS 2776 to open the circuit of line 2780 at contacts 2777 and thus de-energizing solenoid 2621. This will permit LS 2676 of locking device 2595 to open and LS 2676 to close thereby preventing operation of conveyor motors 2658 and 2661 and permitting rotation of the turntable carriage as previously described. During this rotation, LS 2570 is disengaged from cam plate 2568 while LS 2564 will again be closed to restore the circuit of line 2686 to close contacts 2694 and 2695 of RS 2688 by solenoid 2687. Also, when LS 2575 is again engaged by cam 2578, RS 2776 will be again activated, particularly to bring about closure of LS 2616 to restore the closed condition of contacts 2707 of RS 2705 to complete line 2714 to LS 2697. Thus, when a fourth sheet entering the inspection area engages LS 2697, the circuit of lines 2714 and 2715 through contacts 2694 of RS 2688 and line 2716 will re-establish the circuits of lines 2730 and 2743, 2731 and 2744 and 2732 and 2745 to motor 2658 of contacts 2721 and 2733, 2722 and 2734 and 2723 and 2735 of RS 2719 and 2736, opened contacts 2724 also de-energizing brake 2726. The circuit of line 2686 can also be employed via line 2690 to active timing relay TR 2691, in circuit with sources 2000 and 2001. This timer creates a circuit by line 2930 through solenoid 2875 of RS 2874 to source 2001 to reverse the polarity of motor 2661. This will open contacts 2871, 2872 and 2873 and engage contacts 2877, 2878 and 2879 while motor 2661 is idle.

When contacts 2748 of LS 2670 are closed by the leading end of the forwardly moving sheet to energize solenoid 2720 of RS 2719 via line 2756 to halt motor 2658, the branch line 2765 from line 2758 will operate to active TR 2770 which will in due course open lines 2750 and 2756 at contacts 2753 of RS 2754 by solenoid 2755. Initially, TR 2770 will energize solenoid 2762 of RS 2761 by line 2771 to disengage contacts 2760 thereby opening the circuit of lines 2759 and 2773 to solenoid 2775 of RS 2776. TR 2770 will then complete circuits by line 2931 to solenoid 2755 of RS 2754 and lines 2932 and 2933 to simultaneously energize solenoids 2718 of RS 2719 via line 2716, and 2860 of RS 2861, via line 2858, to cause motors 2658 and 2661 to move the sheets from Sides 1 and 2 onto the loading apparatus 28. This, of course, is dependent upon the open condition of LS 2677 on the loading apparatus. LS 2677 by line 2929 at the present time will complete a circuit through solenoid 2768 of RS 2767 to source 2001 thereby opening contacts 2766 to render TR 2770 idle. This is equally true in the case of contacts 2902 upon energization of solenoid 2904 of RS 2903 to render TR 2901 idle. When LS 2678 is again closed, lines 2920 and 2921 will energize solenoids 2720 of RS 2719 and 2862 of RS 2861 to halt motors 2658 and 2661. As earlier described in connection with solenoid 2737 of RS 2736, when LS 2564 is engaged, the circuit by lines 2686 and 2690 to TR 2691 will activate the line 2930 to complete through solenoid 2875 of RS 2874 to open contacts 2871, 2872 and 2873 and close contacts 2877, 2878 and 2879. This will connect line 2868 to line 2881 by line 2935, line 2869 to line 2880 by line 2936 and line 2870 to line 2882 by line 2937 thereby reversing the polarity of motor 2661. Also when LS 2678 is engaged, line 2920 will be made by line 2938 to timing relay TR 2939, in circuit with sources 2000 and 2001, such timer then completing a circuit by line 2940 through opposed solenoid 2876 of RS 2874 to source 2689 thereby opening contacts 2877, 2878 and 2879 while reclosing contacts 2871, 2872 and 2873 to restore the circuits of motor 2661 to their original polarity.

## THE LOADING UNIT

As previously described, the loading unit 28 is situated (see FIGS. 1 and 7) adjacent the east or delivery side of the turntable unit 27 and beneath the loading conveyor drive unit 150 of the conveyor system that is adapted to progressively move the sheet supporting carries 160 through the processing apparatus in its entirety. At this entry end of conveyor system, there is provided on the unit 150 the clamping unit 170 and eccentric shaft actuator unit 180 equipped with power devices to clampingly connect each one of a pair of sheets S to each one of a pair of carriers 160 and then secure the clamping members.

Generally speaking, the loading unit 28 includes a framework having a pair of tiltably mounted frames which, when in a position to receive sheets from the turntable, are disposed in angularly, inwardly disposed planes, bottom to top, of substantially 7° to a medial vertical plane. These frames carry a plurality of swingably supported frames equipped with vacuum cups. By means of roller conveyor systems associated with each tilting frame, sheets are received in paired relation from the roller conveyor systems 2651 and 2652 associated with the aligned sides of the turntable carriage 2501. After the power sources of the conveyors adapted to move the sheets forwardly have been halted, elevator devices engage the lower edges of the sheets and move them upwardly a predetermined distance that is controlled by the vertical dimension of the sheets. This is to locate the upper edges of any pair of sheets at the elevation of a horizontal plane coincident with the horizontal plane in which the aforementioned clamping mem-

bers of a carrier **160** are located. The vacuum cup support frames are then swung outwardly and upwardly to engage and hold the inwardly disposed surfaces of the sheets. At this time, as shown in FIG. **91**, the tilting frames are moved from the angular planes to vertical planes. The sheets are now suitably positioned to be received and supported on their respective carrier **160**.

For a more specific description of the loading unit, reference is now made to FIGS. **88** to **109**, inclusive, wherein the base framework is designated in its entirety by the numeral **3000**, the tilting frames by the numeral **3050**, the elevating devices by numeral **3100** and the vacuum support frames by the numeral **3200**.

Thus, the framework **3000**, as in FIGS. **88**, **90** and **108**, is constructed of longitudinally disposed side beams **3001** and **3002**, pairs of transversely disposed channels **3003** and **3004** adjacent and beneath the respective ends of the beams **3001** and **3002** and a pair of transversely disposed channels **3005** substantially in the medial area thereof. In one way or another, the beams **3001** and **3002** are integrally secured on the upper surfaces of the pairs of channels **3003** and **3004** and channels **3005** and **3006** which in turn are structurally mounted by footing plates **3007** on the floor F of the working area.

As will be noted in FIGS. **88**, **89**, **90**, **93** and **96** as well as FIG. **108**, vertically disposed or column beams **3008** and **3009** are arranged between the pairs of channels **3003** and **3004** with their lower ends affixed to the inner surfaces thereof. These beams or columns are located in the longitudinal axis or vertical plane of the loading unit and are there re-enforced by gusset plates **3010** and structurally interjoined by a bracing member **3011**. On the upper end of each beam **3008** or **3009**, see FIGS. **89** and **90**, a trunnion block **3012** is mounted for pivotal support of the tilting frames **3050**, about which more will be said later.

Each side beam **3001** and **3002** constitutes the mounting support for one of the roller conveyor systems **3014** and **3015** that are formed of regularly spaced drive units, generally designated by the numeral **3016**. These units, as seen in FIGS. **89**, **90**, **96** and **97**, are disposed in an angular plane of substantially 7° to the horizontal and include a bearing block **3019** on the respective beams **3001** and **3002** for journaling a drive spindle **3020**. A sheet support roller **3021** is fixed on the inwardly directed end of each spindle while at least one, preferably two in most instances, sprockets **3022** are keyed on the opposite end. These sprockets, as shown in FIG. **96**, are driven in common by chain belts **3023** with the endmost spindle **3024** of each conveyor system having a second sprocket **3025** at the inner end thereof (FIG. **97**) which by chain belt **3026** is operatively driven from a source of power **3027** including the gear-motor **3028**. Each conveyor system is substantially enclosed in a protective housing **3029**.

For reasons to be later explained, switch devices LS **3032** and LS **3033** are located on the framework **3000**, as shown in FIGS. **46**, **48** and **109**, while switch devices LS **3034** and LS **3035** are mounted on the vertical beam **3009**, these limit switches being supported by brackets **3036**. Generally stated, LS **3032** and LS **3033** when engaged by selected portions of the tilting frames **3050** will effect halting of the same in the illustrated angular plane positions of FIG. **90**. Similarly, LS **3034** and LS **3035** will produce halting of the frames in the vertical plane positions of FIG. **91**.

The tilting frames **3050**, as seen in detail in FIGS. **88**, **90** and **108**, include a lower channel member **3051**, an upper beam member **3052** and a plurality of channels **3053** arranged vertically therebetween in paired relation as indicated by the numerals **3054**, **3055**, **3056**, **3057** and **3058**. Structurally, the channels of each pair are fixed at their lower ends to a respective channel **3051**, and at and adjacent their upper ends to the lower flange of the beam **3052** and to an elongated re-enforcing plate **3059**. As shown in FIG. **88**, of these pairs of channels, pair **3056** is located in the transverse axial plane of the loading unit per se while the numerically noted pairs are arranged in outward and equally spaced relation therefrom.

In the plan view of FIG. **89**, the axial center line of the loading unit, designated by the legend C/L is intended to denote that the same is symmetrically constructed on each side thereof and that the sectional plan view of FIG. **93** will be understood to illustrate portions of the unit to the left of the line C/L while FIG. **96** illustrates portions of the unit toward the right end. FIGS. **89** and **90** best illustrate the position of mounting plates **3060** and **3061** for pairs of pivot blocks **3062** and **3063**. The plates at their ends are fixed to the oppositely disposed channels **3053** of pairs **3054** and **3055** and **3057** and **3058** while the related pivot blocks **3062** and **3063**, in each instance, are journaled on a shaft **3065** carried in its central area in a trunnion block **3012**. The physical mounted relation of the tilting frames **3050** and the framework **3000** is believed best illustrated in the perspective view of FIG. **108**.

The tilt frames are shown in both the angular and the vertical positions they assume in FIG. **91**, and to synchronously move the same, a power source **3068** is located between the central pair of channels **3005**. As viewed in FIGS. **93** and **98**, each power source includes a gear-motor **3069** mounted on one or the other of channels **3005** which at its output shaft **3072** is equipped with a sprocket **3073**. Arranged in axially parallel relation are located threaded shafts **3074** journaled at their respective ends in pillow bearings **3075** mounted on plates **3076** bridging the said channels. Each shaft **3074** at its inwardly disposed end mounts a sprocket **3077** driven by an associated sprocket **3073** through chain belt **3078** entrained thereabout. As shown in FIG. **99**, each shaft **3074** carries an internally threaded block or "ball-screw" nut assembly **3079** that is a component part of a U-shaped member **3080** having bearing rollers **3081** supported in the flanges **3082** thereof. The rollers are adapted to traverse slots **3083** in the flanges **3084** of a U-shaped bracket **3085** which by plate **3086** and angle **3087** is mounted between the channels of pair **3056**. Thus, as the shafts **3074** are operatively driven in reverse directions of rotation, the associated blocks **3079** will advance inwardly to swing the respective frames **3050** to the vertical position. Of course, during outward travel of blocks **3079**, the frames will each be returned to its angular position of substantially 7° inclining inwardly or at a so-called "back" angle. The limit of movement in each direction is controlled by limit switches LS **3032** and **3033** and LS **3034** and **3035** (FIGS. **98** and **109**), and as will be explained in connection with the circuit diagrams of FIGS. **111** and **112**.

The outwardly disposed flange **3089** of the channels of each pair **3054** to **3058**, inclusive, is provided with spherical sheet supporting devices or balls **3090** of a suitable non-abrasive material such as of a thermoplastic composition. These are contained in suitable mounting devices **3091** regularly spaced along the several channels whereby the sheet will be bodily received and freely supported as it is moved in a forward endwise direction by the roller conveyor systems **3014** and **3015**. When the leading end of each sheet, moving to the right as indicated by the arrows designated by the numerals **3092** in FIG. **89**, is suitably beyond the pair of channels **3058**, switch devices LS **3094** and LS **3095**, as the case may be, will be engaged to stop operation of the related motor **3028** of the respective conveyor system. The switch devices, as shown in FIG. **109**, are mounted on similar brackets **3096**.

The elevator devices **3100** are generally carried along the lower margins of the tilting frames **3050**. As illustrated in FIGS. **90**, **92** and **93**, each of these devices includes an angular base plate **3101** which is formed with the vertical flange **3102** of desired length and horizontal flange portions **3103** located at each of the extreme ends. Each flange **3103** is equipped (FIG. **92**) with a block **3104** of nonabrasive material for supporting a glass sheet along its lower edge.

The elevator devices are located, as in FIG. **88**, between the pairs of channels **3054** to **3058**, inclusive, and are adapted to move in upward and downward directions by means of reversibly operable sources of power **3105** including a gear-motor **3106** carried by a mounting plate **3108** on the lower surface of frame channel **3051**. The output shaft of this motor **3106** ex-

tends outwardly from both sides of the motor case and is there united to shaft sections **3112**. As seen in FIG. **9**, the shafts **3112** are supported in bearings **3114** carried by the frame channel **3051**.

Operation of each motor **3106** is controlled by individual switch devices LS **3115** and LS **3117** similarly mounted by brackets **3119** and **3120** on the respective tilting frames **3050**. In the first instance (see FIG. **109**), LS **3115** are located by brackets **3119**, on the upper beam member **3152** of the frames **3050**, for engagement by the upper end of a sheet to thereby produce stopping of operation of the affected motor **3106**. The switch devices LS **3117** are mounted by brackets **3120** adjacent the lower channel member **3051** of each frame and are thus adapted to cause halting of the related motors **3106** when the elevators reach the bottom limit of their travel. In this connection, it will also be noted that switch devices LS **3121** on brackets **3123** on each tilt frame **3050** are located in upwardly spaced relation above the switch devices LS **3117**, and are effective to prevent "over-running" of the elevator devices in the event of failure of LS **3115** to function properly.

As best seen in FIGS. **101** and **105**, each shaft **3112** mounts a plurality of sprockets **3125** that are operatively connected to the elevator devices **3100** through the medium of chain belts **3126** entrained around the sprockets **3125** and sprockets **3127** on shafts **3128** carried by adjustably mounted brackets **3129**. More specifically, as in FIG. **92**, the rearward surface of vertical flange **3102** of base plate **3101** supports a connector bar **3132** having slots **3133** that are adjustedly fixed to said flange **3102** by nut and bolt fastenings **3134**. The opposite ends of each bar **3132**, being reduced in width as at **3135**, are received between links **3136** of chain belts **3126** and connected thereto by pins **3137**. Thus, each chain belt from a bar **3132** is trained downwardly about a sprocket **3125**, upwardly and around sprocket **3127** and then downwardly to its connection to the opposite or upper end of the bar **3132**.

The sprockets **3127** are freely rotatably mounted on the related shaft **3128**, FIGS. **89**, **105** and **106**, that is received at its ends in journal bearings **3141** slidably mounted on related bracket **3129** and shifted by screws **3144** threadably movable relative to block **3145** and having a locknut **3146** to vary the tautness of the associated chain belts **3126**.

The respective ends of each elevator base plate **3101** are equipped with guide rollers **3150**, **3151** and **3152** journaled by the shafts supported in blocks **3153**, such rollers being adapted to traverse the surfaces of guide tracks **3155** mounted by bars **3156** on the spaced flanges **3157** of the channels **3053**, as typically illustrated in FIG. **107**.

Initially, the elevator devices **3100** are located in the lowered position with the upper surfaces of support blocks **3104** in a substantially common horizontal plane sufficiently below the plane of the lower edge of a forwardly moving sheet so as not to conflict with its freedom of movement while supported on the rollers **3021** of the respective roller conveyor systems **3014** and **3015**. At this time, at least one elevator device of each tilting frame will be holding a switch device LS **3117** in its open condition by means of an actuator plate **3160** (FIGS. **101** and **106**) secured to the back surface of the vertical flange **3102**. After movement of the sheets has been halted on the conveyor systems **3014** and **3015**, the motors **3106** are activated to move the elevators upwardly until the upper ends of the sheets engage the respective switch devices LS **3115**. The upward distance of this lifting movement, as hereinabove explained, is determined by the vertical dimension of the sheets to the end that all sheets, of whatever dimensional height, will reach a common upper limit of movement before activating the noted switch devices. In the event that LS **3115** fails to function, the engagement of LS **3121** will produce halting of motor operation. When again activated, in reverse directions, the power source **3105** will lower the elevator devices **3100** until the related LS **3117** is engaged.

As shown in FIGS. **88**, **94**, **95** and FIGS. **100** to **107**, inclusive, the vacuum cup support or swinging frames **3200** comprise a body member formed by tubular side bars **3202** and spaced bridging or cross bars **3203**. These frames **3200** are centrally located between each of the pairs of channels **3054** to **3058**, as in FIGS. **88**, **100** and **101**. Generally stated, each frame **3200** is supported by axles **3205** and **3206** carried in the free ends **3207** and **3208** of crank levers **3209** and **3210**. The opposite ends of crank levers or arms **3209** are swingably supported on axles **3212** mounted at their ends in bearing brackets **3213** fixed on the channels **3053**. The axle **3205** outwardly of related end **3207** of crank lever **3209** is supported on the side bars **3202** at its opposite ends by bearings **3214**.

In the case of crank levers or arms **3210**, they are keyed on a drive shaft **3215**, mounted in bearing brackets **3216** on channels **3053** and extending substantially the length of each tilting frame **3050**. Each of these crank levers are formed with a main body **3217**, on shaft **3215** (FIG. **102**) and a bearing cap element **3218** on which the related axle **3206** is medially received, the outer ends thereof being located in bearings **3219** in side bars **3202**.

Since the vacuum support frames **3200** are intended to swing arcuately in a parallelogram manner of motion relative to the associated channels pairs **3054** to **3058**, means are provided herein for adjusting the lineal distance between axles **3205** and **3206** to agree with the fixed distance between axle **3212** and shaft **3215**. To this end, the bearing cap **3218** (FIG. **95**) is formed with slots **3222** through which securing bolts **3223** are passed and threaded into the body portion **3217**. By loosening bolts **3223**, the cap **3218** can be shifted radially to adjust the spaced relation or distance between axles **3205** and **3206**.

As illustrated in FIGS. **88**, **89** and **94**, each shaft **3215** fixedly carries a sector gear **3225** that is meshed with a drive pinion **3226** on the output shaft of a reversibly operable power source **3227** including a gear-motor **3228** mounted on a plate **3230** bridging the opposed channels **3053** of the tilt frame **3050**. Thus, upon substantially simultaneous rotation of shafts **3215**, crank levers **3210** with crank levers **3209**, will be moved arcuately to swing the related vacuum cup support frames **3200** outwardly and inwardly. LS **3232**, mounted by similar brackets **3234** on a channel **3053** of channel pairs **3058**, are adapted to produce halting of operation of related motors **3228** when the frames **3200** reach the innermost or rest position as in FIGS. **102** and **103** and said switches are engaged by a side bar **3202**. Likewise, when the frames have been moved to the outermost position, as shown in the broken line position in FIG. **94** and designated by the letter O, switch devices LS **3235** mounted by brackets **3237** on the opposite channel **3053** of pair **3058**, are engaged by a side bar **3202** to terminate further movement. An additional switch device LS **3238** is mounted by a bracket **3240** beneath a related switch device LS **3232**. Each of these switch devices is instrumental in interrupting outward movement of the vacuum cup support frames **3200** until the rims of the several vacuum cups are properly engaged with the surface of the sheet. After a selected interval of time, outward movement of the frames **3200** is continued until LS **3235** has been engaged.

FIG. **88** illustrates a preferred arrangement of the plurality of vacuum cups **3245** with at least four being mounted on each of the vacuum cup support frames **3200**. This provides a functional pattern of twenty vacuum sheet supporting members with each tilting frame **3050** and, for reasons to be more fully described, the lower cups in each row are designated by the numeral **3246**.

As seen in FIG. **102**, each vacuum cup **3245** has a metal backing plate **3248** terminating in a tubular annular shank **3249**. This annular shank is slidably supported in the hollow hub **3250** of a mounting plate **3251** and carries a fixed collar or valve fitting **3252** at the extreme end thereof. The plate **3251** is fastened by bolts **3253** to the spaced side bars **3202**, see FIG. **107**. Each cup member is resiliently urged to its foremost position by a coil spring **3254** located between the backing plate **3248** and mounting plate **3251**.

As seen in FIGS. **102** and **103**, each cup **3245**, at the valve fitting **3252**, is connected by flexible tubing **3255** to a supply

pipe **3256**, mounted on each vacuum cup support frame **3200** by clips **3257**. To compensate for the swinging movements of the cup frames **3200** relative to the tilt frames **3050**, each pipe **3255** is connected by a length of flexible tubing **3258** to a manifold pipe **3259** connecting through suitable valves to a source of vacuum. The lower cup **3246** in each vertical row is connected by tubing **3260** to a manifold pipe **3261** mounted by brackets **3262** on the opposite side bar **3202** of each frame **3200**. Pipe **3261** is connected by tubing **3263**, as in the case of tubing **3258**, to a manifold pipe **3264** connected by valves to the source of vacuum. Pipes **3259** and **3264** are supported by brackets **3265** on the upper beam **3052** of each of the tilting frames **3050**.

As earlier set forth in connection with the lifting action of the elevator devices **3100**, all sheets, regardless of vertical dimension, are raised until their upper margin has contacted LS **3115** when the upper edge reaches a predetermined elevation. Obviously, when sheets having a shorter dimension have been raised to this precise elevation, their lower edges may in many instances, be positioned above and consequently out of contact with the lower row of vacuum cups **3246**. To prevent connection of these cups to the source of vacuum in this event, switch devices LS **3267** are mounted by brackets **3268** on a channel **3053** between LS **3117** and LS **3121** and are adapted to restrict the connection of vacuum cups **3246** to the source of vacuum. LS **3267** is equipped with a "rocker" type of arm **3269** so that the switch will be closed as the elevator devices rise and then opened as they descend.

In considering an electrical control system adapted to be employed in operation of the loading unit **28**, it will be recalled that, in sequence, the conveyor rolls **3021** of the conveyor systems **3014** and **3015** on the respective sides of the unit are driven by individual motors **3028**; the elevator devices **3100** are raised and lowered by the reversibly operable motors **3106**; the vacuum cup support frames **3200** are pivoted outwardly and again inwardly by related motors **3228**, and the tilting frames **3050** are swung between their positions in an angular plane and in a vertical plane by associated motors **3069**. The plurality of upper vacuum cups **3245** are connected by pipes **3259** to a source of vacuum through regulating devices on either side of the loading unit such as electrically controlled valve **3272**, and the lower row of cups **3246** are similarly connected by the related pipes **3263** and **3264** to the source of vacuum by way of valve **3273**.

With regard to the clamping apparatus **170** on the loading conveyor drive unit **150**, the direction of pressure to the cylinder **1726** for operating the clamping devices **1615** is controlled by valve **1731** which connects pipes **1729** and **1730**, in sequence, to supply pipe **1732**. Also, the cylinders **1864** for securing the clamping devices **1615** upon operation of the eccentric shafts **1839** are connected by pipes **1870** and **1871** to a supply pipe **1873** by way of valve **1868**.

In the following description of the electrical system for producing cyclic operation of the loading unit, the circuits and functions of the limit switches associated with one side of the unit will be discussed in connection with FIGS. **111** and **112**.

In this connection, reference is also made to FIG. **160** wherein the loading of a glass sheet is schematically illustrated in the views *a* to *g*, with regard to one side of the loading unit **28**. Generally stated, the sheet is moved onto the unit by the rolls of the conveyor system and is supported on its inwardly disposed surface by the spherical sheet supporting devices **3090** as shown in view *a*. When the sheet is fully supported on the conveyor system, the elevator devices **3100**, as in view *b*, are caused to move upwardly into engagement with the lower edge of the sheet and raise the same until the top edge reaches the predetermined elevation. Usually sheets having a vertical dimension of ten feet will then cover the effective area of the rows of vacuum cups **3245** and **3246**. Since the top edge of all sheets must be raised to the same elevation, in the case of sheets having a shorter vertical dimension the elevator devices **3100** will be moved upwardly to an elevation as shown by way of example in view *c*.

After halting of the gear-motors **3105** and **3106** for the elevator devices, the vacuum support frames **3200** are swung outwardly by the crank levers **3209** and **3210** until the rims of the plurality of vacuum cups **3245** and **3246** will engage the inwardly disposed surface of the sheet, as illustrated in view *d*. With the frames stationary, vacuum is drawn in each of the cups to adhere the sheet thereto. As will hereinafter be explained and under the conditions shown in view *c*, a low pressure switch device is actuated to prevent connection of the exposed lower row of cups **3246** to the source of vacuum. In either event, however, the vacuum support frames **3200** are swung further outwardly, as in view *e*, which serves to raise the top edge of the sheet to the elevation of the clamping devices **1614** of the carrier **160**, the lower edge from the elevator devices **3100** and the surface of the sheet from the spherical supporting devices **3090**.

After the tilting frame **3050** has been pivoted inwardly to the vertical position of view *f*, one surface of the sheet will contact the clamping device **1614** and the associated device **1615** will be moved to engage the opposite sheet surface thereby to produce the clamping action by which the sheet will be supported by the carrier throughout the processing operation. At this time, the vacuum is relieved at the cups **3245** and **3246** (if the latter are utilized) and the vacuum support frames **3200** are moved inwardly to their rest positions as indicated in phantom line in view *f*. When the carrier **160** has been moved from the loading conveyor drive unit **150** to the entry conveyor drive unit **145**, the tilting frame **3050** is returned to the angled position of 7° as is shown in view g. It has been stated earlier that the loading unit **28** and the unloading unit **29** are substantially of the same structure and that operation of the unloading unit in a general way is merely a reversal of the functional sequences presently discussed in connection with FIG. **160**. Thus, the sequences of an unloading operation are illustrated in views *a* to *g* of FIG. **161** and will hereinafter be described in that connection.

The aforementioned switch devices LS **2677**, LS **2678** and LS **2679** (FIG. **87**) have been described in connection with their location on the loading unit to control by LS **2677** the forward movement of a pair of glass sheets from the conveyor systems **2651** and **2652** associated with the turntable unit, the halting of a subsequent pair of glass sheets on the turntable carriage **2501** by LS **2678** and the prevention of movement of a subsequent sheet from the inspection area **24** by LS **2679**. These switches (LS **2677**, **2678** and **2679**) are also illustrated in FIG. **111**.

LS **3094**, for halting movement of a pair of sheets as they are moved onto the loading unit **28**, is presently in an open condition which is also true with regard to LS **3115** for halting upward movement of the sheets by elevator devices **2700**. LS **3121** for preventing overtravel of the elevator devices as well as LS **3267** for disconnecting the lower rows of vacuum cups **3246** from the source of vacuum are also in the open condition. On the other hand, LS **3117** will be maintained closed due to the fact that the elevator devices are in their lowermost positions. LS **3235** and LS **3238** for halting outward pivotal movement of the vacuum cup support frames **3200** and for temporarily stopping such outward movement are in their open condition while LS **3232** for halting movement of the frames at their inner positions is presently held in closed condition. Further, LS **3032** (FIG. **112**) for halting movement of the tilting frames **3050** in their angled positions is held closed while LS **3034** to halt the frames in the vertical positions is in the open condition. LS **1765** (FIG. **52**) of the clamping unit **170** is held in the closed condition by the actuator **1770** while LS **1766** is open. LS **1883** (FIG. **58**) of the securing unit **180** in each instance is held open while the oppositely disposed LS **1884** is in the open condition. In considering the operation of the loading unit, reference will herein be directed to the switch devices associated with one side thereof, namely, LS **3032**, **3034**, **3094**, **3115**, **3117**, **3121**, **3232**, **3235**, **3238** and **3267**.

Now, when a pair of sheet supporting carriers **160** on tracks **1017** and **1018** are properly positioned with regard to the clamping unit **170** and securing unit **180** on the conveyor drive unit **150**, as in FIG. **88**, they will have effected the closure of LS **3275** and **3276** to establish a circuit by line **3277** for functioning of the loading unit by way of source line **2000**. In other words, until both of the carriers have been halted in the required centered position, as described in connection with FIG. **66**, a circuit through LS **3275** and LS **3276** will not be completed. Thus, the circuit of line **3277** through LS **3275** and **3276** will complete a circuit from source line **2000** through the solenoid **3278** of a spring-biased relay switch RS **3279**, having contacts **3280**, to source line **2001**, contacts **3280** thereby completing the service of supply line **3281**.

As described in connection with FIG. **86**, line **2919** is adapted to initiate operation of the motors, such as motor **3028**, for the loading unit conveyor systems **3014** and **3015**, the system **3014** to herein be described. To this end, when LS **3275** and LS **3276** are engaged, a third switch device, LS **3283**, is also closed (with LS **3276**) to complete line **2919**. Thus, line **3284** from LS **3283** will be completed through the presently engaged contacts **3285** of spring-biased relay switch **3286**, having solenoid **3287**, to line **3288**. Line **3288** completes a circuit through the solenoid **3290** of RS **3291** to source line **2001**, such relay switch having opposed solenoid **3292**, open pairs of contacts **3293**, **3294** and **3295** and closed pair of contacts **3296** which maintain a circuit by line **3297** through the brake **3298** associated with motor **3028**. When energized, solenoid **3290** closes contacts **3293**, **3294** and **3295** to complete lines **3300**, **3301** and **3302** from sources **3281**, **2001** and **2002** to motor **3028** while opening the circuit of line **3297** to the brake **3298** at contacts **3296**.

When a sheet is bodily supported on the rolls **3021** of each conveyor system **3014** and **3015**, as in view *a* of FIG. **160**, its loading edge will engage and close the respective LS **3094**. LS **3094** will complete a circuit from source **2000** by line **3304** through solenoid **3287** of RS **3286** to source line **2001** and by branch line **3305** to timing relay TR **3306**, in circuit with source lines **2000** and **2001**.

Solenoid **3287** opens contacts **3285** of RS **3286** to break lines **3284** and **3288** thus de-energizing solenoid **3290** of RS **3291** although LS **3283** on the rail or track of unit **150** is held closed by the stationary carrier **160**. TR **3306** monitors a short interval during which the sheet assumes a suitable stationary position on the related conveyor system **3014** or **3015**, before being raised by the elevator brackets **3100**. Initially TR **3306** completes a circuit by line **3308** through solenoid **3292** of RS **3291** to thereby open contacts **3293**, **3294** and **3295** and close contacts **3296** to reset brake **3298** of motor **3028**.

Line **3309** from TR **3306** then makes a circuit through solenoid **3311** of RS **3312** to source **2001**, RS **3312** having opposed solenoid **3313**, open pairs of contacts **3314**, **3315** and **3316** and closed pair of contacts **3317**. Contacts **3317** normally maintain the circuit of a line **3318** through brake **3319** of motor **3106** to source line **2001**. Energization of solenoid **3311** acts to open line **3318** at contacts **3317** and completes circuits from sources **3281**, **2001** and **2002** by lines **3321**, **3322** and **3323** through closed pairs of contacts **3325**, **3326** and **3327** of polarity reversing RS **3328** to lines **3330**, **3331** and **3332** and motor **3106**. RS **3328** is equipped with opposed solenoids **3334** and **3335** as well as presently open pairs of contacts **3336**, **3337** and **3338**.

The duration of operation of motor **3106** for the elevator devices **3100** is dependent upon the vertical dimension of the sheet and consequently upon the distance that the elevator devices will be moved upwardly to raise the sheet until the upper end thereof closes LS **3115** at the top of each tilting frame **3050**. This is illustrated in view *b* of FIG. **160**. Engagement of LS **3115** completes a circuit by line **3340** through solenoid **3313** of RS **3312** thus operating to open the circuits of lines **3321**, **3322** and **3323** at contacts **3314**, **3315** and **3316** and close circuit of line **3318** through brake **3319** at contact **3317**. This will bring motor **3106** to a halt. In the event that LS **3115** fails to function, LS **3121** will be engaged to complete a circuit from line **2000** and line **3341** to line **3340** and thereby through the solenoid **3313**. This acts to prevent over travel of the elevator devices by stopping motor **3106**.

As will hereinafter be more fully described and during upward movement of the elevator devices, actuator plate **3160** on the base plate **3101** of one of the devices will engage LS **3267**.

Branch line **3342** from LS **3115** activates TR **3344**, in circuit with sources **2000** and **2001**, which after a short delay, makes a circuit by line **3345** through the solenoid **3346** of RS **3347** which has an opposed solenoid **3348**, presently open pairs of contacts **3350**, **3351** and **3352** and a closed pair of contacts **3353**, contacts **3353** usually maintaining a line **3355** through brake **3356** of motor **3228** to source line **2001**. Solenoid **3346** acts to open the circuit of brake **3356** at contacts **3353** and closes contacts **3350**, **3351** and **3352** to establish circuits from sources **3280**, **2001** and **2002** by lines **3357**, **3358** and **3359**, presently closed pairs of contacts **3360**, **3361** and **3362** of polarity reversing RS **3363** and lines **3365**, **3366** and **3367** to motor **3228**. RS **3363** is also equipped with opposed solenoids **3369** and **3370** and presently open pairs of contacts **3371**, **3372** and **3373**.

Each motor **3228** operates the related shaft **3215** to pivot the vacuum frames **3200** outwardly and inwardly relative to the associated tilting frames **3050**. This motion, however, is interrupted, before reaching the maximum outward distance, upon closure of LS **3238** which halts motor **3228** until the rims of at least the vacuum cups **3245** are suitably in interfacial relation with the opposed surface of the glass sheet. LS **3238** acts to energize valve **3272** connected to the source of vacuum to create an evacuated condition at the cups **3245** and **3246** and then restore operation of motor **3228**. The final pivoting action of the vacuum frames **3200** in an upward and outward direction with the glass sheets supported thereby places the upper end of the sheet substantially at the proper elevation preparatory to engagement by the clamping devices **1613** of the respective carrier **160** when the associated tilting frame **3050** has been swung to a vertical plane. At this immediate phase of the cycle, the tilting frame **3050** and sheet are still inclined at an angle of 7°. At this time, however, the connection of the lower row of cups **3246** may or may not be interrupted, as aforementioned. Thus, the valve **3273** is provided to control the connection of vacuum cups **3246** with regard to the vertical dimension of the particular sheet that is presently handled by the loading unit. By way of example, when a sheet, having a vertical dimension of 10 feet is raised by the elevator devices **3100** until the upper edge engages LS **3115**, its lower margin will be within the effective area of the lower row of vacuum cups **3246**. On the other hand, when the upper edge of a sheet, having a vertical dimension of 7 feet, as in view *c* of FIG. **160**, engages LS **3115**, the lower margin thereof will be situated well above the area of the lower cups. In this event, the valve **3273** is activated to interrupt communication between pipe **3263** and **3264** to the source of vacuum.

Accordingly when the lower margin of a shorter sheet is raised above the elevational area of the lower row of vacuum cups, LS **3267** will be closed by actuator plate **3160** to complete a circuit by line **3378** from source line **2000** through the valve **3273** to source line **2001** in a preparatory action preceding operation of valve **3272** to connect pipes **3259** and **3264** to the source of vacuum.

For those purposes, LS **3238**, by line **3379** from source line **2000** and through closed contacts **3380** of spring-biased RS **3381**, having solenoid **3382**, completes line **3383** through solenoid **3348** of RS **3347** to source **2201**, thus acting to open lines **3357**, **3358** and **3359** at contacts **3350**, **3351** and **3352** and closing contacts **3353** to complete line **3355** to brake **3356**. By line **3385**, LS **3238** also causes activation of TR **3386**, in circuit with sources **2000** and **2001**, which by line **3387** through solenoid **3382** of RS **3381** operates to disengage contacts **3380** thereby opening line **3379** from source line

2000 to LS 3238. TR 3386 by line 3388 (FIG. 111) then makes a circuit through end 3389 of valve 3272 (FIG. 112) to source 2001 to connect pipe 3390 from a source of vacuum (not shown) to distributor pipe 3391 and to pipe 3259 to the four upper rows of vacuum cups 3245. Of course, pipe 3264 will be connected to the source but the valve 3273, if closed, will interrupt communication with pipes 3263.

Thus, the activity phase of TR 3386 can be adjusted to complete line 3388 through the end 3389 of valve 3272 only after closure of LS 3267 since this limit switch will not be engaged by the plate 3160 and thus will remain in an open condition as determined by the lower margin of a sheet of longer vertical dimension so that the pipe 3390 will be in communication with pipes 3263 and 3264 through the valve 3273.

A low pressure switching device LP 3392 is connected in the distributor pipe 3391 and is adjusted to respond to the pressure drop in pipe 3391 and the degree of vacuum produced at the vacuum cups 3245 and 3246, to firmly adhere them to the surface of the sheet. The device 3392 then completes a circuit by line 3393 (FIG. 112) from source 2000 and line 3394 (FIG. 111) through presently engaged contacts 3395 of spring-biased relay switch RS 3396, equipped with solenoid 3397, and line 3398 through presently engaged contact pair 3399 of relay switch 3400 to and through solenoid 3401 thereof to source line 2001, RS 3400 having opposed solenoid 3402 and presently open contacts 3403. Contacts 3403, when engaged, complete the circuit of line 3404 from source line 2001 to line 3345 extending through solenoid 3346 of RS 3347. This serves to re-establish the circuits of lines 3357, 3358 and 3359 to motor 3228 while de-energizing the brake 3356. The vacuum frames 3200 will now be pivoted to the limit of their outward movement and will cause engagement of LS 3235, as seen in view *e* of FIG. 160.

Upon closure of LS 3235, a circuit is completed by line 3405 through presently engaged contacts 3406 of RS 3407, having opposed solenoids 3408 and 3409 and line 3410 to activate TR 3411, in circuit with source lines 2000 and 2001, which initially completes a circuit by line 3412 through solenoid 3402 of RS 3400 to source line 2001 thereby separating contact pair 3403 and reclosing contact pair 3399. This operates to open the circuit of line 3404. Line 3412 then makes a circuit (FIG. 112) through solenoid 3397 of RS 3396 to source line 2001 which operates to disengage contact pair 3395 to interrupt the circuit of lines 3394 and 3398. TR 3411 then makes a circuit by line 3413 via line 3383 through solenoid 3348 of RS 3347 to again halt motor 3228. TR 3411 by line 3414 then completes a circuit through solenoid 3409 of RS 3407 to open service of line 3405 at disengaged contacts 3406. Line 3414 via line 3415 (FIGS. 111 and 112) also makes a circuit through solenoid 3416 of spring-biased RS 3417 to source 2001, such RS 3417 having presently open pair of contacts 3418.

When solenoid 3416 engages a pair of contacts 3418, a circuit from source 3281 will be established by line 3419, through the solenoid 3420 of RS 3421 to source 2001, this relay switch having opposed solenoid 3422, open pairs of contacts 3423, 3424 and 3425 and presently closed pairs of contacts 3426 which maintain a circuit by line 3427 through the brake 3428 of motor 3069. When energized, solenoid 3420 acts to disengage contacts 3426 while closing contacts 3423, 3424 and 3425 to create circuits from sources 3281, 2001 and 2002 to motor 3069 by lines 3429, 3430 and 3431.

Since motor 3069 operates to swing the tilt frame 3050 inwardly and then outwardly, it is natural that the polarity thereof should be alternatively reversed. To this end, lines 3429, 3430 and 3431 are presently completed through engaged pairs of contacts 3432, 3433 and 3434 of polarity reversing RS 3435 and lines 3436, 3437 and 3438 to motor 3069. RS 3435 is also equipped with opposed solenoids 3440 and 3441 and presently disengaged pairs of contacts 3442, 3443 and 3444. In this connection, it should be noted that when TR 3411 becomes inactive, the circuit of line 3412 becomes ineffectual to maintain solenoid 3397 energized whereupon the contacts 3395 of RS 3396 are moved to the closed position thereby remaking the circuit of lines 3394 and 3398. This is also true with regard to line 3413, line 3414 to solenoid 3409 of RS 3407 and line 3415 to solenoid 3416 of RS 3417 which will disengage contact pair 3418 and operate to deenergize solenoid 3420 of RS 3421.

When the tilt frame 3050 is vertically positioned as in view *f* of fIG. 160, it will engage LS 3034 which will result in the completion of line 3447 from source 2000 through solenoid 3422 of RS 3421, to source 2001 to halt the motor 3069. LS 3034 by line 3448 also completes a circuit to TR 3450, in circuit with sources 2000 and 2001. This timer then completes a circuit by line 3451 and presently closed side 3452 of LS 1765 to line 3453 through end 3454 of valve 1731 to source 2001. Valve 1731 is connected to pressure and sump sources by pipes 1732 and 3455, respectively, and, when valve end 3454 is active, supply pipe 1732 will direct pressure by pipe 1729 to the rod end of cylinder 1726 which, through pairs of sprockets 1748 and 1749, produces motion of chain belts 1745 and 1746 to actuate the slide plates 1636 of the carrier 160 by the plates 1645 and lower the associated clamping levers 1626 into engagement with one surface of the upper margin of the sheet thereby moving the opposite surface positively against bars 1614.

Upon inward movement of the piston rod 1725, the actuator 1770 on slide block 1724 will release LS 1765 and, when the clamping action has been completed, engage LS 1766.

Upon closure of LS 1766 a circuit from source line 2000 by line 3456 also activates TR 3457, in circuit with sources 2000 and 2001. The circuit of line 3456 is completed by line 3458 which is controlled by TR 3457 and consequently is opened when said timer is activated. During inward movement of the piston rod 1725 of cylinder 1726, LS 1765 is released, as above noted, whereupon the side 3452 will open the circuit of lines 3451 and 3453 to de-energize valve and 3454. After a short interval between the sequential phases of operation, TR 3457 completes a circuit by line 3459 through solenoid 3460 of RS 3461 to source line 2001, RS 3461 having opposed solenoid 3462 and presently open pairs of contacts 3463. When solenoid 3460 becomes operable to engage contacts 3463, a circuit is made from source line 2000 by line 3465 through end 3466 of valve 1868 to source 2001, such valve being connected by pipe 1873 to the pressure source and pipe 3467 to sump. Movement of the valve spool from neutral causes valve 1868 to direct pressure by pipes 1871 to the head end of cylinders 1864 whereupon rods 1863 will cause gear racks 1860 to rotate gears 1859 to turn the associated eccentric shafts 1839. Upon the rotation of 180° of gears 1859, the rods 1863 cause blocks 1880 to engage LS 1884 which initially completes a circuit from source 2000 by line 3468 through solenoid 3462 of RS 3461 to source 2001, thereby disengaging contacts 3463 to open line 3465 and permitting valve 1868 to block pipe 1871 as the valve spool returns to neutral. As hereinabove described, the dual action of cylinders 1864 to rotate the related accentric shafts 1839 causes the chuck members 1851 and 1663 to rotate shafts 1657 thereby effectively securing the clamped condition of the sheets with regard to the associated carrier 160.

By branch line 3470 from line 3468, circuits are made to TR 3471 and 3472, in circuit with source lines 3251 and 2001. TR 3471 initially completes a circuit by line 3474 through end 3475 of valve 3272 to source line 2001. This serves to close communication between pipes 3390 and 3391 to relieve the vacuum and to open a similar connection between pipe 3391 and an air pressure pipe 3476 to free the vacuum cups from the sheet by the application of air thereagainst.

At this time, the carriers are supporting the sheets and can be removed from the loading area. This is in accordance with the preferred manner of operation wherein a preceding pair of carriers 160 on the entry conveyor drive unit 145 at the entering end of the processing side of the apparatus (FIGS. 1 and 3) have been advanced into the actual processing areas. By way of example, when the pair of carriers on the loading conveyor

drive unit **150** are to be removed, the circuits to the motors **1467** and **1468** of the conveyor drive unit **145** (FIG. **68**) are completed whereupon the chain belts **1458** and **1459** will begin operation. This action will also complete the circuits of motor **1363** (FIG. **67**) of the bridging carriage **135** to drive the chain belts **1374** and **1375** thereof. Now, with the belt motors of the entry conveyor drive unit **145** and of the bridging carriage **135** operating, the belt motors **1505** and **1506** of the loading conveyor drive unit **150** (FIG. **66**) will be put into operation.

Thus, the bars **1675** at the loading ends of the carriers will advance the same by magnetic contact with the plates **1500** until the chain belts **1524** and **1525** enter the looped ends thereof about the sprockets **1519** and **1520**. Subsequent to separation of the leading bars **1675** from the plates **1500**, and while the trailing bars **1675** are still propelling the associated carriers forwardly by plates **1500**, such leading bars **1675** enter magnetic contact with the plates **1392** carried by the chain belts **1374** and **1375**. Eventually, the trailing bars **1675** separate from the chain belts of the loading conveyor drive unit **150** and the bridging carriage **135** while the leading bars **1675** magnetically engage with the plates of the chain belts **1458** and **1459** of the entry conveyor drive unit **145**. In this way, the carriers are removed from the area above the loading unit **28** and the component elements thereof can be returned to their original positions.

Thus, after TR **3471** has originated the circuit of line **3474** to valve **3272**, a second circuit is completed by line **3480** through the solenoid **3481** of spring-biased relay switch **3482**, having normally disengaged contact pair **3483**. Contact pair **3483** then completes the circuit of line **2318** to remove the carriers **160** from the loading conveyor drive unit **150**, as above set forth. After a second interval of time, TR **3471** completes a circuit by line **3485** through presently closed contact side **3486** of LS **1765**, side **3452** being open, and line **3487** to the end **3488** of valve **1731** and by line **3490** through presently closed LS **1883** to the end **3491** of valve **1868**. The direction of pressure from valve **1731** through pipe **1730** will cause the piston rod **1725** to move outwardly until the slide block **1724** has returned the pins **1760**, carried by chain belts **1745** and **1746**, to their original positions, as in FIG. **53**, and side **3452** of LS **1765** is closed by the actuator plate **1770** and contact side **3486** is opened. Similarly, when the end **3491** of valve **1868** is energized, the direction of pressure from pipe **1873** to pipes **1870** and the rod end of cylinders **1864** will move the related piston rods **1863** inwardly. This will cause the gear racks **1860** to reversely turn the gears **1859** and shafts **1839** through an arc of substantially 180° and to move the blocks **1880** from LS **1884** to open the same while reopening LS **1883**. LS **1883**, in each instance and when released, will neutralize the valve **1868**.

TR **3471** is also adapted to complete through line **3495**, and branch lines **3496** and **3497** therefrom, circuits to the polarity reversing RS **3435**, **3363** and **3328**, respectively, in order that the respective motor **3069**, **3228** and **3106** will be adapted to return the tilting frames **3050**, the vacuum frames **3200** and the elevator devices **3100** to their rest positions. TR **3472**, on the other hand, is adapted to monitor an interval of desired length of time while circuits are set up to reverse the polarity of motors **3069**, **3228** and **3106** and to then initiate their operation in sequentially occurring phases.

Now when circuit lines **3495**, **3496** and **3497** are active, the circuit of line **3495** through solenoid **3440** of RS **3435** will open pairs of contacts **3432**, **3433** and **3434** while engaging pairs of contacts **3442**, **3443** and **3444**. A similar action will be reflected by the circuit of line **3496** through the solenoid **3369** of RS **3363** to source line **2001** which will open pairs of contacts **3360**, **3361** and **3362** while engaging pairs of contacts **3371**, **3372** and **3373**. Line **3495** also extends by way of line **3498** through solenoid **3499** of RS **3500** to source line **2001**, this relay switch having opposed solenoid **3501** and presently disengaged pair of contacts **3502**. When solenoid **3499** is energized, it produces engagement of contacts **3502** to establish a line **3504** from source line **2000** to one side of LS **3032** for reasons to be hereinafter more fully disclosed.

Line **3497** completes a circuit through solenoid **3334** of RS **3328** to source line **2001**, thereby disengaging contact pairs **3325**, **3326** and **3327** while engaging related contact pairs **3336**, **3337** and **3338**.

At the end of the interval of time for which TR **3472** was adjusted, it completes, by line **3506**, a circuit by lines **3419**, the contacts **3418** of RS **3417** being open, through solenoid **3420** of RS **3421** to source line **2001** whereupon contacts **3426** will separate to release brake **3428** and close contacts **3423**, **3424** and **3425** thereby restoring the circuits of lines **3429**, **3430** and **3431**. At this time, however, the circuitry of motor **3069** is by way of contacts, **3442**, **3443** and **3444**. In consequence, line **3429** will extend through contacts **3442** and line **3507** to line **3437** and motor **3069**, line **3430** through contacts **3443** and line **3508** to line **3436** and line **3431** through contacts **3444** and line **3509** to line **3438**. When the tilting frame **3050** has been swung outwardly to the 7° position, as seen in view *g* of FIG. **160**, LS **3032** is closed to complete a circuit from source line **2001** by lines **3504** and **3511** to line **3447** through solenoid **3422** of RS **3421** to source line **2001** to open contacts **3423**, **3424** and **3425** while resetting brake **3428** upon closure of contacts **3426**. By line **3512** LS **3032** also activates TR **3513**, in circuit with source lines **2000** and **2001**. TR **3513** establishes a circuit by line **3515** through the opposed solenoid **3501** of RS **3500** to source line **2001** and causes disengagement of contacts **3502** with resulting opening of line **3504** to source line **2000**. Since LS **3032** is held in the closed condition when the tilt frame is in its rest position of the 7° angle, the circuit of line **3504** to LS **3032** is therefore rendered ineffectual until subsequently operated as required for the purpose hereinabove described. TR **3513** by line **3518** through solenoid **3441** of RS **3435** to source line **2001** then causes opening of contacts **3442**, **34433** and **3444** and recloses pairs of contacts **3432**, **3433** and **3434** thereby restoring the original polarity for the circuitry of motor **3069** to subsequently swing the related tilting frame **3050** inwardly to the vertical position.

By line **3520** (FIG. **111**) from line **3506**, a circuit is then completed to line **3345** through solenoid **3346** of RS **3347** to source line **2001** thereby closing pairs of contacts **3350**, **3351** and **3352** while opening contacts **3353** to release brake **3356**. In the present instance, the circuits of the active motor lines are by way of contacts pairs **3371**, **3372** and **3373** of RS **3363** with the result that line **3357** presently extends through contacts **3371** and line **3522** to line **3366** and motor **3228**, line **3358** being extended by contacts **3372** and line **3523** to line **3365** while line **3359** through contacts **3373** and line **3524** connects to line **3367**.

Branch line **3526** from line **3520** completes a circuit through the presently closed pair of contacts **3527** of RS **3528** and line **3529** through solenoid **3530** to source line **2001**, RS **3528** having opposed solenoid **3531** and open pair of contacts **3532**. This will cause engagement of contacts **3532** which will complete a circuit from source line **2000** by line **3534** to one side of LS **3232** while opening the circuit of line **3526** at disengaged contacts **3527**. Line **3526** by branch line **3530** also completes a circuit through solenoid **3408** of RS **3407** to source line **2001**. This will disengage contact pair **3406** to break the circuit of line **3405** to one side of LS **3235**. Similarly, line **3526** by line **3536** completes a circuit through the presently engaged pair of contacts **3537** of RS **3538** and line **3539** through associated solenoid **3540** to source line **2001**, this relay switch having opposed solenoid **3541** and open pair of contacts **3542**. This will cause engagement of contacts **3452** which will complete a circuit from source line **2001** by line **3543** to one side of LS **3117** while breaking the circuit of line **3536** at then disengaged contacts **3537**.

Operation of motor **3228** will produce rearward pivotal movement of the vacuum frames until LS **3232** is engaged. This limit switch will then complete a circuit from line **3534** to line **3544** and, via line **3383**, through solenoid **3348** of RS

3347 to source line 2001 thereby reopening contacts 3350, 3351 and 3352 and reclosing contacts 3353 to halt motor 3228 and set brake 3356. By line 3545, LS 3232 activates TR 3547 and TR 3548, both in circuit with source lines 2000 and 2001. TR 3547 after a short delay creates a circuit by line 3549 through solenoid 3531 of RS 3528 to source line 2001. This operates to open the circuit of line 3534 at disengaged contacts 3532 and reclose line 3526 at contacts 3527. This will de-activate LS 3232 until its utility is again required in a subsequent cycle of operation since, with the vacuum frames in their innermost position, the switch will be held closed.

TR 3548, on the other hand, initially makes a circuit by line 3550 through solenoid 3370 of RS 3363 to source line 2001 which produces opening of contact pairs 3371, 3372 and 3373 and reclosure of contacts 3360, 3361 and 3362 to restore the original polarity of the circuitry of motor 3228 for subsequent outward swinging motion of the vacuum cup frames 3200. TR 3548 then monitors an interval of time while the motor 3228 is halted and the vacuum frames come to rest and then establishes a circuit by line 3551, extended by line 3309, through solenoid 3311 of RS 3312 to source line 2001 thereby producing closure of contact pairs 3314, 3315 and 3316, with resulting completion of circuit lines 3321, 3322 and 3323 and opening of contact pair 3317 to release brake 3319. Line 3321 thus connects to line 3331 via contact pair 3336 and line 3552, line 3322 to line 3330 by contacts 3337 and line 3553, while line 3323 is extended to motor line 3332 by way of contacts 3338 and line 3554. Reversed polarity of motor 3106 now produces downward movement of the elevator devices 3100 until LS 3117 is engaged.

LS 3117 completes a circuit from line 3543 and by line 3556 and 3340 through solenoid 3313 of RS 3312 to source line 2001. This operates to open pairs of contacts 3314, 3315 and 3316 to interrupt the circuits to motor 3106 while reclosing pair of contacts 3317 to set brake 3319. Further, by line 3557, LS 3117 activates TR 3558, in circuit with source lines 2000 and 2001, which is instrumental in completing a circuit by line 3560 through solenoid 3541 of RS 3538 to source line 2001. This will open the circuit of line 3543 at disengaged pair of contacts 3542 and restore the circuit of line 3536 at contact pair 3537. As in the case of limit switches 3032 and 3232, the breaking of line 3543 will render limit switch 3117 ineffectual as long as the elevator devices 3100 remain in their lower, rest positions. TR 3558 also establishes a circuit by line 3561 through solenoid 3335 of RS 3328 to source line 2001. This will act to reverse the polarity of motor 3106 upon disengagement of contacts 3336, 3337 and 3338 and engagement of contact pairs 3325, 3326 and 3327. Now, the respective motors 3069, 3228 and 3106 will have been halted with the tilting frames 3050, the vacuum frames 3200 and the elevator devices 3100 returned to their original positions for reception of a subsequent pair of glass sheets.

The loading unit is now re-conditioned to receive another pair of sheets from the turntable unit. And, since LS 2677, 2678 and 2679 have been permitted to open by the removal of the preceding pair of sheets to the carrier 160, the circuits of both the turntable 27 and, in sequence, the loading unit 28 are adapted to again receive sheets from the inspection area. As described in connection with FIG. 66 which discusses the circuit system of the belt motors 1505 and 1506 of the conveyor drive unit 150 associated with the loader, when a pair of carriers have been halted on the tracks 1017 and 1018 a circuit from TR 2293 is made by line 2296 to permit operation of the loading unit 28 and in sequence the turntable unit 27.

Referring again to FIGS. 1 and 2, it has earlier been described that when a pair of carriers, loaded with sheets of glass, have been transported to the entry end 13 of the processing side 14, they are positioned to be conveyed through the several chambers of the apparatus. As shown in the above-noted figures, the chambers are separated one from another by valve compartments. These are so designated because as the carriers are sequentially moved forward at least two chambers will be in communication with one another while by means of the valve compartments they will be sealed from the ambient conditions of outside atmosphere or operating conditions in an adjoining chamber. More especially, after being moved into the first chamber and until the carriers leave the sixth chamber, they are located in evacuated areas that are connected to suitable sources of vacuum as indicated by the letters V.

The loading of a pair of carriers 160 with sheets of glass and their eastward movement from the conveyor drive unit 150, across the bridging carriage 135 and onto the tracks of the conveyor drive unit 145 is believed now to be thoroughly understood. Also, the automatic sequencing of these operations has been sufficiently set forth in the descriptions of the interrelated control systems. Thus in considering FIGS. 113 and 114, it is quite apparent that the carriers 160, at least the south carrier being illustrated in FIG. 114, are being moved eastwardly from the bridging carriage 135 onto the tracks 1026 and 1027 of the entry conveyor drive unit 145. In this connection, it will be noted that the leading magnetic bar 1675 of each carrier is engaged with the conveyor chain belts 1458 and 1459 of the unit 145 to provide the conveying force until the motors 1467 and 1468 are halted.

While still considering FIG. 114, the initial unit of the processing side of the apparatus will be seen to include a "de-duster" unit, generally designated by the numeral 350, through which the glass sheets are passed as they are carried into the first valve compartment. This unit, as previously mentioned, removes dust which may have settled on the sheets between the washing apparatus and the vacuum chambers, which dust must be removed before the sheets are coated in order to avoid defects in the films. The de-dusting step is preferably accomplished by subjecting the sheets to jets of partially ionized air. In this connection, and as viewed in FIGS. 115, 116, 117 and 118, the unit 350 includes framing members 3501 formed by vertically disposed pairs of bars 3502 and 3503 that are provided at their upper ends with shafts 3504 carried at their ends in bearing members 3505. These members are supported by brackets 3506 attached to the structural parts of the entry conveyor drive unit 145. As viewed in FIG. 117, the lower ends of each pair of bars 3502 and 3503 are united in spaced, parallel relation by turn-buckle type of links 3507 and resiliently connected to floor-mounted posts 3508 by coil springs 3509. The exact positioning of the thus interjoined pairs of bars 3502 and 3503 is determined by set screws 3510 threadedly carried by the posts 3508 and equipped with lock nuts 3511. Each of the pairs of bars is conneCted by bracing angles 3514 on which perforated air supply pipes 3515 are supported, with an electrode 3516 being axially located in each pipe (FIG. 118). In operation, a sufficient potential, e.g., 5,000 volts (60 cycle, A.C.), is established between the electrode and the pipe to maintain a corona discharge through which the air is passed to partially ionize same. This treatment leaves the glass surface free of any static charge so that it does not attract any dust during its travel into and through the chambers. In this respect, rollers 3517 are provided, rotatably mounted by brackets 3518 on angles 3519 to guide a glass sheet between the pipes 3515.

In considering the valve compartments of the apparatus, reference is now made to FIGS. 113, 123, 126, 127 and 130. Thus, a valve compartment 360 is located at the west end of the first chamber 370 and a valve compartment 361 is located between the chamber 370 and the second chamber 390, FIG. 113. A valve compartment 362 is similarly located between the second chamber and the third chamber 420 (FIGS. 123 and 126) while a valve compartment 363 is arranged between the opposite end of the chamber 420 and an adjoining chamber 440. Likewise, a valve compartment 364 is located between the exit end of chamber 440 (FIG. 127) and the chamber 470 while valve compartment 365 is located between the opposite end of chamber 470 and the adjoining chamber 490, as in FIG. 130. The exit end of chamber 490 is provided with the valve compartment 366.

From a functional view-point, the active progress of a pair of sheets in the fourth chamber determines the initial successive movements in the first three chambers and then the later movements in the fifth and sixth chambers. As will hereinafter be more fully described in connection with the control system of FIG. **139**, at least two, if not three, pairs of sheets can be simultaneously conveyed into and through the filming area of the fourth chamber **440**. Generally stated, after a first pair of sheets have progressed from the entry area of the chamber a distance somewhat longer than their length, a second pair of sheets can be admitted into the entry end of the chamber. Then, if desired, as the first pair of sheets are conveyed toward the exit end of the chamber and the second pair of sheets are passing through the central area, a third pair of sheets can be advanced from the third chamber **420** into the entry area of the filming chamber. After a pair of sheets have been removed from the fourth or filming chamber, they enter the fifth chamber and subsequent pairs or pairs of sheets, in sequence, can be advanced from the third chamber. This permits a pair of sheets in a second station of the second chamber to enter the third chamber after which the pair in a first station of the second chamber will be advanced into the second station. Now, while the filmed sheets in the fifth chamber are moved into the sixth chamber and eventually removed into the transfer area, a subsequent pair of sheets will be advanced from first chamber into the first area of the second chamber. In this way, the carriers in the loading area will be permitted to advance step-wise onto the entry conveyor drive unit **145** and then be conveyed into the first chamber.

The structural casing **3600** of each valve compartment is equipped with a closure panel or door **3601** (FIG. **113**) which, in one way or another, has a sealing element **3602** adapted to effectively seal the open areaway into or out of the respective chambers. And, while the embodiments of such sealing types of closure panels form no part of the instant invention, means is simply shown for pivoting the door from the sealing position as shown in dotted lines to the open position as indicated in dot and dash lines. Such pivoting means includes arms **3603** fixed to a vertically disposed shaft **3604** and swingably journaled in the central areas of the upper and lower surfaces of the door, as at **3605**. The shaft **3604** is caused to revolve by means of an air-actuated cylinder (not shown) that is supplied at its opposite ends with air pressure controlled from valves about which more will be said later. As the door is swung toward the open position, a device on one end of the door is caused to follow a track **3606** whereby the sealing surface of the door will be directed toward a wall of the compartment and thus protected from damage by inadvertent breakage of a glass sheet.

Briefly stated, the door **3601** of compartment **360** is opened when a pair of carriers are to be admitted into the first chamber **370** and then closed to seal the chamber from the door **3601** of compartment **360** to the door **3601** of the valve compartment **361**. This acts to positively and hermetically seal the entry end of the apparatus from the ambient atmosphere. As shown in FIG. **124**, the first chamber **370** is formed by side walls **3700**, floor or bottom wall **3701** and ceiling or top wall **3702**, re-enforced by structural members **3703** (FIG. **113**), to which is fixedly mounted parallel rails **3705** and **3706** supported by brackets **3707** from the ceiling **3702**. It will be noted that the west ends of rails **3705** and **3706** are spaced from the surface of the door **3601** while the exit or east ends extend into the valve compartment **361**. In this connection, it will also be noted that the entry area of the valve compartment **360** is provided with a pair of short rails or tracks **3608** and **3609** which span the space between the pair of tracks **1026** and **1027** of the entry conveyor drive unit **145** and the aligned pair of tracks **3705** and **3706** in the first chamber **370**.

With more particular reference to the source of power (FIGS. **119** and **121**), the pair of chain belts **3710** for the first chamber **370** are equipped with magnetically attractable plates **3711**. The gear-motor **3712** for this pair of belts is mounted on a platform **3713** and its output shaft mounts sprocket **3714** which by chain belt **3715** drives sprocket **3716** on shaft **3717**, such shaft being journaled in bearings **3718** on pedestals **3719**. The shaft **3717** at its outer ends is equipped with sprockets **3722** which by chain belts **3723** drive sprockets **3724** and shaft **3725**. Each shaft **3725** is journaled in sealed bearing devices **3726**. These units are mounted in the walls **3700** of the chamber and are constructed with suitable sealing glands or like elements to prevent objectionable ingress of air which would unbalance the efficiency of the evacuated condition to which the chamber **370** is subjected when in open communication with the second chamber. At its inner end, each shaft **3725** fixedly carries a sprocket **3728** around which each of the chain belts **3710** is entrained.

The opposite looped end of each chain belt **3711** is trained about an idler sprocket **3730**. Since the belt drives for the carriers **160** are located in each of the vacuum chambers of the processing apparatus, the shafts **3724** for driving the sprockets **3728** pass through the walls of the chamber, in all instances, by way of the sealed bearing units such as the units **3726**. As herein provided, the idler sprockets, such as the sprocket **3730**, are mounted by structural supports on the inner surfaces of the chamber walls. This manner of support is common to all of the chambers so that the details illustrated in FIGS. **120** and **121** are similar to all. Thus, each idler sprocket **3730** is mounted by shaft **3731** on bearings **3732** that are secured in the bifurcated ends **3733** of a support bar **3734**. The bar is slidably mounted between keeper plates **3736** on a block **3737** bolted to a base plate **3738** that is fixed to the wall **3700**. At its opposite end, the bar **3734** is provided with a cylindrical threaded rod end **3739** which passes through the outwardly directed flange **3740** of a wall-mounted bracket **3741** and outwardly therefrom is equipped with locknuts **3742**. The face of the flange **3740** toward the mounting block **3737** is provided with a tubular or cup-shaped chamber **3743** for receiving coil spring **3744**. This spring encircles the rod **3739** to abut the body portion of bar **3734** and urge the same to develop the desired tautness in the related chain belt **3710**. Through the use of locknuts **3742**, the expandability of the spring can be controlled to determine the desired tautness.

Also, as in connection with the chain belts of the previously described conveyor drive units, the rollers of each flight of the chain belts **3710** are supported between bars **3745** and **3746** that are secured to the flanges of channels **3747** (upper) and **3748** (lower). Adjacent the idler sprockets **3730**, the channels are mounted by similar brackets **3749** on the plate **3738** while adjacent the drive sprockets **3728** the opposite ends of the channels are supported by brackets **3750** on a wall-mounted plate **3751**.

As earlier described, the pressure of the second chamber **390** is lowered by suitable pumps V and as shown in FIG. **125** chamber **390** is formed by side walls **3900**, floor or wall **3901** and ceiling or top wall **3902**, re-enforced by structural members **3903** (FIG. **123**). Glow discharge devices **3904** in the first area, and **3905** in the second area, are conventionally shown in spaced relation to the side walls **3900** on which they are mounted by brackets **3906**.

The glow discharge devices comprise pairs of aluminum electrodes operating at high alternating current potential which is effective to thoroughly clean the sheet surfaces by ionic bombardment. In this connection, air, oxygen or other gas capable of ionization is bled into the chamber **390** during the cleaning operation to maintain the pressure at a proper level, preferably between $5 \times 10^{-2}$ to $5 \times 10^{-3}$ torr. A dwell period of approximately 140 to 180 seconds in the chamber with the glow operating has been found to be sufficient to enable satisfactory ionic bombardment cleaning, and while it is preferred that this period be split up, half in the first glow area and half in the second glow area for reasons of best sequencing throughout the entire system, it is possible to perform the complete glow discharge cleaning step in one area, e.g., the first area, and not employ the other unit during the time the sheet is positioned in the second area.

When the sheets are to be passed into the chamber **390**, the closure panel **3601** of valve compartment **361** is swung to the open position whereupon the vacuum condition in chambers **370** and **390** between valve compartments **360** and **362**, the latter being adjacent chamber **420**, is substantially equalized. It might be mentioned here that the pressure in chamber **390** is lower than that maintained in chamber **370** during the time the sheets are being acted upon therein so that a short pump down cycle must be initiated after the panels **3601** are again closed. In this second chamber, the carriers **160** traverse tracks **3907** and **3908** into the so-called first area and then aligned tracks **3909** and **3910** in the second area, all of such tracks being supported by brackets **3911** from the ceiling wall **3902**.

As shown in FIG. **123**, sources of power are provided for moving a pair of carriers **160** onto and along the tracks **3907** and **3908** in the first area of the chamber **390** onto the aligned tracks **3909** and **3910** in the second area and then forwardly into the third chamber. In this connection, it will be understood the sources of power and the transmissions thereof into the second chamber as well as in the third chamber, with the exception of dimensional differences, are structurally substantially the same as that shown and described in connection with FIGS. **119** and **121**. Thus the transmission of power from sprockets **3915** and **3916** to the chain belts **3917** and **3918**, respectively, through the side walls **3900** is handled by sealed bearing devices, such as is indicated by the numeral **3726** in FIG. **119**. However, since the second chamber **390** and third chamber **420** are wider than chamber **370**, the journal support for the driving sprockets **3915** and **3916** (FIG. **137**) are each carried by bracket members **3921** and **3922**, indicated in dotted line in FIG. **123**. The devices and idler sprockets **3919** and **3920** for maintaining the desired tautness in the pairs of chain belts **3917** and **3918** are also substantially the same as the mounting bar **3734** in FIGS. **121** and **122** except for the fact that the support therefor in chamber **390** is by bracket members **3923** and **3924**. In this connection, it will be noted that although not shown, since the support structures are substantially the same as in FIGS. **119** and **121**, the pairs of chain belts **3917** and **3918** are supported between the driving sprockets **3915** and **3916**, respectively, and the associated idler sprockets are carried by bars mounted by channels such as identified in FIG. **121** and there designated by the numerals **3745** to **3750**.

With more particular reference to the source of power for the chain belts **3917**, as in FIG. **137**, the gear-motor **3925** on platform **3926** drives sprocket **3927** on shaft **3928** by sprocket **3929** on its output shaft and chain belt **3930** trained thereabout. Shaft **3928** is journaled in bearings mounted on platform **3926** and at its ends is equipped with sprockets **3931** which by chain belts **3932** and sprockets **3933** on shafts **3934** drive the sprockets **3915**. The same is also true with regard to the gear-motor **3935** on the platform **3936**, the control system for which is shown in FIG. **137**. The output shaft of gear-motor **3935** has sprocket **3938** which by chain belt **3939** drives sprocket **3940** on shaft **3941**. This shaft is journaled in bearings on the platform **3936** and at its opposite ends is equipped with sprockets **3942** each of which drives a related shaft **3943** through chain belt **3944** and sprocket **3945**, drive sprocket **3916** for the associated chain belt **3918** being fixed at the inner end of shaft **3943**.

In sequentially occurring steps and with the closure panel **3601** of compartment **361** being again swung to the closed sealed position, the closure panel or door **3601** of valve compartment **362** is opened while of course the similar door **3601** of valve compartment **363** (FIG. **126**) is in the sealed position. Since the third chamber **420** is of course also under high vacuum, i.e., a lower pressure is maintained in chamber **420** than in **390**, as the carriers are moved forwardly from chamber **390** there will be no increase in pressure in the chamber **390**.

As shown in FIG. **128**, the third chamber **420** is formed by side walls **4200**, floor or bottom wall **4201** and ceiling or top wall **4204** and is structurally re-enforced by members **4203** (FIGS. **123** and **126**). In this chamber, the carriers traverse tracks **4205** and **4206** supported from the ceiling **4202** by brackets **4207** and as viewed in FIG. **126**, which is equally true in the other chambers, the entry ends of the tracks are spaced inwardly from the door **3601** of compartment **362** while the exit ends of the tracks extend into the valve compartment **363**. Chamber **420** is equipped with conventionally known electrical strip heaters **4209** carried by wall-mounted brackets **4120** which also mount insulation baffle plates **4211**.

The electrical strip heaters **4209** are effective to heat the sheets to a temperature in the range of from 200° F. to 700° F. In this respect, it has been found to be desirable to heat the sheets if they are to receive certain metal or metal oxide films while certain other materials are best applied to unheated surfaces. For example, aluminum is best applied to glass while the latter is at room temperature while various other materials, such as silica, adhere better and possess better optical properties if applied to heated glass surfaces.

When the door of valve compartment **362** is again closed, the second chamber **390** and first chamber **370** will be adapted to receive a pair of carriers **160** that are subsequently removed from the loading conveyor drive unit **150** and transferred to the entry conveyor drive unit **145**.

As shown in connection with FIGS. **126** and **138**, a source of power, or the gear-motor **4215**, is mounted on a platform **4216** carried by the structural members **4203** of the third chamber **420**. The output shaft of the gear-motor **4215** has a sprocket **4218** which by chain belt **4219** drives shaft **4220** through fixed sprocket **4221**. The opposite ends of shaft **4220** mount sprockets **4223** which by chain belts **4224** drive sprockets **4225** on the outer ends of shafts **4226** (FIG. **138**). These shafts, on each side of the chamber, pass through sealed bearing devices, as is indicated at **3726** in FIG. **119**, and through bracket members fixed to the top wall **4202** and indicated in broken line by the numeral **4227**. Inwardly of the respective bracket members **4227**, each shaft **4226** carries a sprocket **4230** about which one end loop of a conveyor chain belt **4231** is entrained, chain belts **4231** serving to move the carriers **160** through the chamber **420** when the gear-motor **4215** is operating. The opposite looped end of each chain belt **4231** is entrained about an idler sprocket **4232** supported on bracket **4233**.

When the closure doors **3601** of the valve compartments **362** and **363** are closed, the temperature of the glass sheets is raised by the heaters **4209** while the chamber is evacuated to substantially the pressure maintained in the fourth chamber **440**. The sheets are thus conditioned to enter the fourth chamber in which the outwardly directed surfaces of the glass sheets will receive a coating of desired filming material.

The filming chamber **440**, as in FIGS. **126**, **127** and **129**, is formed by side walls **4400**, bottom wall **4401**, top wall **4402**, re-enforced by structural members **4403** and with transversely aligned pairs of alcoves **4404**, **4405** and **4406** being provided in the sidewalls **4400** for mounting of the filming or evaporation sources generally indicated by the numeral **4407** in FIG. **129**. As indicated in FIGS. **126** and **127**, the evaporation sources are mounted in the side walls of the chamber **440** preferably in three vertical rows on each side of the chamber, each row comprising four sources. While any suitable means of heating the metal to be evaporated may be employed, it is preferred to utilize electron bombardment heating means due to the high evaporation rate and high temperature capability thereof. In this connection, excellent results have been obtained when employing sources similar to that described in U.S. Pat. application Ser. No. 287,386 to H. R. Smith, Jr.

All of the sources in any one vertical row will be used to evaporate the same material or mixture of materials. Successive rows may be used for either the same or different materials, with the coating time for each vertical row of sources thus being dependent upon the coating line speed and the length of the coating or filming zone. As an example, the four sources in each first row **4404** may contain chromium metal which is

evaporated at a rate to lay down a film of 60 Angstroms in thickness. This has been found to result in an excellent architectural film on glass having a visible light transmittance of 43 percent and a solar radiation transmittance of 44 percent, these values being obtained with a protective overcoat of silica applied over the chromium as hereinafter described.

Thus, the sources in both subsequent rows **4409** and **4406** may contain silica and be controlled to evaporate a protective overcoat of 0.25 to 1 mil of silica on top of the chromium as the sheets are conveyed therepast. Replenishing of the material in the sources is done from outside of the chamber, either through the shaft of the electron gun heating means or by feed tubes extending through air locks in the chamber wall. Either a granular or a wire feed may be employed.

Chamber **440** is equipped with tracks **4410** and **4411**, supported by brackets **4412** from the ceiling or top wall **4402**, for movement of a pair of carriers **160** through the filming areas. The ends of tracks **4410** and **4411** are spaced inwardly from the surfaces of the closure panels **3601** of the valve compartments **363** and **364**.

The carriers are conveyed through this chamber by a series of pairs of chain belts **4414**, **4415** and **4416** powered by interrelated sources of power such that they will enter at a selected high rate of speed, move through the filming areas at a greatly reduced rate of speed and be removed to the adjoining fifth chamber **470** upon resumption of the higher rate of speed. As shown in FIGS. **126**, **127**, **133**, **134**, **135**, **136**, **139** and **140**, these sources of power are designated by the numbers **4418**, **4419** and **4420**, the power sources being similarly employed gear-motors.

Generally speaking, the gear-motor **4418** on platform **4421**, FIGS. **133** and **135**, by its output shaft drives sprocket **4422** which through chain belt **4423** drives a shaft **4425** by sprocket **4426** thereon. The shaft **4425** is journaled in bearings **4427** mounted by similar brackets **4428** on platforms **4429**. The sprocket **4426** is fixed to the driver component of an electromagnetic clutch **4430**, the driven portion being fixed on the shaft. This shaft mounts a sprocket **4431** which by chain belt **4432** is adapted to drive the shaft from the power source **4419**, as will later be described. The shaft **4425** also drives a fixed sprocket **4433** which by chain belt **4434** operates a pulsing unit **4435**. The pulsing unit is associated with a counting device and their functions will be more fully described in connection with FIG. **139**.

At its outer ends, the shaft **4425** mounts sprockets **4436** which by chain belts **4437** drive sprockets **4438** on shafts **4439**. As seen in FIG. **135**, the shafts pass through sealed bearing devices **4440** mounted on the side walls **4400** and at their inner ends are journaled in bearings **4441** supported by brackets **4442** from the top wall **4402**. The inner ends of shafts **4439** similarly carry sprockets **4443** about which one looped end of the chain belts **4414** are trained. The idler sprockets about which the opposite end loops of the chain belts are entrained are mounted in the same manner as described in connection with the sprocket **3730** of FIG. **122**, the mounting block in the present instance, however, being supported by a bracket **4445** from the top wall **4402**.

Similarly the motor **4419** (FIGS. **133** and **136**), is mounted on a platform **4450** and is equipped on its output shaft with sprocket **4451** which, through chain belt **4452**, drives a sprocket **4453** on a shaft **4454**, such shaft being journaled in bearings **4455** on platform supported brackets **4456**. The sprocket **4453** is connected to the driver component of an electromagnetic clutch **4458**, the driven component being keyed to the shaft **4454**. Adjacent one of its ends, the shaft **4454** fixedly carries an overrunning clutch **4460** with sprocket **4461**, while adjacent the opposite end, there is mounted an overrunning clutch **4462** with sprocket **4463**, FIG. **136**. The sprocket **4461** during certain controlled phases of speed change, operates the sprocket **4431** on shaft **4425** through chain belt **4432**. At intervals of other occurring changes of speed, the sprocket **4463** through chain belt **4464** drives a sprocket **4465** on shaft **4466** which is otherwise driven by the gear-motor **4420**. As viewed in FIGS. **127**, **133** and **134**, the chain belts **4432** and **4464** are similarly supported by a U-shaped track **4467** mounted by posts **4468** on the structural members **4403**.

Shaft **4454** is also equipped with a sprocket **4469** which by chain belt **4470** drives a pulsing unit **4471** mounted by platform **4472** on a portion of the structure **4403**. As will be more fully described in connection with FIG. **139**, the pulsing unit **4471** is operated in conjunction with a counting device that is instrumental in monitoring the distance to be maintained between one pair of sheets in chamber **440** and a subsequent pair of sheets to be admitted. Since the filming sources operate substantially continuously, the relatively close spacing between the pairs of sheets minimizes the amount of filming materials that would otherwise be expended and result in objectionable deposits on the inner surfaces of the side walls **4400** of the chamber.

At each of its outer ends, the shaft **4454** is provided with sprockets **4474** which by chain belts **4475** drive sprockets **4476** on shafts **4477**. As seen in FIG. **136**, the shafts **4477**, in each instance, and in passing through the side walls **4400** of the chamber, are journaled in sealed bearing units **4478**, and inwardly thereof consist of a jack-shafting **4479** coupled together by suitable universal joints **4480**. The endmost portion of this shafting is journaled in a bearing member **4481** and mounts a sprocket **4482** about which a chain belt **4415** is trained. The bearing member **4481** is supported by bracket **4483** on the coiling **4402** of the chamber.

The opposite looped end of each chain belt **4415** is trained about an idler sprocket **4484** (FIG. **136**) journaled in the bifurcated ends of a support bar **4485**, such as has been previously identified by the numeral **3734** and described in connection with FIGS. **121** and **122**. In this instance, the mounting for the bar **4485** is supported on a plate **4486** which by a bracket **4487** is connected to the ceiling or top wall **4402**. Also the pairs of bars **4488** which support the chain belts **4415** between the drive and idler sprockets are mounted by channels **4489** attached to the brackets **4483** and **4487**.

With reference now to the pair of conveyor chain belts **4416**, it has been mentioned earlier that the shaft **4466** is driven at times by the shaft **4454** through the chain belt **4464**. This produces rotation of the shaft **4466** at a selected slow rate of speed while the gear-motor **4420** is associated with this shaft to drive the same at a faster rate of speed. To this end, the output shaft of the gear-motor **4420**, on platform **4492**, mounts a sprocket **4493** which through chain belt **4494** drives a sprocket **4495**, comprising a driving component of an electromagnetic clutch **4496**, the driven portion being fixed to the shaft **4466**. The shaft **4466** is journaled by bearings **4498** mounted by similar brackets **4499** on platforms **4500**. At its outer ends, the shaft **4466** fixedly carries sprockets **4502** which by chain belts **4503** drive sprockets **4504** on shafts **4505** (FIG. **140**). To reduce repetitive description of similar structures, the shafts **4505** are journaled, as are the shafts **4439**, shown in FIG. **135**, and the shafts **4477** of FIG. **136**, with the shafts **4505** driving sprockets **4506** about which one of the looped ends of chain belts **4416** are trained. The opposite looped end of each chain belt is also carried by an idler sprocket **4507** that, as shown in FIG. **135**, is similarly journaled in a bearing bracket **4508**, indicated in dotted line, supported from the ceiling **4402**. Since reference has heretofore been made to FIG. **121** as a typical mechanical arrangement for the drive and support of the conveyor chain belts associated with any one of units, it will be understood that the chain belts **4416** are also supported by bars that are mounted in channel members.

Briefly considering the interrelated operations of the power sources **4418**, **4419** and **4420** and before discussion of the control systems illustrated in FIGS. **139** and **140**, it may here be stated that as a pair of carriers **160** are entering the filming chamber **440**, they are conveyed by the chain belts **4414** that are driven at a substantially high entry rate of speed (such as 80 (FPM) feet per minute). This is due to the fact that the

electromagnetic clutch **4430** on shaft **4423** is acting to drive the same from the gear-motor **4418**. At this time, the sprocket **4431** will drive the chain belt **4432** and sprocket **4461** on shaft **4454** at the same rate of speed. However, since sprocket **4461** is carried by the overrunning clutch **4460**, the high rate of speed will not be in conflict with the slower speed, of about 2 to 8 feet per minute, at which shaft **4454** is normally operated.

When the pair of carriers **160** are both bodily in the entry end of chamber **440**, the electromagnetic clutch **4430** is de-energized and the gear-motor is halted whereby the drive by shaft **4454** and sprocket **4461** will be effective through chain belt **4432** to drive shaft **4425** at a reduced rate of speed by sprocket **4431**. The pair of chain belts **4414** will thereby be driven at the same slow rate of speed as the succeeding pair of chain belts **4415**. During this interval of operation while the carriers are being conveyed through the central area of the filming chamber and the glass sheets pass the filming sources **4407**, the overrunning clutch **4462** will be permitted to drive chain belt **4464** by sprocket **4463** to thereby drive the shaft **4466** by sprocket **4465**. This will cause the pair of chain belts **4416** to operate at a rate of speed common to the pairs of chain belts **4414** and **4415**.

As the pair of carriers approach the exit area of the filming chamber, the gear-motor **4420** is put in operation and electromagnetic clutch **4496** is energized to drive the shaft **4466** at the desired increased rate of speed, such as 80 FPM. During this interval of speed difference between the shaft **4454** and **4466**, the chain belt **4464** will be driven at the faster rate of speed but the overrunning clutch **4462** will release to permit the sprocket **4463** to overrun the speed of shaft **4454**. When the carriers have passed into the fifth chamber **470**, the gear-motor **4420** will be halted and the electromagnetic clutch **4496** de-energized. In the event that a second pair of carriers are moved into the chamber **440**, the gear-motor **4418** will be actuated in the manner above described until it is caused to halt while the chain belts **4414** resume operation at the lower rate of speed.

When rapid conveyance of a pair or pairs of carriers through the chamber **440** is, for one reason or another, necessitated, the gear-motor **4418** is operated with the clutch **4430** energized, the electromagnetic clutch **4458** on shaft **4454** is de-energized to permit the shaft to be driven by chain belt **4432** at the rate of speed of the shaft **4425**. Since the clutch **4458** no longer drives the shaft at the substantially constant slow speed, the clutches **4460** and **4462** will not be affected. In consequence and with the electromagnetic clutch **4496** energized, the pairs of chain belts **4414**, **4415** and **4416** by the related shafts **4425**, **4454** and **4466** will be driven at a common high rate of speed as the carriers are conveyed from the third chamber to the fifth chamber.

As viewed in FIG. **130** and **131**, the fifth chamber **470** is formed by side walls **4700**, bottom wall **4701** and top wall **4702** structurally braced by framing members **4703**. Tracks **4704** and **4705**, supported by brackets **4706** from the top wall **4702**, are provided in this chamber. The chamber **470**, through valve compartment **364**, communicates with the filming chamber **440** to receive glass sheets therefrom while a vacuum is maintained in this total area which is closed by the door of compartment **363** at the entrance end of chamber **440** and the door of compartment **365** at the exit end of chamber **470**. In this connection, it will be noted that the doors **3601** of compartments **364**, **365** and **366** are mounted to close and seal the exit ends of the respective chambers **440**, **470** and **490**. Also, exit ends of the associated pairs of tracks are spaced inwardly from the closure panels or doors while the entry ends of the tracks in the adjoining chamber are located in the compartments.

Referring now to FIG. **131**, the chamber **470** is not required for use in further processing of the glass sheets and serves merely as an interim cooling station to be evacuated just prior to and, if necessary, during communication with the filming chamber **440**. In this respect, the pressure in the chamber **470** will be raised when it is opened to the sixth or final chamber **490** thereby necessitating its communication with suitable pumps to again lower the pressure therein to one essentially approximating that maintained in the coating chamber, e.g. $1 \times 10^{-4}$ to $1 \times 10^{-7}$ torr. Of course, when the closure door **3601** of valve compartment **365** is to be opened, the similar panels of valve compartments **364** and **366** are closed.

A pair of carriers are conveyed through the chamber **470** by means of the pair of chain belts **4708** that are similarly entrained about drive sprockets **4709** and idler sprockets **4710**. Again, reference is made to FIGS. **121** and **122** as being typical of the mechanical supports for these sprockets so that further description here is not believed to be necessary other than that the support for idler sprockets **4710** is indicated in broken line in FIG. **136** and designated by the numeral **4711**.

The driven sprockets **4709** (FIG. **141**) are each fixed on shafts **4713** journaled in bearing brackets **4714** and passing through the side walls **4700** by way of sealed bearing units **4715**. Outwardly of the sidewalls of the chamber, each shaft mounts a sprocket **4716**. The sprockets **4716** are driven from a source of power, such as the gear-motor **4718**, which is mounted by platform **4719** on the framing structure **4703**. The output shaft of the gear-motor is equipped with a sprocket **4721** which by chain belt **4722** and sprocket **4723** drives shaft **4724** journaled by bearings on the platform **4719**. At its opposite ends, shaft **4724** carries fixed sprockets **4727** which by chain belts **4728** drive the related sprockets **4716** on the shafts **4713**.

The chamber **490**, as seen in FIGS. **130** and **132**, has side walls **4900**, bottom wall or floor **4901**, top wall **4902** and structural members **4903** and is provided with a pair of tracks **4904** and **4905** supported by brackets **4906** from the top wall **4902**.

A source of power, such as the gear-motor **4908**, mounted by platform **4909** on the framing structure **4903**, drives the pair of conveyor chain belts **4910** which move a pair of carriers **160** through this sixth chamber. Thus, a sprocket **4912** on the output shaft of the motor through chain belt **4913** drives a shaft **4914** by fixed sprocket **4915**, FIG. **141**. Shaft **4914**, journaled by suitable bearings on the platform **4909**, has a sprocket **4918** fixed at each of its opposite ends, such sprockets driving shafts **4919** through related sprockets **4921** and chain belt **4922**. The conveyor chain belts **4910** are trained about drive sprockets **4923** on the inner ends of shafts **4919** which are journaled in bearing brackets **4925** while the idler sprocket **4926** is journaled in a bracket **4927** supported on the ceiling **4902** of the chamber, this being similar to the mounting arrangement of FIG. **121**.

After the door **3601** of the valve compartment **365** is again closed, the vacuum is relieved in the chamber **490** and the prevailing pressure is raised to substantially that of the ambient atmospheric pressure. As will be clarified during the discussion of FIG. **141**, the door **3601** of the valve compartment **366** will not be permitted to open until this pressure condition is obtained. However, when this pressure is obtained, the pair of chain belts **4910** will convey the carriers **160** outwardly along the tracks **4904** and **4905** and onto the aligned pair of tracks of the transfer carriage **510** in the transfer area **16**. It will be noted in FIG. **130** that the valve compartment **366**, as in the case of the compartment **360**, has a pair of short tracks **3610** and **3611** at the exit end to bridge the distance between the ends of the tracks **4904** and **4905** and the aligned pair on the transfer carriage **510**. As will hereinafter be more fully set forth, the carriage **510** transfers the carriers **160** with the filmed sheets northward from the exit end of the processing side **14** to the entry and **17** of the return side **18** of the conveyor system. This is illustrated in FIG. **130**.

As discussed in connection with FIG. **68**, the forward movement of a pair of carriers **160** from the entry conveyor drive unit **145** is predicated on the preceding departure of a pair of carriers from the first chamber **370** into the second chamber **390**. This action is dependent upon the raising of the pressure in the first chamber to that of the ambient atmosphere since before movement of a pair of carriers from the first chamber

can be initiated, the pressure therein must have been lowered to approximately $2 \times 10^{-1}$ to $5 \times 10^{-3}$ torr and it would be extremely difficult to open the closure panel **3601** of compartment **360** when the chamber was at this pressure due to the force of approximately 14 p.s.i. bearing thereagainst.

Thus, as schematically shown in FIG. **137**, a pressure switch or like device, such as an ionization gauge, **3755** is actuated when the pressure in chamber **370** reaches atmospheric pressure to complete a circuit by line **3756** to one side of LS **2389** (FIG. **68**). As presently shown, this limit switch completes line **3757** to a timing relay TR **3758**, in series with source lines **2000** and **2001**. TR **3755** first completes a circuit by line **3760** through the end **3761** of four-way valve **3762** to source line **2001**, this valve being connected to a source of fluid pressure by pipe **3763** and to sump by pipe **3764**. When thus activated, the valve directs fluid pressure by pipe **3765** to the head end of a cylinder **3766**, behind piston **3767**, such cylinder at the rod and being connected by pipe **3768** to the opposite end of the valve. The piston rod **3769**, during outward movement swings an arm **3770** secured to the end of shaft **3604**. This operates to move the associated closure panel **3601** of valve compartment **360** to the open position.

By line **3775**, TR **3758** completes a circuit through the solenoid **3776** of relay switch RS **3777** which, as will shortly be described, completes the circuits to gear-motor **3712**. RS **3777** is equipped with opposed solenoid **3776**, presently open pairs of contacts **3779**, **3780** and **3781** and closed pair of contacts **3782** which complete line **3783** through the brake **3784** of motor **3712**. When energized, solenoid **3776** produces engagement of contact pairs **3779**, **3780** and **3782** in complete service lines **3785**, **3786** and **3787**, respectively, from source lines **2000**, **2001** and **2002**, to the motor **3712** while de-energizing brake **3784** upon opening of contact pair **3782**. The output shaft of this motor now will drive chain belt **3715** by sprocket **3714** and shaft **3717** to drive chain belts **3723** through sprockets **3722**. This will result in the driving of shafts **3725** and conveyor chain belts **3710**.

TR **3758** then establishes the circuit of line **2390** to TR **2391** (FIG. **68**) which as previously described is instrumental in energizing the coupler clutch **1475** and de-energizing clutch **1479** whereupon the gear-motor **1467**, when started by RS **2370**, will drive conveyor chain belts **1458** and **1459**. This will advance the pair of carriers from the tracks **1026** and **1027** through the de-duster unit **350** and valve compartment **360** onto the tracks **3705** and **3706** of the first chamber **370**.

By branch **3790** from line **3760**, a circuit is made through the solenoid **3791** of spring-biased switch RS **3702** to source line **2001**, the contact pair **3793** normally completing the circuit of line **3794** from presently closed switch device LS **3795**. This will de-energize the end **3796** of valve **3762**. By line **3797**, the circuit of line **3790** is also completed to a valve **3798** which controls either the ingress of filtered air into or the drawing of a vacuum in, the chamber **370**.

As the carriers enter chamber **370**, they will, in one way or another, act to trip LS **3795** to the open position and close an adjacent switch device LS **3800** and as they are bodily received on the tracks **3705** and **3706** and properly positioned in the chamber **370**, switch device **3801** will be engaged. Previously described LS **2414** is simultaneously closed to actuate TR **2416** (FIG. **68**) which is instrumental in reversing RS **2370** to halt motor **1467**. LS **3800** and LS **3801** complete the circuit of line **3802** to a timing device TR **3803**, in series with source lines **2000** and **2001**. After an interval of time, TR **3803** by line **3804** completes a circuit through solenoid **3778** of RS **3777** to source line **2001** thereby disengaging contact pairs **3779**, **3780** and **3781** to halt motor **3712** while setting brake **3784** upon reclosure of contacts **3782**.

Since TR **3758** has ceased to function and the contacts **3793** of RS **3792** have been permitted to close, LS **3795** which has now been released by the trailing end or ends of the carriers **160** will complete the circuit of line **3794** through the end **3796** of valve **3762** to source line **2001**. This will reverse the spool of the valve to direct pressure from pipe **3763** through pipe **3768** to the rod end of cylinder **3766**. Piston rod **3769** will thus be retracted to swing arm **3770** and consequently rotate shaft **3604** to return the closure panel **3601** of valve compartment **360** to its sealed position. Now when the chamber **370** is hermetically closed at valve compartments **360** and **361**, TR **3803** will complete the circuit of line **3805** to the valve **3798** which is adapted to then connect the chamber to a source of vacuum whereby the pressure of chamber **370** will be lowered to that desired therein, e.g., $2 \times 10^{-1}$ to $5 \times 10^{-3}$ torr and preferably about $5 \times 10^{-2}$ torr.

In the ensuing progress of preceding carriers, such as a pair from the first station of chamber **390** to the second station, the pair of carriers in the first chamber **370** can be advanced into the second chamber and onto the pair of tracks **3907** and **3908** of the first station. To this end, a switch device LS **3950** (FIG. **137**) is engaged as a pair of carriers arrive on the tracks **3909** and **3910** of the second station and are halted thereon as will shortly be described. The circuit completed by LS **3950** is controlled by a low pressure switch device **3951** located in the first chamber **370** and activated when the evacuated condition of the chamber is substantially that desired. The required conditions being obtained, the device **3951** establishes a circuit by line **3952** through closed LS **3950** and line **3953** to a timing relay TR **3955**, in series with source lines **2000** and **2001**. TR **3955** first completes a circuit by line **3956** through the end **3957** of a four-way valve **3958** to source line **2001**, such valve being connected to the source of pressure by pipe **3959** and sump by pipe **3960**. When activated, the spool of the valve is moved to direct pressure through pipe **3962** to the head end of cylinder **3963**, behind piston **3964**, such cylinder being connected at the rod end by pipe **3965** to the opposite side of the valve. During outward motion of piston rod **3966**, an arm **3967** connected to shaft **3604** of valve compartment **361** is rotated to rotate said shaft and thus the associated closure panel **3601** to the open position. This will place chamber **370** in communication with the second chamber **390**.

By line **3970**, TR **3955** completes a circuit through solenoid **3971** of relay switch RS **3972** which establishes the service circuits to gear-motor **3925**. RS **3972** is equipped with opposed solenoid **3973**, presently disengaged pairs of contacts **3974**, **3975** and **3976** and closed pair of contacts **3977** which maintain brake **3978** of the motor energized by line **3979**. When energized, solenoid **3971** causes closure of contact pairs **3974**, **3975** and **3976**, while opening contact pair **3977**, to establish circuits from source lines **2000**, **2001** and **2002** and lines **3981**, **3982** and **3983** to gear-motor **3925**.

With the motor **3925** operating the conveyor chain belts **3917**, TR **3955** makes a circuit by line **3985** through the solenoid **3776** of RS **3777** to complete the circuits by lines **3785**, **3786** and **3787** to gear-motor **3712** while opening line **3979** to brake **3978**. Now, with the closure panel **3601** of valve chamber **361** in the open position and the pairs of conveyor chain belts **3710** in the chamber **370** and those (belts **3917**) in the first station of the chamber **390** operating, the carriers are removed from the tracks **3705** and **3706** onto the pair of tracks **3907** and **3908**.

By branch line **3988** from line **3956**, a circuit is simultaneously made through the solenoid **3989** of spring-biased relay switch RS **3990** to source line **2001**, the contact pair **3991** normally maintaining the circuit of line **3992** from presently closed switch device LS **3993**. Disengagement of contact pair **3991** has de-energized the end **3994** of valve **3958**. Line **3988** by branch **3995** also completes a circuit to a valve **3996** which can be employed to control the connection of the vacuum source (not shown) to the chamber **390**.

As the carriers are moved into the first station of the chamber **390**, they actuate LS **3993** to the open position and LS **4000** to the engaged position to complete the circuit if line **4001** to one side of LS **4002**. When the carriers are suitably positioned on the tracks **3907** and **3908** they will have engaged LS **4002**. This pair of limit switches can then make the circuit of line **4001** to a timing relay TR **4003**, in series with source lines **2000** and **2001**. TR **4003** initially makes a circuit

by line **4005** through solenoid **3778** of RS **3777** to disengage the contact pairs thereof and open the circuits to gear-motor **3712** while completing line **3783** to brake **3784** to energize the same to halt the motor.

Since TR **3955** has ceased to function and the contact pair **3991** of RS **3990** have reclosed, the circuit of line **3992** will be completed through LS **3993** as the trailing end of at least one carrier released the same. Line **3992** completes a circuit through the end **3994** of valve **3958**. As the position of the valve spool is reversed, pressure will be directed from pipe **3959** to the rod end of cylinder **3963** through pipe **3965**. As the piston rod **3966** is moved inwardly, the arm **3967** will rotate the shaft **3604** to return the closure panel **3601** of valve compartment **361** to the sealing position. TR **4003** by line **4006** through the solenoid **3973** of RS **3972** to source line **2001**, now causes the circuits to gear-motor **3925** to be opened thereby halting the same as the brake **3978** is again energized. TR **4003** by line **4007** establishes a circuit to valve **3996** thereby to restore the connection of the source of vacuum to chamber **390**, and lower, if necessary, the existing pressure to that desired in the second chamber, namely between $1 \times 10^{-2}$ to $1 \times 10^{-3}$ torr. TR **4003** further completes a circuit by line **4008** to timing relay TR **4009**, in series with source lines **2000** and **2001**. This timer maintains a circuit by line **4010** to activate the circuitry associated with the glow-discharge units **3904** for the period of time to which it has been adjusted.

When a pair of carriers **160** have been removed from the second station of chamber **390** into the third chamber **420** and the closure panel **3601** of valve compartment **362** is returned to the sealed position at the entrance to the third chamber, the pair of carriers in the first station of the chamber **390** (FIG. **123**) can be advanced to the second station.

For this purpose, as shown in FIG. **138**, a switch device LS **4015** in the third chamber **420** is closed by the carriers therein. LS **4015** from source line **2000** completes a circuit by line **4016** to a timing relay **4017** in series with source lines **2000** and **2001**. TR **4017** completes a circuit by line **4020** through the solenoid **4021** of relay switch RS **4022** which, as will shortly be described, completes the circuits to gear-motor **3935**. RS **4022** is equipped with opposed solenoid **4023**, presently open pairs of contacts **4024**, **4025** and **4026** and closed pair of contacts **4027** which complete line **4028** through the brake **4029** of motor **3935**. When energized, solenoid **4021** produces engagement of contact pairs **4024**, **4025** and **4026** to complete service lines **4031**, **4032** and **4033**, respectively, from source lines **2000**, **2001** and **2002**, to the motor **3935** while de-energizing brake **4029** upon opening of contact pair **4027**. The output shaft of this motor now will drive chain belt **3939** by sprocket **3938** and shaft **3941** to drive chain belts **3944** through sprockets **3942**. This will result in the driving of shafts **3943** and conveyor chain belts **3918**.

TR **4017** then establishes the circuit of line **4035** to solenoid **3971** of RS **3972** which will result in engagement of contact pairs **3974**, **3975** and **3976** to complete the circuits to gear-motor **3925** in the first station (FIG. **137**). This will also de-energize brake **3978** upon disengagement of contact pair **3977**. The pair of carriers will thus be moved from the tracks **3908** and **3909** in the first station onto the aligned tracks **3909** and **3910** in the second station.

At the carriers enter onto the pair of tracks **3909** and **3910**, they will, in one way or another, act to close an adjacent switch device LS **4037** (FIG. **138**) and as they are bodily received on the tracks **3909** and **3910** and properly positioned in the second station, switch device **4038** will be engaged. LS **4037** and LS **4038** complete the circuit of line **4039** to a timing device TR **4040**, in series with source lines **2000** and **2001**. After an interval of time, TR **4040** by line **4042** (FIGS. **137** and **138**) completes a circuit through solenoid **3973** of RS **3972** to source line **2001** thereby disengaging contact pairs **3974**, **3975** and **3976** to halt motor **3925** while setting brake **3978** upon reclosure of contact pair **3977**.

TR **4040** then completes the circuit of line **4044** through the solenoid **4023** of RS **4022** to source line **2001**, this resulting in the disengagement of contact pairs **4024**, **4025** and **4026** and reclosure of contact pair **4027** to halt gear-motor **3935** when brake **4029** is energized. TR **4040** finally establishes a circuit by line **4045** to timing relay **4046**, in series with source lines **2000** and **2001**, which by line **4047** activates the circuitry associated with the glow-discharge units **3905** for the period of time to which it has been adjusted.

In the ensuing progress of preceding carriers, such as when a pair are advanced from the chamber **420** to the fourth or filming chamber **440**, the pair of carriers in the second station of the chamber **390** can be subsequently admitted into the chamber **420**. To this end, a switch device LR **4235** (FIG. **138**) is permitted to close when a pair of carriers are removed from the tracks **4205** and **4206** of the chamber **420**. The circuit completed by LS **4235** is controlled by a low pressure switch device **4236** located in the second chamber **390** and activated when the evacuated condition of the chamber is substantially the equivalent of that desired and when a timer (not shown) indicates that the sheets have been subjected to a sufficient glow discharge cleaning cycle. The required conditions being obtained, the device **4236** establishes a circuit by line **4237** through closed LS **4235** and line **4238** to a timing relay TR **4240**, in series with source lines **2000** and **2001**. TR **4240** first completes a circuit by line **4242** through the end **4243** of a four-way valve **4244** to source line **2001**, such valve being connected to the source of fluid pressure by pipe **4245** and sump by pipe **4246**. When activated, the spool of the valve is moved to direct pressure through pipe **4247** to the head end of cylinder **4248**, behind piston **4249**, such cylinder being connected at the rod end by pipe **4250** to the opposite side of the valve. During outward motion of piston rod **4251**, an arm **4252** connected to shaft **3604** of valve compartment **362** is swung to rotate said shaft and thus the associated closure panel **3601** to the open position. This will place the second chamber **390** in communication with the third chamber **420**.

By line **4255**, TR **4240** completes a circuit through solenoid **4257** of relay switch RS **4258** which establishes the service circuits to gear-motor **4215**. RS **4258** is equipped with opposed solenoid **4259**, presently disengaged pairs of contacts **4260**, **4261** and **4262** and closed pair of contacts **4263** which maintain brake **4264** of the motor energized by line **4265**. When energized, solenoid **4257** causes closure of contact pairs **4260**, **4261** and **4262**, while opening contact pair **4263**, to establish circuits from source lines **2000**, **2001** and **2002** and lines **4267**, **4268** and **4269** to gear-motor **4215**.

With the motor **4215** operating the conveyor chain belts **4231**, TR **4240** makes a circuit by line **4271** through the solenoid **4021** of RS **4022** to complete the circuits by lines **4031**, **4032** and **4033** to gear-motor **3935** while opening line **4028** to brake **4029**. Now, with the closure panel **3601** of valve chamber **362** in the open position and the pairs of conveyor chain belts **3918** in the second station of the chamber **390** and those (belts **4231**) in the third chamber **420** operating, the carriers are removed from the tracks **3909** and **3910** onto the pair of tracks **4205** and **4206**.

By branch line **4273** from line **4242**, a circuit is simultaneously made through the solenoid **4274** of spring-biased relay switch RS **4275** to source line **2001**, the contact pair **4276** normally maintaining the circuit of line **4277** from presently closed switch device LS **4278**. Disengagement of contact pair **4276** will have de-energized the end **4279** of valve **4244**. Line **4280** by branch **4273** also completes a circuit to a valve **4281** which can be employed to control the connection of the vacuum source (not shown) to the chamber **420**.

As the carriers are moved into the third chamber **420**, they actuate LS **4278** to the open position and then LS **4283** to the engaged position to complete the circuit of line **4284** to one side of LS **4285**. When the carriers are suitably positioned on the tracks **4205** and **4206**, they will have engaged LS **4285**. This pair of limit switches can then make the circuit of line **4284** to a timing relay TR **4287**, in series with source lines

2000 and 2001. This timing device initially makes a circuit by line 4288 through solenoid 4023 of RS 4022 to disengage the contact pairs 4024, 4025 and 4026 thereof to open the circuits to gear-motor 3935 while completing line 4028 to brake 4029 to energize the same and halt the motor.

Since TR 4240 has ceased to function and the contact pair 4276 of RS 4275 have reclosed, the circuit of line 4277 will be completed through LS 4278 as the trailing end of at least one carrier releases the same. Line 4277 completes a circuit through the end 4279 of valve 4244. As the position of the valve spool is reversed, fluid pressure will be directed from pipe 4245 to the rod end of cylinder 4248 through pipe 4250. As the piston rod 4251 is moved inwardly, the arm 4252 will rotate the shaft 3604 to return the closure panel 3601 of valve compartment 362 to the sealed position. TR 4287 by line 4289 through the solenoid 4259 of RS 4258 to source line 2001, now causes the circuits to gear-motor 4215 to be opened thereby halting the same as the brake 4264 is again energized. TR 4287 by line 4290 establishes a circuit to the valve 4281 thereby to reconnect the chamber 420 to the source of vacuum to lower the pressure to the pressure desired therein and in the fourth chamber 440, namely $1 \times 10^{-4}$ to $1 \times 10^{-7}$ torr. The timer TR 4287 further completes a circuit by line 4292 to TR 4293, in series with source lines 2000 and 2001. This timer maintains a circuit by line 4294 to activate the circuitry associated with the electric strip heaters 4209 for the period of time to which it has been adjusted.

In considering the control systems employed for the gear-motors 4418, 4419 and 4420 and shown by way of example in FIGS. 139 and 140, it will be recalled, according to one mode of operation, that a pair of carriers are moved into the entry end of the chamber 440 by the pair of conveyor chain belts 4414 at a relatively fast rate of speed. such as 80 (FPM) feet per minute. After clearing the area of the valve compartment 363, the speed of the chain belts 4414 is materially reduced to a slower range of 2 to 8 (FPM) feet per minute which is the desired traversing speed for the sheets as they are filmed. As the carriers become magnetically connected to the next pair of conveyor chain belts 4415, they continue forward at the slower rate of speed as provided by the gear-motor 4419. This rate of movement is maintained until the pair of carriers are magnetically contacted by the pair of conveyor chain belts 4416 in the exit end of the chamber. The gear-motor 4420 is then operated to increase the rate of speed to 80 FPM at which the carriers are removed into the fifth chamber 470.

As the pair of carriers are moved into the area of the pair of conveyor chain belts 4415, a subsequent pair of carriers can be advanced from the third chamber 420 at a speed rate of 80 FPM and then moved forwardly from the entry end of the filming chamber 440 at the reduced rate of 2 to 8 FPM. Since during continuous operation of the apparatus and conveyor system, pairs of carriers can periodically follow one another in spaced relation, the ensuing description will be directed to a first pair of carriers in the third chamber 420 and then advancing movement into and through the fourth or filming chamber 440.

Referring now particularly to FIGS. 139 and 140, it will be understood that the gear-motors 4418 and 4420 operate intermittently while the gear-motor 4419 is usually intended to operate continuously. To this end, when a circuit is closed at the contact 4510 by movable contact 4511 of an "on-off" manual switch MS 4512, line 4513 is completed through the solenoid 4514 of relay switch RS 4515 to source line 2001, RS 4515 being equipped with an opposed solenoid 4516, presently engaged pairs of contacts 4517, 4518 and 4519 and disengaged contact pair of 4520 which otherwise complete line 4521 to energize the motor brake 4522. As presently described, contact pairs 4517, 4518 and 4519 maintain service lines 4523, 4524 and 4525 to the gear-motor 4419 which drives the shaft 4454 through sprocket 4451 and chain belt 4452, as previously described, at the aforementioned range of speed of between 2 to 8 FPM. With the gear-motor 4419 in operation, the clutch 4458 can be energized to transmit power from the chain belt 4452 and sprocket 4453 to the shaft 4454. For this purpose, manual switch MS 4526 by movable contactor bar 4527 completes a circuit from contact 4528 and by line 4529 through the solenoid 4530 of a relay switch RS 4531 to source line 2001, RS 4531 being equipped with opposite solenoid 4532 and contact pair 4533. This pair of contacts, when engaged, make a circuit by line 4534 and clutch 4458 so that the sprocket 4453 will drive the shaft 4454.

When the bar 4527 of MS 4526 is engaged with contact 4535, a circuit by line 4536 will be established through opposed solenoid 4532 of RS 4531 which will operate to de-energize the clutch 4458. Similarly, contactor bar 4511 of MS 4512 can be moved to complete a circuit by contact 4537 and line 4538 through solenoid 4516 of RS 4515 which will act to halt operation of the motor.

With reference to FIG. 139, a four-way valve 4340 is connected by pipe 4541 to a source of fluid pressure and pipe 4542 to a sump. One side of valve 4540 is connected by pipe 4544 to the rod end of a cylinder 4545, with contained piston 4546, while the opposite side of the valve is connected by pipe 4547 to the head end of the cylinder. Presently, the direction of pressure to the rod end of cylinder 4545 maintains the piston rod 4548 in the retracted position and, through pivotal arm 4549 holds the closure panel or door 3601 of valve compartment 363 in sealed position at the entry end of chamber 440.

Thus, when a previously admitted pair of carriers 160 have cleared the entry end of chamber 440, a switch device LS 4551 is engaged to produce movement of the door 3601 to the open position. This action, however, is regulated by a low pressure switch device 4552, such as an ionization gauge or the like, located in the third chamber 420 and made operable when the vacuum in this chamber is substantially balanced with that maintained in the filming chamber 440, switch device 4552 being connected to one side of LS 4551 by line 4553. When the circuit is completed from source line 2000 to LS 4551, it is continued by line 4554 to a timing relay 4555, in series with source lines 2000 and 2001. At this phase of control, it will be understood that, since gear-motor 4418 is not operating and clutch 4430 is de-energized, the shaft 4425 is driven at the slower rate of speed by chain belt 4432 from shaft 4454.

TR 4555 initially completes a circuit by line 4557 through the solenoid 4558 of spring-biased relay switch RS 4559 to source line 2001 thereby to disengage contact pair 4560. Normally these contacts maintain a circuit via line 4561 through presently closed switch device LS 4562 to the end 4563 of valve 4540. By way of branch line 4565 through the opposite end 4566 of valve 4540, the direction of fluid pressure through said valve is reversed from pipe 4544 to pipe 4547 whereupon the piston 4546 of cylinder 4545 will project the rod 4548 and by arm 4549 rotate the shaft 3604 and consequently swing the associated closure panel 3601 to the open position in valve compartment 363.

TR 4555 then completes a circuit by line 4567 through the solenoid 4568 of relay switch RS 4569 to source line 2001, this relay being equipped with opposed solenoid 4570, presently disengaged pairs of contacts 4571, 4572 and 4573 and engaged contact pair 4574 which energize the brake 4575 of gear-motor 4418 by line 4576. Contacts 4571, 4572 and 4573 will then complete service lines 4577, 4578 and 4579 to the gear-motor. By line 4581, TR 4555 also makes a circuit through solenoid 4582 of a relay switch RS 4583 to source line 2001, RS 4583 having opposed solenoid 4584 and contact pair 4585 which when engaged will complete a circuit from source line 2000 to energize the clutch 4430 by line 4586. This will drive shaft 4425 to operate the conveyor chain belts 4414 at the speed of 80 FPM and in this event the overrunning clutch 4460 on shaft 4454 will negate the transmission of the rapid operation by sprocket 4431 and chain belt 4432.

With motor 4418 operating to drive the pair of conveyor belts 4414, TR 4555 effects operation of the gear-motor 4215, associated with the conveyor chain belts 4231 of chamber

420, by the circuit of line 4590 through the solenoid 4257 of RS 4258 as in FIG. 138. As previously noted, contact pairs 4260, 4261 and 4262 will complete lines 4267, 4268 and 4269 to gear-motor 4215 while de-energizing brake 4264 at disengaged contact pair 4263. At this time, the sprocket 4433 by chain belt 4434 will operate the pulsing unit 4435 about which more will be said later.

The pair of carriers 160 are now advanced from the chamber 420 into the chamber 440 through the intervening valve compartment 363. The leading end of at least one carrier produces opening of LS 4562 and closure of switch device LS 4592 which by line 4593 completes a circuit through opposed solenoid 4259 of RS 4258 (FIG. 138) to source line 2001 with resultant halting of gear-motor 4215 upon breaking of lines 4267, 4268 and 4269 and remaking of line 4265 to energize the associated brake 4264.

Now, when the trailing ends of the pair of carriers 160 have cleared the exit end of valve compartment 363, TR 4555 will have ceased to function thus opening the circuits of lines 4557 and 4565 and the contact pair 4560 of RS 4559 will have re-engaged. Thus, when LS 4562 is permitted to reclose, the circuit of line 4561 will be restored to the end 4563 of valve 4540. This will reverse the application of fluid pressure from pipe 4547 to pipe 4544 with consequent reclosure of the closure panel 3601 of valve compartment 363 as the piston rod 4548 is retracted into the cylinder 4545.

At this time also, LS 4592 establishes a circuit by line 4594 to a timing relay TR 4595 in series with source lines 2000 and 2001. TR 4595 first creates a circuit by line 4597 through the opposed solenoid 4584 of RS 4583 to disengage contact pair 4585 to open the circuit of line 4586 thus de-energizing clutch 4430. The circuit of line 4598 from TR 4595 then completes through opposed solenoid 4570 of RS 4569 to source line 2001 which halts gear-motor 4418 upon disengagement of contact pairs 4571, 4572 and 4573 and setting of brake 4576 at engagement of contact pair 4574. The pair of conveyor chain belts 4414 will now be driven at the slower rate of speed, i.e., 2 to 8 FPM, as the shaft 4425 is driven from shaft 4454 by way of clutch 4460, chain belt 4432 and sprocket 4431.

As the leading magnetic bars 1675 of the carriers 160 become engaged with the pair of conveyor chain belts 4415 and the trailing bars approach the ends of or depart from engagement with the pair of conveyor chain belts 4414, a switch device 4600 is adapted to be engaged by an actuator (not shown) on the trailing end of at least one carrier to make a circuit by line 4601 to connect the pulsing unit 4471 to an associated counter device 4603, the unit 4471 being operated by sprocket 4469 on shaft 4454 through chain belt 4470. The counter device 4603 records the pulsations of unit 4471 which are produced relatively slowly in accordance with the low rate of speed (2 to 8 FPM) at which conveyor chain belts 4415 are driven. Device 4603 transfers the same to a totalizer 4604 by line 4605.

When, as herein above set forth, the LS 4551 is permitted to reclose and the low pressure device 4552 has again completed the circuit of line 4553, the circuits from TR 4555 can again sequentially produce opening of the closure panel 3601 of valve compartment 363, starting of gear-motor 4418 and energization of the clutch 4430. When each succeeding pair of carriers are advanced sufficiently along the pair of tracks 4410 and 4411 by the conveyor chain belts 4414, the leading end of at least one of the carriers is adapted to close a switch device LS 4606 which by line 4607 will connect the electrical pulsing unit 4435 to an associated counter device 4608. Since the pair of chain belts 4414 are presently driven by gear-motor 4418 at the faster rate of speed, i.e., 80 FPM, the shaft 4425 through sprocket 4433 and chain 4434 will cause the pulsing unit 4435 to transmit pulsations at a comparatively faster rate of speed than the electrical pulsing unit 4471. Thus, as the counter device 4603 slowly reaches a recorded total, as for example, of twenty pulsations, the counter device 4608 will function to record a like number of pulsations from the unit 4435 but at more rapidly occurring intervals and transfer the same to the totalizer unit 4604 by line 4609. When the transferred counts of pulsations are equal in the totalizer unit, a circuit is established by line 4610 connecting to line 4594. This will reactivate TR 4595 to de-energize clutch 4430 and halt gear-motor 4418 described.

The purpose of arriving at a desired balance of pulsations as produced by the units 4471 and 4435 is to provide a suitable spacing between the leading pair of glass sheets and the following pair. Thus, the leading pair will be slowly moved forward by the pair of conveyor chain belts 4415 and the following pair of sheets will be advanced more rapidly in the entry end of the chamber 440 until the rapidly occurring pulsations of the unit 4435 equal the slower pulsations of the unit 4471. The actions of the counter devices 4603 and 4608 and their influence on the totalizer unit 4605 can of course be adjusted to vary the distance between the trailing ends of a first pair of sheets and the leading ends of a second pair of sheets. As pointed out in an earlier portion of the specification, it is desirable to maintain the pairs of sheets as close as is practicable to minimize the loss of the filming materials from sources 4407 that otherwise would be expended and result in objectionable deposits on the walls of the filming chamber 440.

At this time, the pair of conveyor chain belts 4416 are driven in common with the preceding pairs of chain belts 4414 and 4415 by the gear-motor 4419. In this instance, the shaft 4454 drives the shaft 4466, associated with the gear-motor 4420, through the overrunning clutch 4462, sprockets 4463 and 4466 and the chain belt 4465 trained thereabout.

As the leading ends of the carriers approach the pair of chain belts 4416, a switch device 4615 (FIG. 140) is engaged which is connected by control line 4616 to a low pressure device 4617 in the adjoining fifth chamber 470. Since the fifth chamber has previously been in communication with the sixth or exit chamber 490 of the apparatus through the valve compartments 365, it is, of course, required that evacuation of chamber 470 be made to a low pressure equalling that of the filming chamber 440 before the closure panel 3601 of the valve compartment 364 can be moved to the open position.

Accordingly, when the low pressure device 4617 completes the circuit of line 4616 from source line 2000 to LS 4615, the circuit is completed by line 4620 to timing relay 4621, in series with source lines 2000 and 2001. TR 4621 first completes a circuit by line 4624 through the solenoid 4730 (FIG. 141) of a relay switch RS 4731 to source line 2001, such switch controlling the circuitry of the belt gear-motor 4718. Thus, RS 4731 has an opposed solenoid 4732, presently disengaged pairs of contacts 4733, 4734 and 4735 and engaged contact pair 4736 which by line 4737 energizes the brake 4738 associated with the gear-motor 4718. The circuits of lines 4740, 4741 and 4742 through engaged contacts 4733, 4734 and 4735 produce operation of the motor while the opening of line 4737 de-energizes the brake.

While this sequence of events is being carried out, TR 4621 (FIG. 140) completes a line 4626 through solenoid 4627 of a spring-biased relay switch 4628 to source line 2001 to disengage pair of contacts 4629 thereby braking the circuit of line 4630 from the source line 2000 to one side of LS 4632 located in the entry area of chamber 470. Presently closed LS 4632 normally maintains line 4630 through the end 4633 of a four-way valve 4634. This valve is connected by pipe 4635 to a source of fluid pressure and pipe 4636 to a suitable sump. While valve end 4633 is energized as above-described, the flow of fluid pressure from pipe 4635 is by way of pipe 4639 to the rod end of a cylinder 4640, ahead of the contained piston 4641, with the retracted piston rod 4642 holding the closure panel 3601 of valve compartment 364 in the sealed position through shaft 3604 and lever arm 4643.

As the contact pair 4629 of RS 4628 becomes separated to break the circuit to valve end 4633, line 4645 from line 4626 completes a circuit through the end 4646 of the valve 4634. This will direct fluid pressure from pipe 4635 by way of pipe 4647 to the head end of cylinder 4640 behind piston 4641, pipe 4639 then being in connection with sump pipe 4636

through the valve. Projection of the rod **4642** causes lever arm **4643** to rotate shaft **3604** thereby to swing closure panel or door **3601** of valve compartment **364** to the open position.

By line **4648**, TR **4621** makes a circuit through solenoid **4649** of relay switch RS **4650** to source line **2001**, this switch having opposed solenoid **4651**, pairs of contacts **4652**, **4653** and **4654** with contact pair **4655** maintaining the circuit of line **4656** through the brakes **4657** of gear-motor **4420**. While line **4656** to brake **4657** is opened with solenoid **4649** thus energized, engaged pairs of contacts **4652**, **4653** and **4654** complete circuits by line **4658**, **4659** and **4660** to said gear-motor. Now, with the motor for conveyor chain belts **4416** in operation, TR **4621** causes energization of clutch **4496** to connect sprocket **4495** to shaft **4466** thereby driving the same at a rate of **80** FPM. To this end, TR **4621** completes line **4662** through solenoid **4663** of relay switch RS **4664** to source line **2001**, RS **4664** having opposed solenoid **4665** and pair of contacts **4666**. These contacts thus connect the circuit of line **4667** through the electromagnetic clutch **4496**.

During contact of the carriers' magnetic bars **1675** with the pairs of conveyor chain belts **4416** in the exit end of chamber **440** and the ensuing movement toward and into the fifth chamber **470**, the leading end of at least one carrier **160** will produce opening of LS **4632**. However, in this interval of operation, TR **4621** ceases to function thereby opening line **4626** and permitting contacts **4629** of spring-biased RS **4628** to re-engage. Thus, when the trailing ends of carriers have passed into the chamber **470**, at least one of the carriers will release LS **4632** which re-establishes line **4630** through the end **4633** of valve **4634** to reverse the flow of fluid pressure from pipes **4635**, **4647** to pipes **4635**, **4639**. This will retract piston rod **4642** and by lever **4643** turn shaft **3604** to return the closure panel **3601** of valve compartment to its closed position between chambers **440** and **470**.

Upon arrival of the carriers into the chamber **470**, a switch device LS **4670** by line **4671** causes functioning of timing relay TR **4672**, in series with source lines **2000** and **2001**. This timer serves to de-energize the clutch **4496** and then terminate operation of the belt gear-motor **4420** which will permit the shaft **4466** and conveyor chain belts **4416** to be again driven at the relatively slower rate of speed (2 to 8 FPM) as the sprocket **4463** and overrunning clutch **4462** on shaft **4454** resume operation of shaft **4466** via chain belt **4464**. TR **4672** then completes a circuit by line **4673** through opposed solenoid **4665** of RS **4664** to disengage pair of contacts **4666** and open line **4667**. By line **4674**, the timing relay makes a circuit through the opposed solenoid **4651** of RS **4650** to source line **2001** with resultant disengagement of contact pairs **4652**, **4653** and **4654** to open the service lines **4658**, **4659** and **4660** and engagement of contacts **4655** to restore line **4656** to the brake **4657** with resultant halting of the gear-motor. Line **4675** from TR **4672** lastly completes a circuit (FIG. **141**) through opposed solenoid **4732** of RS **4731** to source line **2001**. The pairs of contacts **4733**, **4734** and **4735**, upon separation, open service lines **4740**, **4741** and **4742** to gear-motor **4718** while contacts **4736** through line **4737** reset the brake **4738** to halt the same.

Now, when a preceding pair of carriers **160** have been conveyed from the sixth chamber **490** onto the transfer carriage **510**, the pair of carriers, presently located in the fifth chamber **470**, as has been above described, can be advanced into the sixth chamber **490** upon actuation of a switch device that is closed when the carriers arrive in the fifth chamber. However, before such advance, the sixth chamber, which is at ambient pressure when opened to the atmosphere to enable exit of the carriers, must be pumped down to a pressure in the range of from $2 \times 10^{-1}$ to $5 \times 10^{-3}$ torr. Then, in following order and after the carriers have entered the sixth or up-to-air chamber **490**, the same is elevated to substantially atmospheric pressure before the valve compartment **366** is again opened.

Thus, the completion of a circuit by line **4740** (FIG. **141**) to LS **4741** is dependent upon the actuation of a low pressure device **4742** in the sixth chamber **490**. When the device **4742** is actuated, it completes line **4740** through LS **4741** to line **4743** and a timing relay **4744**, in series with source lines **2000** and **2001**. TR **4744** first completes a circuit by line **4745** through solenoid **4930** of relay switch RS **4931** to source line **2001**. RS **4931** has opposed solenoid **4932** and when the solenoid **4930** is energized, pairs of contacts **4933**, **4934** and **4935** complete a service lines **4936**, **4937** and **4938** to the belt gear-motor **4908** associated with the sixth chamber. Contact pair **4940**, normally engaged, are simultaneously separated to break the circuit of line **4941** through motor brake **4942**.

With the gear-motor **4908** in operation and thereby driving the pair of conveyor chain belts **4910**, TR **4744** makes a circuit by line **4747** through a valve **4748** to temporarily close the connection of the source of vacuum to the chambers **470** and **490**. By branch line **4749**, the solenoid **4750** of spring-biaased relay switch RS **4751** is actuated, this operating to disengage pair of contacts **4752** normally holding line **4753** completed to one side of LS **4754**. This switch device, is the entry area of chamber **490** and normally closed, otherwise makes the circuit of line **4753** to the end **4755** of a four-way valve **4756**. During this phase of circuit control, valve **4756**, connected to a source of fluid pressure by pipe **4757** and a sump by pipe **4758**, directs fluid to the rod end of a cylinder **4759**, ahead of piston **4760**, via pipe **4761**. The attached piston rod **4762** is thus retracted to position the lever **4763** so that the shaft **3604** of closure panel **3601** in valve compartment **365** will maintain said panel in its sealing or closed position.

By line **4765**, the end **4766** of valve **4756** acts to reverse the direction of fluid pressure from pipe **4761** to pipe **4767** connecting such valve to the head end of the cylinder behind the piston **4760**. This operates to project the piston rod **4762** to swing lever **4763** and consequently rotate the closure panel **3601** of valve compartment **365** to the open position.

TR **4744** then completes a circuit by line **4770** through the solenoid **4730** of RS **4731** to source line **2001** thereby engaging pairs of contacts **4733**, **4734** and **4735** to restore service lines **4740**, **4741** and **4742** to belt gear-motor **4718** while de-energizing the brake **4738** as contact pair **4736** are separated. The conveyor chain belts **4708** are thus driven to move the pair of carriers **160** forwardly from chamber **470** into chamber **490**. In entering the sixth chamber, at least one of the carriers causes of opening of LS **4754**. As the carriers are bodily received in the chamber **490**, a switch device LS **4772** is engaged and as the trailing ends of the carriers clear the aperture from valve compartment **365**, LS **4754** is released. LS **4754** thus completes the circuit of line **4753** from source line **2000** to the end **4755** of valve **4756**. Since TR **4744** has ceased to function, valve end **4766** will have been rendered inactive with the result that restoration of line **4753** will be effective to cause the spool of valve **4756** to again reverse the direction of fluid from pipe **4767** to pipe **4761** and the rod end of cylinder **4759**. This will result in retraction of piston rod **4762** and reclosure of the panel **3601** of valve compartment **365** as the associated shaft **3604** is rotated by lever **4763**.

LS **4772** completes a circuit from source line **2000** by line **4774** to timing relay **4775**, in series with source lines **2000** and **2001**. TR **4775** establishes a circuit to re-open the vacuum control valve **4748**, halt the gear-motor **4718** and then the gear-motor **4908**. For these purposes, TR **4775** makes a circuit by line **4776** to the valve **4748**. A circuit by line **4777** is then made through the opposed solenoid **4732** of RS **4731** to source line **2001**. This will operate to disengage pairs of contacts **4733**, **4734** and **4735** thereby opening service lines **4740**, **4741** and **4742** while restoring the circuit of line **4737** to the brake **4738** to halt the spring-biased **4718**. Before "timing out", TR **4775** completes the circuit of line **4778** through the solenoid **4932** of RS **4931** with resulting opening of lines **4936**, **4937** and **4938** at contact pairs **4933**, **4934** and **4935** and closing of line **4941** to brake **4942** at re-engaged pair of contacts **4940**.

With the closure panels **3601** of valve compartments **365** and **366** in their sealed positions, line **4779** from line **4778** can

be extended to valve **4945** which will be operated to connect the sixth chamber **490** to a suitable pump (not shown) whereby the pressure in said chamber will be raised to suitably balance with that of the ambient atmosphere.

Further progress of the pair of carriers **160** with filmed sheets from the exit or sixth chamber **490** is dependent on the positioning of the transfer carriage **510** and the alignment of associated tracks with the pair of tracks **4904** and **4905** in chamber **490**, as will hereinafter be more fully described. However, while yet considering FIG. **141**, it is deemed advisable to complete the discussion of the illustrated circuitry and make suitable reference thereto in connection with the description of the control systems shown in FIGS. **144** and **145**.

Thus, a pressure device **4950** is activated, when the pressure within chamber **490** has been raised to the ambient atmosphere, to complete a circuit by line **4951** to a timing relay TR **4954** in the circuit of the belt gear-motors on the carriage **510** as illustrated in FIG. **145**.

As previously explained, in connection with the belt gear-motors **1233** and **1234** of the shuttle carriage **120**, it is necessary that the belt gear-motors of the loading conveyor drive unit **150** be in operation before the gear-motors **1233**, **1234** are started. Similarly, the circuits to the belt gear-motors of the transfer carriage **510** will be conditioned to start only when the carriage is aligned with tracks **4904** and **4905** of the sixth chamber **490**. In this instance, the pressure switch device **4950** must also be actuated within the chamber after the carriage belt gear-motors have started, followed by operation of the belt gear-motor **4908**.

When TR **4954** is actuated it will make a circuit by line **4956** which causes closure of the valve **4945** and then, by line **4957** through the solenoid **4958** of spring-biased relay switch RS **4959**, operates to disengage the contact pair **4960** thereof. This pair of contacts normally completes the circuit of line **4962** through closed LS **4963** to the end **4964** of a four-way valve **4965**. This valve is connected by pipe **4967** to a source of fluid pressure, by pipe **4968** to a sump, by pipe **4969** to the rod end of a cylinder **4970** and by pipe **4971** to the cylinder head end. Before contacts **4960** are separated, the circuit originating in line **4962** has caused valve **4965** to direct fluid under pressure from pipe **4967** to pipe **4969** ahead of the piston **4972** in cylinder **4970**. This has served to retract the piston rod **4973** and swing the lever **4974** so that rotation of the shaft **3604** will have moved the closure panel or door **3601** of valve compartment **366** to the closed or sealed position.

Upon actuation of RS **4959**, as presently described, cylinder end **4964** is de-energized so that line **4975** from TR **4954** can be effective to complete a circuit through the opposed end **4976** of the valve. Upon reversal of fluid pressure from pipe **4969** to pipe **4971**, and behind piston **4972** in cylinder **4970**, the closure panel **3601** of valve compartment **366** will be moved to its open position. TR **4954** then completes a circuit by line **4980** to initiate the operation of the belt gear-motor **4908**. As will be shortly described in connection with Fig. **145** when belt gear-motors therein are operating, the starting circuit by line **4980** will be made to RS **4931** whereby the gear-motor **4908** will drive the conveyor chain belts **4910** and tandem-wise the magnetic bars **1675** will pass from the conveyor chain belts **4910** in chamber **490** to the conveyor chain belts associated with the transfer carriage **510**. As the carriers move through the valve compartment **366**, LS **4963** will be tripped to its open position while a switch device **4982** will be engaged by trailing end of at least one carrier. This will complete a circuit by line **4983** to a timing relay **4984**, in series with source lines **2000** and **2001**. After a monitored interval of time to ensure that the carriers are clear of the closure panel aperture, TR **4984** makes a circuit by line **4985** through solenoid **4932** of RS **4931** to source line **2001**, this acting to disengage contact pairs **4933**, **4934** and **4935** with resulting opening of service lines **4936**, **4937** and **4938** and restoration of line **4941** to brake **4942** at contact pair **4940** to halt gear-motor **4908**.

Also, since TR **4954** has ceased to function, when contact pairs **4960** of RS **4959** are engaged and LS **4963** is released, the circuit of line **4962** will be restored to the end **4964** of valve **4965**. This will direct fluid through pipe **4969** to the rod end of cylinder **4970**, ahead of piston **4972**, thereby retracting piston rod **4973** to return the closure panel **3601** of valve compartment **366** to its closed position. By line **4986**, TR **4984** also completes a circuit to the valve **4748** to reconnect the chamber **490** to the source of vacuum.

## THE TRANSFER CARRIAGE

In considering transfer of a pair of carriers **160** from the last chamber **490** of the processing apparatus to the return side **18** of the conveyor system, attention is initially directed particularly to FIGS. **130**, **143** and **146**. Herein, the transfer carriage **410** is illustrated in connection with component elements of the frame structure **1000**.

This portion of the structure comprises longitudinally disposed, parallel beams **1050** and **1051** and a northwardly spaced channel **1052**. Beam **1050** is supported at the upper ends of vertically disposed pedestals or columns **1053** and **1054** while the beam **1051** is similarly mounted on the ends of columns **1055** and **1056**. Transverse bracing beams **1057** and **1058** are arranged between the pairs of columns **1053** and **1055**, and **1054** and **1056**. Channel **1052** is mounted by suitable support brackets **1060** on vertical pedestals or columns **1061** and **1062**. The beams **1050**, **1051** and channel **1052** support a pair of transversely located rails **1065** and **1066** forming tracks along which the carriage **510** moves between the south position, as shown in FIG. **130**, to a north position wherein the carriage is aligned with the pair of tracks **1067** and **1068** associated with the return side **18** of the conveyor system. In this connection, it will be seen in FIG. **130**, **146** and **152** that the pair of tracks **1067** and **1068**, in interjoined sections of suitable length, extend from the transfer area **16** to substantially end-to-end abutting relation with the tracks **1028** and **1029** of the conveyor drive unit **152** at the transfer area **12**.

The pair of tracks **1067** and **1068** are supported by spaced structural assemblies **1070** including a beam **1071** mounted on a pedestal **1072** (FIGS. **130** and **150**) and fixedly at one end to a structural column **1061** or **1073**. Also supported by the structural assemblies **1070** are a pair of tracks **1075** and **1076** that, when necessary, can be employed for the storage of pairs of carriers.

With particular reference to the transfer carriage as in FIGS. **130** and **142**, it will be noted that in most respects, this carriage duplicates the structure of the carriage **120** of FIGS. **9** to **13**. Thus, the framework **5100** comprises a pair of parallel beams **5101** and **5102** equally spaced from the longitudinal axis of the carriage and forming, at their lower extremities, tracks or rails for supporting the carriers **160**. At their opposite ends, the beams **5101** and **5102** support pairs of angular beams **5103**, the vertical walls thereof being equipped with blocks **5104** which receive the shafts of ball-bearing casters **5105**. These pairs of casters are adapted to traverse the rails **1065** and **1066** as the carriage **510** is moved by a source of power **5108** including a traction gear-motor **4109** mounted on platform **5110**. The gear-motor **5109** is coupled to a drive shaft **5112** (also see FIG. **144**) through a chain belt **5113** entrained about a sprocket **5114** on the motors output shaft and a sprocket **5115** on shaft **5112**. This shaft is carried by pairs of journal bearings **5116** at the platform **5110** and pairs of bearings **5117** at the beams **5103**. Between each pair of bearings **5117**, the drive shaft **5112** mounts a spur gear **5118** adapted to mesh with an elongated rack gear **5119** secured to the lower surface of each rail **1065** and **1066**.

To move a pair of carriers **160** in either direction, i.e., onto or off from the carriage **510** along the spaced tracks formed on the beams **5101** and **5102**, the carriage is equipped with a pair of similar power sources indicated generally at **5121** and **5122** that are mounted by a platform **5123** on the upper flanges of the beams **5101** and **5102** and include individual,

reversible belt gear-motors **5124** and **5125**. As shown diagrammatically in FIG. **145**, these gear-motors are individually employed to move a respective carrier **160** eastwardly onto the tracks of beams **5101**, **5102**. When, however, the carriers are removed in a westward direction onto the tracks **1067** and **1068** of the return side **18**, the gear-motor **5124** is used as the sole source of power. This is to ensure that each pair of carriers will move as a transversely related entity such as has been described in connection with the entry conveyor drive unit **145** (FIGS. **113** and **114**) and as they are advanced into the first chamber **370** of the processing apparatus.

In the present instance, the beams **5101**, **5102** support a pair of platforms **5127** and **5128** on which are mounted the driving and supporting elements for the pair of conveyor chain belts **5130** and **5131** (FIG. **145**). To this end, the output shafts **5132** and **5133** of gear-motors **5124** and **5125** are equipped with sprockets **5134** and **5135**, respectively, which through chain belts **5136** and **5137** drive sprockets **5138** and **5139** on shafts **5140** and **5141** journaled in bearings **5142** and **5143** mounted on the platform **5127**. The shaft **5140** at one or its outer end mounts a sprocket **5144** and at the opposite or inner end is joined to the driver component of a "tie" or coupler clutch device **5145**. Sprocket **5144** by chain belt **5146** drives a sprocket **5147** on the outer end of a shaft **5148** journaled in bearing bracket **5149** carried by the platform **5127**. Shaft **5148** at its inner end mounts a sprocket **5150** (FIG. **145**) to drive the related conveyor chain belt **5130**.

With regard to the gear-motor **5125**, the output shaft **5133** drives sprocket **5135** by means of a magnetic clutch **5155**, such sprocket **5135** by chain belt **5137** driving sprocket **5139** on shaft **5141**. In this instance, shaft **5141** at its inner end is joined to the driven component of the coupler clutch **5145**. At the outer end, shaft **5141** is equipped with a sprocket **5156** which by chain belt **5147** drives sprocket **5158** carried by shaft **5159** that is journaled in a bearing bracket such as a bearing bracket **5149**. The shaft **5159** at its inner end mounts a sprocket **5160** about which the conveyor chain belt **5131** is entrained. It is believed evident that conveyor chain belts **5130** and **5131** between the drive sprockets **5150** and **5160** and the related idler sprockets are supported in the same manner as are the conveyor chain belts of previously described carriages and further description is not deemed necessary.

By way of example, however, conveyor chain belt **5130** (FIG. **142**) is entrained about an idler sprocket **5163** on shaft **5164** journaled in the adjustably mounted bearing bracket **5165**. Also the upper and lower flights of conveyor chain belts **5130** and **5131** are supported by pairs of bars (not shown) carried by the pair of spaced channels **5166** and **5167** mounted at their ends by brackets **5168** and **5169** supported in one instance by the beams **5103** and by the platform **5110** in the other. This is typical of the mounting arrangement of FIG. **29** described in connection with the loading conveyor drive unit **150**. The links of each chain belt **5130** and **5131** are also formed as the link illustrated in FIG. **14** and likewise are equipped with plates **5170** whereby the magnetic bars **1675** of the carriers **160** will contact the belts during active engagement therewith.

Referring now to FIG. **144**, the power circuits for the traction gear-motor **5109** of the transfer carriage **510** are completed from source lines **2000**, **2001** and **2002** by a relay switch **5175** equipped with opposed solenoids **5176** and **5177**, presently disengaged pairs of contacts **5178**, **5179** and **5180** and presently engaged contact pair **5181** which complete the circuit of line **5182** through magnetic brake **5183**. Likewise, the means for reversing the polarity of gear-motor **5109** is herein provided by a relay switch **5188** equipped with opposed solenoids **5189** and **5190**, presently engaged pairs of contacts **5191**, **5192** and **5193** (which produce southward travel) and with presently disengaged pairs of contacts **5194**, **5195** and **5196** (which are adapted to produce northward travel).

Traversing movements of the transfer carriage **510** are controlled by switch devices LS **5200** and LS **5201** which, upon actuation by fixed cams **5202** and **5203**, respectively, are adapted to produce north and south "jogging" of the carriage to align the tracks formed by the beams **5101** and **5102** with the tracks or rails **4904** and **4905** of the chamber **490** and the bridging rails **3610** and **3611** of the valve compartment **366**. Similarly, LS **5204** and LS **5205** when engaged by cam **5206** or **5207** function to halt operation of the traction gear-motor **5109**, LS **5204** being actuated by cam **5206** in the south portion of the transfer area **16** and LS **5205** by cam **5207** in the north area adjacent the return side **18**. Likewise the carriage **510** is provided with a switch device LS **5208** which is adapted, when actuated by a cam plate **5209** in the south end, or cam plate **5210** in the north end, to reduce the output speed of the gear-motor. LS **5200** and LS **5201** are located in the same area of the carriage **510** as are LS **1301** and **1302** on the carriage **120** (see FIG. **63**), LS **5204** and **5205** similarly to LS **1293** and **1294**, and LS **5208** is located in the same location on carriage **150** as LS **1280** is mounted on the carriage **120**, and actuated by cam plates **1282** or **1284**, reference being directed to FIGS. **9**, **21** and **22**. As presently shown in FIG. **144**, LS **5200** and LS **5201** are disengaged while LS **5204** and LS **5208** are engaged with the carriage **510** in the south end of the transfer area.

After de-energizing motor **5109**, it is believed normal to expect that momentum of the carriage **510** will cause it to come to a halt either slightly south or north of the required position of alignment of the tracks **5101** and **5102** with tracks **4904** and **4905**. Thus, LS **5200** or **5201** are employed, in conjunction with stationary cams **5202** and **5203** to "seek" the required position and in so doing "jog" the motor to momentarily produce the desired direction of motion. Of course, the carriage arrives at the optimum position when the actuator arms of the switch devices are located substantially midway between the opposed ends of the cams.

When LS **5204** is engaged to halt the motor **5109**, a circuit is made by line **5212** from source line **2000** through engaged contact pair **5213** of relay switch RS **5214**, such relay being equipped with opposed solenoids **5215** and **5216** and also engaged contact pair **5217**. Line **5212** extends through engaged contact pair **5218** of relay switch RS **5219**, this relay being equipped with opposed solenoids **5220** and **5221** and engaged contact pair **5222**. By way of line **5225**, the circuit continues through a timer relay TR **5226**, in series with source lines **2000** and **2001** and thence by line **5227** through the engaged contact pair **5228** of relay switch RS **5229**. This relay switch has opposed solenoids **5232** and **5233** and engaged contact pair **5234**. Contact pair **5228** completes the circuit by line **5236** through timing relay TR **5237**, in series with source lines **2000** and **2001**, and line **5238** to one side of LS **5204** and LS **5205**. When closed by cam plate **5206**, as presently described, LS **5204** completes the circuit by line **5239** through the solenoid **5177** of RS **5175** to source line **2001**.

Thus, LS **5200** is adapted to produce northerly directed motion of the carriage **510** and, while in contact with cam **5202**, complete a circuit from source line **2000** through line **5242** from contacts **5217** of RS **5214**, and, by way of lines **5243** and **5244** via contact pair **5234** of RS **5229**, to TR **5237**, in circuit with source lines **2000** and **2001**. Initially, TR **5237** sets up a time interval, during which the motor **5109** is halted, to interrupt the service of lines **5227** and **5236** to render LS **5204** inoperable. It will, of course, be understood that while the carriage is located in the south transfer area the cam plate **5206** will maintain LS **5204** closed which is also true with regard to LS **5205** when engaged by the cam plate **5207** in the north transfer area.

The circuit of line **5244** from LS **5200** is also extended by line **5245** through presently closed LS **5246** to complete a circuit to a timing relay TR **5247**, in series with source lines **2000** and **2001**. This timer device is adjusted to monitor an interval of time of sufficient duration to permit LS **5201** to be engaged, if necessary, to produce any required southward movement and to permit the motor **5109** to halt with the carriage **510** in the rest position. The circuitry controlled by TR **5247** will shortly hereinafter be explained.

TR 5237 then completes a circuit by line 5250 through the solenoid 5232 of RS 5229 to disengage contact pairs 5228, 5234 thereof. The timer completes a circuit by lines 5251 through solenoid 5189 of RS 5188 to source line 2001 thereby disengaging contact pairs 5191, 5192 and 5193 and engaging contact pairs 5194, 5195 and 5196 to reverse the polarity of gear-motor 5109. Finally, TR 5237 opens line 5251 and closes line 5252 through the solenoid 5176 of RS 5175 to source line 2001. This causes engagement of contact pairs 5178, 5179 and 5180 while de-energizing brake 5183 at contacts 5181. The power circuits to motor 5109 will be made through line 5254, contact pair 5194 and line 5255 to line 5256, line 5257, contact pair 5195 and line 5258 to line 5259 and line 5260, contact pair 5196 and line 5261 to line 5262. This causes motor 5109 to move the conveyor carriage 510 northward. Circuit lines 5256, 5259 and 5262 are completed to gear-motor 5109 by way of a resistance 5263 presently controlled by closed LS 5208 by line 5264. By branch line 5265 from line 5252 a circuit is made through solenoid 5233 of RS 5229, this acting to re-engage contact pair 5228 although lines 5236-5238 are disconnected at TR 5237 as well as to re-engage contacts 5234 although lines 5243 and 5244 are presently broken at LS 5200.

In the event that the ensuing slight northward jogging motion of the carriage overruns the position of alignment and LS 5201 is engaged by cam 5203, line 5242 at engaged contact pair 5222 of RS 5219 completes a circuit by line 5266 through LS 5201 and line 5267 to TR 5226, in circuit with source lines 2000 and 2001. A switch device LS 5269 is also shown as being connected at one side to source line 2000.

TR 5266 sets up a time interval, during which the gear-motor 5109 is halted, to interrupt the service of lines 5225 and 5227 and again render LS 5204 inoperable. The timer then completes a circuit by line 5270 through the solenoid 5220 of RS 5219 to disengage contact pairs 5218, 5222 thereof. This timing relay completes a circuit by line 5271 through the solenoid 5190 of RS 5188 to source line 2001 thereby disengaging pairs of contacts 5194, 5195 and 5196 and re-engaging contact pairs 5191, 5192 and 5193 to reverse the polarity of motor 5109. Finally, TR 5226 opens line 5271 and closes line 5272 connecting by line 5252 through solenoid 5176 of RS 5175 to source line 2001. This again causes engagement of contact pairs 5178, 5179 and 5180 of RS 5175 while de-energizing brake 5183 at disengaged contact pair 5181. The power circuits will thus be made through line 5254, contacts 5191 and line 5259, line 5257, contacts 5192 and line 5256, and line 5260, contacts 5193 and line 5262 through resistance 5263 to gear-motor 5109. Since LS 5208 is still held engaged by the cam 5209, motor 5109 will operate at the slower rate of speed to move the transfer carriage 510 southward until it reaches the desired aligned position of tracks 5101 and 5102 with tracks 4904 and 4905. By branch line 5273 from line 5271, a circuit is made through solenoid 5221 of RS 5221 of RS 5219 to source line 2001, this operating to re-engage contact pair 5218 although lines 5225 and 5227 are open at TR 5226 and also to re-engage contact pair 5222 although lines 5266 and 5267 are presently open at LS 5201.

Now, when the transfer carriage 510 arrives at the position of track alignment, TR 5247 becomes active to complete a circuit by line 5275, through the solenoid 5215 of RS 5214 to source 2001. This acts to disengage contact pairs 5213 and 5217 to thereby open the circuit lines generally to the switch devices LS 5200, 5201 and 5204, thereby rendering them inoperable until they have been removed from the control of cams 5202, 5203 and 5206 by northward travel of the carriage 510.

During this interval of time, TR 5247 establishes a circuit by line 5276, connecting by line 5251, through the solenoid 5189 of RS 5188 to source line 2001. This will reverse the polarity of motor 5109 preparatory to subsequent returning northward movement of the carriage 510 from the south end of transfer area 16. This northward movement, as will later be described in connection with FIG. 145, is attributable to the action of switch devices that are actuated when a pair of carriers 160 have been received on the tracks of beams 5101 and 5102 and their ends have cleared the entry ends of said tracks.

Finally, TR 5247 makes a circuit by line 5277 to create the required power lines for operation of the belt gear-motors 5124 and 5125 to drive the associated conveyor chain belts 5130 and 5131. However, in the preferred sequence of operation, the circuit of line 5277, as illustrated in FIG. 145, produces initial operation of motors 5124 and 5125 to drive the associated conveyor chain belts 5130 and 5131 before the gear-motor 4908 for the conveyor chain belts 4910 in the sixth chamber 490 is started. This acts as a precautionary measure since the associated chain belts 5130 and 5131 must be operating to receive and magnetically contact with the bars 1675 on the carriers 160 before the pair of conveyor chain belts 4910 are put into operation to move the carriers by the related magnetic bars.

With reference now to FIG. 145, the power circuits for the belt gear-motors 5124 and 5125 of the transfer carriage 510 are completed from source lines 2000, 2001 and 2002 through associated switch devices about to be described. Since in the first phase of operation these motors are operable for the same purpose to drive the related chain belts 5130 and 5131, it is believed that the description of a typical electrical circuit for one gear-motor, such as the motor 5124, will suffice both, it being understood that substantially all of the control system of FIG. 145 is to be similarly employed in the operation of gear-motor 5125. Thus, the service circuits for belt gear-motor 5124 are made by a relay switch RS 5280 equipped with opposed solenoids 5281 and 5282, presently disengaged pairs of contacts 5285, 5284, 5285 and 5286 and presently engaged contact pairs 5287 which maintain the circuit of line 5288 to the brake 5289 for the gear-motor. Likewise, the means for reversing the polarity of gear-motor 5124 is herein provided by a relay switch 5292 equipped with opposed solenoids 5293 and 5294, presently engaged pairs of contacts 5295, 5296 and 5297 (which produce eastward travel of a carrier) and with presently disengaged pairs of contacts 5298, 5299 and 5300 (which produce westward travel).

The control system for each of the belt gear-motors 5124 and 5125 also includes switch devices that are actuated by the bar 1692 of each carrier 160 as the carrier arrives in the desired "centered" position on the tracks of the transfer carriage 510. LS 5305 is tripped by the leading end 1694 of the bar 1692 as the carriers are advanced onto the tracks of beams 5101 and 5102, and in sequence LS 5306 is engaged by the end 1694 and then LS 5307. LS 5305 and LS 5307 when actuated, produce jogging operation of the related belt gear-motor, such as the gear-motor 5124, to move the related carrier slightly backward (west) and then, if necessary, slightly forward (east) to the centered position. LS 5306, on the other hand, causes the gear-motor to stop operation.

As herein contemplated, line 5277 (FIG. 144) is completed to a timing relay TR 5310, in series with source lines 2000 and 2001. TR 5310 initially completes the circuit of line 5311 through the solenoid 5312 of a relay switch RS 5313, such relay also being equipped with opposed solenoid 5314 and contact pairs 5315 and 5316 which are engaged when the solenoid 5312 is thus energized. The utility of the contact pairs of RS 5313 will be hereinafter more fully explained.

TR 5310 then completes the circuit of line 5318 through the solenoid 5281 of RS 5280 to source line 2001, whereby contact pair 5283 will make a circuit by line 5320, contacts 5295 and line 5321 to the gear-motor 5124; line 5322, contacts pair 5296 and line 5323; and line 5324, contact pair 5297 and line 5325 to the gear-motor. When disengaged, contact pair 5267 will break line 5288 to de-energize brake 5289.

When the gear-motor 5124, and similarly gear-motor 5125, is started, the contact pair 5286 will complete a circuit by line 5327 through the timing relay TR 5310, and thence by line 5328 through the pressure switch device 4950 (FIG. 141). As normally contemplated, this device will have been actuated by the rise in pressure within the chamber 490 to atmospheric and thus complete line 4951 to TR 4954. As described in con-

nection with FIG. 141, TR 4954 completes the circuits by line 4956 to valve 4945 thereby closing the same; line 4957 through solenoid 4958 of RS 4959 to open the circuit of line 4962; and line 4975 through the end 4976 of valve 4965 which will result in opening of the closure panel 3601 of the valve compartment 366 and then establish the circuit of line 4980 through the solenoid 4930 of RS 4931 to start the belt gear-motor 4908. As previously explained, while the trailing end of at least one carrier permits the closure of LS 4963, it also actuates LS 4982 which results in halting of the motor 4908 as the closure panel 3601 of the valve compartment 366 is returned to the closed position.

Now as the bar 1692 of the carrier 160 advancing on the track of beam 5101 engages LS 5306, a circuit is completed from source line 2000, by line 5330 through the engaged pair of contacts 5315 of relay switch RS 5313, presently engaged pair of contacts 5332 of relay switch RS 5333, line 5334 through timing relay TR 5335, line 5336, engaged pair of contacts 5337 of relay switch RS 5338, line 5339 through timing relay TR 5340 and line 5341 to LS 5306.

RS 5333 is equipped with opposed solenoids 5343 and 5344 and presently engaged pair of contacts 5345 as well as contact pair 5332. Likewise, RS 5338 is provided with opposed solenoids 5348 and 5349 and presently engaged pair of contacts 5350 as well as contact pair 5337.

LS 5306 is adapted to complete the circuit of line 5341 to line 5352 which makes a circuit through the solenoid 5282 of RS 5280 to source line 2001. This will disengage contact pairs 5283, 5284, 5285 and 5286 to break the circuits of gear-motor 5124 while setting brake 5289 thereof upon reclosure of contact pair 5287.

Usually, residual momentum of the carrier 160 will cause it to come to a halt either slightly east or west of the required "-centered" position on the track of beam 5101 when the gear-motor 5124 ceases to operate. More importantly, during this particular phase of carrier movement, the end portion 1694 of the actuator 1692 on the carrier is moved into engagement with LS 5307 at a point beyond or slightly east of the desired "centered" position of the carrier on the entry conveyor drive unit. Thus, LS 5305 or LS 5307 is employed, in conjunction with the end portions 1694 and 1695 of actuator bar 1692, to "seek" the required position and in so doing "jog" the gear-motor to momentarily produce the desired direction of motion. Of course, the optimum position is reached when the actuator arms of the switch devices LS 5305 and LS 5307, are located substantially midway between the opposed end portions of the bar 1692. At this time, the actuator bar 1692 by its horizontal leg 1693 will maintain LS 5306 in its closed condition.

LS 5307 is thus adapted to produce westward motion of the related carrier and while in contact with end portion 1694 complete a circuit from source line 2000 via line 5353 from contacts 5316 of RS 5313. By way of line 354 through contacts 5345 of RS 5333, LS 5307 completes a circuit by line 5355, to TR 5335 in series with source lines 2000 and 2001.

Initially, TR 5335 sets up a time interval, during which the motor 5124 is halted, to interrupt the service of lines 5334 and 5336 to render LS 5306 inoperable. The timer also completes a circuit by line 5356 through the solenoid 5343 of RS 5333 to disengage contact pairs 5332, 5345 there of. TR 5335 then completes a circuit by line 5338 through solenoid 5293 of RS 5292 to source line 2001 thereby disengaging contact pairs 5295, 5296, and 5297 and engaging contact pairs 5298, 5299 and 5300 to reverse the polarity of gear-motor 5124. Finally, TR 5335 opens line 5358 and closes the circuit of line 5359 through the solenoid 5281 of RS 5280 to source line 2001. This causes engagement of particularly contact pairs 5283, 5284 and 5285, while de-energizing brake 5289 at contacts 5287. The power circuits to motor 5124 will now be made through line 5320, contact pair 5298 of RS 5292 and line 5361 to line 5323; line 5322, contact pair 5299 and line 5362 to line 5321; and line 5324, contact pair 5300, and line 5363 to line 5325. This causes motor 5124 to operate associated chain belt 5130 to move the carrier 160 slightly westward. By branch line 5365 from line 5359, a circuit is made through solenoid 5344 of RS 5333, this acting to re-engage contact pair 5332 although lines 5334 and 5336 are disconnected at TR 5335 as well as to reengage contacts 5345 although lines 5354 and 5355 are presently broken at LS 5307. When TR 5335 is inactive, line 5336 is completed, as above described, through TR 5340 and line 5341 to LS 5306 to effect halting of the gear-motor 5124.

If the ensuing slight jogging westward motion of the carrier slightly overruns the centered position and LS 5305 IS engaged by end portion 1695, line 5353 at engaged contact pair 5350 of RS 5338 completes a circuit by line 5366 through LS 5305 and line 5367 to TR 5340, in circuit with source lines 2000 and 2001. Initially, TR 5340 sets up a time interval, during which the gear-motor 5124 is halted, to interrupt the service of lines 5339 and 5341 and again render LS 5306 inoperable. The timer completes a circuit by line 5368 through the solenoid 5348 of RS 5338 to disengage contact pairs 5337 and 5350 thereof. TR 5340 then completes a circuit by line 5369 through the solenoid 5294 of RS 5292 to source line 2001 thereby disengaging pairs of contacts 5298, 5299 and 5300 and re-engaging contact pairs 5295, 5296 and 5297 to reverse the polarity of motor 5124. Finally, TR 5340 opens line 5369 and closes the circuit of line 5370, via line 5359, through solenoid 5281 of RS 5280 to source line 2001. This again causes engagement of contact pairs 5283, 5284 and 5285 while de-energizing brake 5289 at disengaged contact pair 5287. The power circuits will thus be made through line 5320, contacts 5295 and line 5321; line 5322, contacts 5296 and line 5323; and line 5324, contacts 5297 and line 5325 to the gear-motor 5124 to produce eastward movement of the carrier. By branch line 5371 from line 5370, a circuit is made through solenoid 5349 of RS 5338 to source line 2001, this operating to re-engage contact pair 5337 although lines 5339 and 5341 are open at TR 5340 and also re-engaging contact pair 5350 although lines 5366 and 5367 are presently open at LS 5305. Also when TR 5340 ceases to function, lines 5339 and 5341 will be restored to complete the circuit of line 5352 through LS 5306 thereby again halting the gear-motor.

The circuit of line 5367 from LS 5305 is also adapted by line 5373 to complete a circuit through timing relay TR 5374, the same being in series with source lines 2000 and 2001. Timer device TR 5374 is adjusted to monitor a time interval of sufficient duration to permit the motor 5124 to halt and thereby the related carrier 160 to come to a rest position and to then complete a circuit by line 5375 through the solenoid 5314 of RS 5313 to source 2001. This acts to disengage contact pairs 5315 and 5316 to thereby open the circuit lines generally to the switch devices LS 5305, 5306 and 5307, thereby rendering them inoperable until they have been removed from the control surfaces of the associated actuator bar 1692 by westward travel of the carrier 160 from the transfer carriage 510 and onto the rails 1067 and 1068 of the return side 18 of the conveyor system.

After a lapse of time, TR 5374 establishes a circuit by line 5376 and line 5358 through the solenoid 5293 of RS 5292 to source line 2001. This will reverse the polarity of motor 5124 preparatory for eventual westward movement of the sheet supporting carrier 160 from the carriage 510.

TR 5374 also completes a circuit by line 5377 to a timing relay TR 5378, in series with source lines 2000 and 2001. TR 5378 monitors an interval of time sufficient for the carriers to become stationary on the tracks of beams 5101 and 5102 and then completes a circuit by line 5380 through the coupler clutch 5145 to source line 2001 and then acts to open the circuit of a line 5381 which normally maintains the magnetic clutch 5155 energized. TR 5378 also completes a circuit by line 5382 to an associated timing relay 5383, also in series with source lines 2000 and 2001. TR 5383 completes the circuit of line 5385 through the solenoid 5189 of RS 5188 to source line 2001, this acting to disengage contact pairs 5191, 5192 and 5193 and engage contact pairs 5194, 5195 and

5196. This will reverse the polarity of the traction gear motor 5109 for movement of the carriage 510 in a northward direction. By line 5386, TR 5383 completes a circuit through the solenoid 5176 of RS 5175 thereby completing the service lines of the gear-motor and bring about north movement of the carriage along the rails or tracks 1065 and 1066. After the switch devices LS 5200, LS 5201 and 5204 have been removed from the area of the fixed cams 5202, 5203 and 5206, TR 5383 through the circuit of line 5387 energizes the solenoid 5216 of RS 5214 (FIG. 144) to re-engage contact pairs 5213 and 5217 for subsequent use of the line circuits 5212 and 5242 when the transfer carriage arrives in the northern end of the transfer area 16.

In this northern end, fixed cams 5390 and 5391 are located to actuate LS 5200 and 5201 for the same purpose, i.e., to produce jogging operation of the traction gear motor 5109, as did the cams 5202 and 5203 in the southern end of the axes 16. Thus, as the carriage 510 enters the northern end, LS 5205 will be engaged by the aforementioned cam 5207 to cause halting of the gear-motor. However, if the carriage momentum causes engagement of LS 5201 by the cam 5390, a sequence of reversing operation will be carried out upon actuation of RS 5219 and TR 5226. Likewise, slight southward overrunning of a position whereat the beams 5101 and 5102 will be aligned with the tracks 1065, 1066 will bring LS 5200 into engagement with the cam 5391 to produce slight northern movement of the carriage as previously described.

At this time, the switch device LS 5246 in the circuit of line 5245 will be opened while the switch device RS 5269 will be closed. LS 5246 is adapted to be moved to open position by a cam plate 5395, which will be understood to be mounted on one of the support tracks 1065 or 1066, before LS 5200 or LS 5201 are carried into the vicinity of fixed cam plates 5390 and 5391. LS 5246, being in the circuit of line 5245, breaks this circuit to TR 5247 thereby rendering the timer inoperable in the event that LS 5200 engages cam plate 5391 to move the carriage in a slight northward "jogging" motion. This is due to the fact that disengagement of contact pairs 5213 and 5217 of RS 5214 and energization of solenoid 5189 of RS 5188 is not required at this interval of operation.

LS 5269, on the other hand, is engaged by a cam plate 5396 to complete a circuit by line 5397 to a timing relay TR 5398, in series with source lines 2000 and 2001. This timer initially makes a circuit by line 5400 to initiate operation of the belt gear-motor of the first conveyor drive unit 550 in the return line as will shortly be described in connection with the control system of FIG. 155. TR 5398 then establishes a circuit by line 5401, via line 5318 (FIG. 145), through the solenoid 5281 of RS 5280. As previously set forth, this will produce operation of the belt gear-motor 5124 through service lines 5320, 5361 and 5323; 5322, 5362 and 5321, and 5324, 5363 and 5325, contact pairs 5298, 5299 and 5300 being presently engaged. Finally, TR 5398 by line 5402 completes a circuit through solenoid 5190 of RS 5188 thereby to disengage contact pairs 5194, 5195 and 5196 while re-engaging contact pairs 5191, 5192 and 5193 to reverse polarity of the traction gear-motor 5109 for eventual movement of the transfer carriage toward the south end of the transfer area 16.

Due to action of TR 5378, the coupler clutch 5145 is energized and magnetic clutch 5155 de-energized so that when gear-motor 5124 resumes operation, the transmission of power by chain belt 5136 will drive shaft 5140 and shaft 5141 through the clutch 5145. Since this will constitute a single or common source of power for the conveyor chain belts 5130 and 5131, the carriers 160 advanced thereby will move as a transversely aligned pair onto the rails or tracks 1067 and 1068.

As the trailing ends of the carriers are received on the entry ends of tracks 1067 and 1068, a switch device 5405 (also see FIG. 146) will be closed to complete a circuit by line 5406 to a timing relay 5407, in series with source lines 2000 and 2001. TR 5407 initially establishes a circuit by line 5410 through the solenoid 5282 of RS 5280 to source line 2001, this action serving to disengage contact pairs 5283, 5284, 5285 and 5286 to halt the belt motor 5124 as the brake 5289 is energized by the circuit from engaged contact pair 5287. Line 5411, from the timer and via line 5369, is completed through solenoid 5294 of RS 5292 to source line 2001. This will disengage contact pairs 5298, 5299 and 5300 and re-engage pairs 5295, 5296 and 5297 for subsequent use of gear-motor 5124 in the south end of the transfer area to move a pair of carriers as they are received on the transfer carriage 510 from the sixth chamber 490 of the processing apparatus. TR 5407 then makes a circuit by line 5412 through the solenoid 5176 of RS 5175 to source 2001, this serving to engage contact pairs 5178, 5179 and 5180 to supply energy to the traction gear-motor 5105. The transfer carriage is thus propelled along the tracks 1065 and 1066 to the south end of the transfer area.

## RETURN CONVEYOR DRIVE UNITS

Referring back to FIGS. 1, 2 and 3, it will be seen that a plurality of return conveyor drive units are located in aligned, end-to-end relation between the entry end 17 of the return side 18 and conveyor drive unit 152 at the exit end. Proceeding west or to the left, the return conveyor drive units are designated generally by the numerals 550, 551, 552 (FIG. 2), 553 and 554 (FIG. 1). As illustrated in FIGS. 147 and 153, these drive units are identical to one another structurally and in function. Thus, a typical structure or framework 5500 of these units, for example, the unit 550, is illustrated in its entirety in FIG. 148. Herein, the pair of beams 1067 and 1068 are supported by the structural assemblies 1070 and are united at spaced distances by structural frames or platforms 5501. At the west end of each framework 5500, there is provided a platform 5502 for the mounting of a source of power, such as the belt gear-motor 5503 (FIGS. 149 and 150), while adjacent the east and of the framework there is provided a platform 5505 (FIGS. 147, 148 and 149) on which the bearing assembly for the conveyor chain belt idler sprocket, shortly to be described is supported.

As has previously been noted in connection with certain of the carriage or conveyor drive units, such as carriages 120 and 510 and conveyor units 145 and 150, provision has been made to compensate for variation in operation of two belt gear-motors and resulting slight irregularities in the arrival positions of the carriers by the so-called "jogging" procedure to bring the carriers into transversely aligned relation. In the case of the conveyor drive unit 145 and the transfer carriage 510, this aligned relation has been maintained by employing one of the two gear-motors to produce further movement of the pair of carriers. Likewise, throughout the portions of the conveyor system in the processing apparatus, one gear-motor has been used to advance the pair of carriers. For this same purpose, one belt gear-motor is provided on each of the conveyor drive units 152 and 550 to 554.

In this connection, and as will be described with regard to FIGS. 154 and 156, when a pair of carriers are delivered from the transfer carriage 510, it is contemplated that they will be advanced continuously along the return conveyor side, through the drive unit 152, the bridging carriage 136 and onto the conveyor drive unit 151 associated with the sheet unloading unit 29 (FIGS. 5 and 152). Also, provision is herein made in the related circuit control systems for progressively halting the pairs of carriers, received from the transfer carriage 510, in the event that the shuttle carriage 120 has temporarily displaced the bridging carriage 136 to receive a pair of unloaded or empty carriers from the conveyor drive unit 151 at the north end 19 of the transfer area 12 and deliver them to the south side 11 of the area for transfer onto the loading conveyor drive unit 150.

With reference now to FIGS. 149 and 150, the output shaft 5507 of the belt gear-motor 5503 is equipped with sprocket 5508 which through related chain belt 5509 drives a sprocket 5510 on shaft 5511, journaled by bearings 5512 on the platform 5502. Shaft 5511 mounts sprockets 5514 at its outer

ends that drive sprockets **5515** on shafts **5516** by chain belts **5517**. The shafts **5516** are supported in bearing brackets **5518** and at their inner ends carry fixed sprockets **5519** that are similarly located with reference to an adjacent track **1067**, **1068** and drive an idler sprocket **5522** by means of related conveyor chain belt **5523**. Each sprocket **5522** is secured on a shaft **5524** journaled in an adjustably mounted bearing bracket **5525** (FIG. **149**) supported on the platform **5505**. As is common to all of the conveyor chain belts, the links of chain belts **5523** are equipped with plates **5526** for magnetic attachment by the bars **1675** of each carrier **160**.

To support the upper and lower flights of the conveyor chain belts **5523**, support rails **5530** are mounted on the opposed flanges of channel members **5531**, **5532**. These channel members are supported in the manner previously described on a bracket **5533** suspended from the platform **5502** and a similar bracket **5533** suspended from the platform **5502** and a similar bracket **5534** from the platform **5505**. Since each conveyor drive unit, as in FIG. **148**, is of sufficient length to accommodate at least two pairs of carriers, if necessary, the distance between the platforms **5502** and **5505** is fairly long and to sustain the weight of the chain belts **5523**, bars **5530** and channel members **5531** and **5532**, the structural frames **5501** are spaced therebetween to support additional mounting brackets **5535**.

As earlier explained, when a pair of carriers **160** are received on the tracks **1067**, **1068** and are moved westward by the pair of conveyor chain belts **5523**, they can be advanced directly onto the unloading conveyor drive unit **151** (FIG. **152**). If, however, the shuttle carriage **120** is located to receive a pair of empty carriers, the bridging carriage **136** being displaced, the pair of carriers on the tracks **1067**, **1068** will be successively halted on one of the conveyor drive units **550–553** until the pair on the conveyor drive unit **554** can be received on the exit conveyor drive unit **152** and then carried by the tracks of the bridging carriage **136** onto the unloading conveyor unit **151**.

Accordingly, this sequence of events will be made understandable if operation of the drive unit for the bridging carriage **136** is first described, followed by that of the exit conveyor drive unit **152** and the conveyor drive unit **550**. Thus, the electrical circuit control system diagrammatically illustrated in FIG. **154**, by way of example, is to produce operation of the belt gear-motor **5538** of the bridging carriage **136**. As illustrated in FIG. **156**, the similar control system for the exit conveyor drive unit **152** includes additional switch devices to effect successive halting of the belt gear-motors related with conveyor drive units **550**, **551**, **552** and **553**, as well as the drive unit **554** (FIGS. **155** and **156**).

## THE NORTH BRIDGING CARRIAGE 136

In connection with FIGS. **15** to **18**, it was stated that the bridging carriage **136** was structurally a duplicate of the bridging carriage **135**. However, in the present description of the carriage **136**, the pertinent details and elements thereof will be identified by individual numerals to prevent confusion. Thus, the bridging carriage **136** has a framework **5540** including parallel beams **5541** and **5542**, the lower flange of each beam constituting a support rail or track for the carriers **160**.

At their opposite ends, the upper flanges of the beams **5541**, **5542** have secured thereto transversely disposed pairs of flanges **5543** formed with blocks for the mounting of shafts of ball-bearing casters **5544**, such casters supporting the carriage **136** on the transverse tracks **1021** and **1022**. Adjacent the "west" end of the framework **5540**, a platform **5545** is mounted on the beams for the belt gear-motor **5538** while at the opposite or "east" side a platform **5546** is located.

The output shaft **5550** of the gear-motor **5538** is provided with a sprocket **5551** which by chain belt **5552** drives sprocket **5553** on shaft **5554**. This shaft carries sprockets **5555** on its outer ends which drive sprockets **5556** on shafts **5557** by means of chain belts **5558**. On its inner end, each shaft **5557** mounts a sprocket **5559** about which one end loop of a conveyor chain **5560** is entrained. The opposite looped end of each conveyor chain belt **5560** is entrained about an idler sprocket **5562** on a shaft **5563** journaled in the bearing bracket **5564** suspended from the platform **5546**. Between the drive sprockets **5559** and idler sprockets **5562**, the conveyor chain belts **5560** are conventionally supported on bars secured to channels **5566** and **5567**, such channels being mounted by a bracket **5568** suspended from the platform **5545** and a bracket **5569** at platform **5546**.

As described in an early portion of the specification, the bridging carriage **136** is moved to the phantom line position of FIG. **5** when the shuttle carriage **120** enters the north side **19** of the transfer area **12** to receive a pair of empty carriers **160** from the unloading conveyor drive unit **151**. For this purpose, the pairs of casters **3344** traverse the rails **1021**, **1022** and the weights **1429** (FIG. **7**) act on cables **1424** to return the carriage to the full line position as the shuttle carriage **120** again moves southward.

## THE EXIT CONVEYOR DRIVE UNIT 152

As illustrated in FIGS. **5**, **151**, **152** and **153**, the framework **5572** of the conveyor drive unit **152** comprises the beams or tracks **1028** and **1029** that are carried at their respective west ends by the beam **1035** supported at its ends by column **1036** and the adjacent column **1024**. The opposite ends of the tracks **1028** and **1029** are attached to the beam **1071** of a support assembly **1070**. The tracks on their upper flanges support a pair of platforms **5573** and **5574**.

The belt gear-motor **5576** for the unit **152** is mounted on the platform **5573** and the output shaft **5577** (FIG. **156**) thereof is equipped with a sprocket **5578** to drive chain belt **5579**. This chain belt by sprocket **5580** on shaft **5581**, journaled in bearings **5582**, is adapted to drive sprockets **5583** fixed on the opposite shaft ends. Sprockets **5583** by chain belts **5584** are adapted to drive sprockets **5585** on shafts **5586**, with these shafts being journaled in bearing brackets **5587**. Each shaft **5586** mounts a sprocket **5588** at its inner end for driving a related conveyor chain belt **5590** (FIG. **154**). As previously set forth the opposite looped end of each chain belt is entrained about an idler sprocket whose shaft is journaled in a bearing bracket **5591** suspended from the platform **5574**. Similarly, the chains are supported by bars of channels **5592** and **5593** carried by brackets **5594** and **5595**.

## THE RETURN CONVEYOR DRIVE UNITS

The conveyor drive units **551**, **552**, **553** and **554** are identical in structure to the previously described conveyor drive unit **550** and are equipped respectively with a belt gear-motor **5600**, **5602**, **5604** and **5606** for driving an associated pair of conveyor chain belts **5601**, **5603**, **5605** and **5607** (FIGS. **155** and **156**). The assemblies of sprockets, shafts and chain belts to transmit the drive to the pairs of conveyor chain belts are similar to those illustrated in FIGS. **149**, **150** and **152** and further detailed description is not believed to be necessary.

## BRIDGING CARRIAGE CONTROL SYSTEM

With reference now to FIG. **154**, the service circuits for belt gear-motor **5538** are completed through a spring-biased relay switch RS **5609** having a solenoid **5610** and presently engaged pairs of contacts **5611**, **5612** and **5613**. The solenoid **5610** is energized by a circuit of line **5614** from source line **2000** through a switch device LS **5615** which is held in closed position by cam plate **5616**, supported on the beam **1035** (FIGS. **151** and **153**), with the carriage **136** aligned with the unloading and exit conveyor drive units **151** and **152** respectively. The circuits from source lines **2000**, **2001** and **2002** are therefore opened when the carriage **136** is displaced from its aligned position by the shuttle carriage **120**, as has been described, and moved northward to the position shown in phantom line in FIG. **5**.

A switch device LS **5617** is actuated substantially simultaneously with LS **5615** and is thereby closed by the action of cam plate **5616**. This switch will also open when released by the cam plate as the bridging carriage **136** is moved into the phantom line position of FIG. **5**. LS **5617** is instrumental, when in the closed condition, in completing the circuit of a line **5618**, which originates in the electrical control system for one of the conveyor drive units of the return side **18** (FIG. **156**), to the circuitry of motor **5576**. Completion of line **5618** at LS **5617** and line **5619** through a timing relay TR **5620**, in series with source lines **2000** and **2001**, creates the necessary circuit for starting operation of the unloading conveyor drive unit **151**. Otherwise, when LS **9617** is open by location of the bridging carriage **136** in the phantom line position of FIG. **5**, the starting of the gear-motors of the unloading conveyor drive unit **151** will not be made effective (see FIG. **157**).

Each of the rails **5541** and **5542** support switch devices LS **5623** and LS **5624** by similar brackets **5625**. LS **5624** is located adjacent the west ends thereof.

Normally these service circuits are completed through the contact pairs of RS **5609** by lines **5627**, **5628** and **5629** to a double-action relay switch RS **5630** equipped with opposed solenoids **5631** and **5632**, presently disengaged pairs of contacts **5633**, **5634**, **5635** and **5636** and presently engaged pair of contacts **5637** which by line **5638** complete a circuit through the brake **5639** of gear-motor **5536** to source line **2001**.

As herein provided, the solenoid **5631** of RS **5630** is adapted to cause engagement of contact pairs **5633**, **5634** and **5635** upon completion of a circuit of a line **5640** originating in the electrical control system (FIG. **137**) of the unloading conveyor drive unit **151**, which circuit is dependent on the westward movement of a pair of carriers **160** toward the last conveyor drive unit **554** as they are advanced along the return side **18** from the transfer carriage **510** and received in sequence on the conveyor drive units **550**, **551**, **552** and **553**. Assuming that each of these conditions have been set and the gear-motors of the unit **151** are put in operation, the completion of line **5640** through solenoid **5631** to source line **2001** will effect engagement of contact pairs **5633**, **5634** and **5635** to extend the service of source lines **2000**, **2001** and **2002** by way of lines **5627** and **5642**, **5628** and **5643** and **5629** and **5644** to gear-motor **5538** to start the same while opening contact pair **5637** to break the circuit of line **5638** to brake **5639**. Engagement of contact pair **5636** establishes a line **5645** through a timing relay TR **5646**, in series with source lines **2000** and **2001**, to activate the same via line **5647**. While functioning, TR **5646** interrupts the circuit of lines **5645** and **5647** and, after the gear-motor **5538** is operating to drive the pair of conveyor chain belts **5560**, creates a line circuit **5648** extended to the electric control system associated with the exit conveyor drive unit **152**.

As the leading end portion **1695** of the actuator bar **1692** of each carrier passes through the area of the bridging carriage **136**, it sequently engages previously described switch devices LS **5623** and **5624** associated with each rail **5541** and **5542**; in the present instance attention being directed to LS **5623**. This switch, which is normally closed, is intended to produce halting of gear-motor **5576** (FIG. **156**) of the unit **152** when the associated carriers are bodily, though temporarily, supported on the rails **5541** or **5542** of the carriage **136** and for this purpose is connected by line **5650** to presently open LS **5651**, actuated simultaneously with LS **5624** at the opposite end of carriage **136**. As herein contemplated, although in no ways restrictive to other uses of the switch devices LS **5623** and LS **5624**, while LS **5623** is supported in the open position by the horizontal lag **1693** of an actuator bar **1692**, the circuit of line **5650** will also be open through LS **5651** to source line **2000**.

Likewise, a circuit of line **5652** through presently closed LS **5624** is open at LS **5653** which is opened simultaneously with LS **5623**. In consequence, then the trailing end portion **1694** of the actuator bar **1692** clears LS **5623** and LS **5653**, the same will be permitted to close. In the first instance, when the leading end **1695** of the bar **1692** engages LS **5624** to open the same, it also actuates LS **5651** to the closed position thereby completing a circuit from source line **2000** and line **5650** to LS **5623**. A circuit is now made by line **5655** from LS **5623** to a timer device TR **5636**, in series with source lines **2000** and **2001**, to establish a circuit by line **5658** to halt the gear-motor **5576**, as will be described in connection with FIG. **156**.

When the trailing end **1694** of the bar **1692** releases LS **5623**, LS **5653** is also closed to complete source line **2000** by the line **5652** to the presently open LS **5624**. When the carriers **160** are moved from tracks **5541** and **5542** and are bodily supported on tracks **1030** and **1031** of the unloading conveyor drive unit **151**, the trailing end portion **1694** of the actuator bar **1692** releases LS **5624** whereupon the circuit of line **5652** will be completed via line **5659** to a timing device TR **5660**, in series with source lines **2000** and **2001**. This timer monitors an interval of time to ensure that the carriers **160** have been bodily moved from the tracks **5541** and **5542** and then completes a circuit by line **5661** through solenoid **5632** of RS **5630** which will open the service of lines **5642**, **5643** and **5644** to halt the gear-motor **5538** while line **5638** restored at contact pair **5637** will again energize the brake **5639**.

With reference now to FIG. **156**, the service circuits for belt gear-motor **5576** for the exit conveyor drive unit **152** are completed through a relay switch RS **5665** having opposed solenoids **5666** and **5667** and presently engaged pairs of contacts **5668**, **5669** and **5670**.

A circuit by line **5672** is controlled by a switch device LS **5673**, moved to open condition by a cam **5674** mounted on the adjacent end of the bridging carriage **136**. When this carriage is displaced, LS **5673** is closed, upon release from the cam plate, to complete line **5672** to a timing relay TR **5675**, in series with source lines **2000** and **2001**, by line **5676**, TR **5675**, while functioning, opening the circuits of lines **5672** and **5676**.

During normal operation of the control system to remove a pair of empty carriers from the unloading conveyor drive unit **151** and onto the shuttle carriage **120**, TR **5675** provides a time interval of normally expected duration for the bridging carriage **136** to be returned from its displaced position and completes a line **5677** through the solenoid **5666** of RS **5665**. This serves to temporarily disengage the pairs of contacts **5668**, **5669** and **5670** to ensure that the electrical control system for the unit **152** will be inoperable during the displacement of carriage **136**. Of course, when the carriage **136** returns to its normal position, TR **5675** will have ceased to function to open line **5677** and reclosed switch LS **5615** (FIG. **154**) will have re-established the circuit of line **5618** to solenoid **5667** of RS **5665**.

During this first time interval, TR **5675** institutes a second time period of longer duration in the event that the carriage **136**, for one reason or another, is held in its displaced position and pairs of carriers are received on the conveyor drive units of the return side **18** in regularly spaced sequences. At termination of the second time interval, TR **5675** is adapted to establish a line **5678** to one side of a pair of contacts associated with a relay switch in the electrical control system for the conveyor drive unit **554** and a line **5679** to limit switches LS **5680** and LS **5681**. However, during the aforementioned first and relatively short interval of time, TR **5675** will not complete lines **5678** and **5679**.

When the carriage **136** is located in the position of alignment with the exit conveyor drive unit **152**, LS **5673** will be reopened while LS **5615** and LS **5617**, of the control system for the bridging carriage **136**, will be closed by the action of cam plate **5616** (FIG. **154**). Thus, the solenoid **5667** can be again energized by the circuit of line **5618** from the control system of unit **553** through the switch device LS **5617** which is held in closed position by cam plate **5616**, with the carriage **136** aligned with the unloading and exit conveyor drive units **151** and **152**, respectively.

Each of the rails **1028** and **1029** of the conveyor drive unit **152** support the switch devices LS **5680** and LS **5681** by

similar brackets **5682**. LS **5680** and LS **5681** are located at the east ends of the rails.

When solenoid **5667** is energized, service circuits are completed through the contact pairs of RS **5665** by lines **5685**, **5686** and **5687** to a double-action relay switch RS **5690** equipped with opposed solenoids **5691** and **5692**, presently disengaged pairs of contacts **5693**, **5694**, **5695** and presently engaged pair of contacts **5697** which by line **5698** complete a circuit through the brake **5699** of gear-motor **5576** to source line **2001**.

As herein provided, the solenoid **5691** of RS **5600** is adapted to cause engagement of contact pairs **5693**, **5694** and **5695** upon completion of the described circuits (lines **5618**, **5640** and **5648**) originating in the electrical control system (FIGS. **154**, **156** and **157**) of the bridging carriage **136**, the unloading conveyor drive unit **151** and a return conveyor unit, such as the unit **553** by way of example, which circuits are dependent on the westward movement of a pair of carriers **160** from the preceding conveyor drive units **552** and **551** as they are advanced along the return side **18** from the transfer carriage **510** and the conveyor drive unit **550**. Assuming that each of these conditions have been met, and the gear-motor of the unit **554** is in operation, the completion of line **5648** from TR **5646** (FIG. **154**) through solenoid **5691** to source line **2001** will affect engagement of contact pairs of RS **5690** to extend the service of source lines **2000**, **2001** and **2002** by way of lines **5685** and **5703**, **5686** and **5704** and **5687** and **5705** to belt gear-motor **5576** to start the same while opening contact pair **5697** to break the circuit of line **5698** to brake **5699**.

## THE ELECTRICAL CONTROL SYSTEM FOR CONVEYOR UNIT 550

With reference now to FIG. **155**, the service circuits for belt gear-motor **5503** for the return side conveyor drive unit **550** are completed through a relay switch RS **5725** having opposed solenoids **5726** and **5727** and presently disengaged pairs of contacts **5728**, **5729** and **5730**. Solenoid **5726** is normally energized by line **5732** maintained through one side of a timing relay TR **5733**, in series with source lines **2000** and **2001** and functioning as will shortly be described. Service circuits are completed through the contact pairs of RS **5725** by lines **5735**, **5736** and **5737** to a double-action relay switch RS **5740** equipped with opposed solenoids **5741** and **5742**, presently disengaged pairs of contacts **5743**, **5744**, **5745** and **5746** and presently engaged pair of contacts **5747** which by line **5748** complete a circuit through the brake **5749** of gear-motor **5503** to source line **2001**.

As herein provided, the solenoid **5741** of RS **5740** is adapted to cause engagement contact pairs **5743**, **5744** and **5745** upon completion of circuit line **5400** originating in the electrical control system (FIG. **144**) for the return shuttle carriage **510**, which circuit is dependent on alignment of the rails **5101**, **5102** with the rails **1067**, **1068** of the first conveyor drive unit **550**. Contact pairs **5743**, **5744** and **5745** will thus complete the service of lines **5735** and **5730**, **5736** and **5751** and **5737** and **5752** to gear-motor **5503**. Assuming that this condition has been met and the belt gear-motor **5503** of the unit **550** is in operation, the completion of line **5401** through solenoid **5281** of RS **3280** (FIGS. **144** and **145**) to source line **2001** effects engagement of contact pairs of RS **5250** to produce operation of belt gear-motor **5124**. For reasons shortly to be explained, the circuit of line **5400** is extended through a counting relay CR **5753**, in series with source lines **2000** and **2001** and line **5754** to solenoid **5741**.

Engagement of contact pair **5746** establishes a line **5755** through a timing relay TR **5756**, in series with source lines **2000** and **2001**, to activate the same via line **5757**. While functioning, TR **5756** interrupts the circuit of lines **5755** and **5757** and, after the gear-motor **5503** is operating to drive the associated pair of conveyor chain belts **5523**, creates the line circuit **5758** extended through a counting relay CR **5759**, in series with source lines **2000** and **2001**, and line **5760** to the electric control system for the next conveyor drive unit **551**.

While being moved westward from the entry ends of rails **1067** and **1068**, at least one of the carriers **160** will move a switch device LS **5762** to closed position thereby completing a line **5763** to TR **5733**. This will cause the timing relay to break the circuit of line **5732** through solenoid **5726** of RS **5725** and then make a line **5764** through the opposed solenoid **5727** to source line **2001**. This will disengage the contacts pairs **5728**, **5729** and **5730** to temporarily open service lines **5735** and **5750**, **5736** and **5751** and **5737** and **5752** to gear-motor **5503**. The purpose for halting the pair of carriers is to provide an interval for inspection of the filmed surfaces of the glass sheets, if desired. When TR **5733** ceases to function, the circuit of line **5764** will be opened and that of line **5732** closed through solenoid **5726** to re-engage contact pairs **5728**, **5729** and **5730** and restart belt gear-motor **5503**.

Advancing westwardly from the vicinity of LS **5762**, at least one of the carriers engage a switch device LS **5766** connecting CR **5753** to the source lines **2000** and **5735** by line **5767**. This will condition CR **5753** for subsequent use, the effective functioning thereof being dependent upon completion of a line **5768** originating in CR **5759** of the electrical control system for the conveyor drive unit **551** as will shortly be explained.

As the leading end **1695** of one of the actuator bars **1692** is carried into the entry area of the rails **1067** and **1068** associated with the conveyor drive unit **551**, it moves a switch device LS **5770** to the closed position, one side of LS **5770** being connected to source line **2000** and the other side by line **5771** to a timing relay **5772**, in series with source lines **2000** and **2001**. TR **5772** monitors an interval of time for the trailing ends of the carriers to clear the exit area of the rails **1067** and **1068** of the conveyor drive unit **550** and then makes a circuit line **5773** through opposed solenoid **5742** of RS **5740** to source line **2001**. This will serve to disengage contact pairs **5743**, **5744**, **5745** and **5746** to halt operation of the belt gear-motor **5503** while re-setting the brake **5749** therefor at closed contact pair **5747**.

As the carriers **160** are received on the tracks **1067** and **1068** of the conveyor drive unit **551** (FIG. **147**), the leading magnetic bars **1675** will engage the contactor plates of the conveyor chain belts **5601** that are presently driven by the gear-motor **5600**.

## THE ELECTRICAL CONTROL SYSTEM FOR CONVEYOR UNIT 551

The service circuits to the gear-motor **5600** are completed through a relay switch RS **5780** having opposed solenoids **5781** and **5782**, and presently engaged pairs of contacts **5783**, **5784** and **5785**. These pairs of contacts complete lines **5788**, **5789** and **5790** through contacts pairs **5792**, **5793** and **5794** of a relay switch RS **5795**, equipped with opposed solenoids **5796** and **5797**. When solenoid **5796** is energized by the circuit of line **5758** from TR **5756** associated with the control system for the conveyor drive unit **550** and line **5760** from CR **5759**, lines **5788**, **5789** and **5790** are completed to the gear-motor via lines **5798**, **5799** and **5800**. RS **5795** has presently open contact pair **5801**, which normally completes line **5802** to the motor brake **5803**, and an additional contact pair **5804**. When engaged, this contact pair makes a circuit by line **5805** to a timing relay **5806**, in series with source lines **2000** and **2001**, the circuit of line **5805** being caused to activate the timer by line **5807**. While functioning, TR **5803** opens the service of lines **5805** and **5807** and completes a circuit by line **5808** through a counting relay **5810**, in series with source lines **2000** and **2001**, and line **5811** to begin operation of the belt gear-motor **5815** for the conveyor drive unit **552**.

After tripping LS **5770** to the open position to break the circuit of line **5771**, the leading end **1695** of an actuator bar **1692** engages a switch device **5817** connecting CR **5759** to source lines **2000** and **5788** by line **5818**. As in the case of CR **5753**, CR **5759**, while thus conditioned for services, is caused to function upon completion of a line circuit **5819** from the electrical control system for the conveyor drive unit **552**.

As the leading ends of the pair of carriers are moved past the entry area of the conveyor drive unit **552**, the leading end **1695** of an actuator bar **1692** engages and closes the switch device LS **5822**, this switch being connected to source line **2000** and by line **5823** to a timing relay TR **5824**, in series with source lines **2000** and **5788** and **2001** and **5790**. This timer provides the necessary lapse of time for the trailing ends of the carriers to clear the exit area of the tracks **1067** and **1068** of the conveyor drive unit **551**, and the end **1694** of the bar **1602** to trip LS **5822**, and then completes a circuit by line **5825** through the solenoid **5797** of RS **5795** to source line **2001**. The action of solenoid **5797** will disengage contact pairs **5792**, **5793** and **5794** and **5804** to open lines **5798**, **5799**, **5800** and **5805**. This essentially will halt operation of belt gear-motor **5600** while engaged contact pair **5801** will again energize the brake **5803**.

## THE ELECTRICAL CONTROL SYSTEM FOR CONVEYOR UNIT 552

The services circuits for belt gear-motor **5602** for the return side conveyor drive unit **552** are completed through a relay switch RS **5830** having opposed solenoids **5831**, **5832** and presently engaged pairs of contacts **5833**, **5834** and **5835**. Service circuits are thus completed through the contact pairs of RS **5830** by lines **5837**, **5838** and **5839** to a double-action relay switch RS **5840** equipped with opposed solenoids **5841** and **5842**, presently disengaged pairs of contacts **5843**, **5844**, **5845** and **5846** and presently engaged pair of contacts **5847** which by line **5848** complete a circuit through the brake **5849** of gear-motor **5815** to source line **2001**.

As herein provided, the solenoid **5841** of RS **5840** is adapted to cause engagement of contact pairs **5843**, **5844** and **5845** upon completion of the circuit line **5811** originating in the electrical control system for the return side conveyor drive unit **551**. Contact pairs **5843**, **5844** and **5845** will thus complete the service of lines **5837** and **5851**, **5838** and **5852** and **5839** and **5853** to gear-motor **5602** thereby to drive the pair of conveyor chain belts **5603** through a sprocket and belt train duplicating that hereinabove shown and described in connection with gear-motor **5503** and conveyor chain belts **5523**. With the belt gear-motor **5602** of the conveyor drive unit **552** in operation, the contact pair **5846** makes a circuit by line **5854** to a timing relay **5855**, in series with source lines **2000** and **2001**, the circuit of line **5854** being caused to activate the timer by line **5856**. While function, TR **5853** opens the service of lines **5854** and **5856** and completes a circuit by line **5857** through a counting relay **5858**, in series with source lines **2000** and **2001**, and line **5859** to begin operation of the belt gear-motor **5604** for the conveyor drive unit **553** to drive the associated pair of conveyor chain belts **5605**.

After releasing LS **5822** to the open position, the leading end **1695** of an actuator bar **1692** engages a limit switch LS **5865** connecting CR **5810** to source lines **2000** and **3837** by line **5866**. In this respect, CR **5810** while thereby conditioned to function, as are the counting relays CR **5753** and CR **5759**, upon completion of a circuit by line **5867** from the electrical control system for the conveyor drive unit **553**.

As the leading ends of the pair of carriers are moved past the entry area of the conveyor drive unit **553**, the leading end **1695** of an actuator bar **1692** engages and closes the switch device LS **5870**, this switch being connected to source line **2000** and by line **5871** to a timing relay TR **5872**, in series with source lines **2000** and **2001**. This timer provides the necessary lapse of time for the trailing ends of the carriers to clear the exit area of the tracks **1067** and **1068** of the conveyor drive unit **552** and the end **1094** of the bar **1692** to trip LS **5870** and then completes a circuit by line **5873** through the solenoid **5842** of RS **5840** to source line **2001**. The action of solenoid **5842** will disengage contact pairs **5843**, **5844**, **5845** and **5846** to open lines **5851**, **5852**, **5853** and **5854**. This essentially will halt operation of belt gear-motor **5602** while engaged contact pair **5847** will again energize the brake **5849**.

## THE ELECTRICAL CONTROL SYSTEM FOR CONVEYOR UNIT 553

The service circuits for belt gear-motor **5604** for the return side conveyor drive unit **553** are completed through a relay switch RS **5880** having opposed solenoids **5881**, **5882** and presently engaged pairs of contacts **5883**, **5884** and **5885**. Service circuits are thus completed through the contact pairs of RS **5880** by lines **5887**, **5888** and **5889** to a double-action relay switch RS **5890** equipped with opposed solenoids **5891** and **5892**, presently disengaged pairs of contacts **5893**, **5894** and **5895** and **5896** and presently engaged pair of contacts **5897** which by line **5898** complete a circuit through the brake **5899** of gear-motor **5604** to source line **2001**.

As herein provided, the solenoid **5891** of RS **5890** is adapted to cause engagement contact pairs **5893**, **5894** and **5895** upon completion of the circuit line **5857** originating in the electrical control system for the return side conveyor drive unit **552**, CR **5858** and line **5859**. Contact pairs **5893**, **5894** and **5895** will thus complete the service of lines **5887** and **5901**, **5888** and **5902** and **5889** and **5903** to gear-motor **5604** thereby to drive the pair of conveyor chain belts **5605** through a sprocket and belt train duplicating those hereinabove shown and described. With the belt gear-motor **5604** of the conveyor drive unit **553** in operation, the contact pair **5896** makes a circuit by line **5905** to a timing relay **5906**, in series with source lines **2000** and **2001**. The circuit of line **5905** being caused to activate the timer by line **5907**. While functioning, TR **5906** opening the service of lines **5905**, **5907** and completes a circuit by line **5908** through a counting relay **5909**, in series with course lines **2000** and **2001**, and line **5910** to begin operation of the belt gear-motor **5606** for the conveyor drive unit **554** to drive the associated pair of conveyor chain belts **5907**.

By the line **5618** from line **5908**, a line is extended, via LS **5617** and line **5619** (FIG. **154**), to the electrical control system for the unloading conveyor drive unit **151** (FIG. **157**). This will ensure that the associated conveyor chain belts will be driven and in sequence the gear-motor **5538** of the bridging carriage **136** will be started. In turn, the belt-gear-motor **5576** of the exit conveyor drive unit **152** will be operated to advance the pair of carriers **160** as they are moved from the conveyor drive unit **554**. On the other hand, if a pair of unloaded carriers have not been, or are being, removed from the unit **151** the circuit of line **5619** to the control system thereof will not be completed or, during displacement of the bridging carriage **136**, the starting circuit to the gear-motor **5538** will not be established. In either event, the pair of carriers entering upon the rails **1028** and **1029** of the exit conveyor unit **152** will be halted thereon.

After releasing LS **5870** to the open position, the leading end **1695** of an actuator bar **1692** engages a limit switch LS **5920** connecting CR **5858** to source lines **2000** and **5887** by line **5921**. In this respect, CR **5858**, while thereby conditioned to function, as are the counting relays CR **5753**, CR **5759** and CR **5810**, is caused to function upon completion of a line circuit **5922** from the electrical control system for the conveyor drive unit **554**.

As the leading ends of the pair of carriers are moved past the entry area of the conveyor drive unit **554**, the leading end **1695** of an actuator bar **1692** engages and closes the switch device LS **5925**, this switch being connected to source line **2000**, **5887** and by line **5926** to a timing relay TR **5927**, in series with source lines **2000** and **2001**. This timer provides the necessary lapse of time for the trailing ends of the carriers to clear the exit area of the tracks **1067** and **1068** of the conveyor drive unit **553** and the end **1694** of the bar **1692** to trip LS **5925** and then completes a circuit by line **5928** through the solenoid **5892** of RS **5890** to source line **2001**. The action of solenoid **5892** will disengage contact pairs **5893**, **5894**, **5895** and **5896** to open lines **5901**, **5902**, **5903** and **5905**. This essentially will halt operation of belt gear-motor **5604** while engaged contact pair **5897** will again energize the brake **5899**.

THE ELECTRICAL CONTROL SYSTEM FOR CONVEYOR UNIT 554

The service circuits for belt gear-motor 5806 for the return side conveyor drive unit 554 are completed through a relay switch RS 5930 having opposed solenoids 5931, 5932 and presently disengaged pairs of contacts 5933, 5934 and 5935. Service circuits are thus completed through the contact pairs of RS 5930 by lines 5937, 5938 and 5939 to a double-action relay switch RS 5940 equipped with opposed solenoids 5941 and 5942, presently disengaged pairs of contacts 5943, 5944 and 5945 and presently engaged pair of contacts 5947 which by line 5948 complete a circuit through the brake 5949 of gear-motor 5606 to source line 2001.

As herein provided, the solenoid 5941 of RS 5940 is adapted to cause engagement of contact pairs 5043, 5944 and 5945 upon completion of the circuit line 5910 originating by line 5908 in the electrical control system for the return side conveyor drive unit 554. Contact pairs 5943, 5944 and 5945 will thus complete the service of lines 5937 and 5932, 5938 and 5953 and 5939 and 5954 to gear-motor 5606 thereby to drive the pair of conveyor chain belts 5607 through sprocket and belt train duplicating those hereinabove shown and described. With the belt gear-motor 5606 of the conveyor drive unit 554 in operation, the contact pair 5946 is adapted to complete the circuit by line 5678 which, however, is dependent upon activation of TR 5675 for the aforementioned longer interval of time.

As the leading end 1695 of one of the actuator bars 1692 is carried into the entry area of the rails 1028 and 1029 associated with the exit conveyor drive unit 152, it moves a switch device LS 5965 to the closed position, one side of LS 5965 being connected to source lines 2000 and 5937 and the other side by line 5966, to a timing relay 5967, in series with source lines 2000 and 2001. TR 5967 monitors an interval of time for the trailing ends of the carriers to clear the exit area of the rails 1067 and 1068 of the conveyor drive unit 554 and then makes a circuit by line 5968 through opposed solenoid 5942 of RS 5940 to source line 2001. This will serve to disengage contact pairs 5943, 5944 and 5945 to halt operation of the belt gear-motor 5912 while resetting the brake 5949 therefor at closed contact pair 5947.

As the carriers 160 are received on the tracks 1028 and 1029 of the exit conveyor drive unit 152 (FIG. 15), the leading magnetic bars 1675 will engage the contactor plates of the conveyor chain belts 5590 that are presently driven by the gear-motor 5576.

As above described, the service circuits to the gear-motor 5576 are completed by actuation of RS 5690 by line 5648 which is made when the electrical control system for the bridging carriage 136 has been activated by the circuit of line 5640 originating in the control system of the unloading conveyor drive unit 151 (FIG. 157) to the electrical control system for the bridging carriage 136.

After releasing LS 5965 to the open position, the leading end 1695 of an actuator bar 1692 engages a limit switch LS 5970 connecting CR 5909 to source lines 2000, 2001 and 5937, 5939 by line 5971. In this respect, CR 5909 is conditioned to function, as are the previously described counting relays, and is caused to function upon completion of a line circuit 5972 from the electrical control system for the exit conveyor drive unit 152.

The circuit of line 5972 is adapted to be completed from LS 5680 when the bridging carriage 136 has been displaced by the shuttle carriage 120. As explained earlier and when this occurs, LS 5673 is also removed from the control of the cam plate 5674 and is thereby permitted to create the circuit of line 5677 through the solenoid 5666 of RS 5665 to open the service of lines 5685, 5686 and 5687.

Referring now to the utility of the counting relays, CR 5753, CR 5759, CR 5810, CR 5858 and CR 5909, it has previously been noted that when the bridging carriage 136 has been displaced by the shuttle carriage 120 and moved north to the phantom line position of FIG. 5, the circuitry to produce operation of the belt gear-motor 5576 will be interrupted. Due to normal delays that are expected to be experienced in the operation of the conveyor system in its entirety, the bridging conveyor 136 may be held in its displaced position for an interval of time longer than that estimated to be required for a pair of carriers to be moved from the entry end of the return side 18 directly onto the unloading conveyor drive unit 151. In this event, the following pair of carriers must be delayed on the exit conveyor drive unit 152 and subsequently advancing pairs of carriers to be progressively halted on the several units 550, 551, 552, 553 and 554 in the return side of the conveyor system.

Thus, when LS 5673 is closed upon release from the cam plate 5674, the circuit of line 5672 will be completed through TR 5675 by lines 5672 and 5676. This results in the establishment of line 5677 through solenoid 5666 for the relatively short interval of time for the bridging carriage 136 to be displaced from and then returned to its normal operative position.

Now, when the next pair of carriers 160 are removed from the shuttle carriage 510 and successively produce operation of the gear-motors 5503, 5600, 5602 and 5604 of the conveyor drive units 550, 551, 552 and 553, they will eventually reach the area of conveyor drive unit 554. As previously indicated, the line 5910 from CR 5909 and line 5908 has produced actuation of RS 5940 and consequent operation of motor 5606. After the second longer interval of time, TR 5675 activates the circuit of line 5678 through contact pair 5946 of RS 5940 to line 5975 through the solenoid 5667 of RS 5665 and by branch line 5976, connecting to line 5648, through the solenoid 5691 of RS 5690. This serves to complete lines 5685, 5686 and 5687 through contact pairs 5668, 5669 and 5670 and lines 5703, 5704 and 5705 via contact pairs 5693, 5604 and 5695 of RS 5690. Also, lines 5679 is completed from TR 5675 to LS 5680 and LS 5681.

As the leading end 1695 of an actuator bar 1692 engages LS 5680 it will complete the circuit of line 5679 and line 5980 to a timing relay 5981. This relay functions to complete a holding circuit by line 5972 to CR 5909 to produce its operation. LS 5681 completes the circuit of line 5679 and line 5983 to timing relay TR 5984 which monitors a period of time sufficient for the pair of carriers to arrive bodily on the rails 1028 and 1029 on the exit conveyor drive unit 152 and then completes a circuit by line 5985 and line 5658 through the solenoid 5692 of RS 5690 to source line 2001. This disengages contact pairs 5692, 5693 and 5694 to halt operation of the gear-motor 5576 while engaged pair of contacts 5697 restores line 5698 to energize the brake 5699. By line 5986, TR 5984 also completes a circuit to activate TR 5620 (FIG. 154). While functioning, TR 5620 opens the circuit of line 5618 which normally is completed to the solenoid 5667 of RS 5665 and also the circuit of line 5619 that normally is instrumental in the energization of the solenoid 6101 of RS 6100 (FIG. 157).

In following order, the next pair of carriers will pass through the conveyor units 550, 551, 552 and 553 and upon entering onto the rails 1067 and 1068 of the unit 534, will engage LS 5970 to complete line 5971 to CE 5909 since the holding circuit of line 5972 has been established. While functioning, CR 5909 completes the circuit by line 5922 to CR 5858 of the conveyor drive unit 553 and simultaneously opens the circuit of lines 5908 and 5910. Thus, as the carriers approach the exit area of unit 554, a further circuit by line 5987 through the solenoid 5931 of RS 5930 will produce disengagement of contact pairs 5033, 5934 and 5935 to open the service lines to the gear-motor 5606.

In following order, the next pair of carriers entering the unit 553 will close LS 5920 to start the functioning of CR 5858, an activating circuit having been made by line 5922. This counting relay makes a circuit by line 5867 to CR 5810 of unit 552, opens lines 5857 and 5859 and makes a circuit by line 5988 through the solenoid 5881 of RS 5880. As before, the halting

of gear-motor **5604** will stop the pair of carriers **160** before they reach the exit area of the rails **1067** and **1068** associated with the conveyor drive unit **553**.

If the conditions existent in the north end **19** of the transfer area **12** still persist, CR **5810** will be activated upon closure of LS **5865** to establish a circuit by line **5819** to CR **5759** in the electrical control circuit for the conveyor drive unit **551**. This will also complete line **5989** through the solenoid **5831** of RS **5830** to disengage contact pairs **5833**, **5834** and **5835**. The circuit of lines **5808** and **5811** will be similarly interrupted which will prevent operation of the gear-motor **5602** by movement of a subsequent pair of carriers.

Likewise, when a pair of carriers engage LS **5817**, the existence of line **5819** will complete line **5815** thereby to complete line **5768** to CR **5753**, open the circuit of lines **5758** and **5760** and make a circuit by line **5990** through the solenoid **5781** of RS **5780** to disengage related contact pairs **5783**, **5784** and **5785**.

When a following pair of carriers from the shuttle carriage **510** are received on the rails **1067** and **1068** of the conveyor drive unit **550** and engage LS **5766**, the holding circuit of line **5768** from CR **5759** to CR **5753** will cause the same to open the circuit of lines **5400** and **5754**. CR **5753** then establishes a circuit by line **5991** and line **5764** through the solenoid **5727** of RS **5725**. This, of course, will occur after the carriers have passed through the inspection area and activated LS **5762** as above described.

When the bridging carriage **136** has been permitted to return to its normal position of alignment between the conveyor units **151** and **152**, the release by cam plate **5616** will permit LS **5615** and LS **5617** to reclose. While LS **5615** will be effective to restore the circuit of line **5614** through solenoid **5610** of RS **5609** to re-engage contact pairs **5611**, **5612** and **5613**, line **5986** will actuate TR **5620** to complete a circuit by line **5992** to a counting relay CR **5993** (FIGS. **154** and **156**). After establishing line **5992**, TR **5620** ceases to function thereby permitting restoration of lines **5618** and **5619**.

This counting relay produces successive actuation of RS **5665**, RS **5930**, RS **5885**, RS **5830**, RS **5780** and RS **5725**. This will permit the pair of carriers on the exit conveyor drive unit **152** to be forwarded to the unloading conveyor drive unit **151**. After removal of the carriers **160**, when unloaded, by the shuttle carriage **120**, the bridging carriage **136** will return from its displaced position and produce reclosure of LS **5615** and LS **5617**. While LS **5615** re-establishes the service of lines **2000**, **2001** and **2002** through RS **5609**, LS **5617** completes lines **5618** and **5619** through TR **5620**. Line **5619** can thus be completed to initiate operation of the unloading conveyor drive unit **151**. Line **5992** from TR **5620** to CR **5993** upon the first counting impulse will complete a line **5994** through the solenoid **5667** of RS **5665** to re-engage contact pairs **5668**, **5669** and **5670** while the line **5648** from TR **5646** (FIG. **156**) through solenoid **5691** of RS **5690** will engage the contact pairs thereof. The pair of carriers **160** on the exit conveyor unit **152** will thereby be advanced to the unloading conveyor drive unit **151**.

When this pair of carriers have been removed by the shuttle carriage **120**, the subsequent impulsing activation of CR **5993** will create a circuit by line **5995** through the solenoids **5932** and **5941** of RS **5930** and RS **5940**, respectively, in the electrical control system for the conveyor drive unit **554**. This will advance the pair of carriers on the associated rails **1067** and **1068** along the rails **1028** and **1029** of the unit **152** to the unloading conveyor unit **151**. The third, fourth and fifth operations of CR **5993** will in following order similarly establish line **5996** to the solenoids **5882** and **5891** of RS **5880** and RS **5890** respectively, for the conveyor drive unit **553**; line **5997** to the solenoids **5832** and **5841** of RS **5830** and RS **5840** for conveyor drive unit **552**; and line **5998** to solenoids **5782** and **5796** of RS **5780** and RS **5795** for the conveyor drive unit **551**. Finally, on the sixth count, CR **5993** will complete a circuit by line **5999** through the solenoid **5741** of RS **5740** for the conveyor drive unit **550**, line **5732** from TR **5733** normally completing through solenoid **5726** to reclose RS **5725**. When CR **5993** ceases to function, the pairs of carriers temporarily halted on the several conveyor units **152**, **554**, **553**, **552**, **551** and **550** will have been cleared through the unloading and transfer areas and the usual operation of the conveyor units of the return side **18** can be resumed.

## THE UNLOADING CONVEYOR DRIVE UNIT 151

The structural details of the unloading conveyor drive unit **151**, as illustrated in FIGS. **5**, **33**, **34** and **152**, will be seen to be substantially mirror images of the loading conveyor drive unit **150** of FIGS. **5**, **27**, **28** and **29**. Operation of the unit **151**, as will shortly be described in connection with FIG. **157**, substantially follows the pattern of operation of the unit **150** in that a pair of sheet-supporting carriers **160** are received during westward movement from the bridging carriage **136** and then, after being unloaded, delivered to the shuttle carriage **120** during eastward movement.

Thus, the unit **151** comprises a framework **6050** that is carried at its ends by the structural beams **1025** and **1037** that are supported by columns **1023**, **1036** and **1038**, **1039**, respectively, and braced by beams **1040**. Essentially this framework comprises the beams forming the tracks **1030**, **1031** at their lower flanges and platforms **6051** and **6052** secured to the upper flanges. Belt gear-motors **6055** and **6056**, for driving associated conveyor chain belts **6057** and **6058** are mounted on the platform **6051**. In this connection, the typical assembly of shafts, sprockets and chain belts to drive the pairs of conveyor chain belts has been before described and it is believed that it will suffice here to note that the gear-motors, such as the gear-motor **6055**, drive the shaft **6060** for the driver sprocket **6061** journaled in a bearing bracket **6062** suspended from the platform **6051**. Similarly, the shaft **6064** for each idler sprocket **6065** is journaled in a bearing bracket **6066** suspended from the bracket **6052**. In like manner, the flights of the conveyor chain belts **6057** and **6058** are supported on bars of channels **6067** and **6068** carried by brackets **6069** and **6070** attached to platforms **6051** and **6052** respectively.

The conveyor drive unit **151** is also equipped with a releasing unit or device, generally designated by the numeral **6075** including cylinders **6076**, for producing reverse turning of the eccentric shafts **1657** of the carriers **160** which causes the cam rollers **1656** to release the clamping or securing action previously imposed on the plurality of levers **1626**. This was more fully disclosed in connection with the activator unit **180** in FIGS. **58**, **59** and **60**. A sheet unclamping unit, generally designated by the numeral **6080** and including a cylinder **6081**, is associated with the framework **6050** to produce reverse sliding motion of the plates **1636** to raise the levers **1626** thereby releasing the upper ends of the glass sheets from between the several clamping members **1614** and **1615** of each carrier. This structure was discussed in connection with the clamping unit **170** of FIGS. **35** to **49**, also see FIGS. **55** and **56**.

When the belt gear-motors **6055** and **6056** have moved a pair of carriers **160** onto the rails **1030** and **1031** and are then halted, the device **6075** will reversely turn the eccentric shafts **1657** followed by the unclamping action of the unit **6080** which will be more fully described in connection with FIGS. **158** and **159**. After the sheets have been received on the sides of the unloading unit **29**, the device **6075** and unit **6080** will be operated to subsequently perform their related functions on the next pair of carriers delivered from the return side **18** of the conveyor system.

## THE ELECTRICAL CONTROL SYSTEM FOR THE UNIT 151

With reference now to FIG. **157**, service circuits for the belt gear-motors **6055** and **6056** are completed from source lines **2000**, **2001** and **2002** by way of a relay switch as **6100**. RS **6100** for the gear-motor **6055** to herein be described is thus equipped with opposed solenoids **6101** and **6102**, presently

disengaged contact pairs **6103, 6104, 6105** and **6106** and presently engaged contact pair **6107** which through line **6108** maintains the brake **6109** for the gear-motor energized. The means for reversing the polarity of motor **6055** is provided by a relay switch RS **6112** having opposed solenoids **6113** and **6114**, presently engaged contact pairs **6115, 6116** and **6117** and disengaged contact pairs **6118, 6119** and **6120**.

The framework **6050** also supports switch devices for (1) LS **6122** for halting operation of the gear-motor **6055**; (2) LS **6123** for producing jogging operation of the gear-motor to move the carrier slightly eastward, and (3) LS **6124** to produce westward movement of the carriers until they are located in the desired centered position above the unloading unit **29**.

As described in connection with FIG. **156**, when the electrical control system for the return conveyor drive unit **553** is activated, the line **5618** is completed through LS **5617** (FIG. **154**) and line **5619**. This line completes a circuit through solenoid **6101** of RS **6100** to source line **2001** to produce engagement of contact pairs **6103, 6104, 6105** and **6106** while deenergizing the brake **6109** at disengaged contact pair **6107**. Contact pair **6103** now complete a circuit by line **6126**, contact pair **6115** of RS **6112** and line **6127** to the gear-motor **6055**; contact pair **6104**, line **6128**, contact pair **6116**, line **6129** to the gear-motor; and contact pair **6105**, line **6130**, contact pair **6117** of RS **6112** and line **6131**.

While similarly engaged, contact pair **6106** will make a circuit by line **6133** through a timing relay **6134**, in series with source lines **2000** and **2001**, to line **6135**. After the conveyor chain belts, such as the belt **6057**, is driven by the gear-motor **6055**, TR **6134** disconnects lines **6133** and **6135** and establishes the circuit of line **5640** to initiate operation of the belt gear-motor **5538** of the bridging carriage **136** as described in connection with FIG. **154**.

As mentioned earlier in connection with the control system of FIG. **64**, when the conveyor gear-motor **5538** of the bridging carriage **136** is put into service as well as the conveyor gear-motors, such as the gear-motor **6055**, of the conveyor drive unit **151**, a circuit will be completed to LS **2021** (FIG. **64**) whereby operation of the traction gear-motor **1211** will be halted. This is automatically accomplished when the shuttle carriage **120** is moving northward (letter *n* of FIG. **64**), and the striker plate **1310** engages LS **1312** on the track **1021** (FIGS. **21** and **22**). Thus, when the circuit of line **5640** is completed by TR **6134**, a branch circuit by line **6136** will be made to LS **1312**, line **6136** thus connecting to line **2022** (FIG. **64**). Of course, when TR **6134** is not caused to function, line **6136** will not be established to LS **1312** and the shuttle carriage **120** will be permitted to move toward the north side **19** of the transfer area **12**.

In actual practice, it can be expected that momentum of one carrier **160** will cause it to come to a halt slightly west of the centered position on track **1030** of the unloading unit **151** when the gear-motor **6055** ceases to operate. Thus, after passing LS **6124**, the leading end **1695** of an actuator bar **1692** will engage LS **6122** which will result in a circuit being made through solenoid **6102** of RS **6100** to disengage the contact pairs **6103, 6104, 6105** and **6106** while re-engaging contact pairs **6107** to reset the brake **6109**. This circuit by line **6137** is extended from source line **2000** through the engaged contact pair **6139** of a relay switch **6140**, having opposed solenoids **6141** and **6142** and contact pair **6143**; line **6144** through engaged contact pair **6146** of a relay switch RS **6147** having opposed solenoids **6148** and **6149** and engaged contact pair **6150**; line **6152** and a timing relay TR **6153**; line **6154** through engaged contact pair **6156** of a relay switch RS **6157**, having opposed solenoids **6158** and **6159** and engaged contact pair **6160**; and line **6162** through a timing relay TR **6163** and line **6164** to LS **6122**. By line **6165**, LS **6122** is adapted to energize solenoid **6102** of RS **6100** thereby disengaging contact pairs **6103, 6104** and **6105** to open the service lines to gear-motor **6055** while resetting the brake **6109** at contact pair **6107**.

More importantly, during this particular phase of carrier movement, when the end portion **1695** of the actuator bar **1692** on the carrier is moved into engagement with LS **6123** at a point beyond or slightly west of the desired centered position of the carrier above the loading unit, this momentum of the carrier causes the chuck member **1663**, in its coupling action with the chuck member **1851** of the eccentric shaft actuator unit **6075** (FIG. **152**), to thrust the same into the chamber **1848** of the driven member **1834** against the influence of contained spring **1850**. This action has been previously described in connection with FIG. **61**. Thus, LS **6123** or **6124** are employed, in conjunction with the end portions **1694** and **1695** of an actuator bar **1692**, to seek the required position and in so doing jog the motor to momentarily produce the desired direction of motion. Of course, the optimum position is reached when the actuator arms of the switch devices are located substantially midway between the opposed end portions of the bar **1692**. At this time, the desired "chucked" relation of members **1663** and **1851** will be realized with the member **1851** in its normally outward disposed relation with reference to the driven member **1834** by way of example (see FIG. **57**).

In the event that the carrier **160** comes to rest at a location on rail **1030** slightly west of the centered position, leading end **1695** of the actuator bar **1692** will close LS **6123**. This will complete a circuit from the source line **2000** by line **6166** from contact pair **6143** of RS **6140** and contact pair **6100** of RS **6157** by line **6167** and LS **6123**, to line **6168** to TR **6163**, in series with source lines **2000** and **2001**. At this time, the circuit of line **6137** is completed by lines **6162** and **6164** through TR **6163** to LS **6122** and this timer initially functions to open lines **6162** and **6164**. The timer then makes a circuit by line **6169** through the solenoid **6158** of LS **6157** to disengage contact pairs **6156** and **6160**.

TR **6163** then makes a circuit by line **6170** to cause energization of solenoid **6113** of RS **6112** to disengage contact pairs **6115, 6116** and **6117** and engage contact pairs **6118, 6119** and **6120**. This will connect the service of line **6126** and contact pair **6118** to line **6129** by line **6171**; line **6128** and contact pair **6119** to line **6127** by line **6172**; and line **6130** and contact pair **6120** to line **6131** by line **6173** to reverse the polarity of gear-motor **6055**. TR **6163** then opens line **6170** and completes a circuit by line **6174** to energize the solenoid **6101** of RS **6100** to re-engage principally contact pairs **6103, 6104** and **6105** and disengage contact pair **6107**. TR **6163** by line **6175** also energizes solenoid **6159** of RS **6157** to re-engage contact pairs **6156** and **6160** although lines **6162** and **6164** are presently open at TR **6163** and lines **6167** and **6168** are open at LS **6123**. When TR **6163** ceases to function, the circuit of lines **6162** and **6164** will of course be restored and, since LS **6122** is held closed by the leg **1693** of actuator bar **1692**, line **6165** will be again completed through solenoid **6102** of RS **6100**.

While LS **6123** is still engaged, a circuit is made by line **6176** from line **6168** to a timing relay TR **6177**, in series with source lines **2000** and **2001**. This timing device is adjusted to monitor an interval of time of sufficient duration to permit LS **6124** to be engaged, if necessary during required eastward movement of the associated carrier **160**, by the end **1694** of the actuator bar **1692** and to perform its intended function as will shortly be explained.

In the event that the ensuing jogging eastward movement of the carrier overruns the centered position, LS **6124** is engaged to complete a circuit by line **6166** through the engaged contact pair **6150** of RS **6147**, line **6179**, LS **6124** and line **6180** to TR **6153**, in series with source lines **2000** and **2001**. At this time, the circuit of line **6137** is closed by line **6154** from TR **6153** and line **6164** from TR **6163** so that line **6165** can be completed by LS **6122** to energize solenoid **6102** of RS **6100** thereby halting gear-motor **6055**. TR **6153** initially functions to open the lines **152** and **6154** to TR **6163** and LS **6122**. The timer then completes a circuit by line **6181** through the solenoid **6148** of RS **6147** to disengage contact pairs **6146** and

6150 thereof. TR 6153 then completes the circuit of line 6182 through the solenoid 6114 of RS 6112 to engage contact pairs 6115, 6116 and 6117, while disengaging contact pairs 6118, 6119 and 6120. TR 6153 opens line 6182 and by the circuit of line 6183, via line 6174 energizes solenoid 6101 of RS 6100 to engage contact pairs 6103, 6104 and 6105 to restore the service of lines 6126, 6127; 6128, 6129 and 6130, 6131 to the gear-motor 6055. This will result in the required westward motion of the associated carrier 160. TR 6153 by line 6184 through solenoid 6149 of RS 6147 serves to re-engage contact pairs 6146 and 6150.

Timer device TR 6177 is adjusted to monitor a time interval of sufficient duration to permit the motor 6055 to halt and thereby the related carrier 160 to come to rest position and to then complete a circuit by line 6185 through the solenoid 6141 of RS 6140 to source 2001. This acts to disengage contact pairs 6139, 6143 to thereby open the circuit lines generally to the switch devices LS 6122, 6123 and 6124 thereby rendering them inoperable until the actuator bar 1692 has been removed from their vicinity by eastward travel of the carrier from the unloading unit 151 and onto the shuttle carriage 120.

During this lapse of time, TR 6177 establishes a circuit by line 6186, connecting by line 6170, through the solenoid 6113 of RS 6112 to source line 2001. This will reverse the polarity of motor 6055 preparatory to subsequent eastward movement of the empty carrier 160 from the unloading conveyor unit 151. This subsequent eastward movement, as will later be described in connection with FIGS. 158 and 159, is attributable to the action of switch devices that are actuated when a pair of glass sheets have been released along their top edges from the clamping members 1614 and 1615 (FIG. 161) and are to be removed from the unloading area on the tracks 1030 and 1031. The instant of this removing action is of course determined by the demands of production and movement of the shuttle carriage 120 into the north and 19 of the transfer area 12.

TR 6177 also establishes the circuit of line 6188 which is instrumental in initiating release of the sheets from supporting carriers 160. In this connection, line 6188 is shown in FIG. 158. TR 6177 then completes the circuit of line 6189 to a timing relay TR 6190 in series with source lines 2000 and 2001.

As described in connection with FIGS. 5 and 65 and when the shuttle carriage 120 approaches the north end 19 of the transfer area 12, it moves into contact with bridging or transfer carriage 136 to displace the same to the phantom line position of FIG. 5. Upon alignment of the rails 1201 and 1202 of the carriage 120 with the rails 1030 and 1031 of the unloading conveyor drive unit 151, the cam plate 2120 on the carriage 136 engages LS 2121. This operates to complete the circuit of line 2122 with resulting completion of line 2137. This line is adapted to produce operation of the belt gear-motors 1505 and 1506 of the loading conveyor unit 150 in the south end 11 of the transfer area 12 and serves the same purpose in the north end 19 to start the gear-motor of the unloading conveyor unit 151.

Accordingly, after a pair of sheets have been released from the supporting carriers 160, as will hereinafter be described in connection with the electrical control systems of FIGS. 158 and 159, the belt gear-motors, such as the gear-motor 6055, will be started to drive the related conveyor chain belts. In this respect, when the bridging carriage 136 is in the displaced position, the previously described circuit of line 5640, FIG. 157, will not be completed to start the associated gear-motor 5538.

Now when the electrical control system for the shuttle carriage belt gear-motors, such as the gear-motor 1233, completes the circuit of line 2137, the source will be connected by line 6192, via line 6174, through the solenoid 6101 of RS 6100 to source line 2001, this acting to complete the service lines to the gear-motor 6055. As previously described, these circuits are made by line 6126, contact pair 6118 of RS 6112 and line 6171 to line 6129; line 6128, contact pair 6119 and line 6172 to line 6127; and line 6130, contact pair 6120 and line 6173 to line 6131. TR 6190 also makes a circuit by line 6194 to one side of a switch device LS 6195 which is adapted, when the carriers depart from the east ends of rails 1030 and 1031 onto the shuttle carriage rails, to complete line 6196 through solenoid 6102 of RS 6100 thereby to halt gear-motor 6055.

Then, by line 6198, TR 6190 completes presently engaged contact pair 6200 of spring-biased relay switch RS 6201, equipped with solenoid 6202 and presently disengaged pairs of contacts 6203, 6204 and 6205. Line 6207 through contacts 6200 completes this circuit from line 6198 to timing relay TR 6208, in series with source lines 2000 and 2001.

TR 6208 functions to monitor an interval of time sufficient for the pair of empty carriers to be received on the rails of the shuttle carriage and is initially active to complete a circuit by line 6209 through solenoid 6202 of RS 6201 to source line 2001 thereby disengaging contact pair 6200 to open lines 6198 and 6207 while engaging contact pairs 6203, 6204 and 6205. Contacts 6203 complete a circuit from source line 2000 by line 6210 through the solenoid 6142 of RS 6140 to thereby re-engage the contact pairs 6139 and 6143 thereof. Similarly, the circuit of line 6211 through contact pair 6204 is completed through solenoid 2004 of RS 2003 (FIG. 64) to source line 2001. This operates to re-engage the related pairs of contacts 2006, 2007 and 2008, while releasing brake 2025 at opened contact pair 2009, to cause operation of gear-motor 1211 and resulting southward movement of the shuttle carriage 120. Contacts 6205 make a circuit by line 6212, via line 6182, through the solenoid 6114 of RS 6114 to source line 2001. While energized, solenoid 6114 serves to disengage contact pairs 6118, 6119 and 6120 and re-engage contact pairs 6115, 6116 and 6117. The polarity of gear-motor 6055 will accordingly be reversed for operation to drive the conveyor chain belt 6057 in a westward direction during reception of a subsequent pair of sheet supporting carriers 160 on the unloading drive unit 151. TR 6208 before ceasing to function establishes line 6213 which initiates operation of the actuator device 6076 and unclamping unit 6080 to their rest positions (FIG. 159).

Of course, when TR 6190 and TR 6208 cease to funCtion, the control system for the unloading conveyor drive unit 151 will be conditioned to operate in the manner first described and when the carriers 160 are to be moved westward along the rails 1030, 1031. Also, when the bridging carriage 136 is returned to its position of alignment, eventual activation of the control system for the gear-motor 5538 thereof will result in completion of line 5649 to initiate operation of the actuator device 6076 and unclamping unit 6080 as discussed in connection with FIG. 159.

## THE UNLOADING UNIT 29

The unit 29 is a structural duplicate of the loading unit 28, described in connection with FIGS. 88 to 109, and 111 and 112. Generally stated, the unloading unit 29 has a base framework 6215 which includes vertical columns 6216 having at their upper ends trunnion blocks 6217 on which the tilting frames 6218 are pivotally supported by bearing members 6219, certain of the above details being shown in FIG. 161. Presently, reference will be made in the order of their use to the pertinent details of the unloading unit, such as the vacuum frames 6220, supported by crank arms 6221 on the tilting frames 6218 and having the plurality of vacuum cups 6222 and 6223, and related gear-motors, such as the gear-motor 6226 (FIG. 158); the elevator devices 6225 and the gear-motors, such as the gear-motor 6226; the tilting frames 6218 and associated gear-motors, such as gear-motor 6227 (FIG. 159); and the roller conveyors 6228 and gear-motors such as the gear-motor 6229.

In this connection, outward and inward operation of the vacuum support frames 6220 is controlled by switch devices LS 6232 and LS 6233. Midway inward motion of the vacuum

frames is controlled by LS **6234**. Operation of the elevator devices **6225** is similarly controlled by LS **6237** and LS **6238**. LS **6239** is adapted during upward motion of the elevator devices to restrict the application of vacuum to the lower row of vacuum cups **6223** in the event that the vertical dimension of the sheets is less than the maximum which has previously been described, as on the order of 10 feet. Operation by the cylinders **6076** is produced by a four-way valve **6240** controlled by LS **6241** and LS **6242** and operation of cylinder **6081** is produced by a valve **6243** controlled by LS **6244** and LS **6245**. Outward motion of the tilting frames **6218** to the angled position of 7° from the vertical is controlled by LS **6247** and by LS **6248** at their limit of motion to the vertical position. Operation of the roller conveyors **6228** is similarly controlled by lLS **6249**.

In this connection, the limit switches of the unloading unit **29** are mounted in the same location on the framework **6215** and columns **6216** as are the complementary limit switches on the loading unit **28**. Referring to FIG. **109**, by way of example, LS **6232** is mounted similar to LS **3235**; LS **6233** to LS **3232**; LS **6234** to LS **3228**; LS **6238** to LS **3117**; LS **6247** to LS **3022**; and LS **6248** in the same position as LS **3034**. LS **6237**, serving the same purpose as LS **3115** to halt upward movement of the elevator devices, is mounted as shown in FIG. **110**. LS **6237** is actuated by the position of the lower edge of a sheet whereas LS **3115** is actuated by the upper edge of a sheet, this being true with regard to all sheets being located with reference to a support carrier and regardless of the vertical dimension.

Briefly reviewing operation of the unloading unit **29** and when a pair of carriers **160** come to rest on the tracks of the unloading conveyor drive unit **151**, the chucking ends **1663** of the shafts **1657** will be coupled with the mating chucks **1851** of the actuator unit **6075**. At this time, the tilting frames **6218** are vertically positioned as is shown in full line in FIG. **91**. Reference is also made to FIG. **161** wherein the following sequences of operation are schematically illustrated in views *a* to *g* inclusive. Thus in view *a*, the sheet *a* supported by a carrier **160** is shown in position to be received onto the unloading unit **29**. The several vacuum frames **6220** are swung outwardly and are halted with the rims of the vacuum cups **6222**, **6223** in surface contact with the inwardly disposed surfaces of the sheets. The elevator devices **6225** are then moved upwardly until halted with their sheet supporting members spaced substantially 1 inch, or slightly less, below the bottom edges of the sheets. This is shown in view *b*. Vacuum is now applied to the plurality of vacuum cups **6222** and, if the vertical dimension of the sheets is in the order of ten feet, to the lower row of vacuum cups **6223**. The eccentric shaft actuator unit **6075** then produces rotation of the shafts **1657** to release the securing action imposed on the clamping levers **1626**. The levers are raised from clamping engagement with the upper edges of the sheets by operation of the unclamping unit **6080**.

When pair of glass sheets are thus physically disengaged from the clamping elements **1614**, **1615** of the related carriers **160**, the tilting frames **6218** are moved outwardly to the angled position of 7°as shown in phantom line in FIG. **91** and in view *d* of FIG. **161**, followed by inward motion of the vacuum frames **6220** until the inwardly disposed surfaces of the sheets are brought in contact with the spherical sheet supporting devices (**3090** of FIG. **90**) mounted on the channels (**3053**) of each tilting frame. This is shown in view *d*. While the vacuum frames are halted in a substantially midway position, the vacuum is relieved and the sheets slide freely downward until received on the elevator devices **6225**, as in view *e*. These devices are then lowered beneath the plane of the roller conveyors **6228** thereby depositing the sheets for following westward movement onto the roller conveyor systems of the turntable unit **30**, as is shown in view *f*. During this action, the vacuum support frames **6220** are moved to their innermost positions.

After the sheets have been bodily removed from the roller conveyor systems **6228** to the turntable unit **30**, the tilting frames **6218** are returned to the vertical position, as in view *g*. Following removal of the pair of carriers **160** from the conveyor drive unit **151** onto the shuttle carriage **120**, the elements of the actuator unit **6075** and of the unclamping unit **6080** are caused to return to their original positions for use when a subsequent pair of carriers arrive in the unloading area.

With reference now to FIGS. **158** and **159**, when the pair of carriers **160** have halted on the tracks **1030**, **1031** of the unloading conveyor drive unit **151**, and properly positioned with regard to the actuator unit **6075** and unclamping unit **6080**, the glass sheets supported thereon can be removed onto the elevator devices **6225** of the unloading unit **29**. As described in connection with FIG. **157** and upon completion of operation of the belt gear-motors **6055**, **6056** of the conveyor drive unit **151**, a circuit by line **6188** produces operation of the unloading unit **29**. To this end, line **6188** connects through a timing relay TR **6260**, in series with source lines **2000** and **2001**, to line **6261** which will produce a circuit through solenoid **6262** of relay switch **6263** to source line **2001**. RS **6263** has an opposed solenoid **6264**, disengaged contact pairs **6265**, **6266** and **6267** and engaged contact pair **6268** which by line **6269** energizes the brake **6270** for gear-motor **6223**. Solenoid **6262** acts to disengage contact pair **6268** and engage contact pairs **6265**, **6266** and **6267** thereby making line circuits **6273**, **6274** and **6275** through engaged contact pairs **6277**, **6278** and **6279** of relay switch as **6280** and lines **6202**, **6283** and **6284** respectively to the gear-motor **6224**. RS **6280** is equipped with opposed solenoids **6285**, **6286** and presently disengaged contact pairs **6287**, **6288** and **6289**.

The gear-motor **6224** thus operates to pivot the related vacuum support frame **6220** outwardly until the rims of the vacuum cups **6222** and **6223** are in surface contact with the glass sheet. At this time, LS **6232** will be closed to complete a circuit by line **6291** through presently engaged contact pair **6292** of a relay switch RS **6293**, having opposed solenoids **6294** and **6295**, and line **6297** to activate a timing relay **6298**, in circuit with source lines **2000** and **2001**. This timer initially completes a circuit by line **6299** through opposed solenoid **6264** or RS **6263** to halt operation of the gear-motor **6224** and re-energize brakes **6270**. After motion of the vacuum support frame **6220** has halted, TR **6298** creates a circuit by line **6300** through solenoid **6294** of RS **6293** to engage contact pair **6296** and disengage contact pair **6292** thereby opening line **6291** to LS **6232**.

By line **6301**, line **6300** is also extended via engaged contact pair **6302** of a relay switch RS **6303** and line **6304** through the associated solenoid **6305** to disengage contact pair **6302** and engage contact pair **6303**, RS **6303** having an opposed solenoid **6307**. Contact pair **6306** establish a circuit from source line **2000** by line **6308** to one side of LS **6233**. By line **6309**, TR **6298** establishes a line through solenoid **6285** of RS **6280** thereby disengaging the contact pairs **6277**, **6278**, **6279** and engaging contact pairs **6287**, **6288** and **6289** to reverse the polarity of gear-motor **6224** preparatory to inward swinging motion of the vacuum support frames.

The timer then completes a circuit by line **6310** to solenoid **6311** of relay switch RS **6312** to source line **2001**. RS **6312** has opposed solenoid **6313**, disengaged contact pairs **6314**, **6315** and **6316** as well as engaged contact pair **6317** which maintain the brake **6318** for gear-motor **6225** energized by line **6319**. When engaged, contact pairs **6314**, **6315** and **6316** complete circuits through the engaged contact pairs **6322**, **6323** and **6324** of relay switch RS **6325** by way of lines **6326** and **6327**, **6328** and **6329**, **6330** and **6331** to the motor. TR **6325** has opposed solenoids **6332**, **6333** and disengaged contact pairs **6334**, **6335** and **6336**. As the elevator devices **6225** are moved upward, LS **6238** is released and upon location of the elevator support surfaces at the aforementioned distance of substantially one inch beneath the lower edge of the sheet, LS **6237** is engaged. As viewed in FIG. **110**, this switch device is mounted by a bracket **6337** on the rear surface of at least one elevator device on each side of the unloading unit **29** and

has a "cat-whisker" type of actuator arm **6338**. Engagement of the arm **6338** causes LS **6237** to complete a circuit by line **6340** from source line **2000** through engaged contact pair **6341** of a relay switch RS **6342**, having opposed solenoids **6343** and **6344** and disengaged contact pair **6345** and also line **6346** to a timing relay **6347**, in series with the source lines **2000** and **2001**. By line **6348**, LS **6237** is connected through solenoid **6313** of RS **6312**. This will disengage contact pairs **6314**, **6315** and **6316** to open the circuits of lines **6326**, **6328** and **6330** to halt gear-motor **6226** while resetting the brake **6318** at engaged contact pair **6317**. With upward movement of the elevator devices stopped, and since LS **6237** is held engaged, TR **6347** makes a circuit by line **6349** through the solenoid **6343** of RS **6342** to open the circuit of line **6340** at disengaged contact pair **6341** while engaging contact pair **6345**. The circuit of line **6349** is also completed by line **6350** through the engaged contact pair **6351** of a relay switch RS **6352**, having opposed solenoids **6353**, **6354** and disengaged contact pair **6355**, and by line **6356** through solenoid **6353** to source line **2001**. This will disengage contact pair **6351** to open lines **6350**, **6356** and establish a line **6357** from source line **2000** to one side of presently open LS **6238** through contact pair **6355**. TR **6347** further serves by line **6358** through solenoid **6332** to reverse RS **6325** by disengagement of contact pairs **6322**, **6323**, **6324** and engagement of contact pairs **6334**, **6335**, **6336** for subsequent downward movement of the elevator devices **6225**.

TR **6347** then completes a circuit by line **6360** (FIG. **159**) through the end **6361** of a valve **6362** connected to a source of vacuum by pipe **6363** and to air under pressure by pipe **6364**. By pipe **6366**, the valve is connected through a low-pressure switch device LP **6367** which by pipe **6368** connects pipe **6366** to the conductor conduits **6369** to the upper rows of vacuum cups **6222**. Branch pipe **6371** is connected through a valve **6372** to conduits **6373** for the lower rows of cups **6223**, valve **6372** being normally open and moved to closed position upon engagement of LS **6239**.

As earlier noted and as seen in view *b* of FIG. **161**, when the glass sheets have a vertical dimension of at least 10 feet, valve **6372** connects the cups **6223** to the source of vacuum. Thus, if the arm **6338** of LS **6237**, controlling upward movement of the elevator devices, is engaged by the lower edges of the sheets before LS **6239** is engaged, the valve **6372** will not be closed and the vacuum in pipes **6368** and **6371** will be made effective through conduits **6369**, **6373** to the entire plurality of rows of vacuum cups **6222** and **6223**. Therefore, the degree of vacuum produced at the vacuum cups to adhere them to the surfaces of the sheets will cause the low-pressure device LS **6367** to respond to the pressure drop in pipes **6366**, **6368**. Otherwise, as shown in view *c* of FIG. **161**, the lower row of vacuum cups **6223** will be located beneath the lower edge of the sheet and LS **6239** will be engaged to close valve **6372** by line **6374**.

LS **6367** is connected by line **6375** to source line **2000** and line **6376** to presently closed side of **6381** of LS **6241** to line **6382** through the end **6384** of the four-way valve **6240**, connecting by pipe **6385** to a source of pressure and to exhaust by pipe **6386**.

Valve **6240** is connected by pipe **6388** to the rod end of the cylinder **6076** of the actuator device **6075**, cylinder **6076** having contained piston **6389** and rod **6390**. A pipe **6391** also connects valve **6240** to the head end of the cylinder (behind piston **6389**). As presently controlled, the direction of fluid pressure through pipe **6388** will retract piston rod **6390** and thereby cause the attached gear rack (**1860**, FIG. **60**) to turn the associated shaft **1839** so that the chuck member **1851** through chuck member **1663** will similarly turn the eccentric shaft **1657** of the carrier **160** until the cam rollers have released their pressure on the clamping levers **1626**. It will be understood that cylinder **6076** is representative of both of the cylinders **1864**, described in connection with FIGS. **58**, **59** and **60** which, as described in connection with the loading unit **28**, operate gear racks **1860** to turn the related shafts **1839** by the fixed spur gears **1859**. In the present instance to release the cam action on the plurality of levers **1626** of the clamping devices **1615**, the shafts **1839** are rotated in reverse directions to those indicated by the arrows (FIG. **60**) designated by the numerals **1857** and **1858**.

As the rod **6390** leaves its rest or inner position, the side **6381** of LS **6241** is opened while the side **6329** is closed. Also, upon reaching the opposite limit of projected travel, the related rod **6390** causes LS **6242** to be moved to its closed position. This completes a circuit by lines **6393** and **6394** to a timing relay TR **6395**, in series with source lines **2000** and **2001**. TR **6395** opens the circuit by lines **6393**, **6394** since LS **6242** is maintained closed until fluid pressure is directed through pipe **6391** to cylinder **6076**, as will later be described. The timer then completes a circuit by line **6397** through the engaged contact pair **6398** of a relay switch RS **6399** and line **6401** through solenoid **6402** of RS **6399** to source line **2001**, RS **6399** also having an opposed solenoid **6403** and contact pair **6404**. While solenoid **6402** is thus energized, the circuit of lines **6397** and **6401** via contact pair **6398** will be broken while contact pair **6404** will establish a circuit by line **6405** from TR **6395** and line **6406** to end **6407** of a four-way valve **6243**, connected by pipe **6409** to a source of fluid pressure and pipe **6410** to exhaust. Valve **6243** is connected by pipe **6412** to the rod end of cylinder **6081**, ahead of contained piston **6413**, and by pipe **6414** to the head end. When the associated piston rod **6415** is retracted, the chain belts of the unclamping unit **6080** will (see FIG. **56**) actuate the plate **1636** of the carrier **160** to move the levers **1626** upwardly and remove the clamping members **1615** from the surface of the sheet. At this time, LS **6244** has been released to closed position and LS **6245** then moved to closed position. LS **6244** completes a line **6417** through solenoid **6403** of RS **6399** to disengage contact pair **6404** and break the circuit of lines **6405** and **6406** to source line **2000**. While contact pair **6398** is re-engaged, the fact that TR **6395** has ceased to function will negate the circuit of lines **6397** and **6401** to solenoid **6402**.

With the pair of sheets being released from their supported relation on the related carriers **160** and secured to the vacuum support frames **6220** by cups **6222** and **6223**, the associated tilting frame **6218** can now be swung outwardly. To this end, line **6418** from line **6417** is completed by line **6419** through a timing relay TR **6420**, in series with source lines **2000** and **2001**, TR **6420** functioning initially to break the circuit of lines **6418**, **6419** therethrough. The timer than makes a circuit by line **6422** through the solenoid **6423** of a spring-biased relay switch RS **6424**, having contact pair **6425**.

Contact pair **6425** establishes a circuit from source line **2000** and line **6427** through the solenoid **6430** of relay switch RS **6431**. RS **6431** has an opposed solenoid **6432**, disengaged contact pairs **6433**, **6434**, **6435** and engaged contact pair **6346** maintaining by line **6437** the brake **6438** of gear-motor **6227**. Then engaged contact pairs **6433**, **6434** and **6435** complete service lines **6440**, **6441** and **6442** through engaged contact pairs **6445**, **6446** and **6447** of relay switch RS **6448** and lines **6450**, **6451** and **6452** to the gear-motor **6227**. RS **6448** has solenoids **6455**, **6456** and disengaged contact pairs **6457**, **6458** and **6459**. As the tilting frame **6218** swings outwardly from the vertical position, LS **6247** is released and, when in the inclined position of 7°, as in view *d* of FIG. **161**, LS **6248** is engaged. Since LS **6248** is held is its engaged condition until the frame returns to the vertical position, a circuit therethrough is made by line **6460** through engaged contact pair **6462** of relay switch **6463**, the latter having opposed solenoids **6464** and **6465** and contact pair **6466**. When engaged, LS **6248** will make a circuit by lines **6460**, **6467** to a timing relay TR **6468**, in series with source lines **2000** and **2001**, and also a circuit by line **6469** through opposed solenoid **6432** of RS **6431** to disengage contact pairs **6433**, **6434** and **6435** thereby halting gear-motor **6227**. TR **6468** makes a circuit by line **6470** through the solenoid **6464** of RS **6463** to disengage contact pair **6462**, while engaging contact pair **6466**.

By line 6471 via line 6470, a circuit is made through engaged contact pair 6472 of relay switch RS 6473 and line 6474 to associated solenoid 6475, RS 6474 also having opposed solenoid 6476 and contact pair 6477. Contact pair 6477, when engaged, make a circuit by line 6478 to one side of LS 6247 which is presently open. A further circuit from TR 6468 by line 6481 is made through solenoid 6455 of RS 6448. This operates to disengage contact pairs 6445, 6446 and 6447 and engage contact pairs 6457, 6458 and 6459 to reverse the polarity of gear-motor 6227 pending return to the tilting frame 6218 to the vertical position.

TR 6468 then establishes a circuit by line 6483 (FIG. 158) via line 6261 to solenoid 6262 of RS 6263. Presently, the circuits of lines 6273, 6274 and 6275 from contact pairs 6265, 6266 and 6267 will be completed respectively via contact pair 6287 of RS 6280, line 6484 to line 6283; contact pair 6288 and line 6485 to line 6282; and contact pair 6289 and line 6486 to line 6284. The vacuum support frames 6220 now swing inwardly until LS 6234 is engaged and the supported sheet is contacted by the spherical sheet supporting devices (3090 FIG. 90 and view *e* of FIG. 161) on the channels of the tilting frame 6218. LS 6234 is adapted to complete a circuit by line 6488 through engaged contact pair 6489 of a spring-biased relay switch RS 6490, having a solenoid 6491, and a circuit by line 6492 via line 6299 through the solenoid 6264 of RS 6263. While inward movement of the vacuum support frames is thus interrupted at associated contact pairs 6265, 6266 and 6267, LS 6234 makes a line circuit 6494 to a timing relay TR 6495, in series with source lines 2000 and 2001. Initially TR 6495 completes a circuit by line 6498 (FIG. 159) through the end 6499 of valve 6362. This acts to close vacuum pipe 6363 and connect fluid pressure pipe 6364 to pipe 6366 which applies air under pressure to the plurality of rows of vacuum cups 6222 and 6223 thereby to release the respective sheet therefrom and permit it to slide the relatively short distance downwardly onto the support surfaces of the elevator devices 6225.

TR 6495 also establishes a holding line 6501 through the solenoid 6491 of RS 6490 to disengage contact pair 6489 until LS 6234 is released during further movement of the related vacuum support frames to their inner or rest position. To this end, TR 6495 completes a circuit by line 6504 via line 6261 through solenoid 6262 of RS 6263 to re-engage contact pairs 6265, 6266 and 6267 and de-energize brake 6270 at disengagec contact pairs 6268. Gear-motor 6224 will thus resume operation which will produce inward movement of the vacuum frame 6220 and consequent separation of the vacuum cups from the sheet surface. By a circuit of line 6505 via line 6310 through solenoid 6311 of RS 6312 to source line 2001, contact pairs 6314, 6315 and 6316 will be engaged while disengaged contact pair 6317 will de-energize the brake 6319 of gear-motor 6226. Since the circuits to this gear-motor will be reversed to produce downward movement of the vacuum frames 6225, the service of lines 6326, 6328 and 6330 will be made respectively by contact pair 6334 and line 6508 to line 6329, contact pair 6335 and line 6509 to line 6327, and contact pair 6336 and line 6510 to line 6331 and the gear-motor.

Now, as the vacuum support frames 6220 reach their inner rest positions, LS 6233 is engaged to complete a circuit from source line 2000 and line 6308 through engaged contact pair 6306 of a relay switch RS 6303, having the opposed solenoids 6305, 6307 and disengaged contact pair 6302. Line 6308 through LS 6233 to line 6515 completes a circuit via line 6299 through solenoid 6264 of RS 6263 to again halt gear-motor 6223 upon disengagement of contact pairs 6265, 6266 and 6267.

LS 6233 also activates a timing relay TR 6517 by line 6518 and since LS 6233 is held engaged until the vacuum support frames again are moved from the rest position, TR 6517 initially completes a circuit by line 6520 through solenoid 6307 of RS 6303 to disengage contact pair 6306, opening line 6308, and also engaging contact pair 6302. Line 6520 via branch line 6521 makes a circuit through contact pair 6296 of RS 6293 and by line 6522 through solenoid 6295. This operates to disengage contact pair 6296 and re-engage contact pair 6292 for restoration of line 6291 to one side of LS 6232. TR 6522 then establishes a circuit by line 6525 through the opposed solenoid 6286 of RS 6280 to disengage contact pairs 6287, 6288 and 6289 and re-engage contact pairs 6277, 6278 and 6279 for reversal of the service circuits to the gear-motor 6223 to produce subsequent outward movement of the vacuum support frames.

With further reference to the operation of gear-motor 6226, and lowering of the elevator devices 6225 to their lower, rest positions, the bottom edge of the sheet is located on the rollers of the conveyor system 6228 as the elevator support surfaces descend beneath the plane of the roller surfaces. This is shown schematically in view *f* of FIG. 161. LS 6238 is engaged at this time to complete the circuit of line 6357 from source line 2000 by way of engaged contact pair 6355 of relay switch 6352 having the opposed solenoids 6353, 6354 and disengaged contact pair 6351. LS 6238 thus completes the circuit of line 6357 via lines 6526 and 6348 through solenoid 6313 of RS 6312 to source line 2001 thereby disengaging contact pairs 6314, 6315 and 6316 to halt the gear-motor 6225 and reset brake 6319 at engaged contact pair 6317. LS 6238 also completes line 6527 to a timing relay TR 6528, in series with source lines 2000 and 2001. TR 6528 establishes a circuit by line 6530 through the solenoid 6531 of relay switch RS 6532 which has opposed solenoid 6533, disengaged contact pairs 6534, 6535 and 6536 and engaged contact pair 6537 normally energizing motor brake 6538 by line 6539. Engaged contact pairs 6534, 6535 and 6536 complete service lines 6542, 6543 and 6544 to gear-motor 6229 to drive the rollers of the conveyor system 6228.

TR 6528 also makes a circuit by line 6546 through solenoid 6354 of RS 6352 to source line 2001, thereby disengaging contact pair 6355 and opening line 6357 to LS 6238, the same being desired since the limit switch is held closed with the elevator devices in the lowered position. Line 6546 via line 6548 makes a circuit through contact pair 6345 and line 6549 through solenoid 6344 of RS 6343 which serves to re-engage contact pair 6341 which will restore the circuit of line 6340 to one side of LS 6237. This upper limit switch, of course, remains open while the elevator devices are in the lowered position. A further line 6550 from TR 6525 is completed through solenoid 6333 of RS 6325 to source line 2001 to disengage contact pairs 6334, 6335 and 6336 while re-engaging contact pairs 6322, 6323 and 6324 to restore the original polarity of the gear-motor 6226 for upward movement of the elevator devices 6225 during a subsequent unloading of a pair of glass sheets.

The sheet is removed by the conveyor system 6228 onto the aligned conveyor system 6551 of the turntable unit 30 (FIG. 152) as will shortly be explained. However, as the lower edge of the sheet passes the west end of the conveyor system 6228, it will trip LS 6249 to complete a circuit by lines 6552 and 6553 through the timing relay TR 6260 in series with source lines 2000 and 2001. This timer initially opens the circuit of lines 6552, 6553 and is adjusted to monitor an interval of time slightly longer than that normally expected to elapse after the trailing ends of the sheets have released LS 6249. TR 6260 then completes the circuit of a line 6555 through solenoid 6533 of RS 6532 to source line 2001. This will open service lines 6542, 6543 and 6544 to gear-motor 6229 at disengaged contact pairs 6534, 6535 and 6536, with resultant halting of the conveyor systems 6228, while energizing brake 6538 at contact pair 6537. While TR 6260 is active, the circuit of lines 6188, 6261 will be opened and then reclosed when the timer ceases to function, this ensuring that particularly the effective circuits to RS 6263 of the gear-motor 6224 cannot be established inadvertently.

The circuit of line 6555 via branch line 6556 to line 6427 (FIG. 159) is extended through the solenoid 6430 of RS 6431 to source line 2001. This will re-engage contact pairs 6433, 6434 and 6435 to complete service lines to the gear-motor

6227 for inward swinging of the tilting frame 6218 to the vertical rest position as in view *g* of FIG. 161. In the present instance, line 6440 is completed by contact pair 6457 of RS 6448 and line 6560 to line 6451; line 6441 by contact pair 6458 and line 6561 to line 6450; and line 6442 by 6459 and line 6562 to line 6452 and the gear-motor 6227. During such inward movement, LS 6248 is released.

Now, at the vertical position of the tilting frame 6218, LS 6247 is engaged to complete line 6478 by line 6565 through the opposed solenoid 6432 of RS 6431 via line 6469. This will again open the service lines to the gear-motor 6227 to halt operation while resetting the brake 6438 thereof. Line 6566 from LS 6247 completes a circuit to a timing relay 6567, in series with source lines 2000 and 2001. TR 6567 functions, after stopping of gear-motor 6227, to make a circuit by line 6569 through solenoid 6456 of RS 6448 to source line 2001, thereby to disengage contact pairs 6457, 6458 and 6459 and to re-engage contact pairs 6445, 6446 and 6447 for eventual outward swinging movement of the tilting frame 6218. TR 6567 then makes a circuit by line 6571 through the solenoid 6476 of RS 6473 with resultant engagement of contact pair 6472 and disengagement of contact pair 6477 to open line 6478 to one side of LS 6247 which will be held closed by the vertically disposed frame 6218. The circuit of line 6571 via branch line 6572 also is extended by the contact pair 6466 of RS 6463 and line 6573 through the associated solenoid 6465 to source line 2001. This serves to disengage contact pair 6466 and re-engage contact pair 6462 again restoring line 6460 to one side of presently open LS 6248.

As earlier described in connection with the transferring operations of the shuttle carriage 120, the pair of empty carriers 160 are removed from the unloading conveyor drive unit 151 when the carriage 120 arrives in the north end 19 of the transfer area 12 and has displaced the bridging carriage 136, as shown in phantom lines in FIG. 5. The pair of carriers 160 are thus removed from the rails 1030 and 1031 of the conveyor drive unit 151 and received on the rails or tracks 1201, 1202 of the shuttle carriage 120 for transfer to the south end 11 of the transfer area 12. When this act has been accomplished and the bridging carriage 136 has resumed its normal position, the associated members of the actuator unit 6075 and unclamping device 6080 can be returned to their original positions. To this end, the circuit of line 5649 from TR 5646 of FIG. 154, by way of contact pair 6579 of a relay switch RS 6580 is completed by line 6581 through the associated solenoid 6582 to source line 2001, RS 6581 having opposed solenoid 6583 and contact pair 6584. Thus, engaged contact pair 6584 make a circuit from source line 2000, by line 6586 to a timing relay TR 6583. This timer initially completes a circuit by line 6590 through the opposed solenoid 6583 to disengage contact pair 6584 and re-engage contact pair 6579, it being understood that, having energized solenoid 6582, line 5649 is open at TR 5646.

TR 6588 then establishes the circuit of a line 6592 via the presently closed side 6392 of LS 6241 and line 6593 through the end 6594 of valve 6240. This will connect fluid pressure pipe 6385 by pipe 6391 to the head end of cylinder 6076 thereby causing piston 6389 to project the associated rod 6390. The gear rack, or racks, 1860 of the actuator unit 6075 will thus be moved to the rest position and as LS 6242 is permitted to open. Similarly at the rest position, the action of piston rod 6390 will engage LS 6241 to open the side 6392 and reclose the side 6381 thereof.

Line 6592 through presently closed LS 6245 will be completed through the end 6595 of valve 6243, this operating to connect fluid pressure pipe 6409 to the head end of cylinder 6081 by pipe 6414. During retracting movement of the piston rod 6415, the chain belts 1745, 1746 (FIGS. 52 and 53) of the unclamping device 6080 will be reversely driven to carry associated pairs 1760 and lugs 1761 in a direction opposite to that indicated by the arrow 1763 (FIG. 56) to the rest position of the lugs 1761 as therein shown. The piston rod 6415 initially produces opening of LS 6245 and at the end of its projecting motion, recloses LS 6244; however, since TR 6395 has ceased to function the circuit of lines 6397, 6401, 6405 and 6406 will not be remade at this time.

In an earlier portion of the specification, it was said that when the filmed sheets are released from a pair of carriers, they are received on the unloading unit 29 and thence conveyed to the turntable mechanism 30. As viewed in FIG. 152, this unit is adapted to receive one of the pair of sheets simultaneously on its opposite sides, as is illustrated in FIG. 71 and described in connection with the turntable unit 27. After the conveyor systems 6551 have been halted, the "south" conveyor system is operated to deliver the supported sheet onto the run-out conveyor 31 at which point the sheet can be removed for final inspection. The turntable is then indexed 180° so that the second sheet can be removed to the conveyor 31. In this connection, it is to be noted that the turntable 30 receives a pair of sheets and then discharges them one at a time whereas the turntable 27 receives a sheet on one side, then on the opposite side, and then delivers the pair of sheets in unison to the leading unit 28. It is therefore believed obvious that the structure of the turntable unit or mechanism as illustrated in FIGS. 69 to 85 can be taken as representative of both units 27 or 30 and that an electrical control system as disclosed in FIGS. 86 and 87 can be, with only minor modification, employed to satisfactorily accomplish the run-out operation.

It is realized that the manner of progressively moving the carriers from one conveyor unit to another has been described in connection with the attraction of the permanently magnetized bars 1675 on the carriers 160 to the plates attached to the links of the traction chain belts. Thus, a pair of sheet supporting carriers proceed from above the loading unit 28 through the several chambers of the processing apparatus; are transferred in sequence to the return side of the conveyor system M, and are thence delivered to a position above the unloading unit 29. As described, the empty carriers are then carried by the shuttle carriage 120 to a point at which they can be delivered to the loading area above the unit 28. It has been noted that the plurality of traction chain belts employed throughout the conveyor system M are formed by links having lugs equipped with plates such as described in connection with the plate 1264 of FIG. 14. However, it is believed readily apparent and within the spirit of this invention to alternatively equip the sheet supporting carriers with solid or laminated bars of metal. These solid bars, operating in the same manner as the bars 1675, are attracted to permanently magnetized plates carried by the links of the several chain belts and insulatingly connected thereto.

It is to be understood that the forms of the invention herewith shown and described are to taken as illustrative embodiments only of the same, and that various changes in the shape, size and arrangement of parts, as well as various procedural changes may be resorted to without departing from the spirit of the invention.

We claim:

1. Apparatus for treating sheets of material, comprising
   a. a plurality of chambers in end to end relation to one another, one of said chambers constituting a coating chamber;
   b. means for conveying sheets of material successively through each of said chambers;
   c. carrier means supporting said sheets in a vertical position for movement along said conveying means;
   d. means for creating a vacuum in each of said chambers;
   e. means in said coating chamber for coating the sheets as they move therethrough;
   f. valve compartments disposed between adjacent chambers for placing them in communication when open and separating them when closed;
   g. valve compartments located at the respective entry and exit ends of said plurality of chambers, and
   h. means responsive to positioning of the carrier means in said chambers to permit opening and closing said valve

compartments in predetermined sequence from the entry end to the exit end of said plurality of chambers.

2. Apparatus for treating sheets of material as defined in claim 1, in which the means in the coating chamber for coating the sheets comprises thermal evaporation means.

3. Apparatus for treating sheets of material as defined in claim 2, in which said thermal evaporation means comprises a plurality of electron beam evaporation sources arranged in vertical and horizontal rows positioned in at least one side wall of said coating chamber.

4. Apparatus for treating sheets of material as defined in claim 1, in which said conveying means includes drive means in each chamber moving in a fixed horizontal path and said carrier means includes means engageable with said drive means to move said carrier means through successive chambers.

5. Apparatus for treating sheets of material as defined in claim 4, in which the means on said carrier means engageable with said drive means comprise magnetic means.

6. Apparatus for treating sheets of material as defined in claim 4, in which said drive means comprises an endless chain belt in each of said chambers traveling in a horizontal path, and in which said carrier means comprises a plurality of individual carriers, and means on each carrier for magnetically connecting the carrier to the endless chain belt in each succeeding chamber to move the carriers therethrough.

7. Apparatus for treating sheets of material as defined in claim 6, in which said last named means comprises spaced permanently magnetized members carried by each carrier and magnetically attracted to and moved along by each succeeding chain belt, the distance between adjacent chain belts being less than the distance between the magnetized members on each carrier.

8. Apparatus for treating sheets of material as defined in claim 1, in which said coating chamber comprises an entry area, a coating area and an exit area, and including:

a. individual conveyors in said entry area, coating area, and exit area for successively receiving the carrier means supporting said sheets;

b. means for driving the conveyor in the entry area at a predetermined constant speed;

c. means for driving the conveyor in the coating area at a predetermined constant speed substantially less than the speed of the conveyor in the entry area;

d. means for driving the conveyor in the exit area at a predetermined constant speed substantially greater than the speed of the conveyor in the coating area, and

e. means for reducing the speed of the conveyor in the entry area to that of the conveyor in the coating area when the carrier means is received in said entry area.

9. Apparatus for treating sheets of material as defined in claim 8, in which each of said conveyors comprises an endless chain belt traveling in a horizontal path and said carrier means includes a plurality of individual carriers, and including means for successively magnetically connecting each carrier to the chain belt in the entry coating, and exit areas to advance said carrier through the coating chamber.

10. Apparatus for treating sheets of material as defined in claim 9, in which said last named means comprises spaced permanently magnetized members carried by each carrier and magnetically attracted to and moved along by each succeeding chain belt, the distance between adjacent chain belts being less than the distance between the magnetized members on each carrier.

11. Apparatus for treating sheets of material, comprising:

a. a plurality of chambers including an entry chamber, an exit chamber and a plurality of intermediate chambers in end to end relation to one another, one of said intermediate chambers constituting a coating chamber;

b. conveyor means in each of said chambers;

c. a plurality of carriers mounted for movement along said conveying means;

d. means carried by said carriers for supporting the sheets in a vertical position;

e. means for creating a vacuum in each of said intermediate chambers;

f. thermal evaporation means in said coating chamber;

g. a first valve compartment at the entry end of the entry chamber, a second valve compartment at the exit end of the exit chamber and valve compartments between each intermediate chamber and the adjacent chambers for placing them in communication with one another when open and separating them when closed;

h. means for individually raising and lowering the pressure in the entry chamber and exit chamber;

i. conveyor means positioned outwardly of said entry chamber;

j. means responsive to a predetermined relatively high pressure in said entry chamber to open the valve compartment at the entry end thereof to permit passage of a carrier from said last-named conveyor means into said entry chamber, and

k. means automatically operable when said carrier reaches a predetermined position in said entry chamber to close the valve compartment at the entry end thereof.

12. Apparatus for treating sheets of material as defined in claim 11, including:

a. means operable by said responsive means for initiating operation of the conveyor means outwardly of the entry chamber and also within said entry chamber to move a carrier into the said entry chamber, and

b. means engageable by said carrier when it is received in said entry chamber to bring both of said conveyor means to a stop.

13. Apparatus for treating sheets of material as defined in claim 11, including:

a. means in said entry chamber responsive to a predetermined relatively low pressure therein to open the valve compartment between the entry chamber and adjacent intermediate chamber to permit passage of a carrier from said entry chamber into said intermediate chamber, and

b. means automatically operable to close said last-named valve compartment when said carrier reaches a predetermined position in said intermediate chamber.

14. Apparatus for treating sheets of material as defined in claim 13, including:

a. means operable by said low pressure responsive means for initiating operation of the conveyor means in said entry chamber and adjacent intermediate chamber, and

b. means engageable by said carrier when it is received in said intermediate chamber to bring both of said conveyor means to a stop.

15. Apparatus for treating sheets of material as defined in claim 13, including:

a. means responsive to a predetermined relatively low pressure in the exit chamber to open the valve compartment between said exit chamber and the adjacent intermediate chamber to permit the passage of a carrier from said intermediate chamber into said exit chamber, and

b. means automatically operable to close said last-named valve compartment when said carrier reaches a predetermined position in said exit chamber.

16. Apparatus for treating sheets of material as defined in claim 15, including:

a. means operable by said last-named responsive means for initiating operation of the conveyor means in said intermediate chamber and in said exit chamber, and

b. means engageable by said carrier when it is received in said exit chamber to bring both of said conveyor means to a stop.

17. Apparatus for treating sheets of material as defined in claim 15, including:

a. conveyor means positioned outwardly of said exit chamber;

b. means responsive to a predetermined relatively high pressure in said exit chamber to open the valve compartment at the exit end thereof to permit passage of a carrier from said exit chamber to the conveyor means outwardly thereof, and

c. means automatically operable to close said last-named valve compartment when said carrier reaches a predetermined position on said conveyor means positioned outwardly of said exit chamber.

18. Apparatus for treating sheets of material as defined in claim 17, including:

a. means operable by said second low pressure responsive means in said exit chamber for initiating operation of the conveyor means in said exit chamber and the conveyor means outwardly thereof, and

b. means engageable by said carrier when it is received on said conveyor means located outwardly of said exit chamber to bring both of said conveyor means to a stop.

19. Apparatus for treating sheets of material, comprising:

a. a plurality of chambers arranged in end to end relation and including in succession:

I. an entry chamber,

II. a cleaning chamber,

III. a heating chamber,

IV. a coating chamber,

V. a cooling chamber, and

VI. an exit chamber;

b. conveyor means in each of said chambers;

c. a plurality of carriers for suspending sheets in vertical position mounted on said conveying means and movable through each of the chambers at a substantially constant rate of speed;

d. a first valve compartment at the entry end of the entry chamber, a second valve compartment at the exit end of the exit chamber, and valve compartments between each two adjacent intermediate chambers for placing said chambers in communication with one another when open and separating them when closed;

e. means for independently regulating the pressure in each of said chambers, and

f. means controlled by the pressure in said chambers for opening and closing said valve compartments in predetermined sequence.

20. Apparatus for treating sheets of material as defined in claim 19, in which each valve compartment includes a panel and individual means for opening and closing said panels.

21. Apparatus for treating sheets of material as defined in claim 19, including:

a. means in the cleaning chamber for cleaning the sheets;

b. means in the heating chamber for heating the sheets, and

c. means in the coating chamber for coating the sheets.

22. Apparatus for treating sheets of material as defined in claim 21, in which the means in the coating chamber for coating the sheets comprises thermal evaporation means.

23. Apparatus for treating sheets of material as defined in claim 22, in which said thermal evaporation means comprises a plurality of electron beam evaporation sources arranged in vertical and horizontal rows positioned in at least one side wall of said coating chamber.

24. Apparatus for treating sheets of material as defined in claim 21, in which the means in the cleaning chamber for cleaning the sheets comprises glow discharge means.

25. Apparatus for treating sheets of material as defined in claim 19, in which

a. the cleaning chamber includes glow discharge cleaning means, and

b. the coating chamber includes thermal evaporation coating means.

26. Apparatus for treating sheets of material as defined in claim 19, including:

a. conveyor means positioned outwardly of said entry chamber;

b. said means for opening and closing including means responsive to a predetermined relatively high pressure in said entry chamber to open the valve compartment at the entry end thereof to permit passage of carriers into said entry chamber, and

c. means automatically operable to close said last-named valve compartment when said carriers reach a predetermined position in said entry chamber.

27. Apparatus for treating sheets of material as defined in claim 26, including:

a. means operable by said responsive means for initiating operation of the conveyor means outwardly of the entry chamber and within the entry chamber to move carriers from the former conveyor means onto the latter conveyor means, and

b. means engageable by said carriers in said entry chamber to bring both of said conveyor means to a stop.

28. Apparatus for treating sheets of material as defined in claim 19, including:

a. said means for opening and closing including means in said entry chamber responsive to a predetermined relatively low pressure therein to open the valve compartment between the entry chamber and the cleaning chamber to permit passage of carriers from said entry chamber into said cleaning chamber, and

b. means automatically operable to close said last-named valve compartment when said carriers reach a predetermined position in said cleaning chamber.

29. Apparatus for treating sheets of material as defined in claim 28, including:

a. means operable by said low pressure responsive means for initiating operation of the conveyor means in said entry and in said cleaning chambers,

b. means engageable by said carriers when received in said cleaning chamber to bring both of said conveyor means to a stop.

30. Apparatus for treating sheets of material as defined in claim 19, including:

a. said means for opening and closing including means in said cleaning chamber responsive to a predetermined relatively low pressure therein to open the valve compartment between the cleaning chamber and the heating chamber to permit passage of carriers from said cleaning chamber into said heating chamber, and

b. means automatically operable to close said last-named valve compartment when said carriers reach a predetermined position in said heating chamber.

31. Apparatus for treating sheets of material as defined in claim 30, including:

a. means operable by said low pressure responsive means in said cleaning chamber for initiating operation of the conveyor means in said cleaning chamber and in said heating chamber, and

b. means engageable by said carriers when received in said heating chamber to bring both of said conveyor means to a stop.

32. Apparatus for treating sheets of material as defined in claim 19, in which said coating chamber comprises an entry area, a coating area and an exit area, and including:

a. conveyor means in each of said areas;

b. means for driving the conveyor means in the entry area at a predetermined relatively constant high speed;

c. means for driving the conveyor means in the coating area at a predetermined constant speed substantially less than the speed of the conveyor means in the entry area;

d. means for synchronizing the speed of the conveyor means in the entry area with the speed of the conveyor means in the coating area preparatory to movement of the carriers into said coating area;

e. means for driving the conveyor means in the exit area at a predetermined constant speed substantially greater than the speed of the conveyor means in the coating area, and

f. means for synchronizing the speed of the conveyor means in the exit area with the speed of the conveyor means in the coating area preparatory to movement of the carriers into the exit area to maintain a continuous movement of said carriers through said coating area.

33. Apparatus for treating sheets of material as defined in claim 32, in which said synchronizing means includes:

a. speed changing means interposed in the driving means for the conveyor means in the entry area to cause said entry area conveyor means to be driven by and at the reduced

speed of the conveyor means in the coating area when the driving means for the entry area conveyor means is disconnected to effect passage of the carriers from the entry area into the coating area at the reduced speed of the coating area conveyor means, and

b. speed changing means interposed in the driving means for the conveyor means in the exit area to cause said exit area conveyor means to be driven by and at the speed of the conveyor means in the coating area when the driving means for the exit area conveyor means is disconnected to effect passage of the carriers from the coating area into the exit area at the reduced speed of the coating area conveyor means.

**34**. Apparatus for treating sheets of material as defined in claim **19**, in which the coating chamber comprises an entry area, a coating area and an exit area, and including:

a. said means for opening and closing including means in said heating chamber responsive to a predetermined pressure therein to open the valve compartment between the heating chamber and the coating chamber to permit passage of carriers from said heating chamber into said coating chamber, and

b. means automatically operable to close said last-named valve compartment when said carriers reach a predetermined position in the entry area of the coating chamber.

**35**. Apparatus for treating sheets of material as defined in claim **34**, in which the conveying means in the coating chamber comprises individual conveyor means in the entry area, the coating area and the exit area, and including:

a. means operable by said responsive means in said heating chamber for initiating operation of the conveyor means in the entry area of said coating chamber and in the said heating chamber, and

b. means engageable by said carriers when received in said entry area of the coating chamber to bring the conveyor means in said heating chamber to a stop while the conveyor means in the coating chamber continue to operate to move the carriers therethrough.

**36**. Apparatus for treating sheets of material as defined in claim **35**, in which the conveyor means in the entry area, in the coating area and in the exit area of the coating chamber comprise stationary support means and endless chain belts associated therewith and mounted for movement in a horizontal path, and including:

a. individual motors for driving said chain belts at predetermined constant speed;

b. sprockets about which each chain belt is trained;

c. a shaft connected to one of the sprockets for each chain belt and driven by the respective motor for driving said chain belt;

d. drive connections between the shaft for the chain belt in the entry area and the shaft for the chain belt in the coating area;

e. means engageable by said carriers when received on the stationary support means in said entry area to disconnect the shaft from the respective motor and to simultaneously bring said motor to a stop, and

f. means interposed in said drive connections for causing the chain belt in the entry area to be driven at a speed less than said predetermined constant speed by the motor for the chain belt in the coating area when the motor for the chain belt in said entry area has been stopped.

**37**. Apparatus for treating sheets of material as defined in claim **36**, including:

a. drive connections between the shaft for the chain belt in the coating area and the drive shaft for the chain belt in the exit area, and

b. means interposed in said drive connections for causing the chain belt in the exit area to be driven at a speed less than said predetermined constant speed by the motor for the chain belt in the coating area when the motor for driving the chain belt in said exit area is stopped.

**38**. Apparatus for treating sheets of material as defined in claim **37**, including:

a. electrical pulsing means driven by the shaft for the chain belt in the coating area to produce a series of regularly spaced pulsations according to the predetermined relatively slow constant speed of said shaft;

b. counting means for recording the series of pulsations;

c. switch means engageable by said carrier in the coating area to initiate operation of the counting means with said electrical pulsing means;

d. second electrical pulsing means driven by the shaft for the chain belt in the entry area to produce a series of regularly spaced pulsations according to the predetermined relatively high constant speed of said motor;

e. second counting means for recording the second series of pulsations;

f. switch means engageable by a succeeding carrier when received in said entry area to initiate operation of said second counting means with the second pulsing means in said entry area;

g. pulsation totalizing means operable to receive the relatively slow pulsations of the first counting means in said coating area and the pulsations at the predetermined relatively high constant speed of the second counting means in the entry area to establish a balanced condition therebetween, and

h. means operable when the balanced condition of pulsations has been established by said totalizing means to bring the motor for the chain belt in the entry area to a stop with the said succeeding carrier spaced a predetermined distance from the preceding carrier.

**39**. Apparatus for treating sheets of material as defined in claim **36**, including means engageable by said carrier in the exit area to initiate operation of the motor for the chain belt in said exit area to drive the chain belt in said exit area at a predetermined relatively high constant speed.

**40**. Apparatus for treating sheets of material as defined in claim **39**, in which the conveyor means in the cooling chamber, comprises:

a. an endless chain belt mounted for movement in a horizontal path;

b. sprockets about which said chain belt is trained;

c. a motor for driving said chain belt;

d. means engageable by a carrier in the exit area of the coating chamber to initiate operation of the motor for the chain belt in the cooling chamber;

e. means in said cooling chamber responsive to a predetermined low pressure therein to open the valve compartment between the coating chamber and cooling chamber to permit passage of the carrier from the coating chamber into said cooling chamber, and

f. means automatically operable to close said valve compartment when said carrier reaches a predetermined position in said cooling chamber.

**41**. Apparatus for handling sheets of material as claimed in claim **40**, including;

a. means engageable by said carrier when said carrier reaches a predetermined position in the cooling chamber to bring the motor for the chain belt in said cooling chamber to a stop, and

b. means simultaneously responsive to stopping of the last-named chain belt to bring the motor for the chain belt in the exit area of the coating chamber to a stop whereby the motor for the chain belt in the coating area of said coating chamber will drive the chain belt in said exit area at the said predetermined relatively slow speed.

**42**. Apparatus for handling sheets of material as defined in claim **19**, including:

a. said means for opening and closing including means responsive to a predetermined relatively low pressure in the exit chamber and said cooling chamber to open the valve compartment therebetween to permit passage of carriers from said cooling chamber into said exit chamber;

b. means automatically operable to close said last-named valve compartment when said carriers reach a predetermined position in said exit chamber;

c. means operable by said last-named responsive means for initiating operation of the conveyor means in said cooling chamber and exit chamber, and

d. means engageable by said carriers in said exit chamber to bring both of said conveyor means to a stop.

43. Apparatus for treating sheets of material as defined in claim 19, including:

a. conveyor means positioned outwardly of said exit chamber;

b. said means for opening and closing including means responsive to a predetermined relatively high pressure in said exit chamber to open the valve compartment at the exit end thereof to permit passage of carriers from said exit chamber to the conveyor means outwardly thereof;

c. means automatically operable to close said last-named valve compartment when said carriers reach a predetermined position on said outwardly positioned conveyor means;

d. means operable by said responsive means in said exit chamber for initiating operation of the conveyor means in said exit chamber and said conveyor means outwardly thereof, and

e. means engageable by said carriers on said outwardly disposed conveyor means to bring both of said conveyor means to a stop.

44. Apparatus for treating sheets of material as defined in claim 19, in which the pressures in the entry chamber, cleaning chamber, cooling chamber, and exit chamber are variable and the pressures in the heating chamber and coating chamber are maintained substantially equal and constant.

45. Apparatus for treating sheets of material as defined in claim 19, including:

a. conveyor means positioned outwardly of the entry chamber;

b. conveyor means positioned outwardly of the exit chamber, and

c. said means for opening and closing including means responsive to predetermined pressures in said entry and exit chambers to actuate said means for opening and closing said valve compartments at the respective entry end and exit end of said chambers;

d. means responsive to the position of the carriers in said plurality of chambers between said entry and exit chambers for opening and closing the valve compartments between two adjacent chambers;

e. means responsive to the position of carriers in said entry chamber to close the valve compartment at the entry end thereof, and

f. means responsive to the position of carriers on the outwardly disposed conveyor means to close the valve compartment at the exit end of said exit chamber.

46. Apparatus for treating sheets of material as defined in claim 1, in which

a. said conveying means includes drive means comprising an endless chain belt arranged in each chamber for movement in a fixed horizontal path;

b. sprockets about which the chain belt is trained;

c. individual motors for driving each chain belt, and

d. a permanently magnetized member mounted on said carrier means and being magnetically attracted to the chain belts to move said carrier means along said path.

47. Apparatus for treating sheets of material as defined in claim 46, in which a plurality of permanently magnetized members are mounted on each carrier means and spaced from one another a distance greater than the distance between adjacent chain belts so that one magnetic member will be magnetically attracted to the chain belt in one chamber before the following magnetic member becomes disengaged from the chain belt in the preceding chamber, whereby continuous movement of the carrier means through the chambers can be maintained.

48. Apparatus for treating sheets of material as defined in claim 1, in which said carrier means includes

a. means for clamping the sheets along their upper edges to support the same in a vertical position prior to movement thereof into said chambers;

b. means for automatically actuating the clamping means to clamp the sheets after said sheets have been moved into position relative thereto, and

c. means for automatically actuating the clamping means to disengage the sheets after they have been removed from said chambers.

49. Apparatus for treating sheets of material as defined in claim 48, in which said clamping means includes:

a. fixed clamping members and movable clamping members mounted for pivotal and sliding movement;

b. means for moving said movable clamping members downwardly and inwardly to clamp the upper edge of a sheet against said fixed clamping members, and

c. means for securing said movable clamping members in clamping position.

50. Apparatus for treating sheets of material as defined in claim 48, in which:

a. said conveying means includes drive means comprising an endless chain belt arranged in each chamber for movement in a fixed horizontal path;

b. sprockets about which the chain belt is trained;

c. individual means for driving each chain belt, and

d. a permanently magnetized member mounted on said carrier means and being magnetically attracted to said chain belts to move said carrier means through said chambers.

51. Apparatus for treating sheets of material as defined in claim 49, in which a plurality of permanently magnetized members are mounted on each carrier means and spaced from one another a distance greater than the distance between adjacent chain belts so that one magnetic member will be magnetically attracted to the chain belt in one chamber before the following magnetic member becomes disengaged from the chain belt in the preceding chamber, whereby continuous movement of the carrier means through the chambers can be maintained.

52. Apparatus for treating sheets of material as defined in claim 19, including:

a. conveyor means spaced in parallel side-by-side relation in each chamber;

b. carriers movable along each conveyor means for supporting sheets in a vertical position, and

c. a single source of power for driving both of said carriers to move said sheets in unison.

53. Apparatus for treating sheets of material as defined in claim 19, in which said conveyor means comprises a pair of spaced parallel monorails mounted in each chamber and including

a. an endless chain belt disposed opposite each monorail;

b. carriers supported by and movable along said monorails;

c. permanently magnetized members mounted on each carrier and magnetically attracted to the respective chain belt, and

d. means for simultaneously driving said chain belts to move the carriers in unison.

54. Apparatus for treating sheet materials as defined in claim 19, in which said conveyor means comprises:

a. drive means including an endless chain belt arranged in each chamber for movement in a horizontal path;

b. sprockets about which each chain belt is trained;

c. individual means for driving each chain belt, and

d. a permanently magnetized member mounted on each carrier and being magnetically attracted to said chain belts to move said carrier along said path.

55. Apparatus for treating sheets of material as claimed in claim 54, in which a plurality of permanently magnetized members are mounted on each carrier and spaced from one another a distance greater than the distance between adjacent chain belts so that one magnetic member will be attracted to the chain belt in one chamber before the following magnetic member becomes disengaged from the chain belt in the

preceding chamber whereby continuous movement of the carriers through the chambers can be maintained.

**56**. Apparatus for treating sheets of material as defined in claim **19**, in which the carriers include:

a. means for clamping the sheets along their upper edges to support the same in a vertical position prior to movement of the carriers into said entry chamber;

b. means for automatically actuating the clamping means to clamp the sheets after said sheets have been moved into position relative thereto, and

c. means for automatically actuating the clamping means to disengage the sheets after said carriers have been removed from said chambers.

**57**. Apparatus for treating sheets of material as claimed in claim **56**, in which said clamping means includes:

a. fixed clamping members and movable clamping members mounted for pivotal and sliding movement;

b. means for moving the movable clamping members downwardly and inwardly to clamp the upper edge of a sheet against said fixed clamping members, and

c. means for securing the movable clamping members in clamping position.

**58**. Apparatus for treating sheets of material as defined in claim **56**, in which said conveyor means comprises:

a. drive means including an endless chain belt arranged in each chamber for movement in a horizontal path;

b. sprockets about which each chain belt is trained;

c. individual means for driving each chain belt, and

d. a permanently magnetized member mounted on each carrier and being magnetically attracted to the chain belts to move the said carrier along said path.

**59**. Apparatus for treating sheets of material as defined in claim **58**, in which a plurality of permanently magnetized members are mounted on each carrier and spaced from one another a distance greater than the distance between adjacent chain belts so that one magnetic member will be attracted to the chain belt in one chamber before the following magnetic member becomes disengaged from the chain belt in the preceding chamber whereby continuous movement of the carrier through the chambers can be maintained.

**60**. Apparatus for handling sheets of material as claimed in claim **1**, including:

a. a return conveyor located in spaced parallel relation to the plurality of chambers and having an entry end and an exit end transversely aligned with exit end and entry and respectively of the plurality of chambers;

b. a transfer carriage;

c. means for supporting the transfer carriage for transverse movement from a position in alignment with the exit end of the chambers to a position in alignment with the entry end of the return conveyor;

d. drive means on the transfer carriage for moving a carrier means from the exit end of said chambers onto the transfer carriage;

e. means engageable by the carrier means when received on the transfer carriage to bring said drive means to a stop;

f. means operable automatically when the first drive means is stopped to reverse the operation thereof for subsequent movement of said carrier means from said transfer carriage;

g. second drive means on said transfer carriage;

h. means responsive to stopping of the first drive means to initiate operation of the second drive means for moving the transfer carriage along the supporting means to a position in alignment with the entry end of the return conveyor,

i. means engageable by said transfer carriage when the same reaches a position in alignment with the entry end of the return conveyor to bring said second drive means to a stop,

j. means operable automatically when said second drive means is stopped to reverse operation thereof for subsequent movement of the transfer carriage from the position in alignment with the entry end of said return conveyor, and

k. means responsive to stopping of said second drive means to initiate operation of the first drive means to remove the carrier means from the transfer carriage onto the entry end of the return conveyor.

**61**. Apparatus for handling sheets of material as defined in claim **60**, including:

a. drive means on the return conveyor, and

b. means associated with said last-named responsive means for simultaneously initiating operation of said drive means on the return conveyor to move the carrier means along said return conveyor when said carrier means is removed from said transfer carriage by said first drive means.

**62**. Apparatus for handling sheets of material as defined in claim **60**, including:

a. means engageable by the carrier means when received on the return conveyor to bring the said first drive means to a stop;

b. means responsive to stopping of the first drive means to initiate operation of the second drive to return the transfer carriage to a position in alignment with the exit end of the chambers, and

c. means engageable by said transfer carriage at said position of alignment to bring the second drive means to a stop.

**63**. Apparatus for handling sheets of material as defined in claim **60**, including:

a. drive means adjacent the exit end of the return conveyor;

b. a sheet unloading unit adjacent to and aligned with the exit end of the return conveyor;

c. a stationary conveyor mounted above the sheet unloading unit;

d. drive means on the stationary conveyor;

e. a bridging conveyor interposed between the exit end of the return conveyor and the stationary conveyor and in alignment therewith;

f. drive means on the bridging conveyor;

g. means engageable by the carrier means adjacent the exit end of the return conveyor to initiate operation of the drive means on the stationary conveyor and the drive means on the bridging conveyor to move the carrier means from said return conveyor, across said bridging conveyor and onto said stationary conveyor,

h. means engageable by the carrier means when it reaches a predetermined position on the said stationary conveyor to bring the said carrier means to a stop above said unloading unit, and

i. means for releasing the sheet from said carrier means onto said unloading unit.

**64**. Apparatus for handling sheets of material as defined in claim **63**, including means responsive to stopping of the carrier means on said stationary conveyor to initiate operation of the sheet unloading unit to receive the sheet from said carrier means.

**65**. Apparatus for handling sheets of material as defined in claim **63**, including:

a. an entry conveyor adjacent to and aligned with the entry end of the plurality of chambers;

b. drive means on the entry conveyor;

c. a shuttle carriage for receiving said carrier means from the stationary conveyor after the sheet has been released therefrom;

d. means supporting the shuttle carriage for transverse movement between a position in alignment with the exit end of the return conveyor and a position in alignment with the entry conveyor;

e. first drive means on the shuttle carriage to move the same transversely into engagement with said bridging conveyor to displace the bridging conveyor and assume its position in alignment with the exit end of the return conveyor,

f. means engageable by said shuttle carriage when it reaches the position in alignment with the exit end of the return conveyor to bring said first drive means to a stop;
g. a second drive means on the shuttle carriage;
h. means responsive to stopping of said first drive means to initiate operation of the second drive means and the drive means on the stationary conveyor to move the carrier means from the stationary conveyor onto said shuttle carriage;
i. means engageable by the carrier means when it reaches a predetermined position on the shuttle carriage to bring the second drive means on said shuttle carriage and the drive means on the stationary conveyor to a stop;
j. means also responsive to stopping of the second drive means to initiate operation of said first drive means on the shuttle carriage to move said shuttle carriage toward a position in alignment with said entry conveyor;
k. a sheet loading unit, and
l. means for moving said carrier means from said shuttle carriage into position to receive a sheet from said loading unit.

**66**. Apparatus for handling sheets of material as defined in claim **65**, in which the sheet loading unit is located adjacent to and in alignment with the entry conveyor; and including:
a. a second stationary conveyor mounted above the sheet loading unit;
b. drive means on the second stationary conveyor;
c. a second bridging conveyor interposed between the entry conveyor and the stationary conveyor and in alignment therewith;
d. drive means on the second bridging conveyor;
e. means engageable by the shuttle carriage when it reaches the position in alignment with the second stationary conveyor to bring said first drive means to a stop, and
f. means responsive to stopping of said first drive means on the shuttle carriage to initiate operation of the second drive means on said shuttle carriage and the drive means on the second stationary conveyor to move the carrier means from the shuttle carriage onto said second stationary conveyor above said sheet loading unit to receive a sheet therefrom.

**67**. Apparatus for handling sheets of material as defined in claim **66**, including means responsive to stopping of the carrier means on the second stationary conveyor to initiate operation of the sheet loading unit to secure a sheet in vertical position on the carrier means.

**68**. Apparatus for handling sheets of material as defined in claim **67**, including
a. means responsive to securing of the sheet on the carrier means to initiate operation of the drive means on the entry conveyor, the drive means on the second bridging conveyor and the drive means on the second stationary conveyor for moving the carrier means from the second stationary conveyor across the second bridging conveyor and onto the entry conveyor, and
b. means engageable by the carrier means when it reaches a predetermined position on said entry conveyor to bring said carrier means to a stop.

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