

- [72] Inventors **Norman M. Hinerfeld**  
Marmoroneck, N.Y.;  
**David S. Noble, Carpinteria, Calif.;**  
**William H. Bartley, Orange, Calif.**
- [21] Appl. No. **827,369**
- [22] Filed **May 23, 1969**
- [45] Patented **Oct. 19, 1971**
- [73] Assignee **Kayser-Roth Corporation**  
New York, N.Y.

**[54] METHODS OF AUTOMATICALLY CONTROLLING MANUFACTURING OPERATIONS SUCH AS SEWING OPERATIONS AND THE LIKE**  
41 Claims, 27 Drawing Figs.

- [52] U.S. Cl. .... **112/262,**  
318/20.102, 346/33 MC
- [51] Int. Cl. .... **D05b 1/00**
- [50] Field of Search ..... 112/2,  
121.11, 121.15, 102, 262, 219 A, 252;  
235/151.11; 346/33 MC; 318/162, 20.102;  
340/172.5

[56] **References Cited**

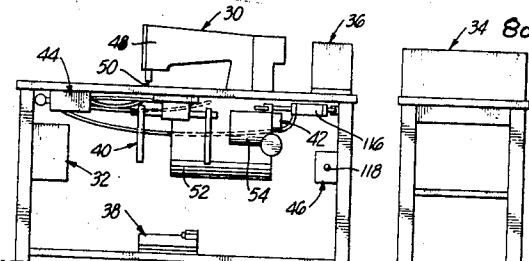
**UNITED STATES PATENTS**

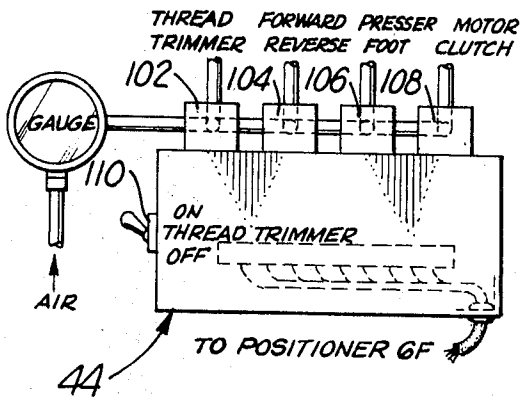
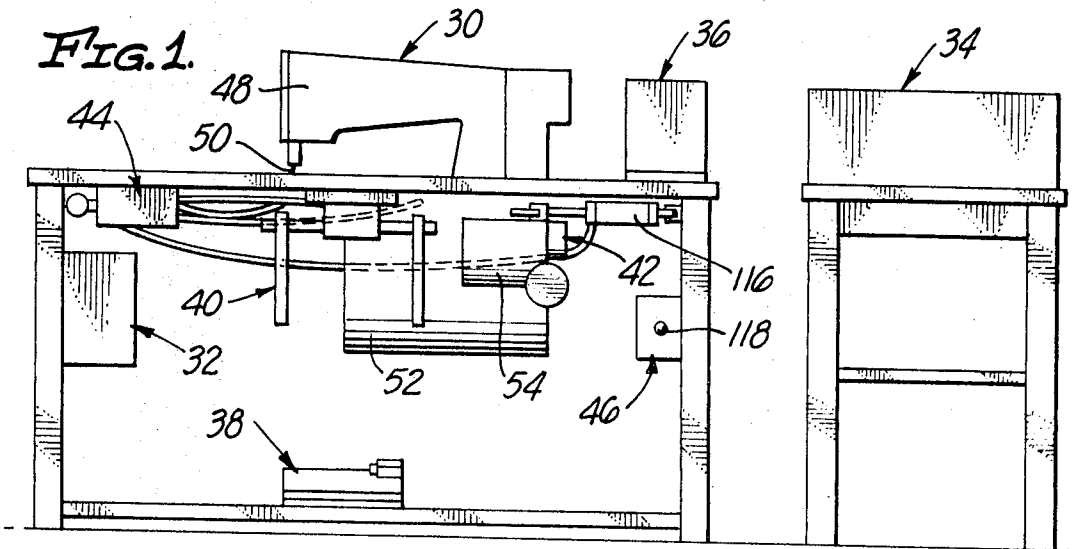
2,537,770	1/1951	Livingston et al. ....	346/33 MC
2,882,847	4/1959	Winz .....	112/219 A
2,996,348	8/1961	Rosenberg .....	346/33 MC
3,178,716	4/1965	Slatin .....	346/33 MC
3,186,366	6/1965	Hass et al. ....	112/219 A
3,324,281	6/1967	Morse .....	318/18 X
3,386,402	6/1968	Ross .....	112/252
3,445,639	5/1969	Martens .....	318/162 X
3,449,540	6/1969	Yanko et al. ....	318/162 X
3,459,144	8/1969	Ramsey et al. ....	112/102 X

Primary Examiner—James R. Boler  
Attorney—Mahoney, Hornbaker & Schick

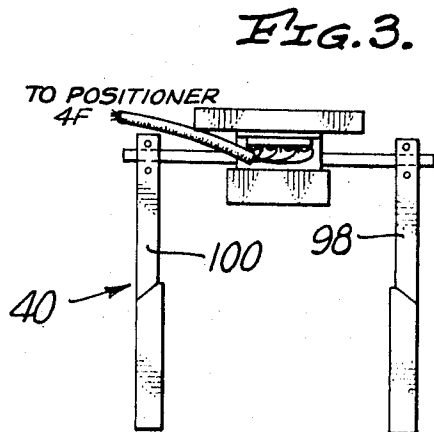
**ABSTRACT:** The manufacturing operations involve equipment preferably in the form of sewing equipment comprised of a usual sewing head with a reciprocal up and down moving needle electrically driven for sewing a plurality of stitches in an article to be sewn. A presser foot retains the article in place during sewing and downwardly against usual feed dogs which move the article forwardly and rearwardly appropriate for the various stitching operations. A needle positioner is operable with the sewing head for positioning the needle in a selected up or down position relative to the article at the termination of any sewing operational step, the needle preferably being positioned down extending through the article between at least certain successive sewing steps so that the article may be manually repositioned by an operator between said steps. A thread cutoff component is operably arranged with the sewing head for cutting off thread used by the needle in stitching at the termination of selected sewing steps, the thread cutoff being operable when the needle is up above the article as positioned by the needle positioner. Required for certain of the methods of the invention, the needle positioner also includes a counter device automatically counting reciprocations of the needle and capable of transmitting an electrical signal equivalent to such movement count. The sewing equipment may be controlled by the usual manually operable switches

such as knee control and foot control switches. The equipment likewise may include usual components such as an automatic pickup for supplying articles to the operator and an automatic stacker for removing sewn articles from the operator, and the sewing head may make use of usual attachments such as pleater and buttonhole attachments. Further, required for certain of the methods of the invention, an automatic controller, a power interface and preferably an automatic recorder are electrically connected with the sewing equipment, and a permanent record command switch is preferably arranged with the foot control switch. The power interface serves to electrically integrate the manually operable switches and the automatic controller with the sewing equipment, said power interface being selectively switchable between a manual mode and an automatic mode. In manual mode, the power interface connects the manually operable switches for usual control of the sewing equipment to perform a plurality of operational steps in an overall sewing operation as the article to be sewn, while at the same time, the power interface translates each of the component operational steps into composite instruction signals for transmission to and temporary recording at the automatic controller, any selected of said composite instruction signals being permanently recorded by the automatic controller in sequence by actuation of the permanent record command switch. Each instruction signal includes both function, the component being operated, and duration, either pure time in time elements or needle reciprocations from the needle positioner and counter. The automatic recorder is connected to the automatic controller and is selectively actionable for inserting in proper sequence into temporary and permanent recording of the automatic controller composite instruction signals equivalent to certain of the composite instruction signals resulting from actual operation of the sewing equipment so that selected of the sewing equipment operations either need nor be replaced by the automatic recorder. Also, the automatic controller is arranged for inserting instruction signals for determined time delays between selected component operations, either by permanently recording actual delays between component operations or by inserting numbers of time elements with the automatic recorder. Instructions for indeterminate time delays between component operations and training time delays intermediate selected component operations may likewise be appropriately inserted into the automatic controller. After completion of the permanent recording, when the power interface is in the automatic mode, the automatic controller may be operated to transmit back to the power interface the permanently recorded instruction signals in sequence which are translated by the power interface into commands for operating the various components to repeat the component operational steps to carry out the overall sewing operation method including the now inserted determined delays, indeterminate delays and training delays. During the determined delays, a preceding operating component is stopped, the determined delay carried out in time, and a latter component started automatically. During the indeterminate delays, the preceding component operation is stopped, but the latter component operation is not started until manually actuated by a manual control. The training delays are indeterminate and may be intermediate a selected component operation interrupting such operation until manual control actuation or between component operations as an ordinary indeterminate delay, in either case, there being means on the automatic controller for selected elimination of the training delays with the effect of removal from the automatic controller permanent recording.

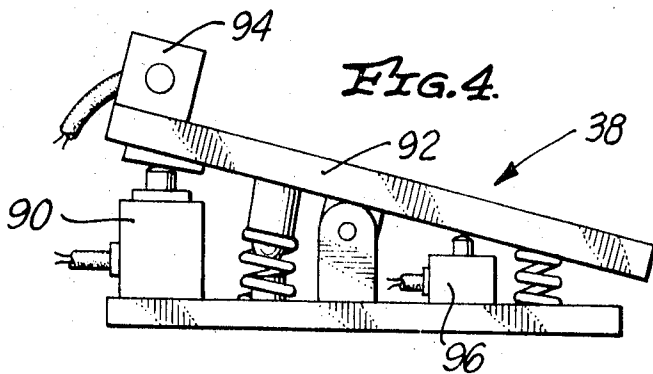




**FIG. 2.**



**FIG. 3.**



**FIG. 4.**

INVENTORS  
 NORMAN M. HINERFELD,  
 DAVID S. NOBLE &  
 WILLIAM H. BARTLEY  
 BY  
 MAHONEY, HORNBAKER  
 & SCHICK  
 ATTORNEYS

FIG. 5.

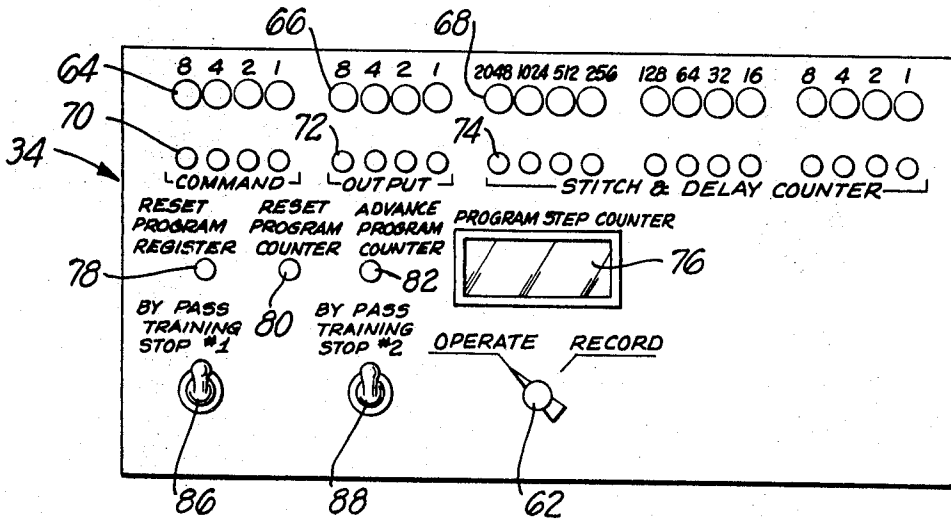


FIG. 6.

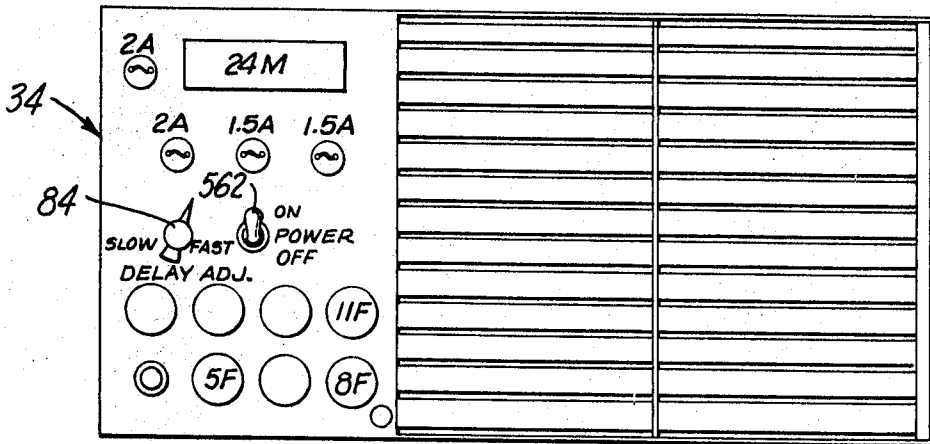
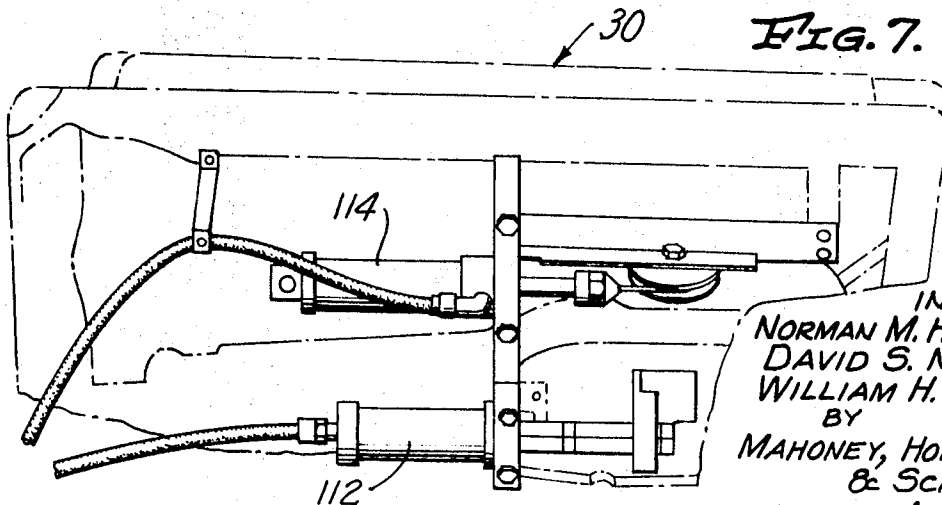


FIG. 7.



INVENTORS  
 NORMAN M. MINERFELD,  
 DAVID S. NOBLE &  
 WILLIAM H. BARTLEY  
 BY  
 MAHONEY, HORNBAKER  
 & SCHICK  
 ATTORNEYS

FIG. 8.

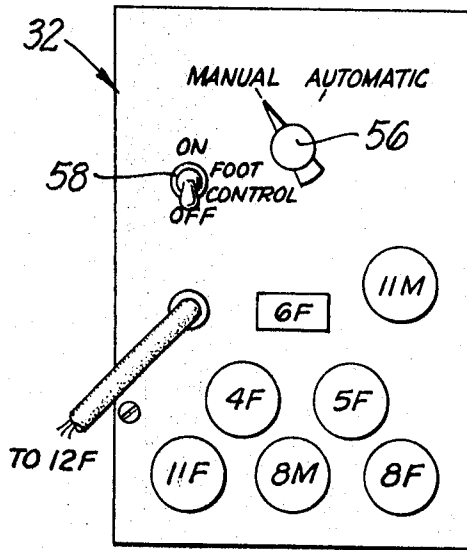


FIG. 9.

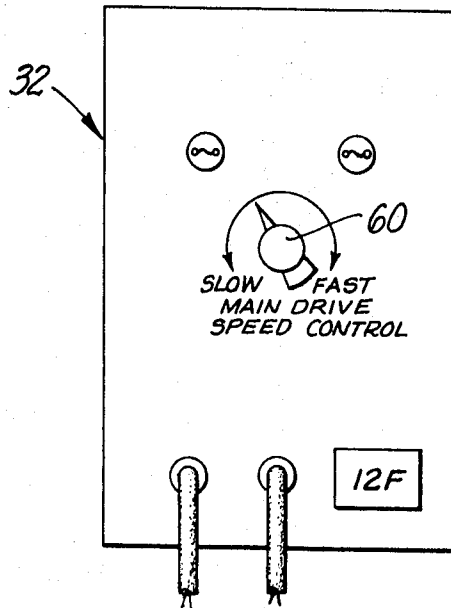
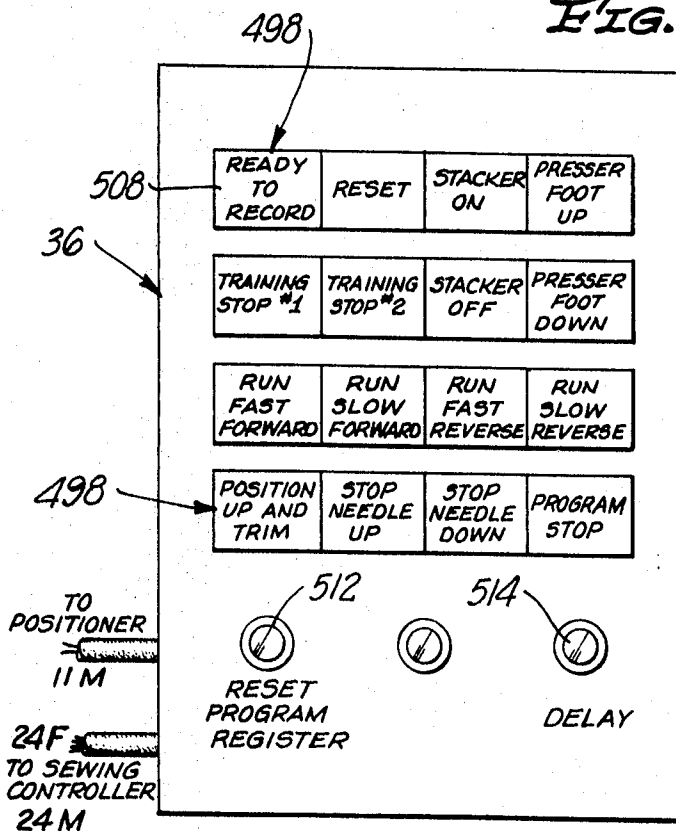


FIG. 10.



INVENTORS  
 NORMAN M. HINERFELD,  
 DAVID S. NOBLE &  
 WILLIAM H. BARTLEY  
 BY  
 MAHONEY, HORNBAKER  
 & SCHICK  
 ATTORNEYS

FIG. 18.

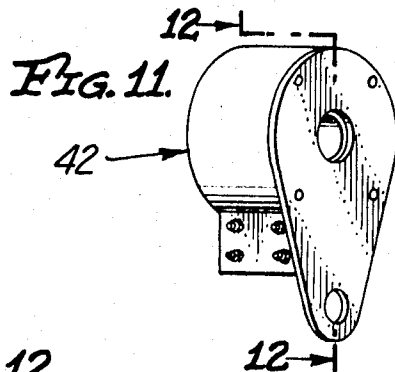
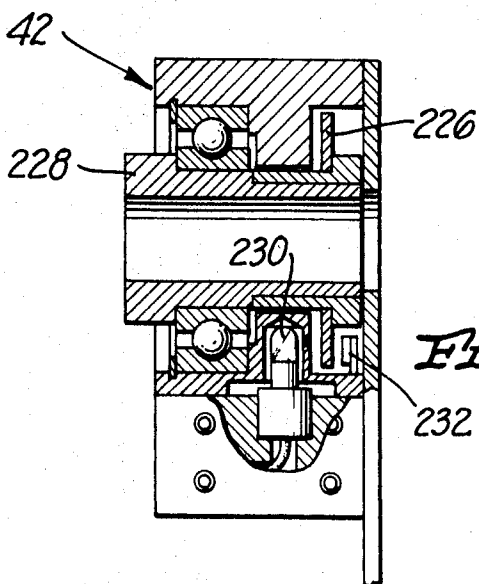
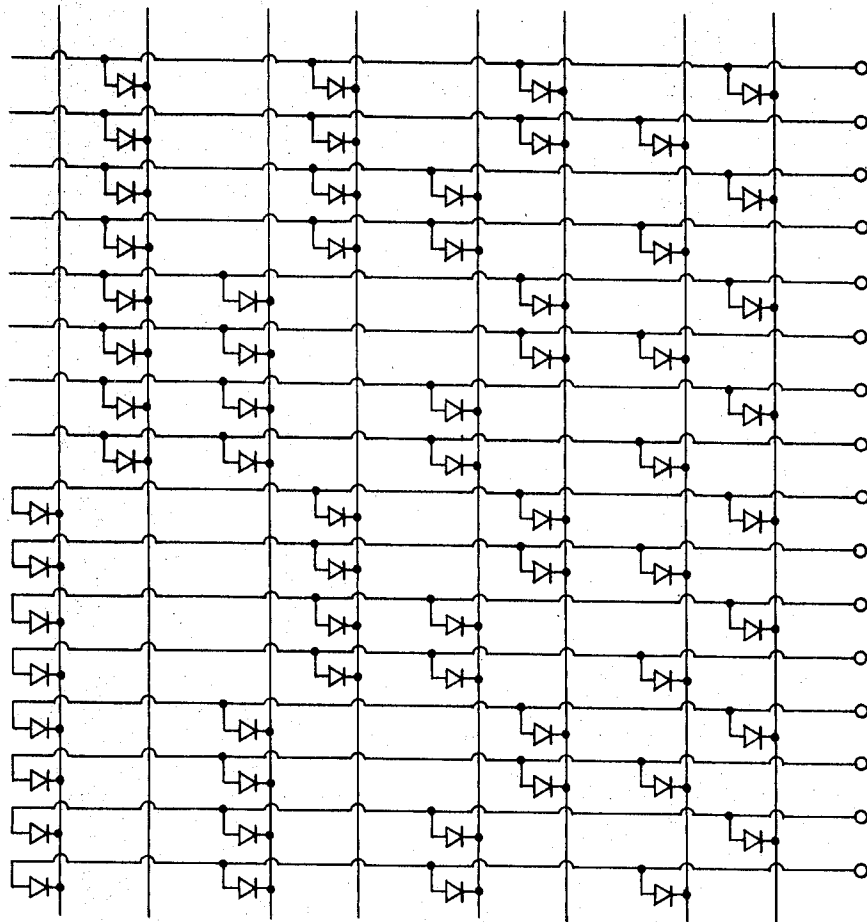
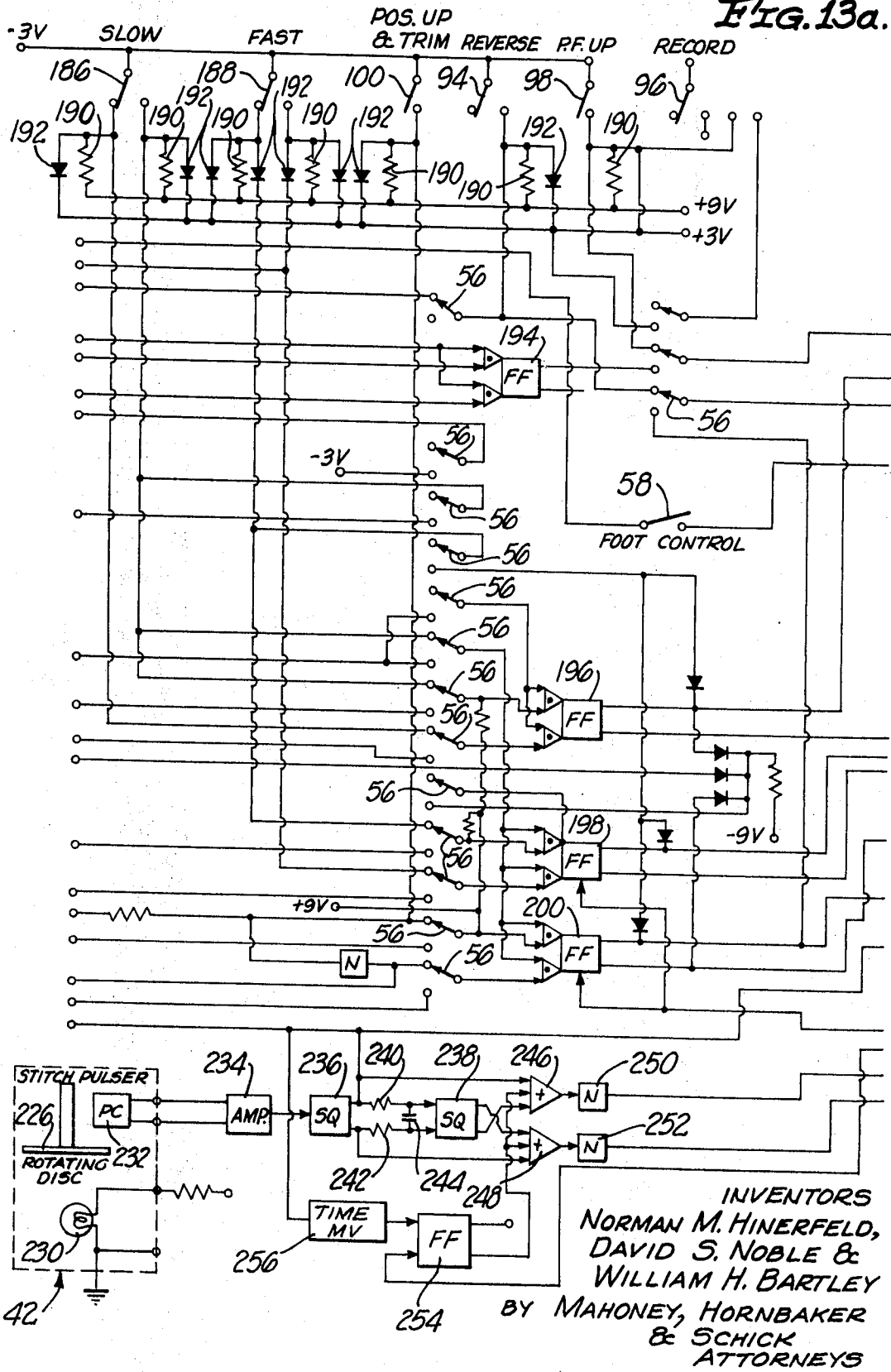


FIG. 12.

FIG. 11.

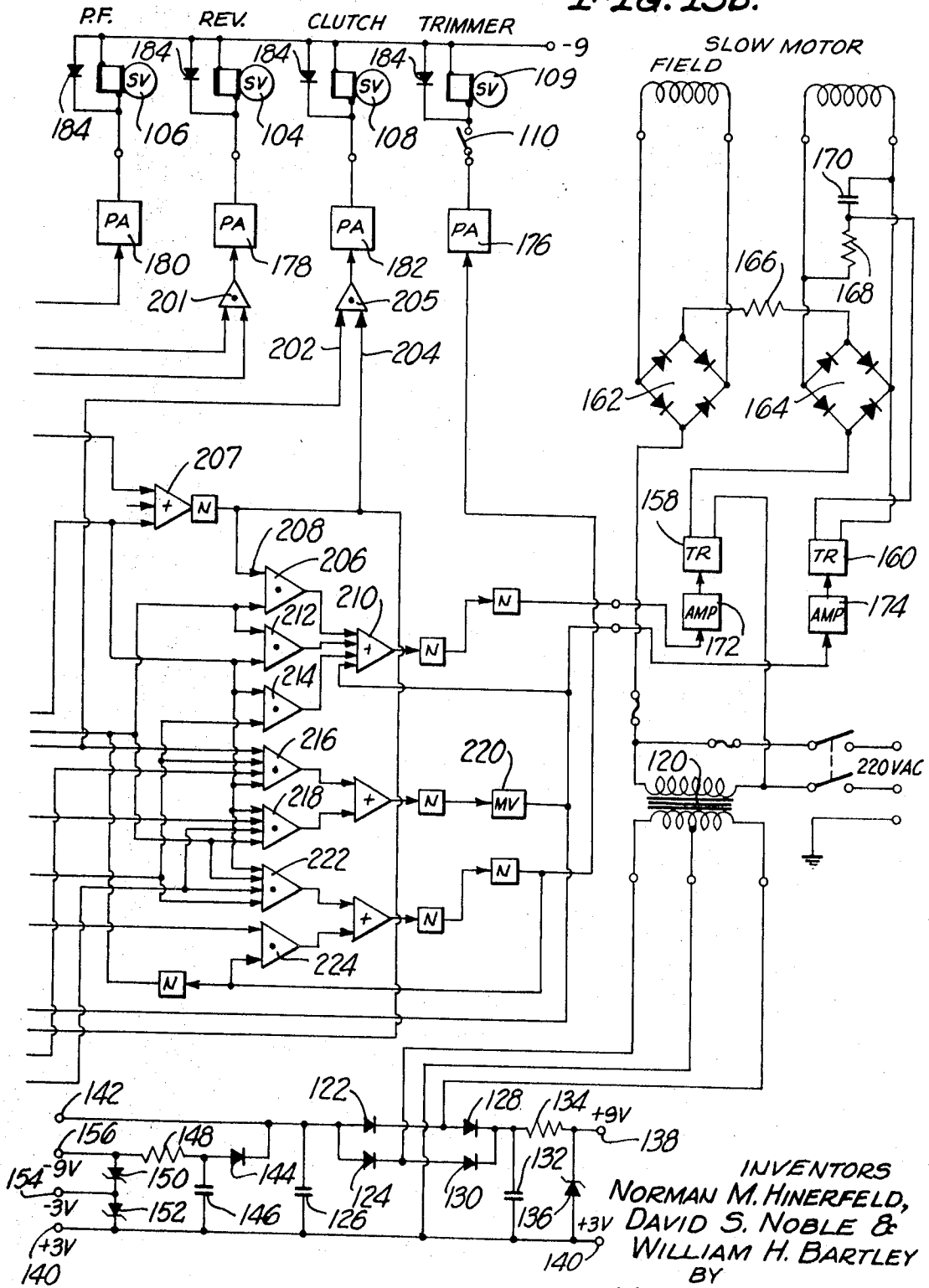
INVENTORS  
NORMAN M. HINERFELD,  
DAVID S. NOBLE &  
WILLIAM H. BARTLEY  
BY  
MAHONEY, HORNBAKER  
& SCHICK  
ATTORNEYS

FIG. 13a.



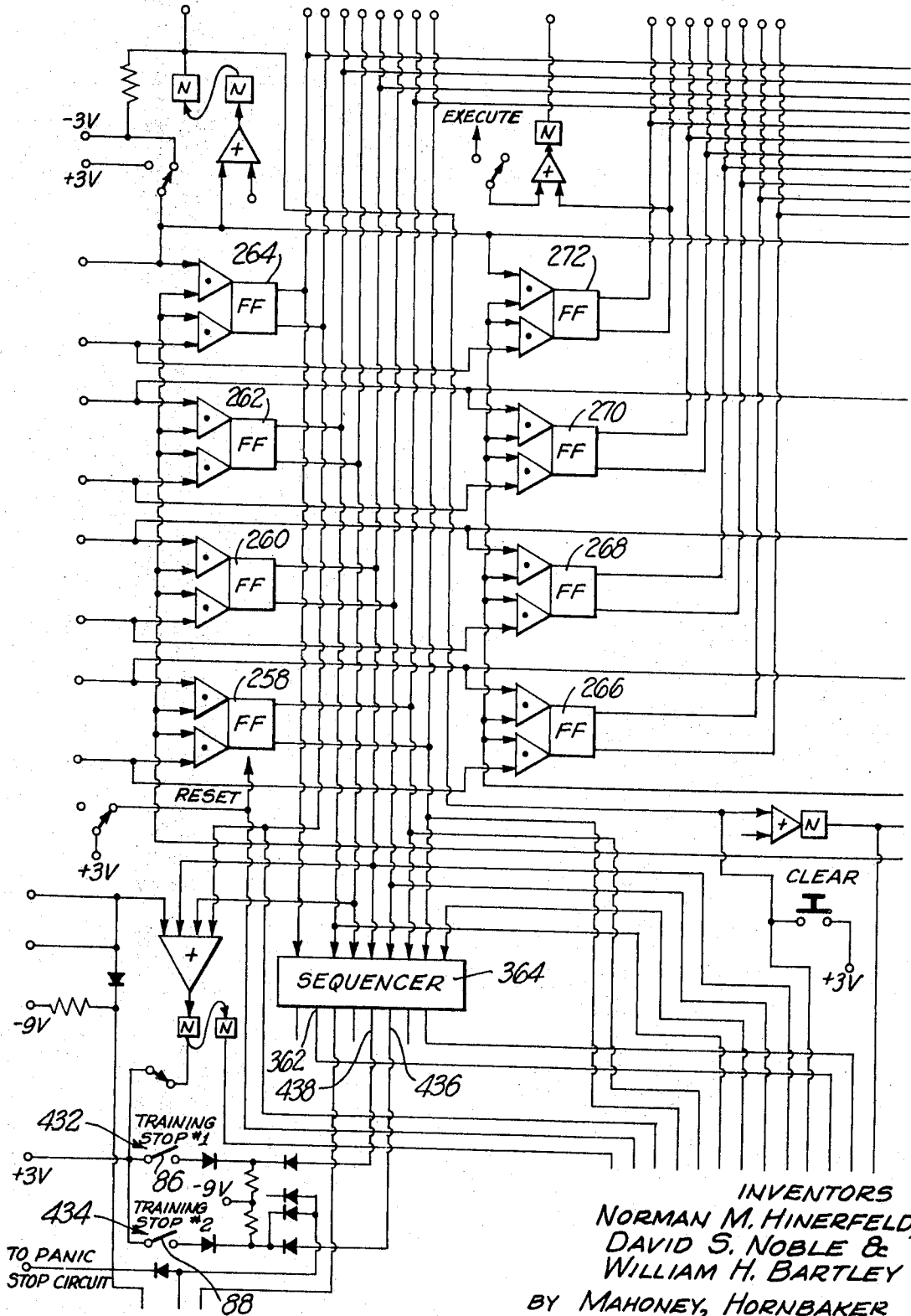
INVENTORS  
 NORMAN M. HINERFELD,  
 DAVID S. NOBLE &  
 WILLIAM H. BARTLEY  
 BY MAHONEY, HORNBAKER  
 & SCHICK  
 ATTORNEYS

FIG. 13b.



INVENTORS  
NORMAN M. HINERFELD,  
DAVID S. NOBLE &  
WILLIAM H. BARTLEY  
BY  
MAHONEY, HORNBAKER  
& SCHICK  
ATTORNEYS

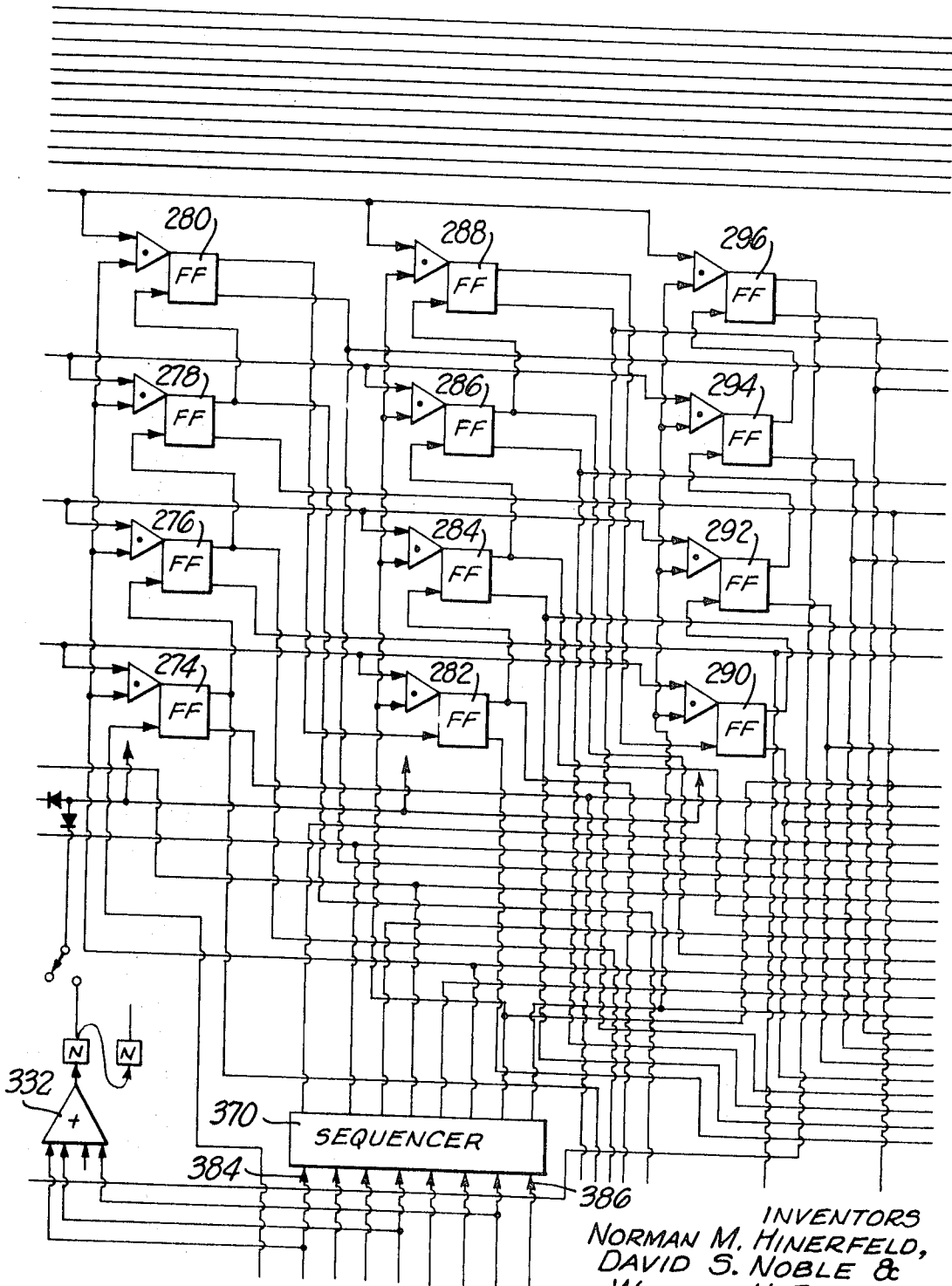
FIG. 14a.



INVENTORS  
NORMAN M. HINERFELD,  
DAVID S. NOBLE &  
WILLIAM H. BARTLEY  
BY MAHONEY, HORNBAKER  
& SCHICK  
ATTORNEYS

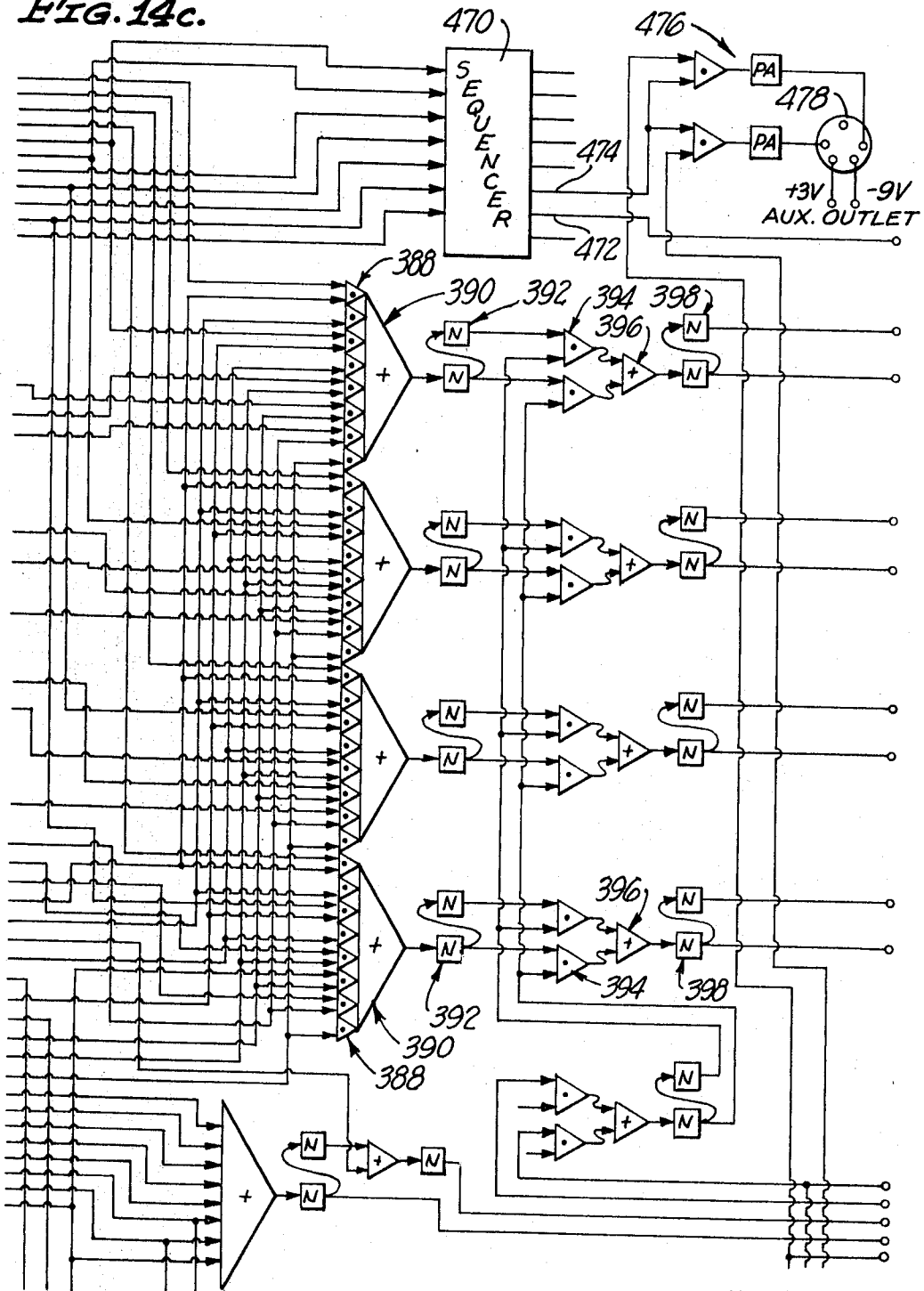


FIG. 14b.



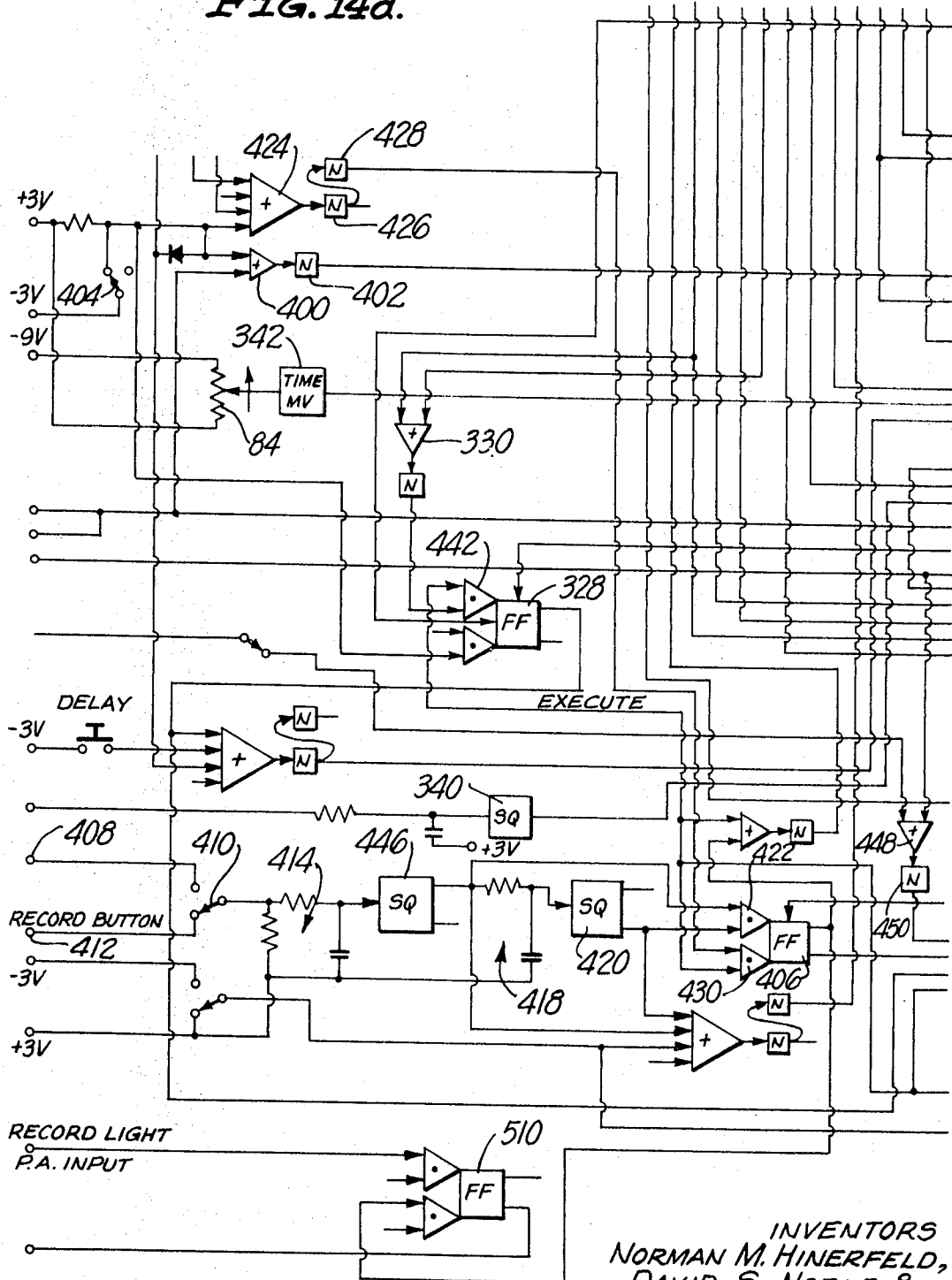
INVENTORS  
NORMAN M. HINERFELD,  
DAVID S. NOBLE &  
WILLIAM H. BARTLEY  
BY MAHONEY, HORNBAKER  
& SCHICK  
ATTORNEYS

FIG. 14c.



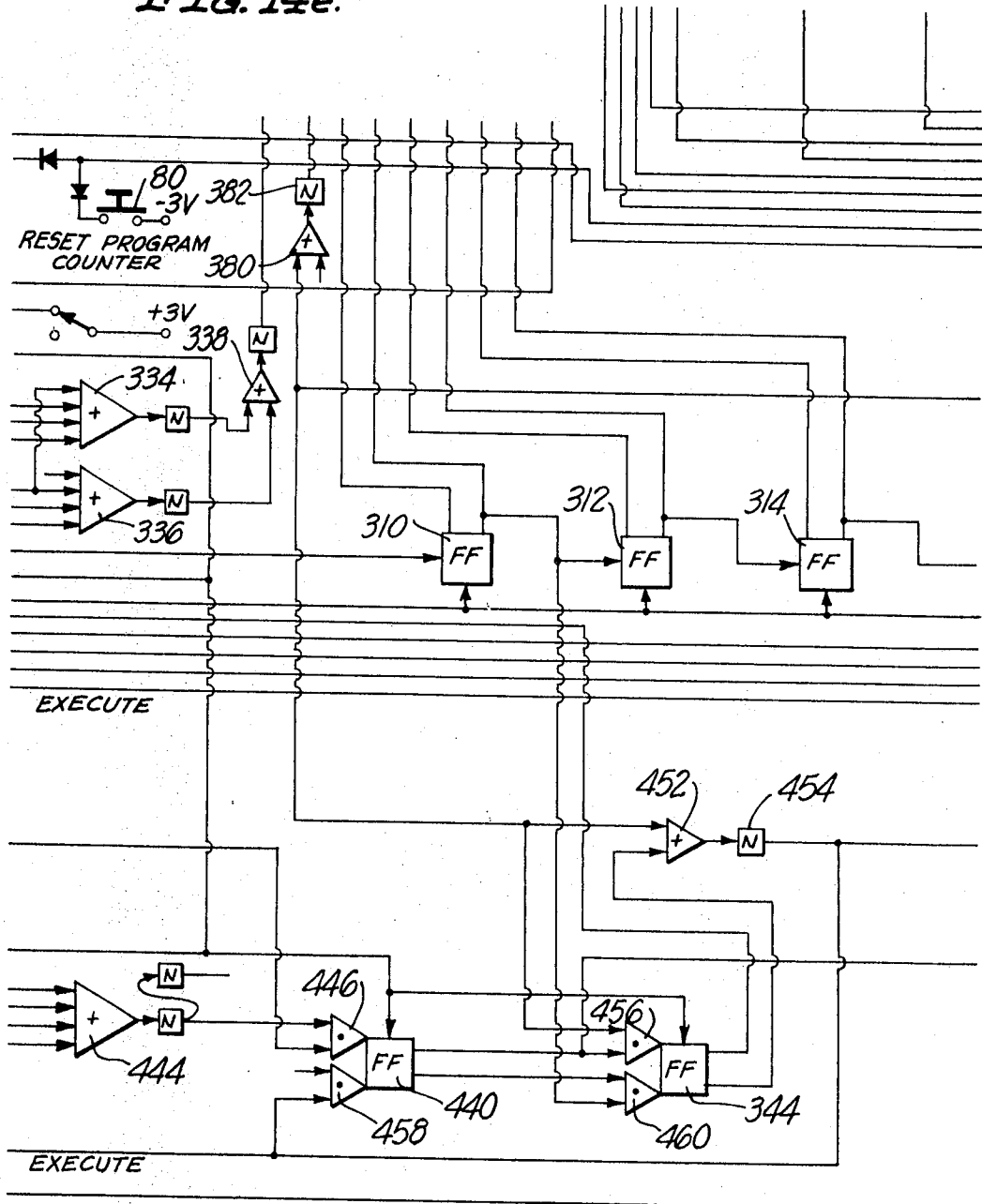
INVENTORS  
NORMAN M. HINERFELD,  
DAVID S. NOBLE &  
WILLIAM H. BARTLEY  
BY MAHONEY, HORNBAKER  
& SCHICK  
ATTORNEYS

FIG. 14d.



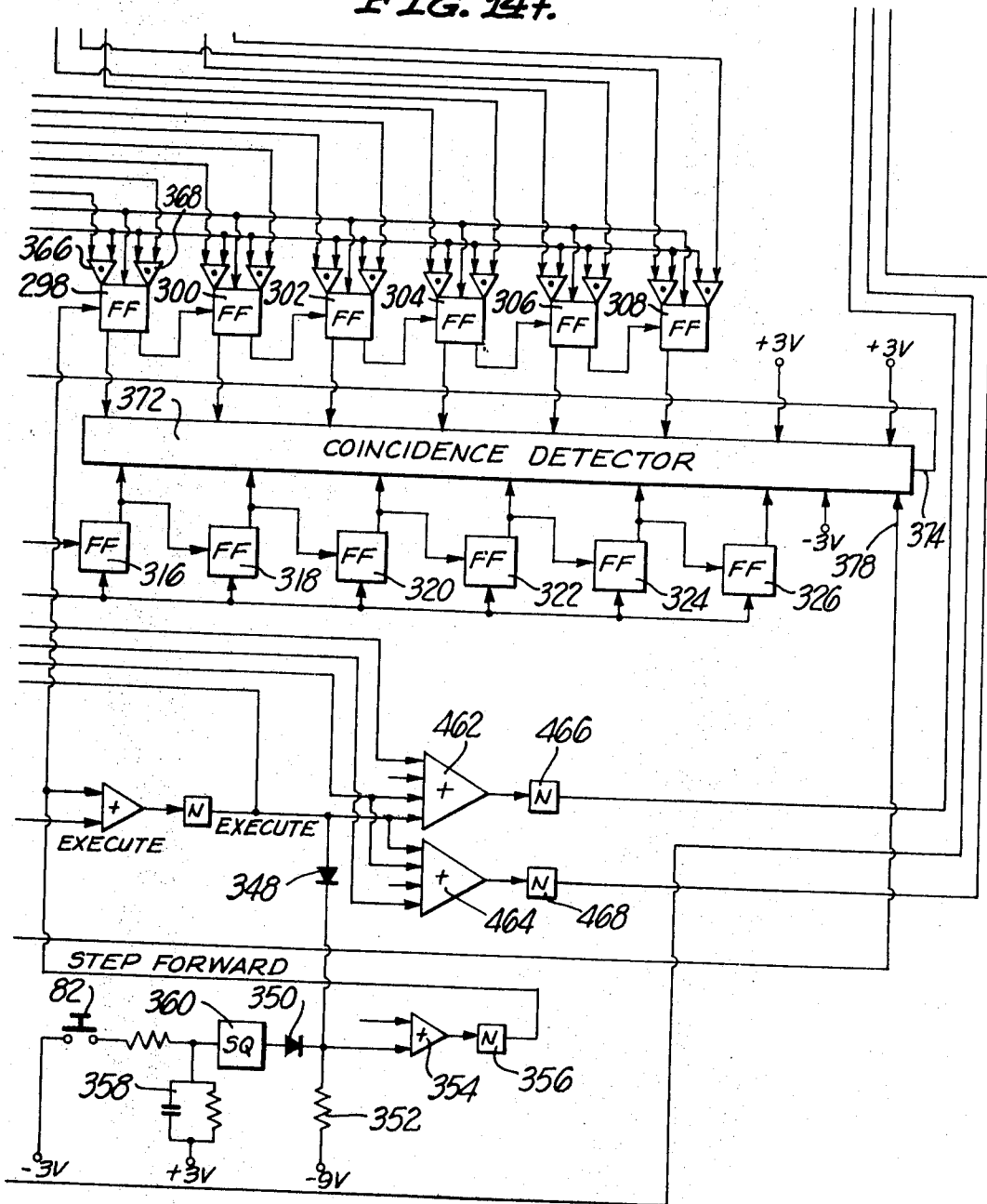
INVENTORS  
NORMAN M. HINERFELD,  
DAVID S. NOBLE &  
WILLIAM H. BARTLEY  
BY  
MAHONEY, HORNBAKER  
& SCHICK  
ATTORNEYS

FIG. 14e.



INVENTORS  
 NORMAN M. HINERFELD,  
 DAVID S. NOBLE &  
 WILLIAM H. BARTLEY  
 BY  
 MAHONEY, HORNBAKER  
 & SCHICK  
 ATTORNEYS

FIG. 14f.



INVENTORS  
NORMAN M. HINERFELD,  
DAVID S. NOBLE &  
WILLIAM H. BARTLEY  
BY  
MAHONEY, HORNBAKER  
& SCHICK  
ATTORNEYS

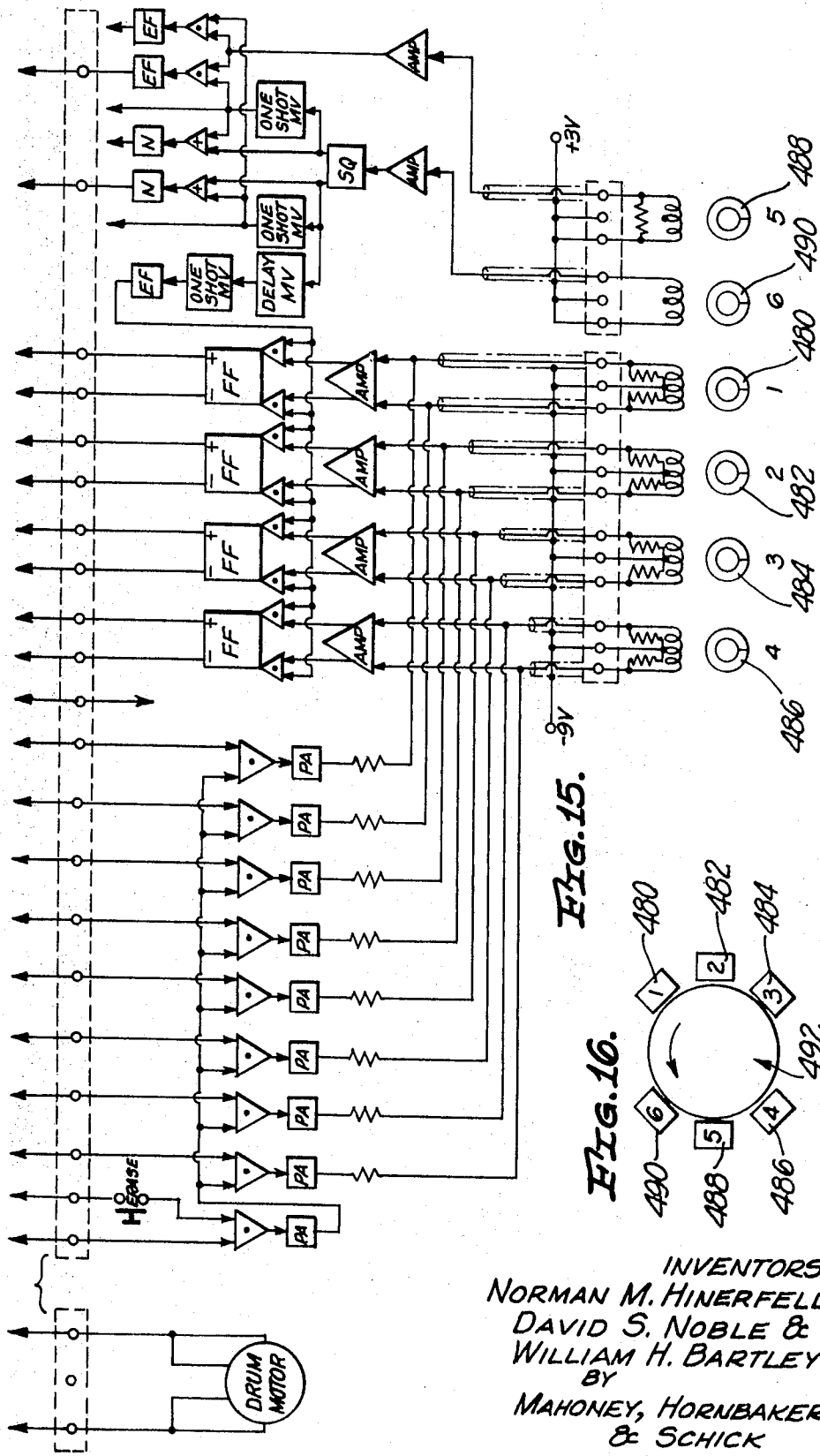
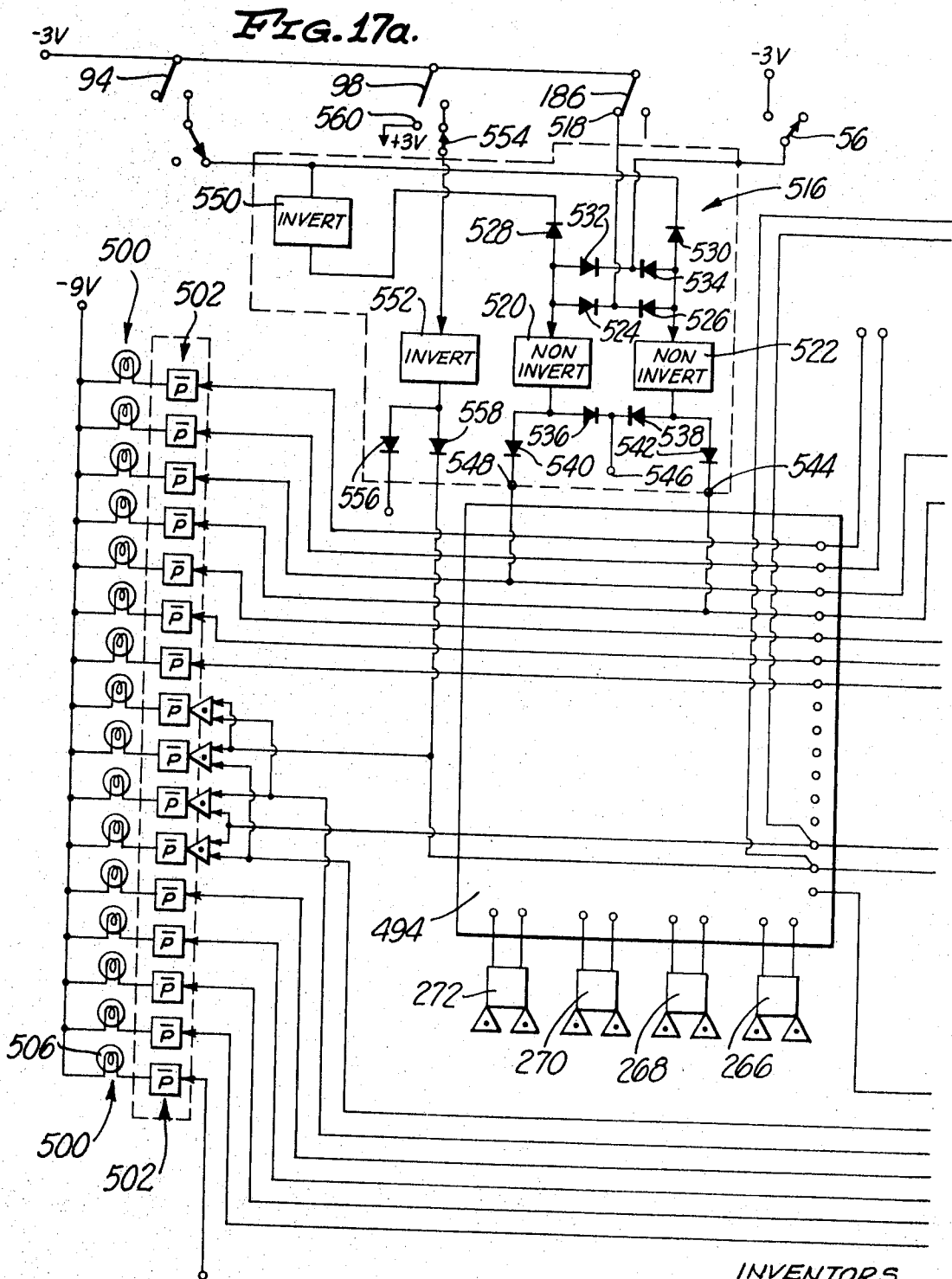


FIG. 15.

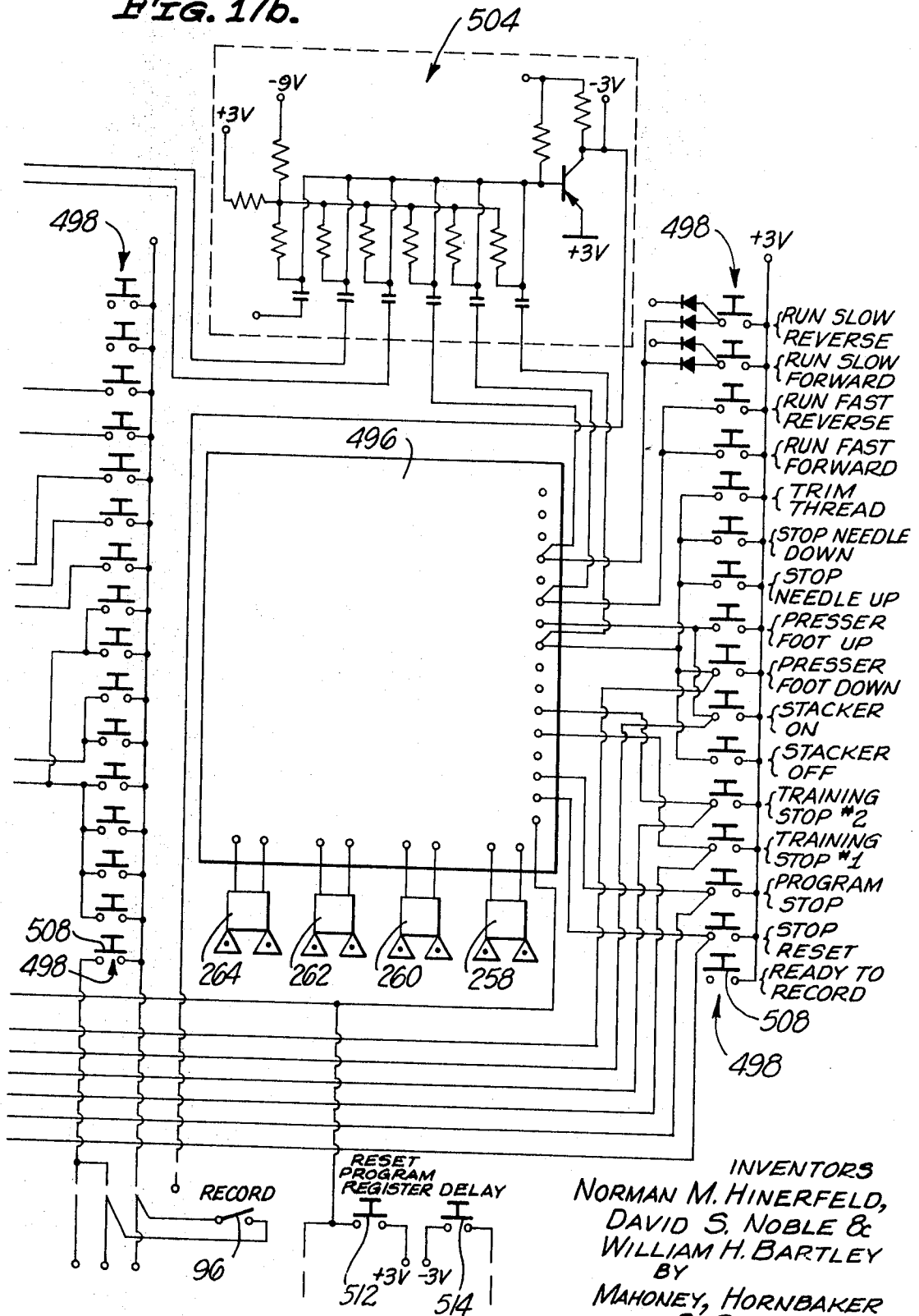
FIG. 16.

INVENTORS  
 NORMAN M. HINERFELD,  
 DAVID S. NOBLE &  
 WILLIAM H. BARTLEY  
 BY  
 MAHONEY, HORNBAKER  
 & SCHICK  
 ATTORNEYS



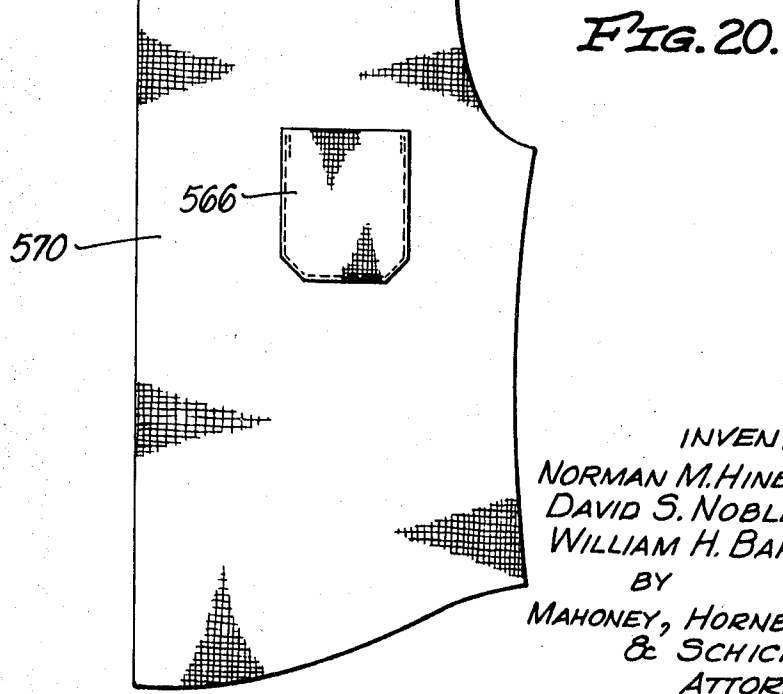
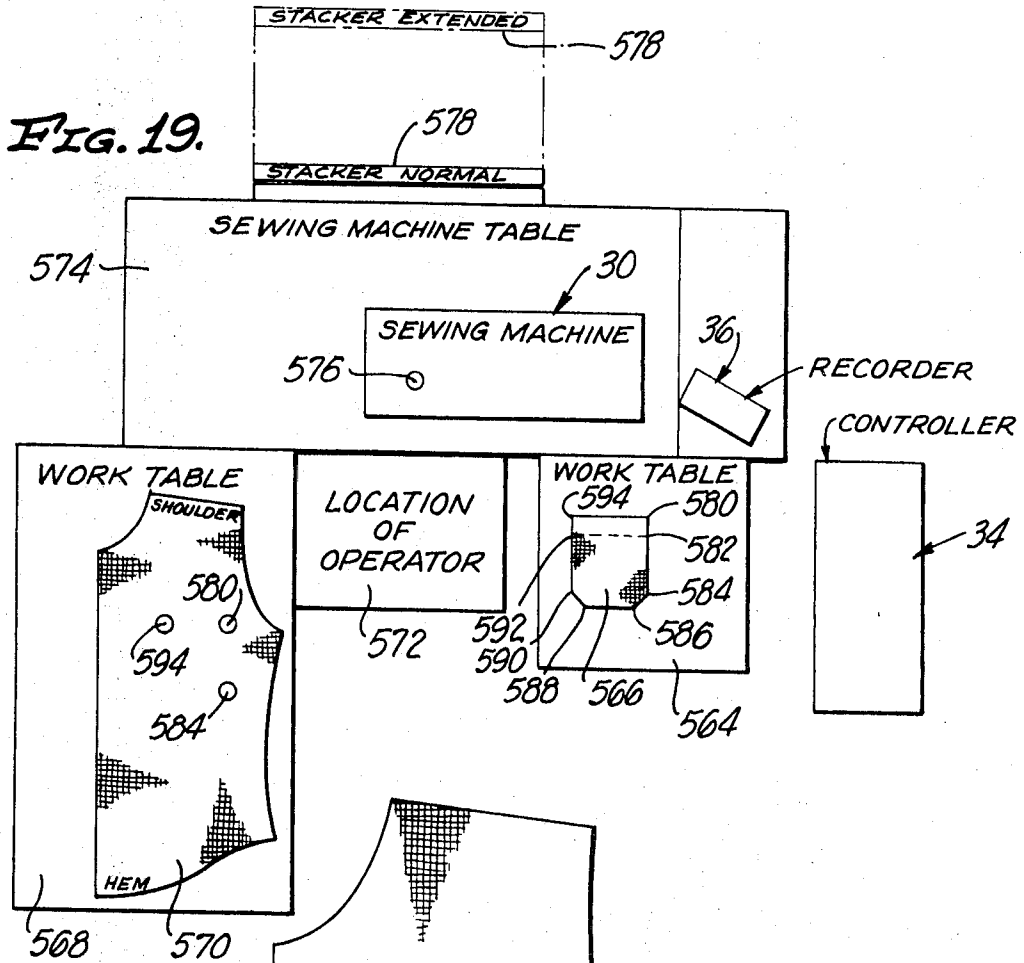
INVENTORS  
NORMAN M. HINERFELD,  
DAVID S. NOBLE &  
WILLIAM H. BARTLEY  
BY MAHONEY, HORNBAKER  
& SCHICK  
ATTORNEYS

Fig. 17b.



INVENTORS  
NORMAN M. HINERFELD,  
DAVID S. NOBLE &  
WILLIAM H. BARTLEY  
BY  
MAHONEY, HORNBAKER  
& SCHICK  
ATTORNEYS





INVENTORS  
NORMAN M. HINERFELD,  
DAVID S. NOBLE &  
WILLIAM H. BARTLEY  
BY  
MAHONEY, HORNBAKER  
& SCHICK  
ATTORNEYS

## METHODS OF AUTOMATICALLY CONTROLLING MANUFACTURING OPERATIONS SUCH AS SEWING OPERATIONS AND THE LIKE

### BACKGROUND OF THE INVENTION

This invention related to methods for automatically controlling manufacturing operations such as sewing operations and the like which has the effect of automatically controlling at least the major portion of a series of sequential manufacturing component operational steps having mixed therein certain manual steps required to be performed manually by an operator in carrying out an overall manufacturing operation on an article to be manufactured, so that not only are the manufacturing component operational steps automatically controlled, but also, the manual steps required to be performed by the operator, thereby increasing the efficiency of the overall manufacturing operation. Furthermore, the novel methods involve the use of manufacturing equipment arranged so that instruction signals for carrying out repeated identical overall manufacturing operations may be recorded in an automatic controller permitting the automatic controller to subsequently automatically control and manufacturing components for carrying out the overall manufacturing operation merely by first carrying out the overall manufacturing operation under the manual control of an operator, various means being provided for inserting the instruction signals in the automatic controller creating time delays in the overall manufacturing operation for the manual step performances by the operator. As a result, the minimum of time is required for the programming of the automatic controller in order to permit the same to automatically control an entire overall manufacturing operation, giving maximum versatility and convenience in use so as to be adaptable to a wide variety of mass production manufacturing operations.

There are many manufacturing operations making use of various forms of automatic production machinery wherein a human operator is required to manually control automatic machinery in performing certain steps of the overall manufacturing operation, while at the same time between certain of the individual automatic machinery steps such operator is required to manually perform certain manual functions or steps with or on the article being manufactured, such as realigning or repositioning the article being manufactured relative to the automatic machinery in order to carry out a subsequent automatic machinery operational step. Still further, in many such cases it is necessary to position the automatic machinery relative to the article being manufactured in one determined position at termination of an automatic machinery operational step in order that the required manual operation may be properly carried out by the operator, while in other instances the manufacturing operational step must be terminated with the manufacturing machinery in another position preparatory to the subsequent manual operation. To even further complicate the situation, one manufacturing equipment operational step might require a given number of machinery movements, the next manufacturing machinery operational step a different number of movements, and still the next manufacturing equipment operational step still a different number of equipment movements, in each manufacturing machinery operational step the equipment being required to be manually controlled by the operator.

Even further, the times required for the manual operation by the human operator between the manufacturing equipment operational steps may be of varying length, one manual step requiring a different length of time from a preceding or a subsequent manual step as determined by the manufacturing equipment operational step preceding such operator manual step and the manufacturing equipment operational step succeeding such operator manual step. There are also many instances in the use of automatic production equipment or machinery comprised of a series of components wherein one automatic machinery operational step may require the use of one component and is immediately followed by the use of

another component, the first component being required to terminate its particular operational step in a determined position in order that the latter component can properly operate and without damaging the first component. Thus, it may be seen that the types of overall manufacturing operations discussed are not readily adaptable to overall automatic control, but rather would appear to require a great amount of individual human operator control which could only be accomplished by a skilled operator after a long period of intensive training.

One industry in which the overall manufacturing operations include all of the difficulties hereinbefore discussed from the standpoint of attempting to make overall manufacturing operations capable of automatic control is the garment industry wherein the articles to be manufactured are garments basically requiring a series of sewing or stitching operations, as well as various other operations. For instance, in considering the wide variety of sewing operations required in the assembling and manufacture of even very simple forms of garments, it is seen that a wide variety and number of sewing steps can be involved, many requiring forward and reverse sewing and many requiring delays therebetween for manual operator repositioning of the garment for the next sewing step to be carried out. Furthermore, during manual operator repositioning of the garment between sewing steps, it is most convenient for the needle of the sewing head to be positioned projecting downwardly through the garment so that proper alignment is maintained relative to the sewing head needle between the sewing steps.

Also, where the garment being manufactured is of a stable material, that is, a material which is not readily stretchable or deformable, each of the sewing steps will more preferably consist of a determined number of needle reciprocal movements or stitches, absolutely requiring the complete attention of the human operator for proper accomplishment. At the same time, at the termination of particular sewing steps, not only is it necessary for the sewing head needle to be positioned down projecting downwardly through the material for a subsequent manual operator repositioning step, it is also absolutely necessary for the presser foot of the sewing head working in conjunction with the needle during stitching to retain the garment material downwardly against feed dogs progressively moving the material during stitching to be raised in order that the garment material will be free for such manual operator repositioning. When the sewing steps have been completed, that is, at the termination of the last sewing step, it is necessary that the sewing head needle will be positioned up in order that the thread cutoff device of the equipment will be able to operate in cutting off the thread being used in the sewing steps without striking the sewing head needle during such thread cutoff.

Certain prior constructions of sewing equipment have included various controls incorporated therein, all requiring manual operation by a human operator, for accomplishing the proper positioning of the sewing head needle in selected up and down positions by means of an automatic needle-positioning device. In use thereof, the human operator is required to terminate a particular sewing step and then selectively actuate the needle-positioning device to position the needle in the desired up or down position before the subsequent manual repositioning or thread cutoff step can be carried out. Also, as an adjunct to sewing equipment, various supplementary devices have been provided such as pickup devices for supplying garment parts to the operator's sewing station and stacker devices on which a garment may be positioned by the operator after completion of the sewing operations for automatic stacking by the stacker devices.

Although these sewing equipment improvements have added somewhat to the convenience of the human operators, each still requires individual control by that operator at an appropriate time. The operators, therefore, must make a wide variety of mental decisions during an overall garment-sewing operation, said decisions being immediately followed by manual actions at proper moments in order to carry out a coordinated overall sewing operation. Thus, it can be seen

that a relatively high degree of operator skill has been required, obtained only through long periods of training and even then such operations are relatively tedious and tiring even to such skilled operators.

To even more clearly illustrate the complications involved with attempts to fully, or even partially, automate sewing operations in the garment industry, consider the example of the great number of individual automatic and manual operations required for sewing a pocket patch or a shirt front. The finished pocket formed by the pocket patch in the example has an open top and the pocket patch will, therefore, require short lengths of multiple stitching at the top corners thereof for reinforcing in addition to the continuous line of stitching completely around the pocket patch periphery with the exception of the top edge thereof. Furthermore, the pocket patch will have straight sides, angled lower corners and a straight bottom. Finally, assume that a stack of shirt fronts is positioned at the left of the operator and a stack of pocket patches is positioned to the right of the operator, an automatic stacker being positioned directly rearwardly of the sewing machine table for final stacking of the completed pocket assembled shirt fronts.

The requirements of the machine operator would be to first pick up a shirt front from the left side and a pocket patch from the right side, placing the pocket patch at proper location on the shirt front and positioning the temporarily assembled garment at proper location beneath the sewing head needle on the sewing machine table, the needle being at the upper right-hand corner of the pocket patch ready for commencing the sewing or stitching operations. At this time, and in order to accomplish this positioning of the temporarily assembled pocket patch and shirt front beneath the sewing head needle, the needle would have to be in the up position and the presser foot likewise up. The operator is now ready to commence sewing and keep in mind that all component operations must be manually actuated by the operator.

In sequence, the presser foot is lowered, the sewing head actuated to sew four stitches forward and stop, the sewing head is actuated to sew four stitches rearwardly and stop. The sewing head is actuated to sew 36 stitches forwardly to the first corner of the lower right-angle pocket corner and stop, such stop preferably requiring the needle to be positioned down extending downwardly through both the pocket patch and shirt front. The presser foot is raised and the assembled pocket patch and shirt front repositioned to align for sewing along the right-angle pocket corner.

The presser foot is lowered and the sewing head is actuated to sew seven stitches along the angled pocket corner and stop with the needle positioned down. The presser foot is raised and the assembled pocket patch and shirt front manually repositioned aligned for sewing along the straight pocket bottom. The presser foot is lowered and the sewing head is actuated to sew 27 stitches along the pocket straight bottom to the first corner of the left angle pocket corner and stop, with the needle positioned down.

The presser foot is raised and the assembled pocket patch and shirt front manually repositioned properly aligned for sewing along the left angled pocket corner. The presser foot is lowered and the sewing head is actuated to sew seven stitches along the left angled pocket corner and stop with the needle positioned down. The presser foot is raised and the assembled pocket patch and shirt front is manually repositioned to align for sewing along the pocket left-hand straight side.

The presser foot is lowered and the sewing head is actuated to sew 36 stitches along the left-hand pocket straight side to the pocket upper left corner and stop. The sewing head is actuated in reverse to sew four stitches rearwardly and stop, then four stitches again forwardly and stop with the needle up followed by actuation of the thread cutoff and presser foot positioned up completing the sewing or operations or steps. Finally, the completely sewn pocket patch and shirt front are removed from the sewing head and positioned over the stacker with the stacker being actuated to properly stack the

same rearwardly of the sewing machine table and permitting the operator to repeat the sequential steps for preparing for and sewing a next pocket patch and shirt front.

Thus, although the sewing of a pocket patch on a shirt front might appear at first consideration as a relatively simple sewing operation, it can readily be appreciated that such a sewing operation requires a great number of closely controlled sewing operations, interspersed with both component positioning operations and operations required to be manually performed by the operator. Furthermore, the operator is required to actuate in various manners the various automatic components, in each case, requiring a mental decision and than a manual movement of proper selected form. Furthermore, the training time for necessary skills in order to accomplish the sewing operations or steps in the proper sequence, as well as the other interspersed steps required, is obviously quite extensive, and even when properly trained, such work is quite tedious and tiring for an operator.

Thus, although small parts of overall sewing operations in the garment industry have been at least partially automatically controlled, no one prior to our present invention has been successful in providing automatic control of virtually an entire overall sewing operation or the methods for carrying out such control. Obviously the wide variety and numbers of problems to be overcome if overall automatic control is to be provided are extremely complex and this particularly true when it is considered that it is clearly impossible to eliminate the human operator from the overall sewing operations. In addition, no one prior to our present invention has been able to reduce training time and to reduce required skills of the ever-present human operator from the sewing operations, all necessary if optimum improvements are to be provided in the garment industry.

#### OBJECTS AND SUMMARY OF THE INVENTION

It is, therefore, an object of our invention to provide methods of automatically controlling manufacturing operations such as sewing operations and the like, such methods involving equipment of the type normally requiring manual actuation of various components by a human operator in a determined sequence and interspersed with required purely manual operations or steps by said operator in order to carry out an overall manufacturing operation, wherein substantially the entire overall manufacturing operations are automatically controlled including determined time delays between certain manufacturing component operational steps during which the operator must perform manual steps in order to properly complete the overall manufacturing operation. As a result, the requirement for the human operator to manually actuate the automatic manufacturing equipment and the sundry decisions by the operator normally involved therewith are completely eliminated, the main steps remaining for the operator once the overall manufacturing operation has been commenced being to manually perform certain more minor operations required between various of the automatic component operations. In this manner, the prior tediousness and skill required for such overall manufacturing operations is greatly reduced, thereby likewise reducing operator-training time necessary for training an operator to be able to carry out the overall manufacturing operations.

As an example, in the garment industry and the various overall sewing operations thereof, each of the individual sewing steps, including positioning and repeated repositioning of various components, is completely automatically controlled. Where manual repositioning of articles to be sewn is required between any of the sewing steps, a time delay period is supplied during which the operator may accomplish such repositioning and after which, the automatic components immediately resume automatic operation under the automatic control.

It is a further object of our invention to provide methods of automatically controlling manufacturing operations such as

sewing operations and the like of the foregoing general character wherein the manufacturing equipment involved including control devices therefor may be set up or programmed for carrying out the determined overall manufacturing operations merely by an operator manually actuating the manufacturing equipment in the usual manner, the various individual of the manufacturing steps being recorded in the automatic controller, after which, the automatic controller is capable of automatically controlling the various components to repeat the overall manufacturing operation, even as to controlling the time on time delays between component automatic operations to provide the operator with sufficient time for manually performing necessary manual operations or steps. In addition, the methods involve the control devices arranged with the manufacturing equipment with certain of the same being capable of actuation for directly inserting into the automatic controller program various predetermined instructions of exact form as would be received from the actual operations of the components during a particular manufacturing step. The various components may, therefore, be manually actuated to carry out certain manufacturing operational steps in one manner, yet the automatic controller may be programmed to repeat such component operational steps in a different manner, all as determined by the particular operator controlling the devices and equipment.

Again as applied to sewing equipment for carrying out an overall sewing operation, the overall sewing operation is carried out by the operator manually actuating the various components in proper sequence, for instance, sequential sewing operations or steps. If, directly after the performance of a particular component operational step, say, of actually sewing 75 stitches in an article to be sewn, it is determined that that particular sewing operation should actually include only 55 stitches, instructions for the automatic controller to carry out the stitching step of only 55 stitches may be inserted into the automatic controller program while the instructions for the 75 stitches is not recorded so that upon repeating the overall sewing operation, the automatic controller will carry out that particular sewing step of only the 55 stitches. Also, the time delays between component operations for operator manually repositioning of the article being sewn can be inserted as instructions into the automatic controller merely by permitting that length of time delay between component manual actuations, or, in the alternative, the actual time delay between component operations taken by the operator may be eliminated from the automatic controller recording and a predetermined time delay inserted into the automatic controller recording or program as a substitute for the actual delay time taken by the operator. Obviously, therefore, although the basic concept of the methods involving such control devices is that of being able therewith to completely program the control devices for automatically carrying out an overall sewing operation merely by once performing the same under component manual actuation, even increased wide versatility of the control devices permits during such programming, the alteration of various steps to give the exact final programming desired.

It is still a further object of our invention to provide methods of automatically controlling manufacturing operations such as sewing operations and the like as hereinbefore discussed wherein indeterminate time delays may be inserted as instructions into the automatic controller programming either between manufacturing equipment component operational steps or intermediate such component operational steps depending on the desired purpose. For instance, if a manual operation between two component operational steps will vary in time length from one repeated overall manufacturing operation to the next, an indeterminate time delay instruction may be inserted into the automatic controller program having the effect of stopping a preceding component operation at the end of its operational step, but requiring some manual actuation by the operator before the subsequent programmed operational step will commence so as to leave the length of the

time delay completely controlled by the operator so that the same can be varied in total length as it is necessary. At the same time, the control devices involved are arranged so that these indeterminate time delays, functional in the same manner, may be inserted at any point in the automatic controller program, even intermediate a particular manufacturing equipment step, the indeterminate time delays in this case being capable of elimination from the automatic controller program without otherwise altering such program at any time during subsequent automatic control of the manufacturing equipment, thereby constituting training time delays which are permitted to remain in the program during the operator training and can be removed from such program after the operator has become sufficiently trained.

It is an additional object of our invention to provide methods of automatically controlling manufacturing operations such as sewing operations and the like of the foregoing general character wherein each of the manufacturing equipment component operational steps is translated by the control devices into a composite instruction for recording in the automatic controller to program the same, such composite instructions thereafter being sequentially translated back into component operations to carry out the various component operational steps during automatic actuation of the manufacturing equipment by the automatic controller. Each composite instruction as received and recorded by the automatic controller is formed from the combination of function and duration, the function being the particular manufacturing equipment component to be automatically actuated and the duration being either a pure time duration measured in particular time units or a given number of component movements as sensed and counted by the automatic controller with the aid of other parts of the control devices. The determined time delays are measured by the automatic controller merely in time units, since no function is involved.

As applied to sewing equipment for performing a particular overall sewing operation on an article to be sewn, examples of the composite instructions of the different duration types might be a series of sequential sewing operations to carry out a series of sequential sewing steps and a final thread cutoff operation. For the sewing steps, such steps are measured in the number of reciprocal movements of the needle performing the sewing steps, such reciprocal movements being sensed and translated to the automatic controller such that an exact count of needle reciprocations is determined and carried out. The thread cutoff operation is programmed for duration merely in time units, there being a sufficient number of time units to make up an overall total time within which the thread cutoff device can effectively perform the thread cutoff operation.

It is also an object of our invention to provide methods of automatically controlling manufacturing operations such as sewing operations and the like involving the above-discussed programmed automatic controller and the composite instructions therefor in order to automatically control the sequential manufacturing operations wherein all of the programmed instructions having the duration thereof measured in manufacturing equipment component movements may be simultaneously altered to alter the time involved in carrying out the same, and all of the programmed instructions having the duration thereof measure in time units may be simultaneously varied in order to vary the total time permitted for a manufacturing equipment component operation or the total length of a determined time delay. As applied to sewing equipment, a variable-speed control is provided for the drive motor driving the reciprocal needle in the sequential sewing operations so that by varying the speed of the drive motor, the total time for accomplishing a given number of needle reciprocations is varied, the program in the automatic controller being that solely of needle reciprocation count so as to be unaffected other than the overall duration of a particular sewing step due to the faster or slower needle reciprocations as counted by the automatic controller. At the same time, the automatic controller is provided with a selected adjustment for the time ele-

ments which make up the total time period permitted by the automatic controller for the determined time delays so that variable adjustment of the time units will proportionately adjust the total length of the time delays without otherwise affecting the programming thereof in the automatic controller. The time unit adjustment is limited in the respect that sufficient time must always be supplied for the complete operation of manufacturing components, such as the thread cutoff, to complete full operation thereof during their particular operational step.

It is still another object of our invention to provide methods of automatically controlling manufacturing operations such as sewing operations and the like wherein certain of the manufacturing equipment components may be controlled by the automatic controller to terminate particular component operational steps by stopping in selected positions of that particular component in order that a directly following step may be properly carried out. In the sewing equipment application, a needle counter and positioner is provided operably connected to the automatic controller for not only permitting the automatic controller to count the number of needle reciprocations as hereinbefore discussed, but also to permit the automatic controller to terminate a particular sewing operational step with the reciprocal needle in either a needle down position extending downwardly through the article being sewn or a needle up position spaced above the article being sewn. Thus, the automatic controller may position the needle down between various of the sewing operational steps during the determined time delays separating such steps for manual repositioning of the article being sewn without the article becoming completely misaligned from the needle. Furthermore, at the termination of a last sewing operational step and prior to the actuation of the thread cutoff, the automatic controller may position the needle up so that the immediately following thread cutoff operation may be accomplished without needle interference and damage thereto.

Other objects and advantages of the invention will be apparent from the following specification and the accompanying drawings which are for the purpose of illustration only.

#### DESCRIPTION OF THE DRAWINGS

FIG. 1 is a somewhat schematic front elevational view of the overall sewing equipment assembly incorporating the unique control devices making up a preferred embodiment of said equipment which may be used for carrying out the method principles of the present invention;

FIG. 2 is an enlarged, fragmentary, front elevational view of an electric solenoid assembly providing power control for certain of the manufacturing components of the sewing equipment assembly of FIG. 1;

FIG. 3 is an enlarged front elevational view of a knee switch assembly removed from the sewing equipment assembly of FIG. 1;

FIG. 4 is an enlarged, side elevational view of a foot switch assembly removed from the sewing equipment assembly of FIG. 1;

FIG. 5 is an enlarged, front elevational view of the automatic controller of the sewing equipment assembly of FIG. 1;

FIG. 6 is a rear elevational view of the automatic controller of FIG. 5;

FIG. 7 is an enlarged, fragmentary, bottom perspective view, part in phantom lines, illustrating certain of the power control units for the sewing head unit of FIG. 1;

FIG. 8 is an enlarged, front elevational view of the power interface or positioner taken from the sewing equipment assembly of FIG. 1;

FIG. 9 is a rear elevational view of the power interface or positioner of FIG. 8;

FIG. 10 is an enlarged, front elevational view of the automatic recorder taken from the sewing equipment assembly of FIG. 1;

FIG. 11 is an enlarged, side perspective view of the needle counter and positioner removed from the sewing equipment assembly of FIG. 1;

FIG. 12 is an enlarged, vertical sectional view looking in the direction of the arrows 12—12 in FIG. 11;

FIGS. 13a and 13b are left-hand and right-hand portions, respectively of a wiring diagram of the power interface of FIGS. 8 and 9;

FIGS. 14a, 14b, 14c, 14d, 14e and 14f are upper left-hand, upper center, upper right-hand, lower left-hand, lower center, and lower right-hand portions of a wiring diagram of the automatic controller of FIGS. 5 and 6;

FIG. 15 is a wiring diagram of the controller recording drum and drive means therefor forming a part of the automatic controller of FIGS. 5 and 6;

FIG. 16 is a schematic view of the controller drum of FIG. 15;

FIGS. 17a and 17b are the left-hand and right-hand portions, respectively, of a wiring diagram of the automatic recorder of FIG. 10;

FIG. 18 is a wiring diagram of matrixes forming a part of the automatic recorder of FIG. 10;

FIG. 19 is a schematic layout of the sewing equipment assembly of FIG. 1 including worktables with parts of articles to be sewn positioned thereon ready for use in a sewing operation; and

FIG. 20 is an enlarged, top plan view of a finished sewn article, the sewing operations thereon being carried out in the layout arrangement of FIG. 19.

#### DESCRIPTION OF THE BEST EMBODIMENT CONTEMPLATED

Referring to the drawings, an embodiment of the control devices for automatically controlling manufacturing equipment according to the methods of the present invention is illustrated and described in the following adapted to sewing equipment of the type normally used, for instance, in the apparel industry for assembling by sewing various articles of apparel. A somewhat schematic view of the sewing equipment is shown in FIG. 1, the more important parts of which are a sewing unit generally indicated at 30, a power interface or positioner generally indicated at 32, an automatic controller generally indicated at 34, an automatic recorder generally indicated at 36, a foot switch unit generally indicated at 38, a knee switch unit generally indicated at 40, a needle counter and positioner generally indicated at 42, a solenoid air valve unit generally indicated at 44 and a main power supply switchbox generally indicated at 46. The plan of description to follow will be to first very briefly and generally describe the various parts of the sewing equipment, then describe more in detail various of these parts including electrical and electronic wiring circuits and the interconnection thereof, and finally a step-by-step procedural use of the sewing equipment both in the manual mode and automatic mode for carrying out the methods of the present invention.

Basically, the purpose of the control devices of the present invention are to modify and supplement somewhat standard sewing equipment for accomplishing three basic method operational objectives, namely, permit normal human manual control of the sewing equipment including various peripheral equipment for performing overall sewing operations on apparel to be manufactured, permit the automatic programming of an automatic controller, for the main part, directly by and during such operator manual control, and after such programming, permit the overall sewing operations to be directed and carried out by the automatic controller with only very modified and relatively simplified aid of the human operator. As a result, although a relatively highly skilled and trained operator is required for the manual operation and the programming of the automatic controller, once the equipment has been programmed for the automatic control, operators of far lesser skills and training may be utilized while still main-

taining and even improving the quality of sewing operations normally obtained through usual manual operator control. Furthermore, under automatic control of the equipment, the human operator is relieved of all but a few of the usually required manual functions so that the operator is under less decisionmaking stress and can function with greatly improved efficiency and less tiring throughout a working day.

#### GENERAL

The sewing unit 30 of FIG. 1 is a single needle sewing unit having a standard sewing head 48 with an up and down reciprocal needle 50, the needle being reciprocally driven at high speed by a high-speed drive motor 52 and being reciprocally driven at slow speed by a slow-speed drive motor 54. The high-speed drive motor 52 is of usual form, constantly rotating, single-direction drive, and clutch actuated for driving connection to the needle 50. The slow-speed drive motor 54 is also of usual construction, single-direction drive and only actuated when slow-speed drive is desired, this slow-speed drive motor having a usual braking circuit therein for selectively stopping the needle 50 in each of an up position spaced above an article being sewn and a down position extending downwardly through the article being sewn.

The sewing head 48 includes also a usual presser foot, not shown, for normally holding the article being sewn downwardly against usual feed dogs, not shown, during the reciprocal sewing movements of the needle 50. The presser foot is selectively vertically movable from normal down position holding the article being sewn against the feed dogs and a raised position spaced upwardly and releasing the article being sewn, the down position of the presser foot being a normal spring-urged position and the raised position being a power-actuated position as will be hereinafter described. The movement of the feed dog or dogs is coordinated with the reciprocal movements of the needle 50 and the feed dogs move from front to rear in sewing forward and from rear to front when sewing rearwardly or backstitching, all again in the usual manner.

As stated, the high-speed and slow-speed drive motors 52 and 54 are both single direction, operably connected for moving both the reciprocal needle and feed dogs in the coordinated movements, the distance of each movement of the feed dogs determining the length of stitch sewn by the needle. The needle 50 and feed dogs are normally driven by the drive motors 52 and 54 in the sew-forward direction, but appropriate mechanism is contained in the sewing unit 30 selectively actionable for converting the drive to sew-reverse movement of the needle and feed dogs. Any of the usual attachments may be provided on the sewing head 48, all operable in usual manner, such as top shirring, pleating and many other attachments.

The sewing unit 30 also includes a usual thread trimmer or cutoff actionable for cutting off both the sewing unit lower thread and the thread of the needle 50 at the termination of sewing operations as desired. The thread cutoff operates from beneath and the actuation for movement thereof in the thread-cutting operation must be coordinated with the position of the needle 50 so that the needle is in the up position and will not be damaged by the thread cutoff. Furthermore, the thread cutoff in the present sewing unit 30 is arranged pneumatically actuated in a manner to be hereinafter described.

The power interface 32, one of the more important electrical and electronic units of the present construction, is a multipurpose unit serving to generally provide a power drive, with the aid of the solenoid air valve unit 44, for all portions of the sewing unit 30 which require actuation in order to carry out a sewing operation. At the same time, the power interface 32 operably connects all of the automatic controller 34, the foot switch unit 38, the knee switch unit 40 and the needle counter and positioner 42 to the sewing unit for both manually controlled and automatically controlled operation thereof. The

power interface 32 is shown in FIG. 1 and in more detailed outside front view in FIG. 8 and rear view in FIG. 9.

Generally, the power interface 32 with selector switch 56 thereof in "manual" placing the power interface in manual mode, operably connects the foot and knee switch units 38 and 40 to the sewing unit 30 for manual control of the sewing unit by an operator through proper actuation of such switch units. Also in manual mode, the power interface 32 serves to translate the various actuations and movements of the components of the sewing unit 30 into low-level electronic signals for recording by the automatic controller 34 when the automatic controller is in a record mode to be hereinafter described. Still further, with the selector switch 56 of the power interface 32 moved to "automatic" placing the power interface in the automatic mode, the power interface serves to translate low-level electronic signals received back from the automatic controller 34 when said controller is in an "automatic" or "operate" mode into commands or directions causing operation of the components of the sewing unit 30 in a determined manner as recorded in the automatic controller.

The low-level electronic signals transmitted to and from the automatic controller 34 by the power interface 32 form for the component operations of the sewing unit 30, as well as sewing unit peripheral equipment, composite instructions recorded by the automatic controller when the sewing unit components are manually actuated and played back by the automatic controller as commands during automatic operation of the automatic controller. These composite instructions for actuation of the components of the sewing unit 30 are made up of function and duration, the function being the particular sewing unit component to be operated or actuated, and the duration being one of pure time measured in time units or the number of movements of a particular sewing unit component, both types being capable of recording by the automatic controller. In the particular embodiment herein involved, the composite instructions for actuation of the presser foot to raise the same and permit it to lower and operation of the thread trimmer for a single operation thereof are measured in time units sufficient to permit such actuation or operation, whereas the composite instructions for the driving of the sewing head needle 50 by the high- and slow-speed drive motors 52 and 54 are measured in needle reciprocations. Instructions for mere time delays are, of course, merely measured in time units.

The power interface 32 also includes a foot control switch 58 providing a choice between requiring sustained actuation of the foot switch unit 38 or merely momentary actuation of the foot switch unit during control of the sewing unit 30 by the automatic controller 34. When the automatic controller 34 is properly programmed and is automatically carrying out an overall sewing operation through its electronic signals to the power interface 32, if the foot control switch 58 is "on," constant pressure is required on the foot switch unit 38 for continued automatic operation of the sewing unit by the automatic controller, but with the foot control switch "off," the only time depression of the foot switch unit is required is at programmed indeterminate delays whereupon momentary foot switch unit depression will resume the automatic program and control.

Where variable-speed control of the components of the sewing unit 30 driven by the high-speed drive motor 52 is desired, which in this case would be the reciprocal movement speed of the sewing head needle 50, the high-speed drive motor 52 is provided as a variable-speed drive motor and the speed thereof is controlled by a selectively adjustable speed control switch 60 on the power interface 32. Increasing the speed of the drive motor 52 will increase the reciprocal speed of the sewing head needle 50 and decreasing the speed of the drive motor will have the opposite effect. In view of the fact that the programmed instructions for the movement of the sewing head needle 50 are predicated on the duration measured by the needle movements, such speed adjustment can be made after programming of the automatic controller 34 without otherwise affecting the program thereof.

The automatic controller 34 shown in FIG. 1 and in more detailed front view in FIG. 5 and rear view in FIG. 6 is a versatile stored program controller which has a storage or memory unit within it in which the series of operations of the sewing unit 30, and preferably certain peripheral equipment, are stored in proper sequence and each instruction or step may then be played back as electrical signal commands to the power interface 32 requiring the components of the sewing unit and the peripheral equipment to carry out the overall sewing operation. At this time, only certain broad features thereof are discussed with a more complete detailed discussion of the electrical and electronic arrangement thereof to follow at a later time. As previously stated, it is possible to program the automatic controller 34 for automatically carrying out an overall sewing operation of the sewing unit nearly completely by manually actuating the various components of the sewing unit through the foot and knee switch units 38 and 40, while at the same time the automatic controller is arranged for inserting many composite and pure time instructions corresponding directly to component operational steps and time delays through selective manual actuation of special controls directly on or operably connected to the automatic controller. Referring to FIGS. 5 and 6, the automatic controller 34 includes a selector switch 62 for setting the automatic controller to record a program for an overall sewing operation or play back such program for automatically controlling the sewing unit 30 to carry out an overall sewing operation. In the "record" position of the automatic controller selector switch 62 with the power interface selector switch 56 in "manual," the automatic controller is set for accepting program instructions. When the automatic controller selector switch 62 is in "operate" position and the power interface selector switch 56 is in "automatic" position, the automatic controller will play back the program thereof to automatically control the sewing unit 30 during an overall sewing operation.

Command lights 64, output lights 66, stitch and delay lights 68, command buttons 70, output buttons 72 and stitch and delay buttons 74 are contained on the automatic controller 34, the appropriate lights being located directly above the appropriate buttons. When a particular program instruction is entered into the automatic controller 34, the appropriate command lights 64 are lit up showing the unique bit pattern contained in that particular program instruction for the command structure of the automatic controller. At the same time, there are a number of program instructions that may, and certain of them must, be entered directly into the automatic controller 34, and this entry is made by use of the command buttons 70, output buttons 72 and stitch and delay buttons 74, all of which will be hereinafter explained in detail.

A program step counter 76 is located on the automatic controller 34 and provides a visual display of the program step numbers. The visual display of the program step counter 76 advances one count at the completion of each step of the program for the overall sewing operation by the sewing unit 30. Furthermore, this program step counter 76 counts in the "octal" numbering system, all of which will likewise be hereinafter explained.

The automatic controller 34 includes a reset program register button 78 which is used to erase instructions placed in the automatic controller as required when an incorrect instruction has been entered into the program thereof. A reset program counter button 80 is provided for resetting the program step counter 76 to "00" when such button is depressed, the reset program counter button being used each time a new program is to be entered into the automatic controller 34. An advance counter button 82 may be used to advance the program step counter 76 by one step or count, such action being required for correcting a program instruction, that is to say, the program instructions may be modified or changed by advancing the program counter which in turn advances the program step counter 76 until the program step number that contains the incorrect instruction has been reached.

As previously discussed, the automatic controller 34 records and counts pure time intervals, whether a time interval of a composite instruction for the complete operation of a component of the sewing unit 30 or merely a time delay between component operations, in time units, and the length of such time units may be set and later after programming shortened or lengthened within determined limits by a delay adjustment switch 84. The midpoint setting of the delay adjustment switch 84 is approximately one-sixtieth of a second for each time unit, the setting at "slow" providing approximately 40 percent more time for each time unit and the setting at "fast" reducing the time allowed for each time unit by approximately 40 percent, so as to provide an overall time adjustment or variation of approximately 20 percent. Thus, assume under automatic or programmed control by the automatic controller 34, an operator is permitted a time interval between component operations of the sewing unit 30 in order to carry out a manual operation such as repositioning material being sewn, the original time interval can be programmed at approximately a 80 percent greater length and after the operator becomes experienced, the interval length can be shortened approximately 80 percent by selective movement of the delay adjustment switch 84.

Where training stops or training delays are programmed in the program of the automatic controller 34 either intermediate operations of a particular component of the sewing unit 30 or directly between component operational steps to provide indeterminate delays wherein the component operations stop and will not start under the automatic control of the automatic controller until the operator manually restarts the same, such training stops or delays may be later eliminated from the program and will be bypassed by the automatic controller in an overall sewing operation. One or more training stops or delays may be controlled by each of a training stop No. 1 switch 86 and a training stop No. 2 switch 88 on the automatic controller 34. With the training stop switches 86 and 88 in one position, the various training stops or delays controlled by each may be inserted into the program of the automatic controller 34 in a manner to be hereinafter described, and later by moving training stop No. 1 switch to another position, all training stops or delays controlled thereby are eliminated from the program, the movement of the training stop No. 2 switch being similar. Thus, training stops or delays may be included in the original program of the automatic controller 34 for controlling automatically an overall sewing operation and after the operator becomes trained so as to no longer need such training stops, the same can be eliminated from the program, for instance, an original training delay after 6 or 8 inches of stitching in a complete stitching step of 12 inches can be eliminated later to provide the total 12-inch stitching step continuously.

The automatic recorder 36 is an auxiliary record unit operably connected to the automatic controller 34 to provide a method of inserting most or all of an entire instruction into the program of the automatic controller directly corresponding to a component operational step of the sewing unit 30 by means of pushbuttons, the automatic recorder being shown in FIG. 1 and in more detailed front view in FIG. 10. In effect, the automatic recorder 36 has certain electrical and electronic circuits permanently set therein capable of actuation by the pushbuttons thereof to transmit to the automatic controller 34 electronic signals corresponding directly to a part of or the total of an electronic signal which would be transmitted from the power interface 32 to the automatic controller during operation of components of the sewing unit 30, thereby permitting insertion of an instruction into the program without actually carrying the same out with the sewing unit components, or replacing the component instruction with a different desired instruction. The automatic recorder 36 will be described hereinafter more in detail.

The foot switch unit 38 is shown in FIG. 1 and in detailed side view in FIG. 4 and has a two-stage drive motor switch 90 actionable by toe pressure on treadle 92, a reverse switch 94

mounted directly on the treadle movable therewith and actuated by side toe movement, and an instruction record switch 96 actionable by heel pressure on the treadle. With the selector switch 56 of the power interface 32 in "manual," light toe pressure on the treadle 92 actuates the first stage of the drive switch 90 to actuate the sewing unit slow-speed drive motor 54, and heavy toe pressure on the treadle, actuates the second stage of the drive switch and actuates the high-speed drive motor 52, in both cases driving the sewing head reciprocal needle 50. With the power interface selector switch 56 in "manual" and with the automatic controller 34 "on" and the selector switch 62 thereof in "record," the same actuations result with light and heavy toe pressure on the treadle 92. With the power interface selector switch 56 in "automatic" and the automatic controller 34 "on" with the selector switch 62 thereof in "operate," light toe pressure on the treadle 92 actuates the first stage of the drive switch 90 to cause the program of the automatic controller to proceed from an indeterminate stop or delay, while heavy toe pressure on the treadle actuates the second stage of the drive switch causing an emergency stop of the automatic controller program and any of the components of the sewing unit 30 being then actuated thereby.

Side toe pressure on the treadle 92 of the foot switch unit 38 actuates the reverse mechanism of the sewing unit 30 causing the sewing head needle 50 and feed dogs to be driven in reverse. Thus, with side toe pressure and light down toe pressure, the slow-speed drive motor 54 is actuated to drive the sewing head needle 50 and feed dogs in reverse at slow speed with heavy toe pressure actuating the high-speed drive motor 52 for fast speed. This is true whether the power interface 32 is in "manual" without the automatic controller 34 or whether the power interface is in "manual" and the automatic controller is in "record," the reverse switch 94 not being used with the power interface in "automatic" and the automatic controller in "operate."

The instruction record switch 96 of the foot switch unit 38 is used only when the power interface 32 is in "manual" and the automatic controller 34 is "on" and in "record," that is, when the components of the sewing unit 30 are being actuated by an operator and instruction signals are being sent to the automatic controller for the recording of a program therein. As the instruction signals are received by the automatic controller 34 from the power interface 32 or as a result of the use of the automatic recorder 36 and the various described buttons on the automatic controller, such instruction signals for each operational step or delay are only temporarily recorded by the automatic controller 34 and will not be permanently recorded in the automatic controller program until the instruction record switch 96 of the foot switch unit 38 is actuated by heel pressure on the treadle 92. The programming procedure of the automatic controller 34, therefore, requires a command by the instruction record switch 96 for permanent recording or programming of the various program steps from the temporary recording thereof.

The knee switch unit 40 shown in FIG. 1 and in more detailed front view in FIG. 3, includes a right knee switch 98 actionable by right knee pressure and a left knee switch 100 actionable by left knee pressure. Actuating the right knee switch 98 with the power interface 32 in "manual" and the automatic controller "off" or "on" and in "record" causes a raising of the presser foot of the sewing head 48 releasing material being sewn by the sewing head needle 50, the presser foot being raised for the length of time of such actuation.

External control of the automatic controller 34 is provided by the right knee switch 98 when the power interface 32 is in "automatic" and the automatic controller is in "operate" thereby controlling the components of the sewing unit 30 according to a program permanently recorded therein. The effect of this external control is that upon actuation of the right knee switch 98, the automatic controller 34 is caused to advance to its next programmed step which may be a stop or delay or may be an actuation of some sewing unit component,

whatever might be in the program of the automatic controller. For instance, assume that material being sewn is of an unstable character so that it is impossible to determine the total number of stitches required in a particular sewing step, the automatic controller 34 might be programmed to drive the sewing head needle 50 through a set number of stitches and then proceed with such stitching with the termination thereof not being determined until terminated by the operator. This external control feature of the right knee switch 98 would be used for stopping or terminating such sewing step at the appropriate time by actuation thereof to advance the automatic controller 34 to its next programmed step which might be, for instance, a delay step with the sewing head presser foot up to permit repositioning of the material or might be a stop with the sewing head needle 50 in up and actuation of the thread trimmer or cutoff.

The left knee switch 100 of the knee switch 40 when actuated with the power interface 32 in "manual" and the automatic controller 34 "off," will cause the sewing head needle 50 to be positioned up and will actuate the thread trimmer or cutoff upon the treadle 92 of the foot switch unit 38 being released. The sewing head needle 50 can only be positioned properly from slow speed but release of the foot switch treadle 92 requires the treadle to pass through the slow-speed phase so as to accomplish such needle positioning and permit actuation of the thread trimmer. Actuation of the left knee switch 100 with the power interface 32 in "manual" and the automatic controller "on" and in "record" causes a pure time delay to be recorded by the automatic controller for the period of time the left knee switch is actuated, the instruction for the needle position up and actuation of the thread trimmer being required to be placed in the automatic controller program through preset instructions in the automatic recorder 36 as previously described. The left knee switch 100 is not used when the power interface 32 is in "automatic" and the automatic controller 34 is in "operate" automatically controlling the components of the sewing unit 30.

The needle counter and positioner 42 will be described later but has the purpose of detecting the position of the sewing head needle 50, whether the needle is up or down, measuring the speed of the needle drive for thread trimming and counting the number of needle movements or stitches for programming the automatic controller 34 and later counting stitches during automatically controlled needle drive by the automatic controller. In other words, the needle counter and positioner 42 serves to first count the needle movements during manual control for programming and then count the needle movements for automatic control from the programming, advancing the program of the automatic controller 34 to the next step upon determination of the programmed number of needle movements or stitches. Also, the needle counter and positioner 42 determines or senses the position of the sewing head needle 50 at slow speed and stops the slow-speed drive motor 54 with the needle positioned "up" or "down" as required.

The solenoid air valve unit 44 is shown in FIG. 1 and in enlarged front view in FIG. 2 with certain of the air cylinders controlled thereby being shown in FIG. 1 and FIG. 7. This solenoid air valve unit 44 includes a series of solenoid air valves actuated through the power interface 32 by the various switches as previously described for manual control and by the automatic controller 34 for programmed automatic control, said valves including a thread trimmer solenoid valve 102, a forward-reverse solenoid valve 104, a presser foot solenoid valve 106 and a motor clutch solenoid valve 108. The solenoid air valve unit 44 also mounts an on-off thread trimmer switch 110 which, when moved to "off," eliminates the thread trimmer from any possible actuation despite actuation of the appropriate controls therefor.

Actuation of the thread trimmer solenoid valve 102 directs air to the thread trimmer air cylinder 112 at the underside of the sewing unit 30 as shown in FIG. 7 to actuate the thread trimmer. Actuation of the forward-reverse solenoid valve 104



directs air to the reverse air cylinder 114 at the underside of the sewing unit 30 as shown in FIG. 7 to operate the reverse mechanism of the sewing unit and cause reverse drive of the sewing head needle 50 and the feed dogs. Actuation of the presser foot solenoid valve 106 directs air to and causes raising of the presser foot, the presser foot remaining raised during such valve actuation and automatically lowering upon cessation thereof. Actuation of the motor clutch air solenoid valve 108 directs air to the motor clutch air cylinder 116 engaging the clutch of the high-speed drive motor 52, the clutch being disengaged automatically when the motor clutch solenoid valve is not actuated.

The main power supply switchbox 46 merely mounts an off-main power switch 118 which controls the main electrical power to the sewing unit 30.

#### POWER INTERFACE—POWER SUPPLY

The wiring circuit of the power interface 32, hereinbefore generally described, is shown in FIGS. 13a and 13b with the power supply being at the lower right corner and side of the circuit and being generally of conventional type. Incoming power at 220 volts AC is stepped down by transformer 120 to 24 volts AC, and this voltage is full-wave rectified by rectifiers 122 and 124 to yield a negative voltage across capacitor 126, and is similarly rectified by rectifiers 128 and 130 to yield a positive voltage across capacitor 132. The positive voltage across capacitor 132 is dropped to a regulated 6 volts by resistor 134 and zener diode 136 in a manner which is well known and widely used, to provide a voltage at terminal 138 which is 6 volts more positive than terminal 140 connected to the other side of diode 136. The negative voltage across capacitor 126 is provided in an unregulated state at terminal 142 for use where negative voltage which is not regulated will suffice such as the supply for the solenoid valves 102, 104, 106 and 108 of the solenoid air valve unit 44.

In addition, the negative voltage appearing at the junction of rectifiers 122 and 124 is further rectified by means of rectifier 144 in a manner such that heavy loads on the negative voltage at terminal 142 will be partially isolated from the negative voltage across capacitor 146, such being a well-known and accepted manner of isolating power supply voltages. The negative voltage across capacitor 146 is regulated by a series circuit consisting of resistor 148, zener diode 150 and zener diode 152, the two diodes being used to obtain two regulated voltages, one of which is approximately negative 6 volts at terminal 154 and the other of which is a negative 12 volts at terminal 156. Thus, three voltage supplies are provided, each of approximately 6 volts and connected in series, these voltage outputs being labeled as if measured from an arbitrary nonexistent point at a potential midway between terminal 154 and terminal 140 so as to be designated plus 9 volts, plus 3 volts, minus 3 volts and minus 9 volts.

#### POWER INTERFACE—SLOW-SPEED MOTOR DRIVE CIRCUIT

The purpose of the slow-speed motor drive circuit is to provide a means of operating the slow-speed drive motor 54 of the sewing unit 30 by means of low-level electronic voltages and currents, said motor being a DC motor. This section of the power interface wiring circuit of FIGS. 13a and 13b is made up of two amplifier sections and two Triax or bidirectional Thyristor solid-state switches 158 and 160, two full-wave bridge rectifier circuits 162 and 164, two resistors 166 and 168 and a capacitor 170. The amplifier portion is, in actuality, a switch, the signal to amplifiers 172 and 174 turn "on" or "off" an AC drive voltage of low magnitude which voltage is used to cause the Triax units of Thyristor switches 158 and 160 to be conductive to high-voltage alternating current. Thyristor switch 158 serves to connect the 220-volt incoming supply to a series circuit consisting of the field supply bridge rectifier circuit 162, resistor 166 and the armature supply bridge rectifier circuit 164.

Thus, the incoming AC supply is simultaneously switched and converted to the necessary DC voltage required for the slow-speed drive motor 54 of the sewing unit 30. Resistor 166 is for the purpose of limiting the maximum current, while a "decoupling" circuit consisting of resistor 168 and capacitor 170 is placed between the motor armature and Thyristor switch 160 for the purpose of limiting the maximum rate of change of the voltage across the Thyristor switch 160 and thereby prevent undesired "triggering" of this Thyristor switch 160. Thyristor switch 160 is connected across the AC input terminals for the armature supply bridge rectifier circuit 164 through resistor 168 for the purpose of placing a near short circuit across its bridge so as to obtain braking operation when it is desired to stop the slow-speed drive motor 54 of the sewing unit 30 quite suddenly as is normally done.

During operation of the braking cycle, some of the circuit components are operated with sufficient power to exceed their long-time power dissipation rating. The braking operation should, therefore, be followed by operation which turns off Thyristor switch 158, removing power from the drive circuit of the slow-speed drive motor 54 of the sewing unit 30.

#### POWER INTERFACE—SOLENOID AIR VALVES AND DRIVERS

The thread trimmer, forward-reverse, presser foot and motor clutch solenoid valves 102, 104, 106 and 108 of the solenoid air valve unit 44 have previously been briefly described, along with the purposes thereof for actuation of the various air cylinders operably connected to the sewing unit 30, and electronic power-amplifying circuits 176, 178, 180 and 182 connected thereto permit operation of these solenoid valves by means of low-level electronic signals at their input. Rectifier diodes 184 are provided for each of these solenoid valves 102, 104, 106 and 108 for the purpose of suppressing the high transient voltages which are generated when inductive loads, such as these solenoid valves, are deenergized, as is commonly done. The power-amplifying circuits 178 and 182 have inputs which come from circuits shown symbolically as triangles with a small dot inside the triangle, these circuits being known in the art as AND gates, functioning in such a way such that signal must be applied to both of the inputs to cause actuation of the associated solenoid valve. The on-off thread trimmer switch 110 of the solenoid air valve unit 44 is provided in series with the thread trimmer solenoid valve 102 to permit disabling operation of the thread trimmer if there is any malfunction such that the sewing head needle 50 of the sewing head 20 or the thread trimmer thereof may be damaged.

#### POWER INTERFACE—CONTROL SWITCHES

The various switches of the power interface 32 and shown in the circuit of FIG. 13a as previously briefly described are to permit operation of the sewing unit 30 and peripheral equipment under manual control, and also to permit operation thereof under automatic control by the automatic controller 34 when properly programmed. The power interface selector switch 56 movable between the "manual" and "automatic" positions is shown in FIG. 13a as a series of switches 56, being a multifunction switch provided for the purpose of allowing a choice of manual operation of the sewing unit 30 and peripheral equipment by means of the foot and knee switch units 38 and 40, for automatic operation by means of the program permanently recorded in the automatic controller 34. The effect of moving the power interface selector switches 56 is described in more detail under the section headed "Control flip-flops and Associated Logic."

The foot control switch 58 of the power interface 32 is an "on" and "off" switch for the purpose of providing a choice between requiring sustained operation of the treadle 92 of the foot switch unit 38 or momentary operation of said treadle to effect operation of the sewing unit 30 when under control of the automatic controller 34, again, all of which has been previously explained.

Slow and fast drive motor switches 186 and 188 are portions of the previously described two-stage drive motor switch 90 of the foot switch unit 38 actionable by light and heavy toe pressure on the treadle 92 of the foot switch unit 38 actionable by light and heavy toe pressure on the treadle 92 of the foot switch unit as previously described. Furthermore, slow and fast drive motor switches 186 and 188 are multiple-function switches depending on the settings of the power interface selector switch 56 and the automatic controller selector switch 62 as has been previously described and will be also later alluded to.

In addition to the slow and fast drive motor switches 186 and 188, there are the right and left knee switches 98 and 100 described in the knee switch unit 40, the reverse switch 94 in the foot switch unit 38 actionable by side toe movement as described, and the instruction record switch 96 of the foot switch unit actuated by heel pressure as described.

Various resistors 190 and diodes 192 are associated with switches 186, 188, 98, 100, 94 and 96 for the purpose of establishing the same voltages and current-handling capabilities as the other electronic circuitry involved in the control circuits. That is to say, these resistors and diodes establish compatibility of the switching signals with other electronic control signals existing in the circuitry.

**POWER INTERFACE—CONTROL FLIP-FLOPS AND ASSOCIATED LOGIC**

This section of the circuitry of the power interface 32 as shown in FIGS. 13a and 13b consists of several so-called "flip-flops" and associated "gating" circuits, both being well known and widely used in electronic circuitry. Also, used in this section of the circuitry are delay multivibrators, inverting circuits and squaring circuits, all equally well known and conventionally used.

By way of brief description, a "flip-flop" is an electronic circuit which has two stable states and for descriptive purposes these two states in the following discussion are called TRUE and FALSE. A flip-flop has two output signals which are opposite in state, one of which is called the ONES output and the other is called the ZEROES output. When a particular flip-

original or rest state even though no additional signals are received by the circuit.

A squaring circuit, shown symbolically as a box containing the letters "SQ" is similar to the flip-flop circuit in that it has both a ONES and a ZEROES output. It functions as a decisionmaking circuit and changes state suddenly when a slowly changing input reaches a certain magnitude which causes the output to suddenly reverse with the TRUE output becoming FALSE and vice versa. When the slowly changing input drops somewhat below this preset magnitude, the outputs suddenly revert to their original state.

**POWER INTERFACE—OPERATIONS OF CONTROL CIRCUITS**

With the foregoing general description of the capabilities of the various so-called logical functions, it becomes possible to describe the operation of the control circuits of the power interface 32 as shown in the circuit of FIGS. 13a and 13b. For purposes of tracing through this circuit, it should be borne in mind that the description is based on "negative" logic, that is, a minus 3 volt signal level is considered as the TRUE signal level and a plus 3 volt signal level is considered as a FALSE signal level. Flip-flops 194, 196, 198 and 200 are the basic controlling units in the circuit for the power interface 32.

Flip-flop 194 is used only in the automatic mode and when the power interface selector switch 56 is in its "automatic" position, flip-flop 194 is connected to power amplifying circuit 180 which in turn energizes presser foot solenoid valve 106 causing the presser foot to raise when flip-flop 194 is in the TRUE state and to lower when flip-flop 194 is in the FALSE state. When the power interface selector switch 56 is in the "manual" position, power amplifying circuit 180 is connected to the right knee switch 98 of the knee switch unit 40 and operation of this switch by knee movement will cause the presser foot to raise. Release of the right knee switch 98 causes the presser foot to lower by deenergizing the presser foot solenoid valve 106.

The other three flip-flops, 196, 198 and 200, are used in their various combinations to cause the various modes of operation of the sewing unit 30 with these combinations and their resulting modes of operation being tabulated below:

TABLE 1

Combination Number:	Flip-flop			Operation
	196	198	200	
7.....	TRUE	TRUE	TRUE	Run slow reverse.
6.....	TRUE	TRUE	FALSE	Run slow forward.
5.....	TRUE	FALSE	TRUE	Run fast reverse.
4.....	TRUE	FALSE	FALSE	Run fast forward.
3.....	FALSE	TRUE	TRUE	Position up and trim.
2.....	FALSE	TRUE	FALSE	Stop needle down.
1.....	FALSE	FALSE	TRUE	Stop needle up.
0.....	FALSE	FALSE	FALSE	Stop.

flop is in the TRUE state, its ONES output is in the TRUE condition, and its ZEROES output is in the FALSE condition. When the flip-flop is in the FALSE condition, its ONES output is FALSE and its ZEROES output is in the TRUE condition.

There are two types of so-called "gate" circuits used in the control circuit, namely, AND gate and OR gate. The AND gate has the characteristics that when and only when all of its inputs are TRUE, the output is TRUE, and if any inputs are FALSE, the output is FALSE. The OR gate functions in such a way that if any of its inputs are TRUE, its output is TRUE, and only when no inputs are TRUE is the output FALSE. The AND gates are shown in the wiring circuit as "triangles" with "dots" in the centers thereof, and the OR gates are shown as triangles with "pulses" in the centers thereof.

The inverter circuit, shown symbolically as a box containing an "N," is for the purpose of accomplishing logical inversion of the control signals, converting TRUE to FALSE and FALSE to TRUE. A TRUE input to this circuit results in a FALSE output and a FALSE input results in a TRUE output.

The multivibrator or delay multivibrator circuit is similar to the flip-flop circuit except for having only one stable state. An input signal causes reversal of the state and the multivibrator for a predetermined time after which the circuit returns to its

It can be seen from Table 1 that the ONES outputs of flip-flop 196 and flip-flop 200 will both be TRUE when the flip-flops are both in the TRUE state, and this occurs for combinations 5 and 7 of table 1. These combinations are the only ones which call for reverse operation of the sewing head needle 50 and feed dogs of the sewing unit 30. Thus, the two inputs to AND-gate 201 which controls the power amplifying circuit 178 to cause reverse operation of the sewing head 48 are connected to the ONES outputs of these two flip-flops 196 and 200, the result being that when both flip-flops are in the TRUE state, the sewing head 48 runs in reverse.

Considering the drive to the power-amplifying circuit 182 which controls the motor clutch solenoid valve 108 and through it the main clutch for the high-speed drive motor 52 to drive the sewing head 48 at fast speed, it can be seen that again two TRUE inputs are required at the terminals 202 and 204 of AND-gate 205. One of these inputs comes from the ZEROES output of flip-flop 198, so that the main clutch of the high-speed drive motor 52 can only be energized when this signal is TRUE, which occurs only when flip-flop 198 is in the FALSE state. From the tabulation of table 1, it is seen that this is only on combinations 0, 1, 4 and 5. Looking now at the other input to the AND-gate 205 which is terminal 204, it can

be seen that this occurs only when output of an OR-gate 207 is TRUE, this occurring only when no inputs to the OR gate 207 are TRUE. Since one of these inputs comes from the ZEROES output of flip-flop 196, this can only happen when flip-flop 196 is in the TRUE state, this condition existing only for table 1 combinations 4, 5, 6 and 7. When combined with the previous condition required, it is apparent that the main clutch of the high-speed drive motor 52 can only be energized for table 1 combinations 4 and 5, the only combinations calling for "Run Fast."

Another input to the OR-gate 207 is connected to the foot control switch 58 on the power interface 32, and when this switch is closed, the signal at this input will be FALSE only when the slow drive motor switch 186 of the foot switch unit 38 is actuated by light toe pressure. In this way control can be given to the operator by closing the foot control switch 58 on the power interface 32 so as to require that the treadle 92 of the foot switch unit 38 be depressed by toe pressure to permit continued programmed operation of the sewing unit 30 when the same is under automatic control of the automatic controller 34. When the foot control switch 58 of the power interface 32 is open to OFF, the OR-gate 207 input is open which is equivalent to a FALSE input at this point and operation of the automatic controller 34 occurs once the treadle 92 of the foot switch unit 38 is depressed by toe pressure and continues under automatic controller programmed control whether the slow drive motor switch 186 of the foot switch is held actuated or not.

Now, considering slow-speed operation of the sewing head 48 of the sewing unit 30 by the slow-speed drive motor 54, this is controlled by the flip-flops 196 and 198, both being in the TRUE state. Table 1 shows that when flip-flop 196 is TRUE, this calls for "Run," and when flip-flop 198 is also TRUE, this calls for "Run Slow." The operation of flip-flop 200 in these cases will cause the slow run to be either forward or reverse as was previously described, and to run at slow speed, the main clutch for the high-speed drive motor 52 of the sewing unit 30 should be deenergized which is accomplished by the input to the AND gate controlling the motor clutch solenoid valve 108 through the power-amplifying circuit 182. When flip-flop 198 is in the TRUE state, this input is FALSE and the motor clutch solenoid valve 108 is deenergized. To run at slow speed, the input to Thyristor switch 158 should be TRUE, so the output of the control gates should be TRUE. Several conditions can cause this, but the one which does it under normal Run Slow operation is the AND-gate 206 of the group. The signal at terminal 208 of the AND-gate 206 is TRUE when flip-flop 196 is in the TRUE state, and if foot control switch 58 of the power interface 32 is closed or "on," the slow drive motor switch 186 of the foot switch unit 38 is actuated, the foot switch unit control having been previously described. This terminal 208 signal is one of the inputs to AND-gate 206 and the other input comes directly from flip-flop 198. Since it is the ONES output, it is TRUE when flip-flop 198 is in the TRUE state which is the case on both of the "Run Slow" conditions of table 1, that is, combinations 6 and 7. When both of these inputs to AND-gate 206 are TRUE, the output of OR-gate 210 is TRUE and the Thyristor switch 158 is energized resulting in operation of the slow-speed drive motor 54 of the sewing unit 30.

The STOP operations, combinations 0, 1, 2, and 3 of table 1, for the main part, are somewhat more complex than the normal "Run" operations, although combination 0 of table 1 is relatively straightforward. The condition for combination 0 of table 1 exists when flip-flop 196, flip-flop 198 and flip-flop 200 are all in the FALSE state, and under these conditions no solenoid valves are energized except possibly the presser foot solenoid valve 106 and neither the slow-speed drive motor 54 through slow drive motor switch 186 nor braking control through Thyristor switch 160 are energized except for certain previously existing conditions where this latter control may be momentarily actuated as described later. When the unconditional stop combination 0 of table 1 occurs, flip-flops 196, 198 and 200 being FALSE, the sewing head 48 and the needle 50 thereof coasts to its normal stop and no positioning or trim action occurs.

Conditions 1 and 2 of table 1 are both stop operations in which the braking circuit of the slow-speed drive motor 54 for the sewing unit 30 is used to accurately position the needle 50 in its cycle when sewing action stops. Condition 1 of table 1 stops the sewing head 48 with the needle 50 in the "up" position and condition 2 of table 1 stops it with the needle 50 in the "down" position, this being accomplished by use of AND-gates 212, 214, 216 and 218. AND-gates 212 and 214 are used to actuate the slow-speed drive motor 54 of the sewing unit 30 through the slow drive motor switch 186 until the desired needle position of needle 50 is reached. Flip-flop 196, when in the FALSE condition, is connected to make one input of AND-gate 212 and one input of AND-gate 214 TRUE. The other input of AND-gate 212 is TRUE if flip-flop 198 is in the TRUE state. The other input of AND-gate 214 is TRUE if flip-flop 200 is in the TRUE state. Therefore, if flip-flop 196 is in the FALSE state and either flip-flop 198 or flip-flop 200 is in the TRUE state, the slow-speed drive motor 54 is energized through the slow-speed drive motor switch 186 and the sewing head 48 when the needle 50 thereof runs at slow speed. Under these circumstances, stop action is caused by energizing the braking circuit described in the section SLOW-SPEED MOTOR DRIVE CIRCUITS while maintaining power in the slow-speed drive motor 54, that is, the circuit thereof. This latter requirement is necessary to insure that the field of the slow-speed drive motor 54 stays energized while the motor armature is short circuited by the Thyristor switch 160 since with no field current, proper dynamic braking operation cannot be obtained.

AND-gates 216 and 218 are used to initiate the stop action of the slow-speed drive motor 54 and, therefore, the sewing head needle 50. When a condition such that all inputs of either of these two gates are TRUE, a one-shot multivibrator 220 connected thereto is actuated and its output becomes TRUE. The multivibrator 220 is connected to Thyristor switch 160 and energizes it to cause a short circuit across the armature of the slow-speed drive motor 54, in turn, causing the slow-speed drive motor to stop suddenly. The multivibrator 220 is also connected to the OR-gate 210, along with the outputs of the AND-gates 206, 212 and 214 such that Thyristor switch 158 remains energized during the braking action even if none of the just mentioned gates have an output. This is done to insure field current during braking as described in the previous paragraph.

The output of multivibrator 220 also connects to the flip-flops 198 and 200 which resets either or both of these flip-flops to the FALSE state. Since flip-flop 196 is in the FALSE state at the start of either of these stop actions just described, the three control flip-flops 196, 198 and 200 are now all FALSE and condition 0 of table 1 exists except for the braking operation of the multivibrator 220 which has not yet terminated. This multivibrator 220 holds the braking circuit energized through both Thyristor switches 158 and 160 for approximately one-half of 1 second at which time the multivibrator output switches to FALSE and all circuits except possibly that to the presser foot solenoid valve 106 are deenergized.

The instant of initiation of the braking action is determined by the inputs of AND-gates 216 and 218. Three of these inputs come from the three flip-flops 196, 198 and 200 such that three of the four AND-gate 216 inputs are TRUE under the "Stop Needle Up" conditions, condition 1 of table 1, and three of the four AND-gate 218 inputs are TRUE under the "Stop Needle Down" conditions, condition 2 of table 1. The actual stop action is initiated then by the instant the fourth input becomes TRUE of whichever of AND-gates 216 and 218 has three inputs TRUE. This fourth input in the case of AND-gate 216 is a short duration pulse which occurs at the instant the needle 50 is in the desired "up" position and, in the case of AND-gate 218, it is a pulse which is momentarily TRUE when the needle 50 is in the desired "down" position. The method by which these "up" and "down" pulses are generated is described later under the section describing the needle counter and positioner 42 and its associated circuitry.

The "Position Up and Trim" operation, that is, positioning the sewing head needle 50 "up" and actuation of the thread

trimmer or cutoff, is shown as combination 3 in table 1 and occurs when flip-flop 196 is in the FALSE state and flip-flops 198 and 200 are both in the TRUE state. Under these circumstances AND-gate 222 has three inputs in the TRUE state, the fourth input to this gate being the "down" position pulse just mentioned, which becomes TRUE when the needle 50 reaches the "down" position. At this time the AND-gate 22 has a TRUE output directed through power-amplifying circuit 176 and on-off thread trimmer switch 110, energizing the thread trimmer solenoid valve 102 to thereby actuate the thread trimmer or cutoff mechanism. As previously stated, on-off thread trimmer switch 110 is provided to permit disabling the action of the thread trimmer in case malfunction has occurred causing improper action or timing of the thread trimmer and the position of the sewing head needle 50, that is to say, an improper positioning relationship therebetween.

The TRUE input of the AND-gate 222 is also connected to an AND-gate 224 and to an inverter circuit. The AND-gate 224 is for the purpose of sustaining the output to the thread trimmer solenoid valve 102 from the time of the "down" position of the sewing head needle 50 until the "up" position is reached. The output of the inverter circuit which receives its input from the TRUE output of the AND-gate 222 is used to reset the flip-flop 198 and when this occurs the FALSE-TRUE combination of the control flip-flops, combination 3 of table 1, gets changed to a FALSE-FALSE-TRUE combination. Referring to table 1, it can be seen that this is combination 1 which is the combination that causes "Stop Needle Up" operation of the sewing head needle 50. From this point on, "Stop Needle Up" operation occurs in the same manner as previously described except that the thread trimmer solenoid valve 102 has been energized to energize the thread trimmer mechanism. The slow-speed drive motor 54 and latter the braking circuits thereof are all actuated in the same manner as was described relative to "Stop Needle Down" and/or "Stop Needle Up" operation.

In the preceding, the manner in which the control flip-flops 194, 196, 198 and 200 control the operation of the sewing head 48 and the needle 50 thereof has been described, and the power interface selector switch 56, previously described under the section, POWER INTERFACE—CONTROL SWITCHES, controls the means whereby these control flip-flops are set to the various combinations required. When the power interface selector switch 56 is in the "automatic" position, these flip-flops receive their inputs from the automatic controller 34, to be later described, and when the power interface selector switch 56 is in the "manual" position, flip-flop 194 is not used. With the power interface selector switch 56 in "manual," the presser foot solenoid valve 106 is connected directly to the right knee switch 98 of the knee switch unit 40 and this switch controls the presser foot solenoid valve directly. Also, when the power interface selector switch 56 is in "manual," flip-flop 196 is controlled directly from the slow drive motor switch 186 of the foot switch unit 38 so that when the treadle 92 thereof is depressed with light toe pressure, flip-flop 196 is set to the TRUE state and when the treadle is released, this flip-flop reverts to the FALSE state.

Still further, when the power interface selector switch 56 is in "manual," the inputs of the flip-flops 198 and 200 are, by means of AND gates, isolated from the other control switches unless the slow drive motor switch 186 of the foot switch unit 38 is actuated. When the slow drive motor switch 186 of the foot switch unit 38 is actuated, the flip-flop 198 is immediately set to the TRUE state and this is done by connecting the fast drive motor switch 188 of the foot switch unit 38 to the input AND gates of flip-flop 198. When the treadle 92 of the foot switch 38 is depressed sufficiently to operate the fast drive motor switch 188, flip-flop 198 is set to the FALSE state, and when the treadle is released sufficiently to deactivate fast drive motor switch 188, flip-flop 198 again reverts to the TRUE state. If we assume the flip-flop 200 to be in the FALSE input state, it can be seen from table 1 that light depression of the treadle 92 of the foot switch unit 38 gives combination 6 of table 1 or "Run Slow Forward" operation. Depressing the treadle 92 further, so as to actuate the fast drive motor switch 188, causes the flip-flops to change to combination 4, which is

the "Run Fast Forward" condition. Releasing the treadle 92 sufficiently to deactivate the fast drive motor switch 188 causes the flip-flops to revert to combination 6 of table 1, or the "Run Slow Forward" condition.

Since the input to the flip-flop 198 is closed when the fast drive motor switch 188 of the foot switch unit 38 is deactivated, complete release of the foot pedal causes the flip-flop 196 to change to the FALSE state, but leaves the flip-flop 198 in the TRUE state. This is combination 2 of table 1 and calls for the operation of the sewing head 48 to stop with the needle 50 in the "down" position. By closing the inputs to flip-flops 198 and 200, they are free to be reset by the stop action which was described above.

Examination of the connections to the flip-flop 200 shows two things. One of these is that the part of the power interface selector switch disconnects one of the inputs to the power-amplifying circuit 178 of the forward-reverse solenoid valve 104 from the flip-flop 200 and connects it to the reverse switch 94 of the foot switch unit 38 actuated by the side toe pressure. This has the result that the flip-flop 200 now will have no effect on reverse operation of the sewing head 48 and the needle 50 thereof, and the combinations 5 and 7 of table 1 are not valid. The other feature of the flip-flop 200 concerns its input, which comes from the left knee switch 100 of the knee switch unit 40, and it can be seen that if this latter switch is actuated, the flip-flop 200 will be set to the TRUE state, but if this left knee switch 100 is not actuated, the flip-flop 200 is set to the FALSE state. As just mentioned, this will not affect the run operation, combinations 5 and 7 of table 1 not being valid, but it does affect the stop operation and it can be seen that if the left knee switch 100 is held actuated, when the treadle 92 of the foot switch unit 38 is released and the slow drive motor switch 186 deactuates, the flip-flop 200 will, like the flip-flop 198, be left in the TRUE state when its inputs are closed. From table 1 it can be seen that combination 3 will exist which calls for the sewing unit 30 to go through the "Position Up and Trim" cycle of operation in the manner previously described.

The left knee switch 100 of the knee switch unit 40 is actuated by knee movement to the left and if this knee switch is held to the left when the treadle 92 of the foot switch unit 38 is released, "Position Up and Trim" operation is initiated. If the left knee switch 100 is held to the left and the treadle 92 of the foot switch unit 38 is momentarily actuated by a light tap of the toe, the operation occurs from the stop position of the sewing head 48. As was previously mentioned, the control of reverse operation of the sewing head 48 and the needle 50 thereof is disconnected from the flip-flop 200 when the power interface selector switch 56 is in "manual." This forward-reverse solenoid valve 104 is now connected to the reverse switch 94 of the foot switch unit 38 and if this switch is actuated, the sewing head 40 and needle 50 thereof runs in reverse at either slow or fast speed depending on how far the treadle 92 of the foot switch unit 38 is depressed.

#### NEEDLE COUNTER AND POSITIONER—ASSOCIATED CIRCUITRY WITH POWER INTERFACE

The needle counter and positioner 42 is included diagrammatically in the wiring circuit of the power interface 32 as shown in FIGS. 13a and 13b, and is also shown in FIGS. 11 and 12 in perspective and vertical section, the same being a vital part of the overall control of the sewing head 48 and the needle 50 thereof as well as being a vital adjunct to the automatic controller 34. The needle counter and positioner 42 includes a small, partly translucent, partly opaque disc 226, connected to a sleeve 228 which is rotated by a shaft of the sewing unit 30, that is, a shaft exactly movable rotatably with the reciprocal "up" and "down" movements of the sewing head needle 50. The disc 226 is positioned between a light source 230 and a light-detecting cell 232, the disc being properly circumferentially positioned relative to the reciprocal positions of the sewing head needle 50 such that the disc opaque segment comes between the light source 230 and the light-detecting cell 232 when the sewing head needle reaches the needle "down" position as previously described, and clears the path

between the light source and light-detecting cell when the sewing head needle reaches the desired needle "up" position.

Thus, the needle counter and positioner 42 is arranged to provide an electronic signal which can be used to provide a signal for stopping the sewing head needle 50 at a desired needle "down" position, can be used to provide a signal for stopping the sewing head needle at a desired needle "up" position, can be used to provide a signal which lasts from the needle "down" position to the needle "up" position for sustaining actuation of the thread trimmer solenoid valve 102 and the thread trimmer mechanism operable thereby, and can be used to provide a signal at each revolution of the sewing head 48, that is, a signal for each reciprocal movement of the sewing head needle 50, which can be counted electronically to maintain an exact count of the number of sewing stitches the sewing head needle carries out.

The light-detecting cell 232, a photocell, has the output thereof connected to amplifier 234 of the power interface 32 as shown in the wiring circuit of FIGS. 13a and 13b, and the output of the amplifier 234 is connected to a squaring circuit 236 which has a ONES and ZEROS output. As has been described, these outputs change suddenly at a point where the opaque sector of the disc 226 is becoming interposed between the light source 230 and the light-detecting cell 232 of the counter and positioner 42, and revert again suddenly to their original state when the disc opaque sector is passing out from between the light source and the light-detecting cell. This sudden change is desirable for proper operations of the electronic circuits no matter what the speed of the sewing head 48 and the needle 50 thereof at the time the conditions occur, and also to effect a "decision" as to the exact time of causing the various control electronic elements operations.

The squaring circuit 236 is connected to another squaring circuit 238 of the same type through resistors 240 and 242 having a capacitor 244 across the same, and these resistors and capacitor serve to delay the action of the second squaring circuit 238 to a slightly later time than the first squaring circuit 236. This time delay is used to generate a short duration pulse at the time of change in state of the squaring circuits and this can be done in any of several ways, but this method permits the use of "direct current coupling" which tends to be more reliable and easier to test, as well as lends itself to use in conventional AND and OR circuits which allow for use of additional control signals.

The output of the first squaring circuit 236 is TRUE during the time from the "down" position of the sewing head needle 50 to the "up" position thereof and, of course, the other output of this first squaring circuit 236 is TRUE during the remainder of the time from the "up" position to the "down" position. The outputs of the first and second squaring circuits 236 and 238 are connected OR-gates 246 and 248, respectively, so that when the "down" position is reached, the output of the OR-gate 248 becomes FALSE until the second squaring circuit 238 changes, and when the "up" position is reached, the output of the OR-gate 246 becomes FALSE until the second squaring circuit 238 changes. The OR-gates 246 and 248 are connected to inverter circuits 250 and 252 respectively, which provide a TRUE output during this short period of time. The OR-gates 246 and 248 also have a third input which, when held in the TRUE state, prevents an output and thereby can be used to inhibit a TRUE output signal from appearing at the outputs of the inverter circuits 250 and 252. Thus, a "down" position output pulse for the sewing head needle 50 is received from the OR-gate 248 and the inverter circuit 252, and an "up" position output pulse is received from the OR-gate 246 and the inverter circuit 250, each at the appropriate times as indicated.

The third input, previously mentioned, to the OR-gates 246 and 248, that is, the "inhibit" inputs, is connected to a flip-flop 254 and this flip-flop is set to inhibit the "up" position and "down" position pulses whenever the sewing head 48 is operated for moving the needle 50 thereof. This inhibit operation remains present until the flip-flop 254 is set to the TRUE state by an input from a type of multivibrator 256 which pro-

vides an output when its input is removed for a sufficiently long period of time. This period of time is set to be such that only when the movement of the sewing head needle 50 has slowed to a speed low enough to be able to cause proper thread trimming action by the thread trimmer or thread cutoff actuated by the thread trimmer solenoid valve 102, and only after such slowing to the low speed will output pulses occur. This electronic action is provided as a safety feature to reduce the likelihood of actuation of the thread trimmer solenoid valve 102, and therefore the thread trimmer at high speed, even though most sewing units now have mechanical damage to the sewing head needle 50 or the blades of the thread trimmer.

#### AUTOMATIC CONTROLLER—GENERAL

The wiring circuit for the automatic controller 34 is shown in FIGS. 14a, 14b, 14c, 14d, 14e and 14f, with the circuit of the storage drum thereof being shown more in detail in FIGS. 15 and 16. As previously stated, the automatic controller 34 has a storage or memory unit within which the series of operational steps for the sewing unit 30 and peripheral equipment may be stored, each step then being played back from such memory as required. Each instruction step consists of 20 binary digits, although the basic design of the control and memory unit allows for as many as 32 binary digits. Eight of these binary digits are used for command purposes and the additional 12 are for numerical data associated with the command, such as delay time or stitch count as determined by the previously described needle counter and positioner. A total of 64 steps can be carried out in a single program of the automatic controller 34 and these steps are carried out sequentially except for a certain type of instruction which causes the sequence of steps to be altered or broken.

The instruction step about to be recorded in the program of the automatic controller 34 if the selector switch 62 thereof is in "record," or performed if the automatic controller is in automatic mode by the selector switch being in "operate," is indicated at the program step counter 76 at the front of the automatic controller 34 as is shown in FIG. 5. This display is in "octal" code for the base 8 numbering system in which there are no eight or nine digits, and this has been done for reasons of circuit simplicity, not necessarily being a requirement. The octal numbers corresponding to the decimal number of a given program are shown in the following table 2. The eight command digits mentioned have been assigned various functions for control of either the sewing unit 30 or the program of the automatic controller 34, these eight binary digits or "bits" being divided into two groups of four binary digits, each group of four making up a one-out-of-16, or hexadecimal, character. One of these is referred to as the "command" character and the other as the "output" character, since one primarily influences the output to which the action applies, thus, composite instructions. In the case of the output commands to the sewing unit 30, the output character can also contain certain "command" information, and the way in which these combinations are used is shown in the following tables 3 and 4.

TABLE 2.  
DECIMAL TO OCTAL CONVERSION

Decimal	Octal	Decimal	Octal	Decimal	Octal
Step	No.	Step	No.	Step	No.
0	0	22	26	44	54
1	1	23	27	45	55
2	2	24	30	46	56
3	3	25	31	47	57
4	4	26	32	48	60
5	5	27	33	49	61
6	6	28	34	50	62
7	7	29	35	51	63
8	10	30	36	52	64
9	11	31	37	53	65

Table 2—Continued

10	12	32	40	54	66
11	13	33	41	55	67
12	14	34	42	56	70
13	15	35	43	57	71
14	16	36	44	59	73
16	20	38	46	60	74
17	21	39	47	61	75
18	22	40	50	62	76
19	23	41	51	63	77
20	24	42	52		
21	25	43	53		

TABLE 3.

ASSIGNMENT OF COMMAND CHARACTER BITS

Decimal Number	Binary Digits			Command Effect
	8	4	1	2
15	1	1	1	1 Reserved for Future
14	1	1	0	1 Reserved for future
13	1	1	1	0 Activate Output
12	1	1	0	0 Deactivate Output— Terminate by knee switch
11	1	0	1	1 Activate Output
10	1	0	0	1 Deactivate Output— Terminate by stitch count
9	1	0	1	0 Activate Output
8	1	0	0	0 Deactivate Output— Terminate after time delay
7	0	1	1	1 Transfer to Specified Instruction
6	0	1	0	1 Reserved for future
5	0	1	1	0 Training Stop 02
4	0	1	0	0 Training Stop 01
3	0	0	1	1 Reserved for future
2	0	0	0	1 Program Stop
1	0	0	1	0 Program Stop and Reset
0	0	0	0	0 Skip—Do Nothing

TABLE 4.

ASSIGNMENT OF OUTPUT CONTROL CHARACTER BITS

Decimal No.	Binary Digits			Sewing Machine	Other Outputs	Command Effect
	8	4	1	2		
15	1	1	1	1	x	Run Slow Reverse
14	1	1	0	1	x	Run Slow Forward
13	1	1	1	0	x	Run Fast Reverse
12	1	1	0	0	x	Run Fast Forward
11	1	0	1	1	x	Position Up and Trim
10	1	0	0	1	x	Stop Needle Down
9	1	0	1	0	x	Stop Needle Up
8	1	0	0	0	x	Stop
7	0	1	1	1	x	
6	0	1	0	1	x	
5	0	1	1	0	x	Reserved for future
4	0	1	0	0	x	
3	0	0	1	1	x	
2	0	0	0	1	x	Operate Stacker
1	0	0	1	0	x	Operate Presser
0	0	0	0	0	x	Foot Not Used

Associated with the command and output characters are the 12 binary digits of numerical information which were previously discussed and these are used in the control of the sewing unit 30 as either stitch count or time delay information. That is to say, when a command such as No. 11 of table 3 is called for, which calls for an action to be terminated after its specified stitch count, it is necessary to specify the stitch count, and when a command such as No. 9 of table 3 is called for, the

desired time delay must be specified. The stitch counts and time delays are specified by the additional 12 binary digits of the particular instruction.

The foregoing discussion explains the general aspects of the manner in which the automatic controller 34 accomplishes the desired control of the sewing unit 30 and any peripheral equipment therefor. In the following a detailed explanation and description is contained of the manner in which the various combinations of binary digits are entered, stored, recalled, and accomplish the desired results for use of the automatic controller 34.

AUTOMATIC CONTROLLER—MAJOR REGISTERS OR COUNTERS

The circuit diagram of FIGS. 13a, 14b, 14c, 14d, 14e, and 14f shows the detailed logic design of the main control unit of the automatic controller 34. FIG. 14a is the upper left portion of the wiring circuit, FIG. 14b is the upper center portion, FIG. 14c is the upper right portion, FIG. 14d is the lower portion, FIG. 14e is the lower center portion and FIG. 14f is the lower right portion.

The automatic controller 34 includes three major registers or counters which provide the basic control of the entire unit. One of these is the main control register, made up of 20 flip-flops 258 through 296. Another is the program step counter made up of six flip-flops 298 through 308, and the third is the drum position counter made up of nine flip-flops 310 through 326.

AUTOMATIC CONTROLLER—MAIN CONTROL REGISTER

The entire command is normally placed in the main control register, the four command bits being placed in the flip-flops 258, 260, 262 and 264. The output control bits are placed in the flip-flops 266, 268, 270 and 272, while the numerical information is placed in the flip-flops 274 through 280, 282 through 288, and 290 through 296. When a particular command is placed in this main control register, the automatic controller 34 executes the called-for action when an "execute" signal is generated, or records the instruction when a "record" signal is generated.

When the command to be executed calls for termination after either a specified time or a specified stitch count, a pulse source is supplied to the input of the flip-flop 274 which causes the flip-flops 274 through 280, the flip-flops 282 through 288, and the flip-flops 290 through 296 to run as a binary counter. The output of the last flip-flop 296 in this counter chain is connected to a flip-flop 328 and when the counter reaches a count of ZERO it causes the flip-flop 328 to switch to the FALSE state which terminates the instruction. The flip-flop 328 has been set to the TRUE state, which causes the application of pulses to the counter input by a combination of the "execute" signal on the flip-flop 328 and a signal from an OR-gate 330 which is TRUE when the flip-flop 264 is TRUE and the flip-flop 262 is in the FALSE state. This condition exists when the command character is in the combination of bits occurring when the table 3 combinations of 8, 9, 10 or 11 are in the flip-flops. These combinations can be seen as the commands wherein action is called for which terminates on either stitch count or time delay.

There are several ways in which the counter section of the main control register is made to count, one is by the flip-flop 328 being set to the TRUE state as mentioned which provides a TRUE input to OR-gate 332 and causes a FALSE output therefrom. This, in turn, causes a FALSE input to a combination of OR-gates 334 and 336. This combination of the OR-gates 334 and 336 is made up of two four-input OR gates which are, through logical operations, connected in such a way that their outputs are combined and appear as an output of a two-input OR-gate 338 and associated inverter (N) which runs the counter section of the main control register.

Inspection of the manner in which these cascaded OR gates are connected shows that the flip-flop 260 will function to cause either of the outputs of the OR-gates 334 or 336 to reach the counter input. Any TRUE input to the OR-gates 334 and 336 will prevent any output therefrom from causing the counter to run. One of the terminals to the OR-gate 334 is a timing signal which results in this signal driving the counter if all other inputs to this OR-gate 334 are FALSE. The other OR-gate 336 has an input which comes from a squaring circuit 340 whose input, via a noise pulse filter, comes from the needle counter and positioner 42.

The timing signal to the OR-gate 334 mentioned above comes from a timing multivibrator 342 and this circuit is adjustable by means of an adjustable potentiometer which is the delay adjustment switch 84 of the automatic controller 34 previously discussed and shown in FIG. 6. Such adjustment of the delay adjustment switch 84 changes the length of the time unit used by the automatic controller 34 to measure and regulate all program steps measured by pure time, whether composite instruction steps or merely solely time steps such as time delays between component operational steps of the sewing unit 30.

The conditions just described result in either a timing signal or the stitch counter signal causing the counter section of the main control register to run depending on whether the flip-flop 260 is TRUE or FALSE and upon certain other conditions. If the flip-flop 260 is TRUE, input to the OR-gate 334 will be TRUE and the timing multivibrator 342 cannot pass through to the counter. Input to the OR-gate 336 will be FALSE, however, and the stitch counter signal will pass through this gate if another input is also FALSE, this being the case if a flip-flop 344 is FALSE, such condition existing if a command is being executed.

When the counter section is caused to run by the flip-flop 328 being set to the TRUE state, the command terminates by the flip-flop 328 being set to the FALSE state by an input which is the carry from the last counter stage flip-flop 296. Another way in which the counter can be caused to run is by pressing a "delay" button 346 on the automatic recorder 36 which will be hereinafter described more in detail. For present purposes this is a TRUE input to the OR-gate 332 which causes the counter to run from the timing signal multivibrator 342. Another input to the OR-gate 332 will also cause the counter to run and this input comes from the presser foot switch on the sewing unit 30 which is the right knee switch 98 of the knee switch unit 40, via a buffer diode. This input is used to measure the time delay when recording a "Presser Foot Up" command by operating the sewing unit 30 through the manually actuated controls thereof including the knee switch unit 40.

The way in which the delay times are recorded and played back from the counter section without using a bidirectional counter should be understood. The counter, when recording a delay by counting, runs forward from a count of zero, and when this is recorded in the memory, it is inverted as it is recorded. When the inverted signal comes back from the memory, it is the complement of the original number. When the timing or stitch count command is being executed, then the counter still runs forward until it reaches a full count, and when it then "turns over" to zero again, a "carry" is generated which reverses the state of the flip-flop 328 which terminates that program step.

#### AUTOMATIC CONTROLLER—PROGRAM STEP COUNTER

The program step counter keeps track of the program step being executed and as was described, it consists of the flip-flops 298 through 308, each of which is connected to the next for normal binary counter operation. When an "execute" signal is generated, a "not-execute" signal by virtue of two diodes 348 and 350 and a resistor 352 is applied to the input of an OR-gate 354. The output of the OR-gate 354 through an in-

verter 356 is applied to the input counter flip-flop 298. On other input is possible to the flip-flop 298, and this is from the advance program counter button or the "step forward" button 82 earlier described relative to the outside appearance of the automatic controller 34. This other input from the "step forward" button 82 is through a resistor-capacitor filter circuit 358 and a squaring circuit 360, the squaring circuit output normally being TRUE which permits the "not-execute" signal to pass through to the counter input. When the "step forward" button 82 is depressed, the output through the squaring circuit 360 becomes FALSE causing the output of the inverter 356 to become TRUE, and when the button 82 is released, the output of inverter 356 becomes FALSE again and the counter indexes. The type of counter used changes state on a transition from TRUE to FALSE.

The program step counter has two other inputs, one of which is a reset signal which sets the counter to zero and this signal is applied directly to each of the flip-flops 298 through 308, the counter being set to zero when the signal goes TRUE. This happens when the command being executed calls for a reset to zero action, causing terminal 362 of a sequencer 364, used here as a decoder, to become TRUE, and this can only happen on "operate" of the automatic controller 34 since a contact of the automatic controller selector switch 62, previously described, holds this lead at +3 volts or in the FALSE state when in the "record" position. This prevents the reset to zero command from causing any action when it is put in the main control register prior to being recorded. The other way in which the counter can be set to zero is by the reset program counter button 80 previously described relative to the outside appearance of the automatic controller 34. These two described reset actions are connected to the program step counter through two buffering diodes which prevent interaction.

The other input to the program step counter comes from the counter section of the main storage register and is connected to one input of each of the two input set and reset AND gates on the counter flip-flops, an example thereof being AND-gates 366 and 368 of the flip-flop 298. Part of the inputs to these AND-gates 366 and 368 to the flip-flop 298 come from the TRUE and FALSE outputs of the flip-flop 274 in the counter section of the main storage register. The other inputs to these AND gates of the program step counter flip-flops are all connected together and serve to gauge the contents of the flip-flops 274, 276, 278, 282, 284 and 286 into the program step counter flip-flops 298 through 308, which occurs when command No. 7 of table 3 is in the main storage register. This particular command causes the program to jump to a new instruction step instead of indexing to the next number in sequence and when this No. 7 command is used, the location of the instruction to be next in sequence should be specified as one less than the desired instruction, since completion of the "execute" signal will index the counter one step. For this reason, location zero of the program step counter should not be used for a desired program step.

It should be noted that the new program step information which is located in the main storage register will be "upside down" because of the way in which the counter information is "turned over" or complemented. To correct for this, the information is "turned over" again when it is transferred to the step counter and this can be seen, for example, by noting that the TRUE output of the flip-flop 274 goes to the FALSE or "reset" input of the flip-flop 298.

#### AUTOMATIC CONTROLLER—DRUM POSITION COUNTER

The third major section of the automatic controller 34 is the drum position counter and this counter, while being connected as a single nine-stage binary counter, is actually used as a three-stage and a six-stage counter due to the way in which the commands are recorded, one entire command being recorded in the memory as eight sequential sets of four binary

digits. As the memory drum rotates, a "clock" track on which are recorded 512 pulses, provides a timing signal which is connected to the input of the nine-stage drum position counter, and since a nine-stage counter will make a complete counting cycle in 512 counts, it is apparent that the counter and the memory drum will be synchronized. By recording a single reference pulse on a separate "track" of the drum, and using this pulse to set the counter to a zero count, the counter will always reach a zero count as the same place on the drum periphery. This counter, therefore, can be used to uniquely identify each point on the drum periphery.

The first three stages of the counter, the flip-flops 310, 312, and 314, will cycle in a count of 8. The outputs of these three flip-flops are connected to a sequencer circuit 370 which provides a TRUE output at one of eight different output terminals for each of the eight different counts in the counter. These TRUE output signals are used to independently manipulate the eight different four-bit characters of a command.

#### AUTOMATIC CONTROLLER—CONTROL OF INFORMATION FLOW

The last six stages of the drum position counter, the flip-flops 316 through 326, are used to provide the position information or "address" of the 64 program step locations and these flip-flops are connected to a coincidence detector 372. The coincidence detector 372 provides an output at output terminal 374 thereof when the flip-flops 316 through 326 contain the same number as the flip-flops 298 through 308 of the program step counter. An input at an input terminal 378 of the coincidence detector 372 is used to suppress the output at all times except when it is desired, and this in only when a new instruction or command is gated out of the memory or recorded in the memory.

When a TRUE output occurs at the coincidence output terminal 374, this is inverted by a negator circuit or inverter circuit, a connected OR-gate 380 and inverter 382, which causes an input terminal 384 of the sequencer 370 to become FALSE. If input terminal 386 of the sequencer is also FALSE, a time sequence of outputs occurs at the output terminals of the sequencer 370. These outputs of the sequencer 370 are used to set a new command into the main control register, or to switch the outputs of the main control register flip-flops into the "record" circuitry of the memory. This latter action is accomplished by sets of AND gates generally indicated at 388 in FIG. 14c.

The information coming out of the AND-gates 388 via connected OR gates generally indicated at 390 and inverters generally indicated at 392, is then passed through another set of AND gates generally indicated at 394, OR gates generally indicated at 396, and inverters generally indicated at 398, and is used to create signals known as "Williams" type of recording signals, well recognized in the art. These signals are of a nature such that they are TRUE for one-half of the recording interval for one bit and FALSE for the second half of the interval if the bit to be recorded in a ZERO, and FALSE and then TRUE is the bit is a ONE. This type of recording signal is well suited for application in which bits are recorded one at a time, or in this case, eight at a time.

The input terminal 386 of the sequencer 370 is used to feed in a "strobe" pulse which reduces the width of the output pulses to a relatively small time duration, and this is only done on playback or "operate" of the automatic controller 34 so that transients which occur between bits of information cannot get into the main control register. The output of a negator or inverter circuit, OR-gate 400 and inverter 402 shown in FIG. 14d, is used to turn the "strobe" pulses "on" and "off" on "record" and playback or "operate" of the automatic controller 34, and when in the "record" mode, a switch contact 404 forming a part of the automatic controller selector switch 62 connects the input of this inverter circuit to -3 volts, making it TRUE, which causes the output thereof to be FALSE at the connected input terminal 386 of the sequencer 370, allowing full width pulses to be generated by the sequencer 370.

A flip-flop 406 (FIG. 14d) is used as the main run-stop control flip-flop. A terminal 408 is connected to the slow drive motor switch 186 of the two-stage drive switch 90 on the sewing unit foot switch unit 38 and is used to start a cycle of operations when the automatic controller is in the playback or "operate" mode. By means of a switch contact 410 forming a part of the automatic controller "operate" and "record" selector switch 62, the input to the flip-flop 406 may be switched between a terminal 412 connected to the instruction record switch 96 of the sewing unit foot switch unit 38 and the terminal 408 connected to the slow drive motor switch 186 of the foot switch unit, depending on the automatic controller selector switch 62 being in the "record" or "operate" mode. The selected input from either the terminal 408 or the terminal 412 through the switch contact 410 is filtered by a resistor-capacitor combination generally indicated at 414, passed through a squaring circuit 416, passed through a resistor-capacitor delay circuit generally indicated at 418 and is directed as the input through a second squaring circuit 420.

When the input signal selected by the switch contact 410, from either the terminal 408 or the terminal 412, goes TRUE, the output of the first squaring circuit 416 goes TRUE, the output of the first squaring circuit 416 goes TRUE, and since the output of the second squaring circuit 420 is normally TRUE, this output becomes FALSE, but after a short delay time from the output of the first squaring circuit 416 going TRUE. During this short delay time, the inputs to an AND-gate 422 of the flip-flop 406 are both TRUE and flip-flop 406 is set to the TRUE state which starts a step of the sewing unit 30. If the automatic controller selector switch 62 is in the "record" setting placing the automatic controller 34 in the "record" mode, a -3-volt signal is directed by the switch contact 404 through an inverter circuit, and OR-gate 424 and inverters 426 and 428, causing the output of the inverter 428 to be TRUE, and this causes a connected input to an AND-gate 430 of the flip-flop 406 to be TRUE. Therefore, when an "execute" signal occurs, the other input to the AND-gate 430 of the flip-flop 406 becomes TRUE and the flip-flop 406 is set to the FALSE state so that action stops. Since the "execute" signal occurs immediately during "record" operation of the automatic controller 34, the contents of the main control register will have been recorded and the program step counter will index to the next position.

When the automatic controller selector switch 62, determining "operate" or "record," is switched to the "operate" position, the changing of the switch to the "operate" position, the changing of the switch contact 404 switches the +3-volt input into the OR-gate 424 or FALSE and this results in the input of the flip-flop 406, that is, at the AND-gate 430, will be FALSE, and the automatic controller 34, once started by setting the flip-flop 406 to the TRUE state, will continue to operate until either of two inputs into the OR-gate 424 becomes TRUE. One of these inputs of the OR-gate 424 is made TRUE by either the actuation of the "panic stop" or "emergency stop" switch which is the fast drive motor switch 90 on the foot switch unit 38, or through the "training stop" circuits to be hereinafter described. The other input to the OR-gate 424 is made TRUE by decoding a normal "stop" command in the main control register.

The "training stop" circuits referred to in the foregoing are formed by a training stop No. 1 circuit generally indicated at 432 and a training stop No. 2 circuit generally indicated at 434, these circuits including the training stop No. 1 switch 86 and the training stop No. 2 switch 88 previously described relative to the outside appearance of the automatic controller 34. When a training stop No. 1 or No. 2 command is in the main control register, a No. 4 or No. 5 command of table 3 is in the flip-flops 258 through 264 and these cause a TRUE output at either of output terminals 436 or 438 of the sequencer 364. If the respective training stop No. 1 switch and training stop No. 2 switch 86 and 88 are open, these TRUE outputs are permitted to bypass such switches and be directed as an input to the OR-gate 424. If however, either the training stop No. 1 switch 86 or the training stop No. 2 switch 88 is closed, that



particular stop signal cannot pass through the OR-gate 424 and consequently does not effect a stop action on the flip-flop 406.

The other primary control flip-flops are a flip-flop 440 (FIG. 14e), the flip-flop 344 (FIG. 14e), and the flip-flop 328 (FIG. 14d), and the latter of these has been mentioned in connection with the counter section of the main control register. If a command calls for stitch count or delay time, an input of an AND-gate 442 of the flip-flop 328 is TRUE and when the command is executed, flip-flop 328 becomes TRUE causing an input of an OR-gate 444 (FIG. 14e) to become TRUE and an input to an AND-gate 446 of the flip-flop 440 to become FALSE. This prevents any further action of the flip-flop 440 until the flip-flop 328 is reset by termination of the counter operation.

If the flip-flop 328 is not set to the TRUE state, and since an "execute" signal is not normally present, three of the inputs of the OR-gate 444 will all be FALSE once the flip-flop 406 has been set to the TRUE state by the start action described earlier. One other of the inputs to the OR-gate 444 from an OR-gate 448 and an inverter 450 is normally TRUE, and because an input of the OR-gate 448, this input to the OR-gate 444 becomes FALSE only once per revolution of the memory drum and then only at he ZERO or reference position of the drum. The signal which does this is the same one which insures that the drum position counter is set to ZERO at this time and was described in the section on the drum position counter. Under these circumstances, it can be seen that once flip-flop 406 is set in the TRUE state, flip-flop 440 will also be set to the TRUE state at the ZERO position of the memory drum, so that this prevents the generation of a partial coincidence signal at the output terminal 374 of the coincidence detector 372 caused by the flip-flop 440 becoming TRUE during the coincidence period.

When the flip-flop 440 becomes TRUE, the input at the input terminal 378 of the coincidence detector 372 is TRUE and an output will occur at the time of the next program step. This either gates a new command into the main control register or records the one there in the memory. The output of the coincidence detector 372 at the output terminal 374 causes an input to an OR-gate 452 to be TRUE and the output of an inverter 454 to be FALSE. It also causes the flip-flop 344 to become TRUE since an input to an AND-gate 456 of flip-flop 344 is TRUE and since the flip-flop 440 is in the TRUE state, the other input to the AND-gate 456 of the flip-flop 344 is also TRUE.

When the flip-flop 344 is TRUE, one of its outputs connected to the OR-gate 452 is also FALSE so that this input to the OR-gate 452 is FALSE. It can be seen, then, that at the completion of the signal from the output terminal 374 of the coincidence detector 372, the input to the OR-gate 452 therefrom will again become FALSE and since both the inputs to the OR-gate 452 are FALSE, a TRUE signal will appear from the connected inverter 454. This signal is called the "execute" signal and activates whatever action the particular command calls for. It also, via an AND-gate 458 to the flip-flop 440 causes this flip-flop 440 to reset.

Once the flip-flop 440 resets, an input therefrom to an AND-gate 460 of the flip-flop 344 becomes TRUE, and a brief time later an input of the flip-flop 310 will become TRUE and the flip-flop 344 will reset. This input of the flip-flop 344 from the flip-flop 310 is used to prevent immediate reset of the flip-flop 344 by the action of the "execute" signal, since resetting flip-flop 344 causes the "execute" signal to become false again, and it would then "extinguish" itself resulting in a substandard "execute" pulse.

The cycle of events just described occurs each time a new command is executed and since the "execute" pulse also indexes the program step counter, each command carried out is the next one in the sequence. If delay time is called for, or a stitch count is called for, the flip-flop 328 prevents the action of the flip-flops 440 and 344 until the required delay count or stitch count is achieved.

## AUTOMATIC CONTROLLER—AUXILIARY OUTPUT CONTROL

Two four-input OR-gate 462 and 464 with connected inverters 466 and 468 are used to turn auxiliary outputs for the peripheral equipment of the sewing unit 30 "on" or "off", the OR gates and the inverters being shown in FIG. 14f. Furthermore, these OR-gates 462 and 464 and the inverters 466 and 468 pass the "execute" pulse through to the outputs of the respective inverters 466 or 468 depending on whether the command calls for activating or deactivating the particular auxiliary output. Also, the particular output to be controlled depends on the combination of binary digits in the output control character of the command and this is decoded by a sequencer 470 is shown in FIG. 14c. Output terminal 472 of the sequencer 470 is connected through the power interface 32 and thereby to the presser foot solenoid valve 106 of the solenoid air valve unit 44 for the control of the presser foot raising and lowering, said presser foot being a vital part of the sewing unit 30 and the sewing head 48 thereof. The output terminal 474 of the sequencer 470 is connected through an "on" and "off" power amplifier generally indicated at 476, and thence to a receptacle 478 for use in operating a stacker forming a part of the peripheral equipment for the sewing unit 30. The remaining output terminals of the sequencer 470 have been reserved for future use as required.

## AUTOMATIC CONTROLLER—MEMORY DRUM SECTION

The circuit diagram of the memory drum or storage drum section including the recording and readout circuits thereof are shown in FIG. 15. With the previous detailed discussion of the wiring circuit for the automatic controller 34 as shown in FIGS. 14a through 14f, the integration of this memory drum section into the automatic controller 34, as well as the operation thereof, is clearly apparent to those skilled in the art so that a detailed description is not required.

Briefly, as previously mentioned, the recording signals are of the "Williams" type, well known to those skilled in the art, and in addition to the four channels of readout circuitry, there is a clock pulse amplifier and a major cycle pulse or zero position pulse amplifier. The clock pulse amplifier also provides a "strobe" pulse which can be adjusted slightly in time, and this pulse is used to "strobe" or "sample" the information channel amplifiers at the best instant of each bit time to discriminate against spurious noise and switching transients. The zero position pulse is also "clocked" by one of the clock pulses to accurately establish its time of occurrence with the clock pulses.

The six record and readout heads are indicated at 480, 482, 484, 486, 488 and 490 in FIGS. 15 and 16. FIG. 16 shows a diagrammatic end view of the recording drum indicated at 492 and the locations of the various record and readout heads 480 and 490.

## AUTOMATIC RECORDER

The automatic controller 34 is built in such a way that it could be programmed directly by means of pushbuttons, but this method is generally known as microprogramming, where each individual binary digit of each instruction must be inserted individually. In order to simplify this direct programming of the automatic controller 34, an automatic recorder 36 is provided, the purpose thereof being to provide a method for inserting most or all of an entire instruction with a single pushbutton. An additional function of this automatic recorder 36 is to permit the use of remote pushbuttons or switches to insert partial or entire instructions so as to allow programming of the automatic controller 34 by use of the manual control operation of the sewing unit 30, giving a unique, exceedingly fast means of accomplishing complete programming of the automatic controller 34 for accurately carrying out an overall sewing operation including actuation of any peripheral equipment therefor.

The circuit diagram for this automatic recorder 36 is shown in FIGS. 17a and 17b, FIG. 17a being the left-hand part and FIG. 17b being the right-hand part. Furthermore, the fundamental part of this automatic recorder 36 is a diode matrix having the opposite sides thereof with identical circuitry, such matrix sides being separately indicated at 494 and 496 in FIGS. 17a and 17b, the common circuitry thereof being shown in detail in FIG. 18.

The matrix sides 494 and 496 are arranged such that any one of 16 inputs can be momentarily connected to the +3-volt supply, or momentarily set to the FALSE state, which results in setting a combination of four external flip-flops to any one of the 16 TRUE-FALSE combinations which are possible with four flip-flops. When one of the terminals of the right-hand side of the matrix sides 494 and 496 is grounded, the four flip-flops shown at the bottom of that respective matrix side are set to the binary combination representing that terminal location. The two combinations of four flip-flops shown in FIGS. 17a and 17b are the master instruction control flip-flops 258 through 272 of the automatic controller 34 and shown in the FIG. 14a wiring circuit portion thereof. These flip-flops 258 through 272 are not actually a part of this automatic recorder 36, but can be set to any of their possible 256 combinations by the matrix sides 494 and 496 making up the diode matrix of this automatic recorder 36.

The inputs to the automatic recorder 36 are of two types, one is a plurality of pushbuttons at the front panels thereof as shown in FIG. 10 and previously discussed, the same being generally indicated at 498 in this FIG. 17b wiring circuit. These pushbuttons 498 each operate two switch contacts, one contact being used as an input to one of the matrix sides 494 or 496 and the other contact being used as the input to the other matrix side 494 or 496.

The other inputs to the automatic recorder 36 are from power-amplifying circuits of one of two types which, in turn, receive their inputs from external switches. These external switches are not actually a part of this automatic recorder 36, but are shown in FIG. 17a as a part of the "manual" and "automatic" selector switch 56 of the power interface 32, the reverse switch 94 of the foot switch unit 38, the right knee switch 98 of the knee switch unit 40, and the slow drive motor switch 186 forming a part of the two-stage drive switch 90 on the foot switch unit 38, all of which have been previously discussed and are located remote from the automatic recorder 36.

A visual output from the automatic recorder 36 is provided by the use of illuminated pushbuttons and the lamps which illuminate these pushbuttons are generally indicated at 500 in FIG. 17a. Furthermore, the lamps 500 are caused to light by power amplifier circuits generally indicated at 502 in FIG. 17a, these power amplifier circuits being constructed such that when their input is grounded or FALSE, the particular lamp 500 lights and the particular pushbutton 498 is illuminated.

The power amplifier circuits 502 have their inputs grounded in a rather indirect manner, this being done by means of "feedback" effect in that, when an input is momentarily "grounded" or rendered FALSE by the action of one of the pushbuttons 498, the output flip-flops are set to a particular combination, and when this particular combination is present, only the input which caused it will be at the "grounded" or FALSE state. This FALSE state at the inputs to the power amplifier circuits 502 can be used, by the suitable power amplification, to illuminate a specific of the pushbuttons 498 without altering the state of the flip-flops which caused it. If power amplification were not used, the state of the output flip-flops would be altered or their ability to be easily set to a new combination would be affected.

At the upper part of FIG. 17b, a pulse-generating circuit is generally indicated at 504 having several inputs and this circuit does not contribute to the function of the automatic recorder 36 in any way except to cause action of a "ready to record" lamp 506 for a "ready to record" pushbutton 508

when any of the other pushbuttons 498 is depressed. This is accomplished by utilizing a pulse generated within the pulse-generating circuit 504 to set a flip-flop 510 of the automatic controller 34 and shown in the automatic controller wiring circuit at the bottom of FIG. 14d. This flip-flop 510 of the automatic controller 34 is reset to the FALSE state by a signal generated when the instruction record switch 96 of the foot switch unit 38 is actuated to record an instruction, and this flip-flop resetting to the FALSE state causes the "ready to record" lamp 506 on the automatic recorder 36 to extinguish.

When the "ready to record" pushbutton 508 on the automatic recorder 36 is actuated, the flip-flop 510 of the automatic controller 34 is set to the TRUE state causing the input to the "ready to record" lamp 506 of the automatic recorder 36 to go FALSE. This FALSE signal to the "ready to record" lamp 506, acting through its power amplifier circuit 502, causes the lamp to light which illuminates the "ready to record" pushbutton 508. This provides an assist, when recording a program, for keeping track of whether or not a command has been recorded.

Two pushbuttons are shown at the bottom of FIG. 17b, namely, a "reset program register" pushbutton 512 and a "delay" pushbutton 514. The "reset program register" pushbutton 512 is used to "clear" the main control register of the automatic controller 34, and the "delay" pushbutton 514 is used as a pushbutton method of entering delay time in an instruction for recording if it is desired to do so by timing the depression of a button. This "delay" pushbutton 514 causes the same action as the left knee switch 100 of the knee switch unit 40 when the automatic controller 34 has the selector switch 62 thereof in "record." The manner in which these switches accomplish the described action has been discussed relative to the automatic controller 34.

The instruction record switch 96 of the foot switch unit 38 is also shown at the bottom of FIG. 17b. This instruction record switch 96 is merely shown here for clarity of the overall circuit connection and, of course, does not actually form a part of the automatic recorder 36. Furthermore, the manner of operation of this instruction record switch 96 by heel pressure on the treadle 92 of the foot switch 38 has been previously described, as has the integration thereof into and the effect on the automatic controller 34.

The previously mentioned reverse switch 94 of the foot switch unit 38, the right knee switch 98 of the knee switch 40, the selector switch 56 of the power interface 32, and the slow drive motor switch 186 forming a part of the two-stage drive switch 90 of the foot switch unit 38 shown herein at the top of FIG. 17a but likewise not actually forming a part of the automatic recorder 36, are connected into this automatic recorder circuit by four power amplifier circuits and a plurality of miscellaneous diodes, all at the moment generally indicated at 516, but to be specifically pointed out hereinafter. Generally, two of the power amplifiers of these circuits are of the inverting type and two are of the noninverting type, the diodes being used to perform certain combinational logic operations in permitting operation of the automatic recorder 36 by means of the four switches referred to exterior of the automatic recorder.

As was previously described, the inputs to the matrix sides 494 and 496 in this automatic recorder 36 are activated when they are momentarily made FALSE. This means that the inputs to the noninverting power amplifiers must also be made momentarily FALSE to effect actuation, and this further means that the inputs to the inverting power amplifiers must be made momentarily TRUE to effect actuation.

Referring to the slow drive motor switch 186 of the foot switch unit 38, a contact 518 thereof is normally TRUE and becomes FALSE when this slow drive motor switch is actuated, and when this contact 518 goes FALSE, it also permits the inputs of power amplifiers 520 and 522 to go FALSE through action of buffer diodes 524 and 526, unless prevented by the action of buffer diodes 528, 530, 532 and 534 as will be described later. When the inputs of the power amplifiers 520

and 522 go FALSE, this causes the outputs thereof to both go FALSE, and, through buffer diodes 536, 538, 540 and 542, causes terminals 544, 546, and 548 to go FALSE. These terminals 544, 546 and 548 are connected to specific terminals of the matrix sides 494 and 496 so as to result in setting a combination into the flip-flops of the automatic recorder 36 calling for either "run fast forward" or "run fast reverse."

Referring back to the action of the buffer diodes 528 and 530, it can be seen that the buffer diode 530 is connected to the input of a power amplifier 550 and the buffer diode 528 is connected to the output of this same power amplifier 550. As indicated, the power amplifier 550 is an inverting type so that when the input thereof is TRUE, the output must be FALSE, and when the input thereof is FALSE, the output must be TRUE. This means that only one of the inputs of the power amplifiers 520 and 522 can go TRUE when the slow drive motor switch 186 is actuated. As shown, the input to the power amplifier 550 is determined by the position of the reverse switch 94 on the foot switch unit 38, and when this reverse switch 94 is actuated, the "run fast reverse" instruction is placed in the automatic controller 34, and when this reverse switch 94 is not actuated, the "run fast forward" instruction is placed in the automatic controller.

The buffer diodes 532 and 534 are connected to the selector switch 56 of the power interface 32 and when this selector switch is in the "manual" position, that shown in FIG. 17a, there is no effect on the power amplifiers 520 and 522. When, however, this power interface selector switch 56 is in the "automatic" position, opposite that shown in FIG. 17a, the buffer diodes 532 and 534 function to prevent the inputs of either of the power amplifiers 520 or 522 from becoming FALSE, so that there is no input to either of the matrix sides 494 and 496 of the automatic recorder 36.

A fourth of the power amplifiers is a power 552 of the inverting type and when another section, indicated herein at 554 for clarity, of the selector switch 56 on the power interface 32 is in the "manual" position, that shown in FIG. 17a, the input to the power amplifier 552 is received from the right knee switch 98 to the knee switch unit 40. As previously described, when the right knee switch 98 is actuated with the power interface selector switch 56, here the switch section 554 thereof, in "manual," such actuation results in the presser foot solenoid valve 106 of the solenoid air valve unit 44 to be actuated raising the presser foot of the sewing unit 30 or the sewing head 48 thereof.

Thus, when the presser foot is raised by actuating the right knee switch 98, the input to the power amplifier 552 is TRUE, and since this power amplifier is of the inverting type, its output is then FALSE, such output passing through buffer diodes 556 and 558 resulting in appropriate terminals of the matrix sides 494 and 496 being FALSE. The overall result is that the instruction calling for "Presser Foot Up" is placed in the automatic controller 34.

When the power interface selector switch 56 is switched to the "automatic" position so that the switch section 554 thereof is in the position different from that shown in FIG. 17a, the input to the power amplifier 552 is connected to a +3-volt contact 560 so as to be set in the FALSE state. The output of the power amplifier 552, through the inversion, therefore, becomes TRUE and no input is entered into the matrix sides 494 and 496 of the automatic recorder 36.

#### USE OF SEWING UNIT—NORMAL MANUAL CONTROL

The sewing unit 30 can be operated under normal manual control without the programming of the automatic controller 34 being involved or the use of the automatic recorder 36 being involved. In such case, a power switch 562 of the automatic controller 34 would be placed in the "off" position eliminating the automatic controller and the automatic recorder 36 from involvement, and the selector switch 56 of the power interface 32 would be placed in "manual." The sewing unit 30 would then be operated merely by use of the

foot switch unit 38 and the knee switch unit 40, in the manner previously described to carry out an overall sewing operation.

As an example of a relatively simple overall sewing operation, the operation previously generally described in the early portion of this specification may be used, that is, the sewing of a pocket patch on a shirt front. Generally, the various steps are as previously outlined in carrying out the manually controlled operation.

For purposes in more clearly illustrating the programming of the automatic controller for carrying out the same overall sewing operation, and then the automatic control of the sewing unit 30 and certain peripheral equipment for carrying out the same overall sewing operation, a schematic layout of the sewing equipment assembly of FIG. 1, including various worktables with parts of the articles to be sewn positioned thereon ready for use in the overall sewing operation, are shown in FIG. 19, and the finished sewn article is shown in FIG. 20. As shown in FIG. 19, the layout includes a right worktable 564 having a stack of pocket patches 556 to be sewn thereon, a left worktable 568 having a stack of shirt fronts 570 positioned thereon ready for placement and sewing of the pocket patches 556, and an operator location 572 between the right and left worktables 564 and 568.

Furthermore, the layout of FIG. 19 includes the block showing of the sewing unit 30 on a sewing machine table 574. The exact path of vertical reciprocal movement of the sewing head needle 50 being indicated as a needle location dot 576 circled for clarity. The peripheral equipment for the sewing unit 30 is a stacker 578 which is automatically operable between a normal "at rest" position shown in full lines in FIG. 19 and an "extended" or "stacking" position shown in phantom lines in FIG. 19.

In FIG. 20 an assembled shirt front 570 and pocket patch 556 is shown. Multiple stitching at the top corners of the pocket patch 566 are shown adjacent the open pocket top, such multiple stitching being for reinforcement purposes. Furthermore, continuous stitching around the periphery of the pocket patch 566 is shown with the exception of the open pocket top.

Again for purposes of clarity in illustrating the sewing operation, various locations on the pocket patch 556 have been indicated at 580 through 594, and certain of these locations have also been indicated on the shirt front 570.

#### USE OF SEWING UNIT—PROGRAMMING UNDER MANUAL CONTROL

In programming the automatic controller 34 under manual control of the sewing unit 30 for later automatic control of said sewing unit by the automatic controller, the selector switch 56 of the power interface 32 is rechecked to be sure it is in "manual" position and the thread trimmer switch 110 on the solenoid air valve unit 44 is rechecked to be sure that it is in the "on" position, as it would have been required to be during the normal manually controlled sewing operation above. Furthermore, the power switch 562 of the automatic controller 34 would be placed in "on" position, the automatic controller selector switch 62 placed in "record" position, the automatic controller delay adjustment switch 84 preferably placed at a midway position for average time unit use, and the training stop No. 1 and training stop No. 2 switches 86 and 88 placed down into "on" position to permit insertion of training stops or delays. Finally, prior to the commencement of programming of an overall sewing operation, the program step counter 76 will be reset to "00" by depressing step the reset program register button 78 of the automatic controller 34.

The sewing unit 30 is now ready to commence the programming of the overall sewing operation and the programming method is performed as tabulated in the following:

Program Step "00"—This is a blank instruction that is entered into the automatic controller 34 by depressing the instruction record switch 96 of the foot switch unit 38 and an instruction is recorded that requires no action. After such

recording, the program step counter 76 of the automatic controller 34 will index to program step "01," visually indicating the same at the front of the automatic controller.

Program step "01"—The instruction for a training stop or delay No. 1 is entered into the automatic controller 34 by depressing the training stop No. 1 button of the automatic recorder 36 and when this button is depressed, the "ready to record" button 508 thereof will be illuminated. The instruction record switch 96 of the foot switch unit 38 is then depressed to record this training stop or delay. This training stop No. 1 instruction will cause the program of the automatic controller 34 to stop the sewing unit 30 at this program step "01" each time the overall sewing operation is automatically carried out by the automatic controller 34 as long as the training stop No. 1 switch 86 of the automatic controller 34 is in the "on" position. This particular instruction provides the programmer with the necessary control to check the program and when this instruction has been recorded, the program step counter 76 of the automatic controller 34 will index to program step "02."

Program step "02"—The operator will raise the presser foot by using the right knee switch 98 of the knee switch unit 40 and continue to hold the presser foot up by continuing actuation of the right knee switch while picking up one of the shirt fronts 570 and positioning location 580 at the needle location 576, then picking up one of the pocket patches 566 and positioning the same with the location 580 thereof directly over the location 580 of the shirt front 570, and then finally exactly aligning the location 580 of the temporarily assembled pocket patch 566 and shirt front 570 exactly over the needle location 576 of the sewing unit 30. The operator will then lower the presser foot by releasing the right knee switch 98 which will hold the temporarily assembled pocket patch 566 and shirt front 570 exactly positioned as placed. This total step will take about 800 time units of the automatic controller 34 meaning that when the automatic controller is in the "automatic" mode the presser foot will remain raised for a count of 800 time units or approximately 13 seconds, and this 800 time element period has been automatically counted by the automatic controller and temporarily recorded therein during the manually controlled performance, that is, the time from the raising of the presser foot to the lowering thereof. The recording of the overall instruction, that is, the time period, is permanently recorded in the program of the automatic controller 34 by actuating the instruction record switch 96 of the foot switch unit 38, causing the program step counter 76 of the automatic controller 34 to advance to program step "03."

Program Step "03"—The sewing head needle 50 of the sewing unit 30, which has obviously been previously in its "up" position, is now positioned "down" by depressing the "stop needle down" button on the automatic recorder 36 and a delay time of 96 time units is entered directly into the program of the automatic controller 34 by depressing the stitch and delay buttons 76 thereof directly under "32" and "64," a total of "96," illuminating these stitch and delay lights 68. This program instruction provides the time required for the sewing head needle 50 to be positioned down, while at the same time for the operator to regasp the temporarily assembled pocket patch 56 and shirt front 570 for proper control thereof to commence the sewing operation. The instruction is permanently recorded in the automatic controller 34 by actuating the instruction record switch 96 of the foot switch unit 38, although this recording could be accomplished by depressing the "ready to record" pushbutton 508 on the automatic recorder 36 which has been lighted, this choice of recording always being available. The recording action advances the program step counter 76 of the automatic controller 34 to program step "04."

Program Step "04"—A training stop No. 2 instruction is entered into the automatic controller 34 by depressing the "training stop No. 2" button on the automatic recorder 36, the same being permanently recorded in the automatic controller program by depressing the instruction record switch 96 of the

foot switch unit 38. The program step counter 76 of the automatic controller 34 will automatically index to program step "05." By way of further explanation of the training stops being programmed herein, these training stops provide indeterminate delays in the program of the automatic controller 34, which, when the automatic controller training stop switches 86 and 88 are down in the "on" position, will stop the automatic controller program when being carried out in the "operate" mode of the automatic controller each time that particular program step is reached and the delay will remain until the slow drive motor switch 186 of the foot switch unit 38 is actuated for proceeding with the program. Later, if either of the training stops switches 86 or 88 are moved up to "off," the program steps or the program delays controlled by that switch, that is any training stop No. 1 or any training stop No. 2 will automatically be bypassed in the "automatic" mode of the automatic controller 34, the same automatically indexing directly over that or those program steps directly to the next program step in order. Thus, this training stop No. 2 as programmed herein can be used for the purposes of permitting a delay or delays for training operators to use the sewing unit 30 under the automatic control of the automatic controller 34. Keep in mind, also, that any number of separated training delay program steps can be programmed into the automatic controller 34 for control by the training stop switches 86 and 88, each switch eliminating all of its control delays when moved to "off."

Program Step "05"—This program instruction is entered by depressing the toe of the treadle 92 on the foot switch unit 38 fully or with heavy toe pressure so as to actuate the fast drive motor switch 188 thereof until four stitches forward are sewn, at which time the treadle 92 is released. This causes the sewing head needle 50 of the sewing unit 30 to sew from location 580 to location 582 of the pocket patch 566, the four stitches being counted by the needle counter and positioner 42, and temporarily recorded in the program of the automatic controller 34. The instruction is permanently recorded in the automatic controller 34 by actuating the instruction record switch 96 of the foot switch unit 38, and the program step counter 76 of the automatic controller 34 indexes to program step "06."

Program Step "06"—This instruction is entered by depressing the "run fast reverse" button on the automatic recorder 36, and then activating the reverse switch 94 of the foot switch unit 38 while fully depressing the toe of the treadle 92 to simultaneously actuate the fast drive motor switch 188. The operation or step as manually controlled by the operator is to sew in reverse for a total of four stitches, which stitch count is recorded by virtue of the needle counter and positioner 42, the same being temporarily recorded by the program of the automatic controller 34, the same being at the high speed and terminated by release of the foot switch unit 38. Reverse stitching is, therefore, accomplished from the location 582 to the location 580 of the pocket patch 566. This instruction is recorded permanently in the automatic controller 34 by the actuation of the instruction record switch 96 of the foot switch unit 38 and such recording causes the program step counter 76 of the automatic controller 34 to index to program step "07."

Program Step "07"—This instruction is to sew fast forward a total of 33 stitches and is temporarily recorded in the automatic controller 34 by fully depressing the toe of the treadle 92 of the foot switch unit 38 to actuate the fast drive motor switch 188 until the 33 stitches are completed and the count thereof is transmitted to the automatic controller by the needle counter and positioner 42 as before. At the end of the sewing of the 33 stitches, the foot switch unit 38 is released, and this step will accomplish the sewing of the 33 stitches from the location 580 to within approximately one-quarter inch away from the location 584 of the pocket patch 566, and note that this does not carry completely to the location 584 on the pocket patch. The instruction is permanently recorded in the automatic controller 34 by actuation of the instruction record

switch 96 of the foot switch unit 38 and the automatic controller indexes to program step "10."

Program step "10"—The sew slow forward instruction is temporarily entered into the program of the automatic controller 34 by lightly depressing the treadle 92 of the foot switch unit 38 to actuate the slow drive motor switch 186, and is terminated by releasing the foot switch unit when the sewing head needle 50 has exactly reached the location 584 on the pocket patch 566, which, with the pocket patch 566 and the shirt front 570 of stable material, will be three stitches. This instruction is permanently recorded in the program of the automatic controller 34 by actuation of the instruction record switch 96 of the foot switch unit 38, causing the program step counter 76 of the automatic controller to index to program step "11." Note that if the material of the pocket patch 566 and the shirt front 570 is of unstable material so that the location 584 of the pocket patch might vary, a stitching step of indeterminate number of stitches can be permanently recorded in the program by depressing the "run slow forward" button of the automatic recorder 36 without a time limitation and permanently recording the same, which, under automatic control of the automatic controller 34 when in the "operate" mode or setting of the selector switch 62 would require termination of such stitching step by the operator actuating the right knee switch 98 of the knee switch unit 40 to terminate, and then the slow drive motor switch 186 thereof to proceed with the program. This same indeterminate termination of any stitching step can be used if required and gives the necessary versatility for sewing unstable materials.

Program Step "11"—This instruction is to stop the sewing head needle 50 down for subsequent repositioning of the pocket patch 566 and the skirt front 570 and is entered by depressing the "stop needle down" button of the automatic recorder 36 followed by entering a 32-time-unit delay by the stitch and delay button 74 of the automatic controller 34. This instruction will cause the sewing head needle 50 to be positioned down by the needle counter and positioner 42 controlling the same to such position, and the time delay will provide the necessary time for accomplishing such positioning. Thus, the sewing head needle 50 provides the pivot point for the repositioning of the material, and this instruction is recorded permanently in the program of the automatic controller 34 by actuating the instruction record switch 96 of the foot switch unit 38, the program step counter 76 of the automatic controller indexing to program step "12."

Program Step "12"—This instruction is to activate the presser foot solenoid valve 106 raising the presser foot and is accomplished by actuating the right knee switch 98 of the knee switch unit 40 causing the presser foot to raise and the raise delay time to be counted while so raised. During the raising the raised position of the presser foot, the operator manually repositions the pocket patch 566 and the shirt front 570, realigning the same for the subsequent sewing to the location 586 on the pocket patch. The instruction is terminated by releasing the right knee switch 98 causing the presser foot to again lower and the total up and down presser foot movement with the necessary delay time in time units is permanently recorded in the program of the automatic controller 34 by actuating the instruction record switch 96 of the foot switch unit 38, with the program step counter 76 of the automatic controller indexing to program step "13."

Program Step "13"—This instruction is for the purpose of providing the operator with a determined time delay during which the operator will check the position of the pocket patch 56 on the shirt front 570 to be sure that the pocket patch is properly aligned for the proper alignment of the remaining of the locations through the location 594. The determined time delay instruction is entered for temporary recording in the program of the automatic controller 34 by depressing the button under "8" and the button under "64" of the stitch and delay button 74 on the automatic controller 34 giving a total time delay of 72 time units for the required function of the operator. This instruction is permanently recorded in the pro-

gram of the automatic controller 34 by actuating the instruction record switch 96 of the foot switch unit 38, and the program step counter 76 of the automatic controller indexes to program step "14."

Program Step "14"—This step is another training stop No. 2, that is, an indeterminate stop used for training purposes and controlled by the training stop No. 2 switch 88 of the automatic controller 34, as previously discussed relative to program step "04." Furthermore, this program step is entered in the same manner and has the same consequence as the program step "04," the program step counter 76 of the automatic controller 34 then indexing to program step "15."

The remaining program steps are either the same or similar, with a few exceptions, to those previously programmed. The remaining programming explanation, therefore, will only refer to the particular instruction recorded, unless further explanation is required.

Program step "15"—This instruction is to sew fast forward four stitches to within approximately one-quarter inch of the location 586 on the pocket patch 566. Again, note that this is not completely to the location 586 on the pocket patch 566 in view of the sewing head needle 50 being required to be positioned down at the location 586 which can only be accomplished at slow speed and this step is at fast speed.

Program step "16"—This instruction is to sew three stitches at slow speed to the location 586 of the pocket patch 566.

Program Step "17"—This instruction is to position the sewing head needle 50 down for the subsequent material repositioning.

Program Step "20"—This instruction is for the operator to raise the presser foot, pivot the pocket patch 566 and the shirt front 570 around the sewing head needle 50 to align for sewing to the location 588, recheck to verify that the pocket patch is still properly aligned with the shirt front, and lower the presser foot.

Program Step "21"—This instruction is a further determined time delay of sufficient number of time units to permit the operator to regrasp the pocket patch 566 and the shirt front 570 in order to maintain control during the subsequent sewing step.

Program Step "22"—This instruction is to sew fast forward 24 stitches to approximately one-quarter inch from the location 588 on the pocket patch 566.

Program Step "23"—This instruction is to sew slow forward three stitches to the location 588 on the pocket patch 566.

Program Step "24"—This instruction is to position the sewing head needle 50 down preparatory to repositioning of the pocket patch 566 and the shirt front 570 for the next sewing operation or step.

Program Step "25"—This instruction is for the operator to raise the presser foot, reposition the pocket patch 566 and the shirt front 570 aligned for sewing to location 590 on the pocket patch, recheck for proper alignment of the pocket patch 566 over the shirt front 570, and lower the presser foot.

Program Step "26"—This instruction is a determined time delay required for the operator to regrasp the pocket patch 566 and the shirt front 570 for maintaining control during the subsequent sewing operation or step.

Program Step "27"—This instruction is to sew fast forward four stitches approximately one-quarter inch from the location 590 on the pocket patch 566.

Program Step "30"—This instruction is to sew slow forward three stitches to the location 590 on the pocket patch 566.

Program Step "31"—This instruction is to position the sewing head needle 50 down, again to provide the pivot point for the subsequent repositioning of the pocket patch 566 and the shirt front 570.

Program Step "32"—This instruction is for the operator to raise the presser foot, reposition the pocket patch 566 and the shirt front 570 to realign the same for the subsequent sewing to the location 495 of the pocket patch, recheck the alignment of the pocket patch with the shirt front, and lower the presser foot.

Program Step "33"—This instruction is again a determined time delay of a determined number of time units to permit the operator to regrasp the pocket patch 566 and the shirt front 570 for maintaining proper control during the subsequent sewing step.

Program Step "34"—This instruction is to sew fast forward 33 stitches to within approximately one-quarter inch of the location 594 on the pocket patch 566.

Program Step "35"—This instruction is to sew slow forward three stitches to the location 495 of the pocket patch 566.

Program Step "36"—This instruction is to sew slow in reverse four stitches back to the location 592 of the pocket patch 566.

Program Step "37"—This instruction is to sew slow forward four stitches to the location 594 on the pocket patch 566.

Program Step "40"—This instruction is to position the sewing head needle 50 up and to trim or cutoff the threads, that is, both the top and bottom threads, by actuation of the thread trimmer solenoid valve 102 to operate the thread trimmer or thread cutoff. The instruction is entered by depressing the "position up and trim" button on the automatic recorder 36, and setting a time delay of 64 time units by use of the stitch and delay button 74 of the automatic controller 34, the time delay being sufficient for accomplishing the total step. The instruction is permanently recorded in the program of the automatic controller 34 by actuating the instruction record switch 96 of the foot switch unit 38. After such permanent recording of the instruction, the actual operation on the pocket patch 566 and the shirt front 570 can be performed manually by the operator by manually actuating the left knee switch 100 of the knee switch unit 40 with the automatic controller 34 eliminated from the circuit.

Program Step "41"—this instruction is for the operator to raise the presser foot for a sufficient period of time to slide the new permanently assembled or sewn pocket patch 566 and shirt front 570 from beneath the presser foot and place it over the automatic stacker 578.

Program Step "42"—this instruction is for operation of the automatic stacker 578, and is entered by depressing the "stacker on" button on the automatic recorder 36, and also setting a 256-time-unit delay through the stitch and delay buttons 74 of the automatic controller 34. This gives sufficient time for operation of the automatic stacker 578, and assuming the stacker is totally automatic, no instruction is required for the "stacker off."

Program Step "43"—This instruction is for the program step counter 76 of the automatic controller 34 to reset to program step "00," and is entered into the program of the automatic controller by depressing the "reset program register" pushbutton 512 of the automatic recorder 36 and then actuating the instruction record switch 96 of the foot switch unit 38. This will cause the permanent recording of this instruction and will also reset the program step counter 76 of the automatic controller 34 to program step "00." This, therefore, completes the programming of the automatic controller 34 and with this last program step "43," the automatic controller will, under "operate" mode thereof keep proceeding to repeat the entire program permanently recorded every time it reaches this program step "43."

From the foregoing, it can be seen that the automatic controller 34 may be completely programmed, primarily merely by carrying out under operator manual control, the particular sewing operation desired, and an extensive period of programming the automatic controller is not required as has been true with similar type operations which are to be automatically controlled by conventional computers and the like. It is true that the present assembly makes use of the automatic recorder 36 and appropriate auxiliary automatic recording equipment directly on the automatic controller 34 for programming the overall sewing operation just performed, but use of these auxiliary elements or devices in many cases is merely for convenience since most of the programming could be accomplished merely by carrying out the overall sewing operation

under the operator manual control and actuation. In any event, it can be easily appreciated that a great variety of overall sewing operations can be programmed into the automatic controller 34 totally by the operator carrying out the overall sewing operation under the manual actuation.

A further important advantage to the method of programming the automatic controller 34 by carrying out the overall sewing operation under manual actuation of the sewing unit 30 by the operator is that the chances of programming error are reduced to virtually none. This is true whether or not the auxiliary automatic recording equipment, such as the automatic recorder 36 and elements thereof on the automatic controller 34, are required to be used, since the simplicity thereof results in the necessary training of an experienced operator being reduced to one week or less.

#### USE OF SEWING UNIT—AUTOMATIC CONTROL

In use of the automatic controller 34 for automatically controlling the sewing unit 30 to carry out the overall sewing operation previously programmed in the automatic controller, the selector switch 56 of the power interface 32 is switched to "automatic" and the selector switch 62 of the automatic controller 34 is switched to "operate." Prior to the selector switch 62 of the automatic controller 34 being set in "operate," the program step counter 76 of the automatic controller will have been set or indexed to program step "00," so that upon moving the selector switch 62 to "operate," the program will immediately start. The first program step "00" is blank so that the program step counter 76 of the automatic controller 34 will automatically index to program step "01."

In automatically controlling the sewing unit 30 in carrying out the overall sewing operation, the automatic controller 34 will automatically index to the next subsequent program step unless the particular step being carried out is an indeterminate time delay. In the present program of the automatic controller 34, the only indeterminate time delays are the training stops and the automatic controller will remain at that particular program step until the toe of the treadle 92 on the foot switch unit 38 is lightly depressed to actuate the slow drive motor switch 186, at which time the automatic controller will automatically index to the next program step. Thus, in the following only the actuation to end the training stops or delays will be pointed out with the other program steps being carried out consecutively automatically by the automatic controller 34.

Program Step "01"—The operator actuates the foot switch unit 38 to end the training stop No. 1 and index the program step counter 76 of the automatic controller 34 to the program step "02."

Program Step "02"—The operator will pick up a pocket patch 566 and a shirt front 570 properly temporarily assembling the same and properly positioning them under the sewing head needle 50, the needle being aligned with the location 580 on the pocket patch. At the same time, the presser foot of the sewing head 48 will raise and remain raised for 800 time units, after which it will lower

Program Step "03"—The operator will regrasp the temporarily assembled pocket patch 566 and shirt front 570 while the sewing head needle 50 will position down extending downwardly through the pocket patch and shirt front.

Program Step "04"—This is a first training stop No. 2 and the sewing unit will remain idle until the operator actuates the slow driver motor switch 186 of the foot switch unit 38, at which time the program step counter 76 of the automatic controller 34 will index to program step "05."

Program Steps "05," "06," "07," "10" and "11"—The operator will guide the pocket patch 566 and shirt front 570 while the sewing head 48 and the needle 50 thereof sews four stitches forward to the location 582, four stitches rearwardly to the location 580, 33 stitches forwardly fast and then three stitches forwardly slow to the location 584, and the needle will position down.

Program Steps "12" and "13"—The presser foot of the sewing head 48 will raise and remain raised for 128 time units while the operator repositions the pocket patch 566 and shirt front 570, the presser foot will lower and the sewing unit 30 will remain idle for a time delay of 64 time units for the operator to check proper alignment of the pocket patch and shirt front.

Program Step "14"—This is another training stop No. 2 and the sewing unit 30 will continue to remain idle until the slow drive motor switch 186 of the foot switch unit 38 is actuated which will cause the program step counter 76 of the automatic controller to index to the program step "15."

Program steps "15," "16" and "17"—The operator will guide the pocket patch 566 and shirt front 570 while the sewing head needle 50 sews fast forward four stitches, then sews slow forward three stitches, and then positions with the needle down at location 586 of the pocket patch.

Program Steps "20" and "21"—The presser foot of the sewing head 48 will raise, the operator will reposition the pocket patch 566 and the shirt front 570, the presser foot will lower, and the sewing unit 30 will remain idle while the operator verifies the alignment of the pocket patch and shirt front.

Program Steps "22," "23" and "24"—The sewing head needle 50 will sew fast forward 24 stitches, then sew slow forward three stitches to the location 588 of the pocket patch 566, and the needle will be positioned down.

Program Steps "25" and "26"—The presser foot of the sewing head 48 will raise, the operator will reposition the pocket patch 566 and shirt front 570, the presser foot will lower, and the sewing unit 30 will remain idle while the operator verifies the alignment of the pocket patch and shirt front and regrips the same for guiding in the further sewing.

Program Steps "27," "30" and "31"—The sewing head needle 50 will sew fast forward four stitches, then sew slow forward three stitches to location 590 of the pocket patch 566 and then position the needle down.

Program Steps "32" and "33"—The presser foot of the sewing head 48 will raise, the operator will reposition the pocket patch 566 and shirt front 570, the presser foot will lower and the sewing unit 30 will remain idle while the operator regrips the pocket patch and shirt front for guiding during the subsequent sewing operation or step.

Program Steps "34," "35," "36," "37" and "40"—The sewing head needle 50 will sew fast forward 33 stitches, then slow forward three stitches to the location 594 on the pocket patch 566, then sew slow rearwardly four stitches to the location 592, then sew forward four stitches back to the location 594, the needle will position up and the thread trimmer will operate.

Program Steps "41," "42," and "43"—The presser foot of the sewing head 48 will raise, the operator will slide the now permanently assembled pocket patch 566 and shirt front 570 from beneath the sewing head needle 50 and place it on the automatic stacker 578, the automatic stacker will operate, the presser foot will lower and the program step counter 76 of the automatic controller 54 will automatically index back to program step "00" and immediately proceed with the start of a repeat of the entire program.

It can be seen with the use of the automatic controller 34 for automatically carrying out an overall sewing operation performed by the sewing unit 30 that the operator is relieved of the bulk of the decisionmaking and the normally required manual actuation which has heretofore been required for manually actuating sewing units in carrying out such overall sewing operations. The operator does not have to decide the number of stitches to be sewn, decide when the various sewing unit components such as the presser foot of the sewing head 48 are to be raised and lowered or otherwise actuated, nor when to sew slow or when to sew fast. When the material being sewn is of a stable character, the only decisions and manual operations required of the operator are to maintain alignment and perform repositioning of the material parts being sewn, and then the time periods allowed for such opera-

tor manual operations are regulated as to length so that the operator will be aided in maintaining a rhythmical overall sewing operation for producing a greater number of sewn articles with greater accuracy and less fatiguing.

When the operator is of relatively lower skills, the program of the automatic controller 34 can be provided with the training stops or delays permitting the operator to stop for an indeterminate period of time. After a period of time, these training stops can be eliminated, either part or all, merely by switching either or both of the training stop No. 1 and training stop No. 2 switches 86 and 88 on the automatic controller 34 to be "off" position. Thus, despite the complete automatic control of the overall sewing operation by the sewing unit 30, this program control may be used with relatively unskilled operators for convenient training of the same, and after such training the overall programming of the automatic controller 34 need not be altered, but only the various training stops or delays conveniently removed without affecting the overall program.

As previously mentioned, where the sewing of relatively unstable materials is involved, any and probably all of the individual sewing steps may be programmed into the automatic controller 34 so that the automatic controller would automatically control a stitching step for carrying out a predetermined number of stitches, and then the automatic controller would merely maintain the sewing head needle 50 continuing to stitch for an indeterminate stitching, the operator would be required to maintain a visual observation of the progress and stop the stitching at the exact location desired by manually actuating the appropriate manual control or switch. Thus, with these stopping locations varying from one overall sewing operation to the next with the use of the relatively unstable material, the overall sewing operation can still be carried out under the control of the automatic controller 34, but with the operator manual assistance.

It is also possible according to the methods of the present invention and with the sewing equipment controls as described, to insert in a program of the automatic controller 34, indeterminate stops or delays which are not training stops, but rather permanently remain in the program of the automatic controller 34. These indeterminate stops or delays would be used with the sewing equipment, or with other manufacturing equipment, where manual operations or various equipment operations necessary to take place between other program steps are of an indeterminate nature, that is, varying from one overall sewing or manufacturing operation to the next. Such indeterminate delays were not used in the illustrated overall sewing operation, but the possibility of including the same in a program for an overall sewing or manufacturing operation illustrates the wide versatility of the control devices for carrying out the methods of the present invention and their ready applicability to a wide variety of manufacturing equipment.

In the foregoing illustrative programming of the automatic controller 34 with the overall sewing operation, the delay adjustment switch 84 of the automatic controller 34 was maintained at a midpoint adjustment and this adjustment switch provides added versatility for the equipment by permitting adjustments of the time units measured by the automatic controller to either slower time units or faster time units. In other words, by being able to alter the individual length of a time unit, it is possible to alter all program steps having the duration thereof measured in such time units, whether such program steps are composite steps of both component operation and duration measured in time units or merely delays measured in time units, and this can be done after the programming of the automatic controller 34 without affecting such program other than this stated alteration.

As applied to the sewing unit 30, alteration of the time units by the delay adjustment switch 84 of the automatic controller 34 can be used to alter, within limits, the determined delays between sewing steps during which the operator is permitted to perform manual repositioning of the material being sewn. Thus, when the skills of the operator reach an appropriate

level, such delay time adjustment can be used to even further improve the efficiency of the operator, all without affecting the original programming of the automatic controller 34.

Although previously not mentioned relative to the programming of the automatic controller 34, the power interface 32 does include a speed control switch 60 adjustable for regulating the speed, preferably only, of the high-speed drive motor 52, and this adjustment may be used to alter after programming those program steps containing a composite instruction or instructions having the duration thereof measured in component operations or movements. As applied to the sewing unit 30, the movements of the sewing head needle 50 are counted by the needle counter and positioner 42 with such information being transmitted to the automatic controller 34 so that the instructions for the sewing steps are predicated on sewing head needle reciprocal movements and determined thereby. Thus, if the speed control switch 60 is altered, say to faster, each of the sewing head needle reciprocal movements will be faster and the sewing or stitching steps will be of less required duration to perform or accomplish the same number of stitches. This, again, provides even greater versatility for the control devices in carrying out the methods of the present invention with any sewing or other manufacturing equipment automatically controlled thereby.

We claim:

1. In a method of automatically controlling manufacturing equipment normally manually controlled by an operator for carrying out a series of manufacturing operations on an article to be manufactured, the steps of: manually actuating certain manufacturing components of said manufacturing equipment to carry out a series of preplanned manufacturing operations in a preplanned order on an article to be manufactured; during said manufacturing component manual actuation, actuating at least one of said manufacturing components through a plurality of manufacturing operations each comprised of a number of consecutively repeated substantially identical movements during each actuation of said one manufacturing component with the number of said one manufacturing component movements in any given operation of said one manufacturing component being free of required relationship to any other operation of said one manufacturing component; during said manufacturing component manual actuation, recording in an automatic controller at least certain of said manufacturing component actuations in said preplanned order including exactly counting and exactly recording said exact count of the number of said one manufacturing component consecutively repeated substantially identical movements during each of said one manufacturing component manufacturing operations to create at least part of a record of said preplanned manufacturing operations in said preplanned order; and directly using said record created by said manufacturing component manual actuations in said automatic controller, automatically actuating said manufacturing components by said automatic controller to repeat said carrying out of said series of preplanned manufacturing operations in said preplanned order on an article to be manufactured including the repeating of said one manufacturing component exactly counted and consecutively repeated substantially identical movements for each of said one manufacturing component manufacturing operations exactly as recorded by said automatic controller.

2. A method of automatically controlling manufacturing equipment as defined in claim 1 in which each of said manufacturing operations carried out by said step of manually actuating said manufacturing components consists of both function and duration, said function being measured by the particular of said manufacturing components being manually actuated, said duration being measured by the exact number of said consecutively repeated substantially identical movements for each manufacturing operation of at least said one manufacturing component during said manual actuation and an elapsed time measured in a given number of preset time elements sufficient for operation of others of said manufacturing components during said manual actuation; in which said step

of recording said manufacturing component actuations includes the recording of both said function and the exact count of said repeated movements and said time elements for said duration; and in which said step of automatically actuating said manufacturing components by said automatic controller includes said actuating according to said function and said repeated movement and said time element exact counts for said duration.

3. A method of automatically controlling manufacturing equipment as defined in claim 1 in which said method includes the step of during said manufacturing component manual actuation, recording in said automatic controller preplanned instruction commands independently artificially generated free of said manual actuation of said manufacturing components intermediate said recording of said certain manufacturing component actuation but in exact finally intended sequence relative thereto, said preplanned instruction commands when used by said automatic controller causing automatic actuation of particular of said manufacturing components to exactly carry out in proper intended sequence particular of said series of preplanned manufacturing operations; and in which said step of directly using said automatic controller record includes the directly using of said record created by both said manufacturing component manual actuations and said artificially generated preplanned instruction commands.

4. A method of automatically controlling manufacturing equipment as defined in claim 1 in which said method includes the step of during said manufacturing component manual actuation, recording in said automatic controller in exact finally intended sequence determined time delays between said recording of preplanned of said component actuations with said determined time delays being measured in a given exact number of preset time elements and each determined time delay being free of required relationship to any other to form a part of said automatic controller record, and causing said determined time delays in sequence between said preplanned component actuations upon said direct use of said automatic controller record during which determined time delays none of said manufacturing components are actuated.

5. A method of automatically controlling manufacturing equipment as defined in claim 1 in which said method includes the step of during said manufacturing component manual actuation, recording in said automatic controller in exact finally intended sequence determined time delays between said recording of preplanned of said component actuations with said determined time delays being measured in a given exact number of preset time elements and each determined time delay being free of required relationship to any other to form a part of said automatic controller record, and causing said determined time delays in sequence between said determined manufacturing components upon said direct use of said automatic controller record during which determined time delays none of said manufacturing components are actuated; and in which said step of recording said determined time delays in said automatic controller includes the step of during said manufacturing component manual actuation, recording said determined time delays in said automatic controller in said exact finally sequence by one of delaying for a predetermined time between said manufacturing component manual actuations while continuing said recording creating a time delay equivalent to a particular intended of said determined time delays for recording in said automatic controller record and inserting an artificially generated preplanned instruction command calling for a predetermined exact number of said preset time elements into said automatic controller record equivalent to a particular of said determined time delays at appropriate sequential location in said automatic controller record to cause said particular intended determined time delay.

6. A method of automatically controlling manufacturing equipment as defined in claim 1 in which said method includes the step of during said manufacturing component manual actuation, recording in said automatic controller record by artificial generation and independent insertion therein at



preplanned locations in proper sequence indeterminate time delays intermediate certain of said one manufacturing component manufacturing operations causing said automatic controller to delay for an indeterminate period of time upon sequentially reaching one of said indeterminate time delays intermediate one of said one manufacturing component manufacturing operations in said automatic controller record during said direct use of automatic controller record and requiring a manual actuation of said automatic controller to commence resumption of said sequential direct use of said automatic controller record in continuing particular of said one manufacturing component manufacturing operation.

7. A method of automatically controlling manufacturing equipment as defined in claim 1 in which said method includes the step of during said manufacturing component manual actuation, recording in said automatic controller in exact finally intended sequence determined time delays between said recording of preplanned of said component actuations with said determined time delays being measured in a given exact number of preset time elements and each determined time delay being free of required relationship to any other to form a part of said automatic controller record, and causing said determined time delays in sequence between said preplanned component actuations upon said direct use of said automatic controller record during which determined time delays none of said manufacturing components are actuated; and in which same method includes the step of during said manufacturing component manual actuation, recording in said automatic controller record by artificial generation and independent insertion therein at preplanned locations in proper sequence indeterminate time delays intermediate certain of said one manufacturing components manufacturing operations causing said automatic controller to delay for an indeterminate period of time upon sequentially reaching one of said indeterminate time delays intermediate one of said one manufacturing component manufacturing operations in said automatic controller record during said direct use of said automatic controller record and requiring a manual actuation of said automatic controller to commence resumption of said sequential direct use of said automatic controller record in continuing the particular of said one manufacturing component manufacturing operation.

8. A method of automatically controlling manufacturing equipment as defined in claim 1 in which said method includes the step of during said manufacturing component manual actuation, recording in said automatic controller record by artificial generation and independent insertion therein at preplanned locations in proper sequence indeterminate time delays intermediate certain of said one manufacturing component manufacturing operations causing said automatic controller to delay for an indeterminate period of time upon sequentially reaching one of said indeterminate time delays intermediate one of said one manufacturing component manufacturing operations in said automatic controller record during said direct use of said automatic controller record and requiring a manual actuation of said automatic controller to commence resumption of said sequential direct use of said automatic controller record in continuing the particular of said one manufacturing component manufacturing operation; and in which said method includes the step of later permanently eliminating for any desired period of time during later repeated uses of said automatic controller record at least certain of said indeterminate time delays from said automatic controller record without otherwise affecting said automatic controller record and the direct use of said record, said automatic controller record after said certain indeterminate time delay elimination being directly usable to automatically actuate said manufacturing components by said automatic controller in the same preplanned sequence as if said certain determinate time delays had not been inserted in said automatic controller record.

9. A method of automatically controlling manufacturing equipment as defined in claim 1 in which said method includes

the step of during said manufacturing component manual actuation, recording in said automatic controller in exact finally intended sequence determined time delays between said recording of preplanned of said component actuations with said determined time delays being measured in a given exact number of preset time elements and each determined time delay being free of required relationship to any other to form a part of said automatic controller record, and causing said determined time delays in sequence between said preplanned component actuations upon said direct use of said automatic controller record during which determined time delays none of said manufacturing components are actuated; and in which said method includes the step of later selectively varying the determined length of said determined time delays in said automatic controller record by varying the length of each of said preset time elements making up each of said determined time delays without otherwise appreciably affecting said automatic controller record and the direct use thereof in automatically actuating said manufacturing components, said selective varying of said determined time delays causing said determined time delays in said automatic controller record to permanently have the delaying effect according to said selective variation thereof in the same preplanned sequence during later repeated uses of said automatic controller record until further selectively varied.

10. A method of automatically controlling manufacturing equipment as defined in claim 1 in which said step of manually actuating said certain manufacturing components includes the actuation of said one manufacturing component to carry out its said plurality of manufacturing operations and the placing of said one manufacturing component in a first position at the end of some of said one manufacturing component manufacturing operations and in a second position at the end of at least one of said one manufacturing component manufacturing operations; in which said step of recording in said automatic controller said manufacturing component actuations includes the recording of the appropriate of said first and second positions for the stopping of each of said one manufacturing component manufacturing operations; and in which said step of directly using said automatic controller record includes the automatically actuating said one manufacturing component for said plurality of manufacturing operations and the stopping of said one manufacturing component in said appropriate of said first and second positions according to said automatic controller record.

11. A method of automatically controlling manufacturing equipment as defined in claim 1 in which said manufacturing equipment is sewing equipment and said at least one of said manufacturing components is a sewing head with a reciprocal needle actuatable through said plurality of manufacturing operations each comprised of a number of consecutively repeated needle reciprocations for carrying out sewing operations and the others of said manufacturing components are other sewing equipment components actuatable for carrying out operations related to said sewing operations; and in which said steps of manually actuating, recording said manual actuations and directly using said record created include the use of needle reciprocation exact count for determining and controlling each of said reciprocal needle sewing operations, and make use of time periods sufficient for operation of said other sewing equipment components for determining and controlling at least certain of said operations related to said sewing operations.

12. A method of automatically controlling manufacturing equipment as defined in claim 1 in which said manufacturing equipment is sewing equipment and said at least one of said manufacturing components is a sewing head with a reciprocal needle actuated through said plurality of manufacturing operations each comprised of a number of consecutively repeated needle reciprocations for carrying out sewing operations and the others of said manufacturing components are other sewing equipment components actuated for carrying out operations related to said sewing operations; in which said se-

ries of preplanned manufacturing operations include a plurality of consecutive sequential sewing operations; and in which said method includes the step of during said manufacturing component manual actuation, recording in said automatic controller in exact finally intended sequence determined time delays between said sequential sewing operations with said determined time delays being measured in a given exact number of preset time elements and each determined time delay being free of required relationship to any other causing said determined time delays in sequence between said sequential sewing operations during use of said automatic controller record for permitting said operator to reposition said article between said sequential sewing operations.

13. A method of automatically controlling manufacturing equipment as defined in claim 1 in which said manufacturing equipment is sewing equipment and said at least one of said manufacturing components is a sewing head with a reciprocal needle actuated through said plurality of manufacturing operations each comprised of a number of consecutively repeated needle reciprocations for carrying out sewing operations and the others of said manufacturing components are other sewing equipment components actuated for carrying out operations related to said sewing operations; in which said series of preplanned manufacturing operations include a plurality of consecutive sequential sewing operations; in which said method includes the step of during said manufacturing component manual actuation, recording in said automatic controller in exact finally intended sequence determined time delays between said sequential sewing operations with said determined time delays being measured in a given exact number of preset time elements and each determined time delay being free of required relationship to any other causing said determined time delays in sequence between said sequential sewing operations during use of said automatic controller record for permitting said operator to reposition said article between said sequential sewing operations; and in which said method includes the step of during said manufacturing component manual actuation, recording in said automatic controller indeterminate time delays at selected locations in proper sequence in said automatic controller record intermediate certain of said sewing operations causing indeterminate time delays during use of said automatic controller record when said record locations intermediate said certain sewing operations are reached upon said direct use of said record during which none of said sewing equipment components are actuated including said reciprocal needle and requiring a manual actuation by said operator to resume said use of said automatic controller record and actuation of said reciprocal needle.

14. A method of automatically controlling manufacturing equipment as defined in claim 1 in which said manufacturing equipment is sewing equipment and said at least one of said manufacturing components is a sewing head with a reciprocal needle actuated through said plurality of manufacturing operations each comprised of a number of consecutively repeated needle reciprocations for carrying out sewing operations and the others of said manufacturing components are other sewing equipment components actuated for carrying out operations related to said sewing operations; in which said series of preplanned manufacturing operations include a plurality of sequential sewing operations; and in which said method includes the steps of during said manufacturing components manual actuation, recording in said automatic controller record by artificial generation and independent insertion therein at preplanned locations indeterminate time delays causing said automatic controller to delay for an indeterminate period of time upon reaching one of said indeterminate time delays in said automatic controller record during said direct use of said automatic controller record and requiring manual actuation of said automatic controller to commence resumption of said direct use of said automatic controller record, at least certain of said indeterminate time delays being located in said automatic controller record intermediate cer-

tain of said sewing operations, and later permanently eliminating for any desired period of time during later repeated uses of said automatic controller record at least certain of said indeterminate time delays from said automatic controller record without otherwise affecting said automatic controller record and the direct use thereof, said automatic controller record after said certain indeterminate time delay elimination being directly usable to automatically actuate said manufacturing components including said sewing head reciprocal needle by said automatic controller in the same preplanned sequence as if said certain indeterminate time delays had not been inserted in said automatic controller record.

15. A method of automatically controlling manufacturing equipment as defined in claim 1 in which said manufacturing equipment is sewing equipment and said at least one of said manufacturing components is a sewing head with a reciprocal needle actuated through said plurality of manufacturing operations each comprised of a number of consecutively repeated needle reciprocations for carrying out sewing operations and the others of said manufacturing components are other sewing equipment components actuated for carrying out operations related to said sewing operations, said reciprocal needle upon stopping thereof being capable of being positioned in either of a needle down position extending downwardly through an article to be sewn and a needle up position spaced above said article to be sewn; in which said series of preplanned manufacturing operations include a plurality of sequential sewing operations; in which said step of manually actuating said certain manufacturing components includes the actuation of said sewing head reciprocal needle to carry out said sequential repeated reciprocation sewing operations and the positioning of said reciprocal needle upon stopping thereof in said needle down position at the end of some of said sequential sewing operations during which said article to be sewn may be repositioned and in said needle up position at the end of at least one of said sequential sewing operations during which a certain one of said other sewing equipment components requiring such needle positioning for proper actuation thereof may be actuated; in which said step of recording in said automatic controller said manufacturing component actuations includes the recording of the appropriate of said positioning of said sewing head reciprocal needle in its needle down and needle up positions upon the stopping of said sewing operations, the recording of article-repositioning time delays at the ends of said some sequential sewing operations and the recording of actuation of said certain other sewing equipment component at the end of said one sequential sewing operation; and in which said step of directly using said automatic controller record includes the automatically actuating said sewing head reciprocal needle for said sequential sewing operations and the positioning upon stopping of said reciprocal needle in said appropriate of said needle down and needle up positions according to said automatic controller record, the repositioning of said article at the ends of said some sequential sewing operations and the actuation of said certain other sewing equipment component at the end of said one sequential sewing operation.

16. In a method of automatically controlling manufacturing equipment normally manually controlled by an operator for carrying out a series of manufacturing operations on an article to be manufactured, the steps of: manually actuating certain manufacturing components of said manufacturing equipment to carry out a series of preplanned manufacturing operations in a preplanned order on an article to be manufactured; during said manufacturing component manual actuation, temporarily recording in an automatic controller said manufacturing component actuations in said preplanned order; permanently exactly recording at least certain of said temporary recordings in said automatic controller in said preplanned order to create at least part of an exact record of said preplanned manufacturing operations in said preplanned order; and directly using said record at least partially created by said manufacturing component manual actuations permanently recorded in said auto-

matic controller, automatically reactuating said certain manufacturing components by said automatic controller to repeat said carrying out of said series of preplanned manufacturing operations in said preplanned order on an article to be manufactured.

17. A method of automatically controlling manufacturing equipment as defined in claim 16 in which said step of permanently exactly recording at least certain of said temporary recordings includes the elimination of certain of said temporary recordings automatically directly during selected permanent recording of others of said temporary recordings.

18. A method of automatically controlling manufacturing equipment as defined in claim 16 in which said step of permanently exactly recording at least certain of said temporary recordings includes selective elimination of certain of said temporary recordings and selective permanent recording of others of said temporary recordings, replacing selected of said eliminated temporary recordings by permanently recorded commands artificially generated and exactly equivalent to selected manual actuations of said manufacturing components.

19. A method of automatically controlling manufacturing equipment as defined in claim 16 in which said method includes the step of permanently recording in said automatic controller record at interspersed selected locations independently artificially generated commands causing actuation of said manufacturing components exactly according to said independently generated commands upon reaching said record locations during said direct use of said automatic controller record.

20. A method of automatically controlling manufacturing equipment as defined in claim 16 in which said steps of temporarily recording and permanently recording include the recording of said manufacturing component manual actuations in the form of composite instructions consisting of both function and duration, said function of each of said composite instructions being the particular of said manufacturing components actuated, said duration of each of said composite instructions consisting of one of an exact plural number of consecutively repeated substantially identical movements required for a particular at least one of said manufacturing components to carry out particular of said preplanned manufacturing operations and a sufficient length of time for permitting movement of a particular of at least certain others of said manufacturing components for carrying out particular of said preplanned manufacturing operations.

21. A method of automatically controlling manufacturing equipment as defined in claim 16 in which said method includes the step of permanently recording in said automatic controller record determined time delays each of selected time duration between certain of said permanent recordings of said manufacturing components actuations causing exactly equivalent determined time delays between said manufacturing component actuations during said direct use of said automatic controller record and with each determined time delay duration being free of necessary relationship to any other determined time delay duration.

22. A method of automatically controlling manufacturing equipment as defined in claim 16 in which said steps of temporarily recording and permanently recording include the recording of said manufacturing component manual actuations in the form of composite instructions consisting of both function and duration, said function of each of said composite instructions being the particular of said manufacturing components actuated, said duration of each of said composite instructions consisting of one of an exact plural number of consecutively repeated substantially identical movements required for a particular at least one of said manufacturing components to carry out particular of said preplanned manufacturing operations and a sufficient length of time for permitting movement of a particular at least certain others of said manufacturing components for carrying out particular of said preplanned manufacturing operations; in which said method

includes the step of permanently recording in said automatic controller record determined time delays each of selected time durations between certain of said permanent recordings of said manufacturing component actuations causing exactly equivalent determined time delays between said manufacturing component actuations during said direct use of said automatic controller record and with each determined time delay duration being free of necessary relationship to any other determined time delay duration.

23. A method of automatically controlling manufacturing equipment as defined in claim 16 in which said manufacturing equipment is sewing equipment and said manufacturing components include a sewing head with a reciprocal needle actuatable through a plurality of manufacturing operations each comprised of a number of consecutively repeated needle reciprocations for carrying out an equivalent plurality of sewing operations, and other sewing equipment components actuatable for carrying out operations related to said sewing operations; and in which said steps of temporarily recording, permanently recording and directly using said record include the recording for said record of said manufacturing component actuations a record reflecting both function and duration, said function relating to the particular of said sewing head reciprocal needle and said other sewing equipment components being actuated, said duration relating to an exact count of plural numbers of movements of said sewing head reciprocal needle for each of said plurality of said sewing operations and a time period sufficient for movement upon actuation of at least certain others of said other sewing equipment components with said exact count of said reciprocal needle movements in each sewing operation being free of any necessary relationship to said exact count in any other sewing operation.

24. A method of automatically controlling manufacturing equipment as defined in claim 16 in which said manufacturing equipment is sewing equipment and said manufacturing components include a sewing head with a reciprocal needle actuatable through a plurality of manufacturing operations each comprised of a number of consecutively repeated needle reciprocations for carrying out an equivalent plurality of sewing operations, certain of said series of preplanned manufacturing operations including a plurality of sequential sewing operations; in which said steps of temporarily recording, permanently recording and directly using said record include the recording for said record an exact count of plural numbers of reciprocal movements of said sewing head reciprocal needle for each of said plurality of said sewing operations with said exact count of said reciprocal needle movements in each sewing operation being free of any necessary relationship to said exact count in any other sewing operation; in which said method includes the step of permanently recording in said automatic controller to form a part of said automatic controller record determined time delays each of selected time durations between said sewing operations resulting in time delays exactly equivalent to said determined time delays between said sequential sewing operations during which said sewing head reciprocal needle is not actuated during said direct use of said automatic controller record and with each determined time delay duration being free of necessary relationship to any other determined time delay duration; and in which said method includes the step of manually repositioning said article to be manufactured during said determined time delays.

25. A method of automatically controlling manufacturing equipment as defined in claim 16 in which said manufacturing equipment is sewing equipment and said manufacturing components include a sewing head with a reciprocal needle actuatable through a plurality of manufacturing operations each comprised of a number of consecutively repeated needle reciprocations for carrying out an equivalent plurality of sewing operations, and other sewing equipment components actuatable for carrying out operations related to said sewing operations; in which said steps of temporarily recording, permanently recording and directly using said record include the

recording for said record of said manufacturing component actuations a record reflecting both function and duration, said function relating to the particular of said sewing head reciprocal needle and said other sewing equipment components being actuated, said duration relating to an exact count of plural numbers of movements of said sewing head reciprocal needle for each of said plurality of said sewing operations and a time period sufficient for movement upon actuation of at least certain others of said other sewing equipment components with said exact count of said reciprocal needle movements in each sewing operation being free of any necessary relationship to said exact count in any other sewing operation; in which said step of manually actuating said certain manufacturing components includes the manually actuating of said sewing head reciprocal needle to carry out a plurality of sequential sewing operations; in which said steps of permanently recording and directly using said automatic controller record includes the steps of permanently recording in said automatic controller record determined time delays each of selected time durations between said sequential sewing operations by said sewing head reciprocal needle resulting in time delays exactly equivalent to said determined time delays upon said direct use of said automatic controller record during which said sewing head reciprocal needle is not actuated and with each determined time delay duration being free of necessary relationship to any other determined time delay duration; and in which said method includes the step of manually repositioning said article during said determined delays between said sequential sewing operations.

26. In a method of automatically controlling manufacturing equipment normally manually controlled by an operator for carrying out a series of manufacturing operations on an article to be manufactured, the steps of: manually actuating certain manufacturing components of said manufacturing equipment to carry out a series of preplanned manufacturing operations in a preplanned order on an article to be manufactured; during said manufacturing component manual actuations; translating at least certain said manual actuations in said preplanned order into instruction signals corresponding to said manufacturing component manual actuations; permanently recording in an automatic controller at least certain of said instruction signals in said preplanned order to create at least part of a permanent record of said instruction signals corresponding to said preplanned manufacturing operations in said preplanned order; and directly using said permanent instruction signal record created in said automatic controller, retranslating instruction signals permanently recorded in said automatic controller into commands automatically actuating said manufacturing components to repeat said carrying out of said series of preplanned manufacturing operations in said preplanned order on an article to be manufactured.

27. A method of automatically controlling manufacturing equipment as defined in claim 26 in which said method includes the step of recording in said automatic controller preplanned independently artificially generated instruction signals at determined locations in said instruction signal record, said independently generated instruction signals being exactly equivalent to instruction signals causing preplanned particular actuation of particular manufacturing components during said direct use of said instruction signal record.

28. A method of automatically controlling manufacturing equipment as defined in claim 26 in which said method includes the step of recording in said automatic controller record preplanned determined time delay instruction signals at determined locations between said instruction signals for said manufacturing component actuations resulting in preplanned determined time delays each of selected time duration between said determined manufacturing component actuations upon said direct use of said instruction signal record of said automatic controller and with each determined time delay duration being free of necessary relationship to any other determined time delay duration.

29. A method of automatically controlling manufacturing equipment as defined in claim 26 in which at least one of said certain manufacturing components upon said manual actuation thereof is movable through a plurality of consecutively repeated substantially identical movements to carry out each of certain of said series of preplanned manufacturing operations; in which said step of permanently recording in said automatic controller includes the recording in said automatic controller of instruction signals from one of instruction signals translated directly from manual actuation of said repeated movement manufacturing component and instruction signals independently artificially generated but equivalent to those which would be translated from said manual actuation of said repeated movement manufacturing component; and in which said steps of permanently recording said instruction signals and said direct use of said instruction signal record for said actuation of said repeated movement manufacturing component includes the use of instruction signals consisting of both function and duration, said function corresponding to actuation of said repeated movement manufacturing component, said duration being measured in an exact count of the number of repeated movements of said repeated movement manufacturing component during each said actuation with said exact count for any one of said actuations being free of required relationship to said exact count for any other of said actuations.

30. A method of automatically controlling manufacturing equipment as defined in claim 26 in which said certain manufacturing components include a component during each actuation thereof carrying out a plurality of consecutively repeated substantially identical movement and being positionable in either of first and second positions after each actuation thereof, said series of preplanned manufacturing operations including a plurality of manufacturing operations carried out by said positionable manufacturing component; and in which said method includes the step of permanently recording in said automatic controller to create a part of said automatic controller permanent record, instruction signals which when translated cause positioning of said positionable manufacturing component in said first position at the end of certain of said positionable manufacturing component repeated movement actuations and the positioning of said positionable manufacturing component in said second position at the end of at least one of said positionable manufacturing component repeated movement actuations.

31. A method of automatically controlling manufacturing equipment as defined in claim 26 in which said manufacturing equipment is sewing equipment and said manufacturing components include a sewing head with a reciprocal needle actuated through a plurality of manufacturing operations each comprised of a number of consecutively repeated needle reciprocations for carrying out an equivalent plurality of sewing operations; in which said series of preplanned manufacturing operations include a plurality of sequential sewing operations; and in which said method includes the steps of recording in said automatic controller permanent record preplanned determined time delay instruction signals between instruction signals for said sewing head reciprocal needle actuations in carrying out said sewing operations resulting in determined time delays each of selected time duration between said sewing operations upon said direct use of said permanent instruction signal record of said automatic controller and with each determined time delay duration being free of necessary relationship to any other determined time delay duration, and manually repositioning said article during said determined time delays between said sewing operations.

32. A method of automatically controlling manufacturing equipment as defined in claim 26 in which said manufacturing equipment is sewing equipment and said manufacturing components include a sewing head with a reciprocal needle actuated for carrying out sewing operations; in which said series of preplanned manufacturing operations include a plurality of sequential sewing operations; in which said sewing head reciprocal needle upon said manual actuation thereof is mov-

ble through a plurality of needle reciprocations to carry out each of said sewing operations; in which said step of permanently recording in said automatic controller includes the recording in said automatic controller of instruction signals from one of instruction signals translated directly from manual actuation of said sewing head reciprocal needle and instruction signals independently artificially generated but equivalent to those which would be translated from said manual actuation of said reciprocal needle; and in which said steps of permanently recording said instruction signals and said direct use of said instruction signal record for said actuation of said sewing head reciprocal needle includes the use of instruction signals consisting of both function and duration, said function corresponding to actuation of said sewing head reciprocal needle, said duration being measured in an exact count of the number of reciprocal movements of said reciprocal needle during each said actuation with said exact count for any one of said actuations being free of required relationship to said exact count for any other of said actuations.

33. A method of automatically controlling manufacturing equipment as defined in claim 26 in which said manufacturing equipment is sewing equipment and said manufacturing components include a sewing head with a reciprocal needle actuated through a plurality of repeated needle reciprocations for each actuation thereof for carrying out sewing operations and being positionable in either of a needle down position extending downwardly through an article to be sewn and a needle up position spaced above an article to be sewn after each actuation thereof; in which said series of preplanned manufacturing operations include a plurality of sequential sewing operations carried out by said sewing head reciprocal needle; and in which said method includes the step of permanently recording in said automatic controller to create a part of said permanent automatic controller record, instruction signals which when translated cause positioning of said sewing head reciprocal needle in said needle down position at the end of certain of said reciprocal needle sewing operations and the positioning of said reciprocal needle is said needle up position at the end of at least one of said reciprocal needle sewing operations.

34. A method of automatically controlling manufacturing equipment as defined in claim 26 in which said manufacturing equipment is sewing equipment and said manufacturing components include a sewing head with a reciprocal needle actuated through a plurality of repeated needle reciprocations for each actuation thereof for carrying out sewing operations and being capable of positioning at the end of said sewing operation in either of a needle down position extending downwardly through an article to be sewn and a needle up position spaced above said article to be sewn at the end of said sewing operations, a thread cutoff; in which said series of preplanned manufacturing operations include a plurality of sequential sewing operations; in which said method includes the steps of permanently recording in said automatic controller permanent record preplanned determined time delay instruction signals between instruction signals for said sewing head reciprocal needle actuation in carrying out said sequential sewing operations resulting in determined time delays each of selected time duration between said sequential sewing operations upon said direct use of said permanent instruction signal record of said automatic controller and with each determined time delay duration being free of necessary relationship to any other determined time delay duration, and manually repositioning said article to be sewn during said determined time delays between said sequential sewing operations; and in which said method includes the step of permanently recording in said automatic controller to create a part of said permanent automatic controller record, instruction signals which when translated cause positioning of said sewing head reciprocal needle in said needle down position at the end of all of said sequential sewing operations except the last of said sequential sewing operations and the positioning of said reciprocal needle in said needle up position at the end of said last of said sequential sewing operations, and permanently recording in

said automatic controller to create a part of said permanent automatic controller record, an instruction signal which when translated causes actuation of said thread cutoff following said last of said sequential sewing operations.

35. In a method of automatically controlling manufacturing equipment for carrying out a series of manufacturing operations on an article to be manufactured, said series of manufacturing operations requiring according to an overall manufacturing plan interspersed manual operations on said article by an operator, the step of: automatically starting, running and stopping in exact sequence certain manufacturing components of said manufacturing equipment to carry out a series of exactly preplanned sequential manufacturing operations on said article to be manufactured according to said overall manufacturing plan; automatically stopping said manufacturing components between certain of said manufacturing equipment manufacturing operations for selected determined time delays each of selected time durations during which operations are required to be performed manually by an operator on said article according to said overall manufacturing plan and with each determined time delay duration being free of necessary relationship to any other determined time delay duration; maintaining all manufacturing components of said manufacturing equipment free of running throughout said determined time delays; manually performing said operator manual operations on said article during said determined time delays according to said overall manufacturing plan; and automatically starting the appropriate of said manufacturing components at expiration of said determined time delays to continue said series of preplanned sequential manufacturing operations on said article to be manufactured according to said overall manufacturing plan.

36. A method of automatically controlling manufacturing equipment as defined in claim 35 in which said method includes the step of interspersing preplanned indeterminate time delays each of indeterminate time duration intermediate selected of said automatic running of said manufacturing components, said indeterminate time delays causing said manufacturing components to stop and remain stopped until manually actuated to resume said automatic running and complete that particular of said automatic running operation and stop; in which said method includes the steps of terminating each of said indeterminate time delays by said manual actuation; and in which said method includes the step of later eliminating and removing the effect of at least certain of said indeterminate time delays with said elimination of said indeterminate time delays being free of otherwise effecting said automatic carrying out of said manufacturing operations and said determined time delays and with said elimination being permanent for future automatic carrying out of said manufacturing operations.

37. A method of automatically controlling manufacturing equipment as defined in claim 35 in which said method includes the step of selectively proportionally changing permanently until rechanged the duration lengths of a certain plurality of said determined time delays according to the same proportional change despite the freedom of the necessary relationship between said durations and without otherwise effecting said automatic carrying out of said manufacturing operations.

38. A method of automatically controlling manufacturing equipment as defined in claim 35 in which at least one of said certain manufacturing components is a manufacturing component which when started runs through a plurality of consecutively repeated substantially identical component movements to carry out particular of said manufacturing operations; in which said overall manufacturing plan requires a plurality of said particular manufacturing operations involving said one manufacturing component; and in which said step of automatically starting, running and stopping said one manufacturing component includes the controlling of the duration of running of said one manufacturing component in carrying out each of said plural repeated movement one component manufacturing operations by automatically exactly counting

said one component repeated movements and determining the duration length of each of said one manufacturing component manufacturing operations based on exact predetermined numbers of said one manufacturing component repeated movements.

39. A method of automatically controlling manufacturing equipment as defined in claim 35 in which said manufacturing equipment is sewing equipment and said manufacturing components include a sewing head with a reciprocal needle capable of being run through a plurality of needle reciprocations for carrying out each of a plurality of sewing operations; in which said step of automatically starting, running and stopping said certain manufacturing components includes the automatic starting, running and stopping of said sewing head reciprocal needle through a plurality of preplanned sequential sewing operations on an article to be sewn; in which said step of automatically stopping said manufacturing components includes the automatic stopping of said sewing head reciprocal needle between each of said plurality of preplanned sequential sewing operations for said predetermined time delays each of said selected time durations; and in which said step of manually performing said operator manual operations includes the manual repositioning of said article to be sewn during said determined time delays.

40. A method of automatically controlling manufacturing equipment as defined in claim 35 in which said manufacturing equipment is sewing equipment and said manufacturing components include a sewing head with a reciprocal needle capable of being run through a plurality of needle reciprocations for carrying out each of a plurality of sewing operations, said sewing head reciprocal needle being capable of being positioned down upon stopping thereof extending downwardly through an article being sewn; in which said article to be manufactured is an article to be sewn; in which said steps of automatically starting, running and stopping said certain manufacturing components, and automatically stopping said manufacturing components include the automatic starting, running and stopping said sewing head reciprocal needle through a plurality of consecutive sewing operations with said determined time delays between said consecutive sewing operations, automatically positioning said reciprocal needle down extending downwardly through an article to be sewn upon said stopping of said reciprocal needle between said consecutive sewing operations and during said determined time delays therebetween; and in which said step of manually performing said operator manual operations includes the manual repositioning of said article to be sewn with said reciprocal

needle extending downwardly therethrough during said determined time delays between said consecutive sewing operations.

41. A method of automatically controlling manufacturing equipment as defined in claim 35 in which said manufacturing equipment is sewing equipment and said manufacturing components include a sewing head with a reciprocal needle capable of being run through a plurality of needle reciprocations for carrying out each of a plurality of sewing operations, said sewing head reciprocal needle being capable of being positioned in either of a needle down position extending downwardly through an article to be sewn and a needle up position spaced above an article to be sewn upon stopping of said reciprocal needle, a thread cutoff capable of being run with said reciprocal needle in said needle up position for cutting off thread used by said reciprocal needle in carrying out said sewing operations; in which said article to be manufactured is an article to be sewn; in which said step of automatically starting, running and stopping said certain manufacturing components includes the automatic starting, running and stopping said sewing head reciprocal needle through a plurality of reciprocations to carry out each of a plurality of preplanned sequential sewing operations, automatically sensing each of said needle reciprocations during each of said plurality of preplanned sequential sewing operations and automatically determining the length of each of said plurality of preplanned sequential sewing operations by automatically exactly counting said needle reciprocations during each of said plurality of preplanned sequential sewing operations; in which said step of automatically stopping said manufacturing components between certain of said manufacturing operations and automatically determining time delays includes the automatic stopping of said sewing head reciprocal needle and positioning said reciprocal needle in its needle down position extending downwardly through said article to be sewn at the end of each of said plurality of preplanned sequential sewing operations each followed by said determined time delays except the last of said operations; in which said step of manually performing said operator manual operations includes the manual repositioning of said article to be sewn during said determined time delays; and in which said method includes the steps of automatically positioning said sewing head reciprocal needle in its needle up position at the end of said last of said plurality of preplanned sequential sewing operations, and automatically running said thread cutoff after said last sewing operation.

50

55

60

65

70

75