United States Patent

Adler

[15] **3,655,490**

[45] **Apr. 11, 1972**

[54] **APPARATUS FOR PRODUCTION OF PILE CARPETING**

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[73] Assignee: **Adler Process Corp.**, New York, N.Y.

[22] Filed: **May 18, 1970**

[21] Appl. No.: **38,384**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 793,842, Jan. 24, 1969, which is a continuation-in-part of Ser. No. 520,402, Jan. 13, 1966, Pat. No. 3,424,632.

[52] **U.S. Cl.** **156/435,** 156/72, 139/2, 270/83

[51] **Int. Cl.** **D04h 11/08,** D03d 39/00

[58] **Field of Search** 156/72, 435; 28/72.7, 72.5; 300/21

[56] **References Cited**

UNITED STATES PATENTS

3,424,632	1/1969	Adler	156/72
3,309,252	3/1967	Adler	156/72
2,770,283	11/1956	Runton et al.	156/435

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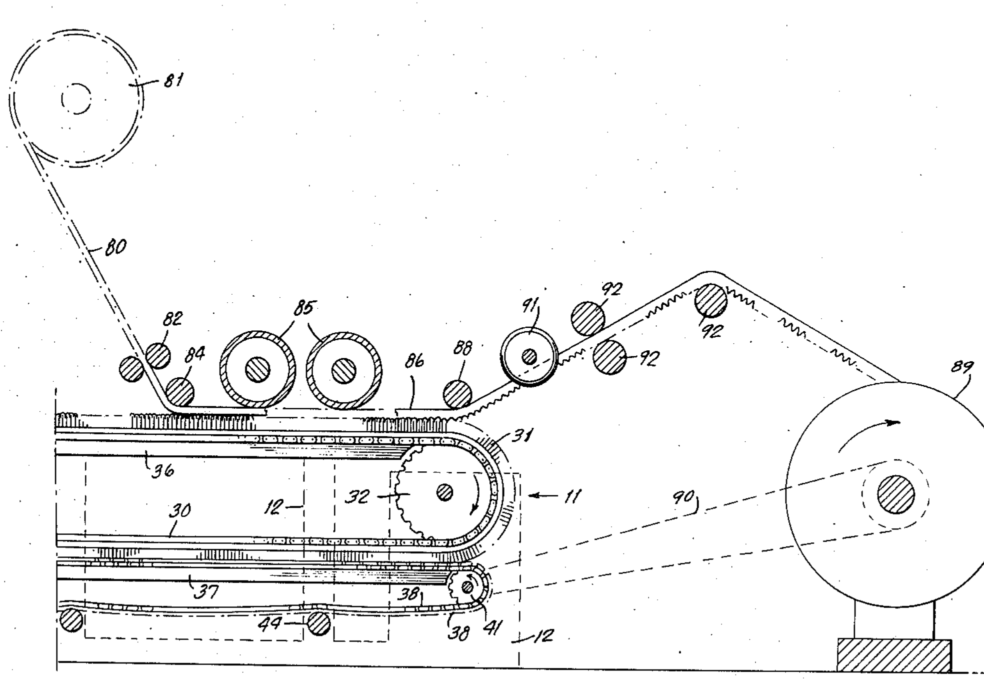
[57] **ABSTRACT**

An improved process and technique for the manufacture of non-woven pile fabrics is provided by an array of loop-forming members disposed in side-by-side relationship, the array of loop-forming members being moved continuously or intermittently between a loop-forming station wherein a loop-forming member or blade descends between two adjacent loop-forming members to press yarns downwardly between said adjacent loop-forming members so as to form loops of yarn therebetween. Between the pair of loop-forming members containing the immediately previously formed loops of yarn a gauge blade is inserted to a distance not greater than and preferably less than the distance said loop-forming blade descends into said first mentioned pair of loop-forming members so as to maintain said previously formed loops of yarn in position and/or at a desired depth between the loop-forming members containing the previously formed loops of yarn as said loop-forming blade descends to form additional loops of yarn.

10 Claims, 24 Drawing Figures



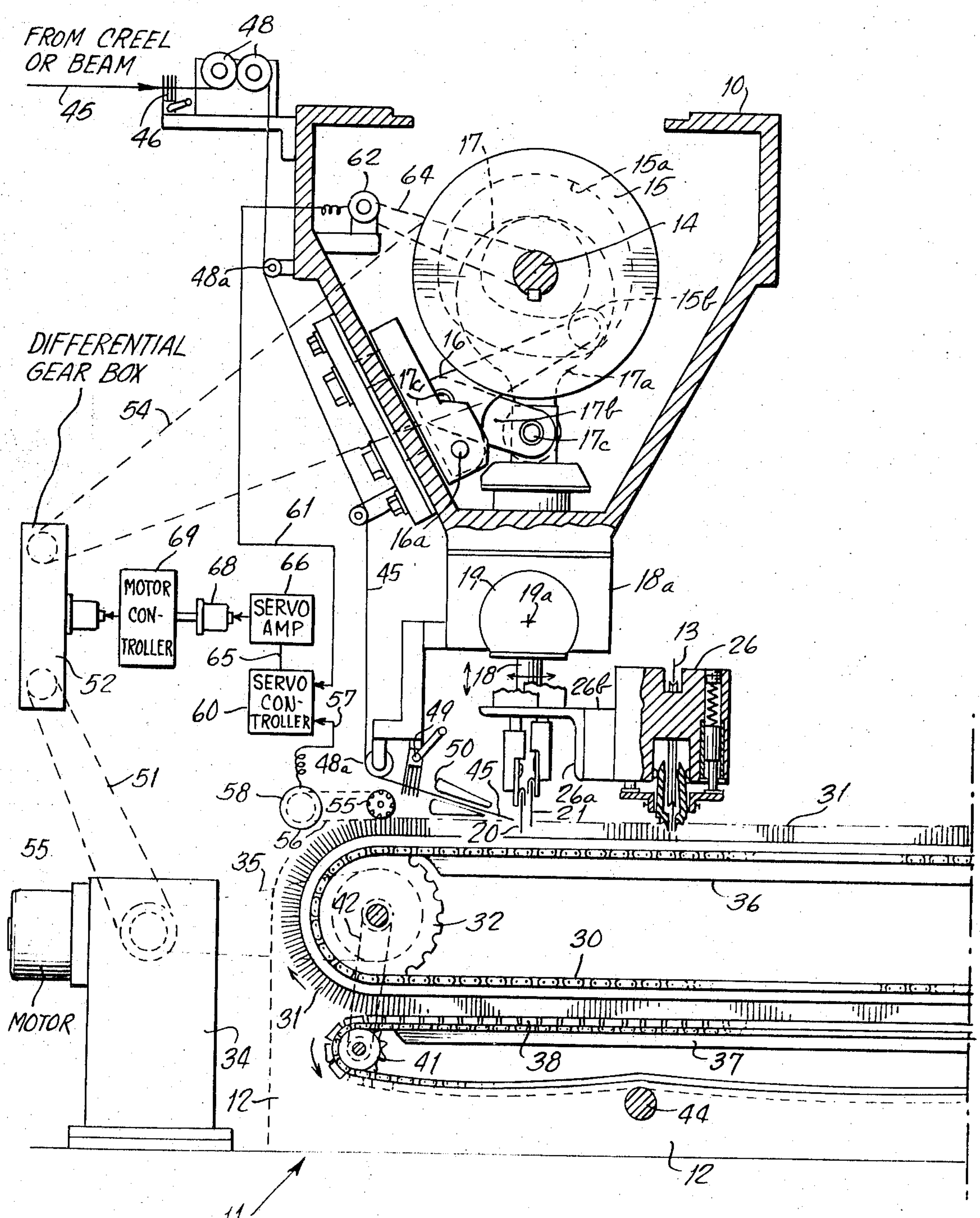


Fig. 1a.

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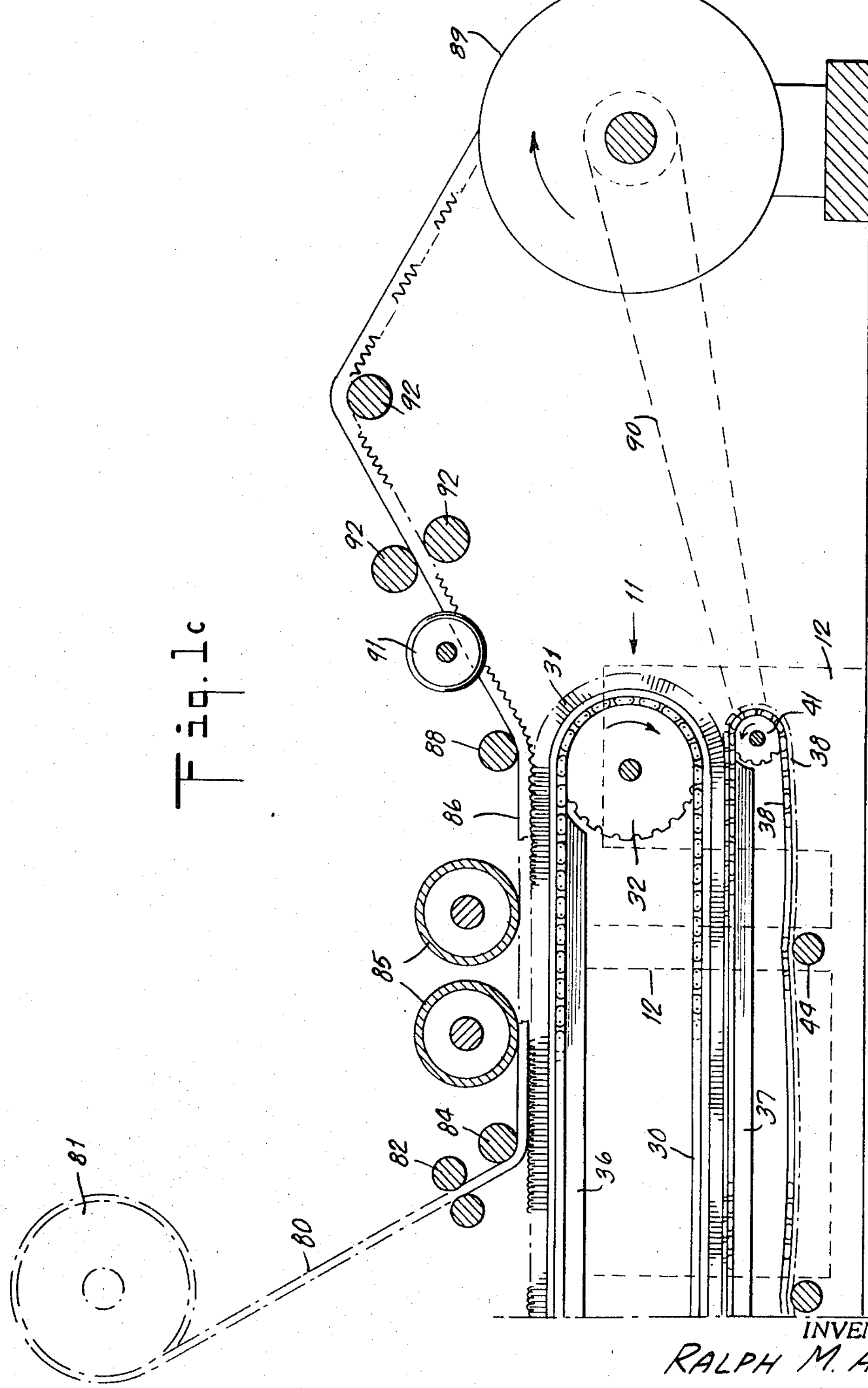

Fig. 1c

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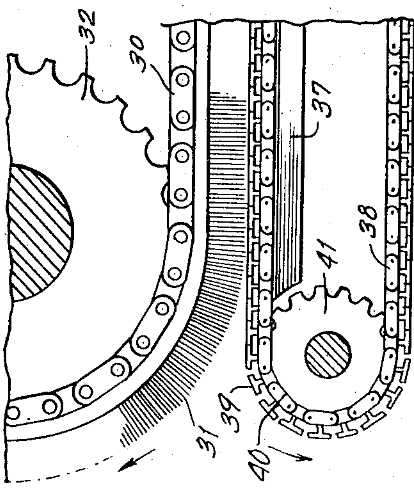

Fig. 2

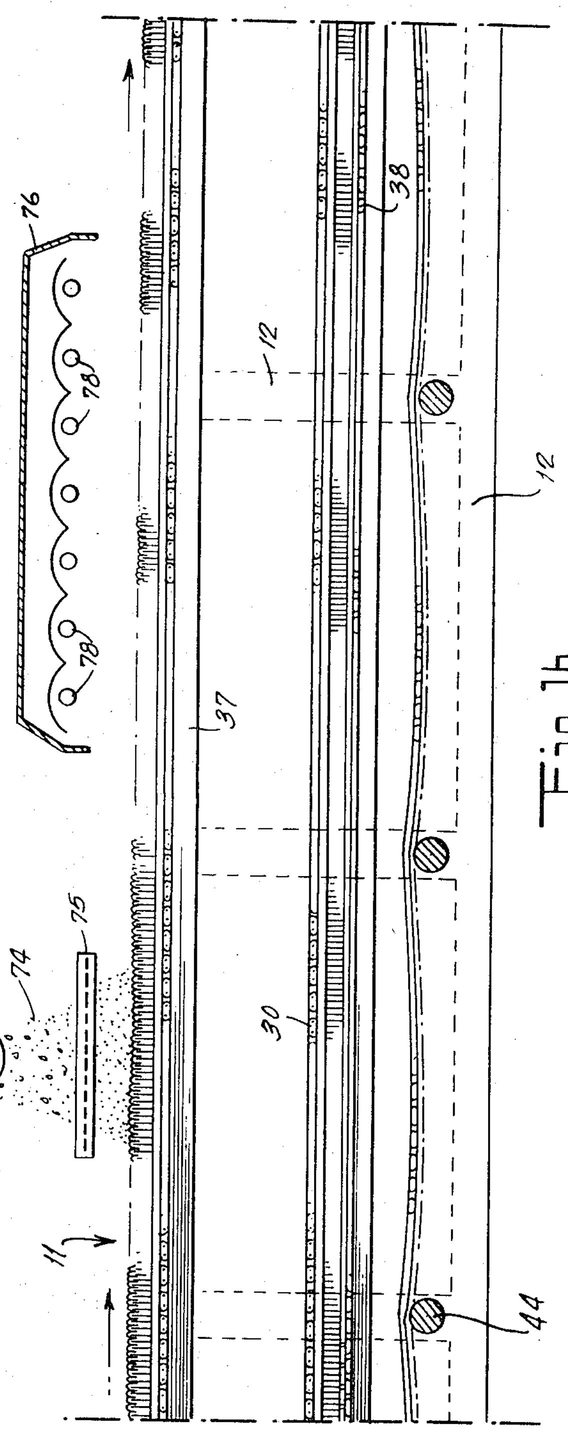

Fig. 1b

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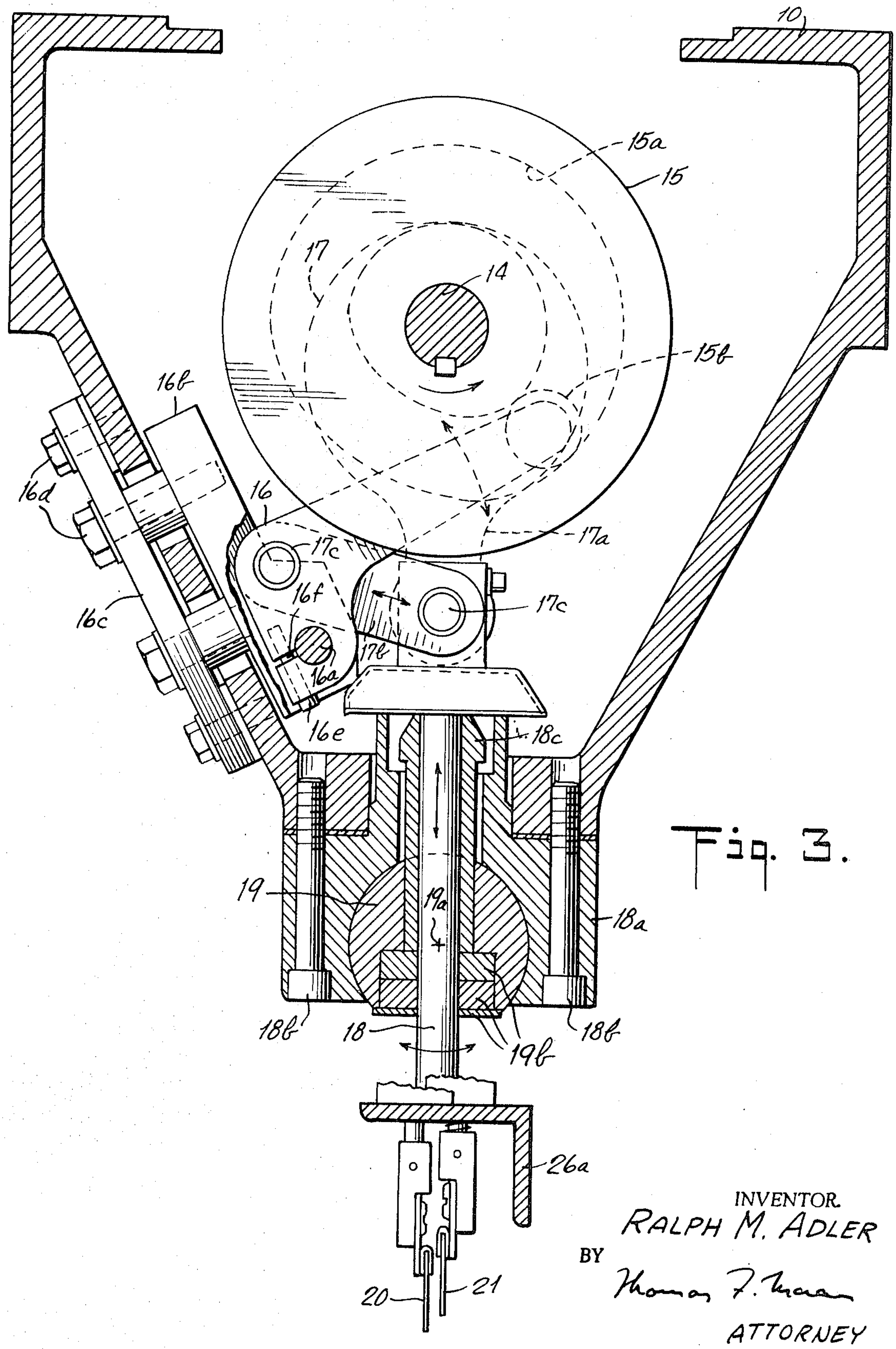

Fig. 3.

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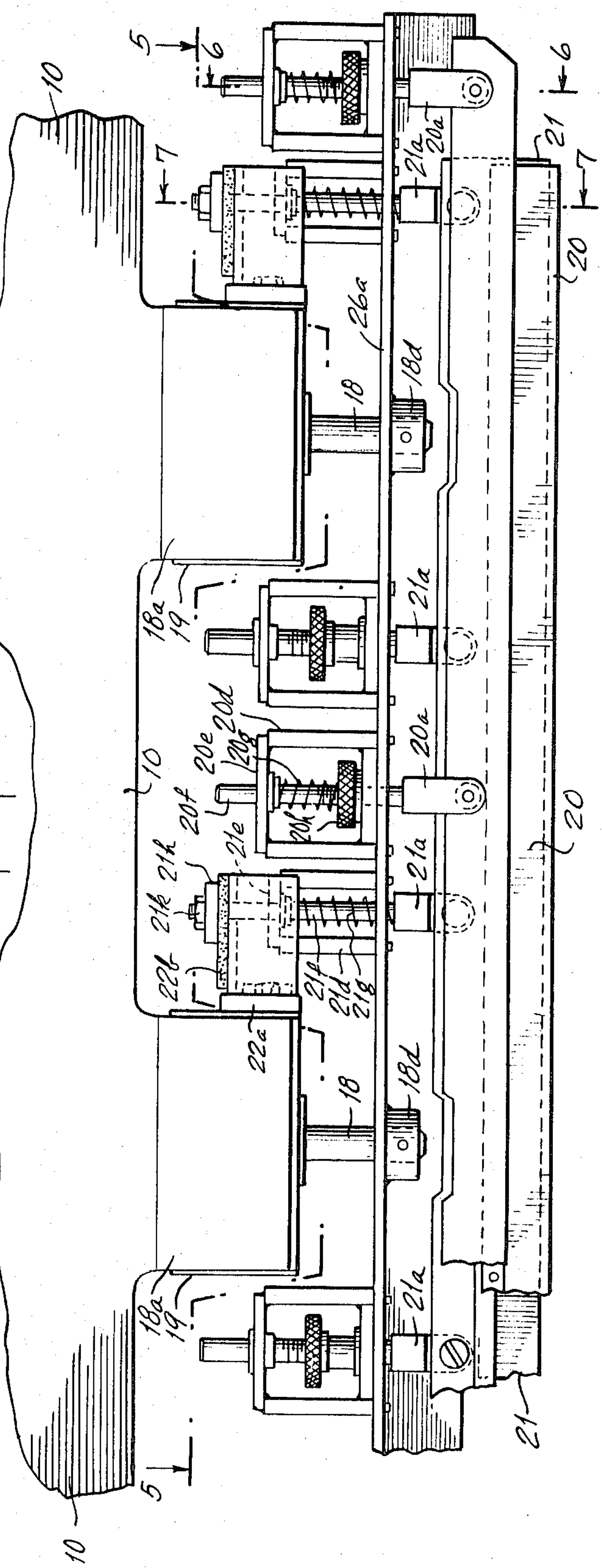

Fig. 4.

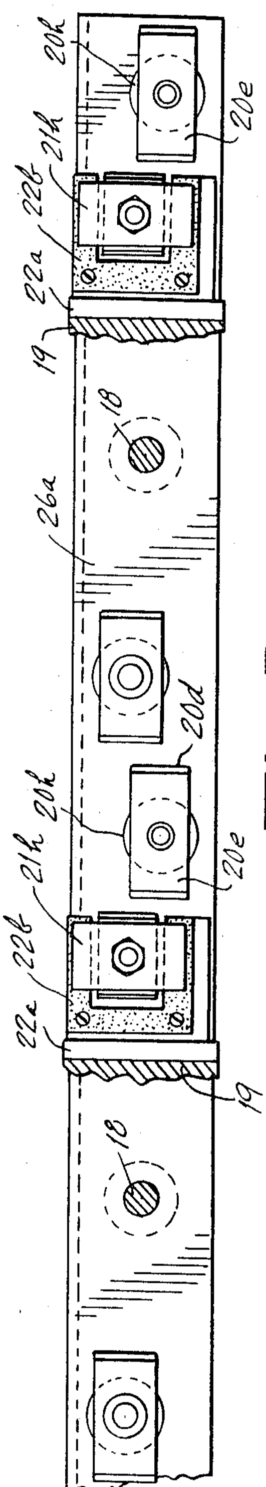

Fig. 5.

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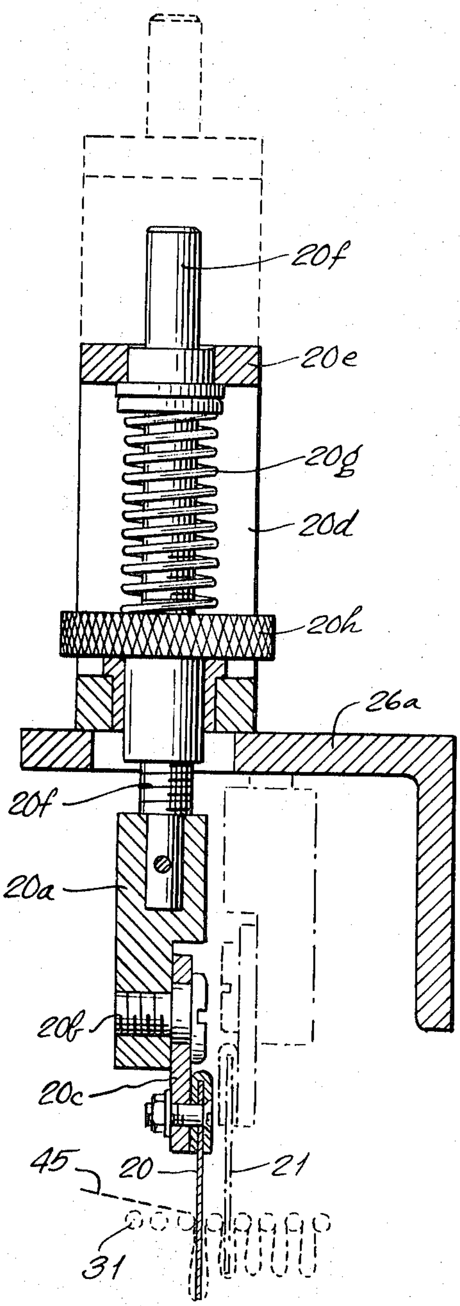

Fig. 6.

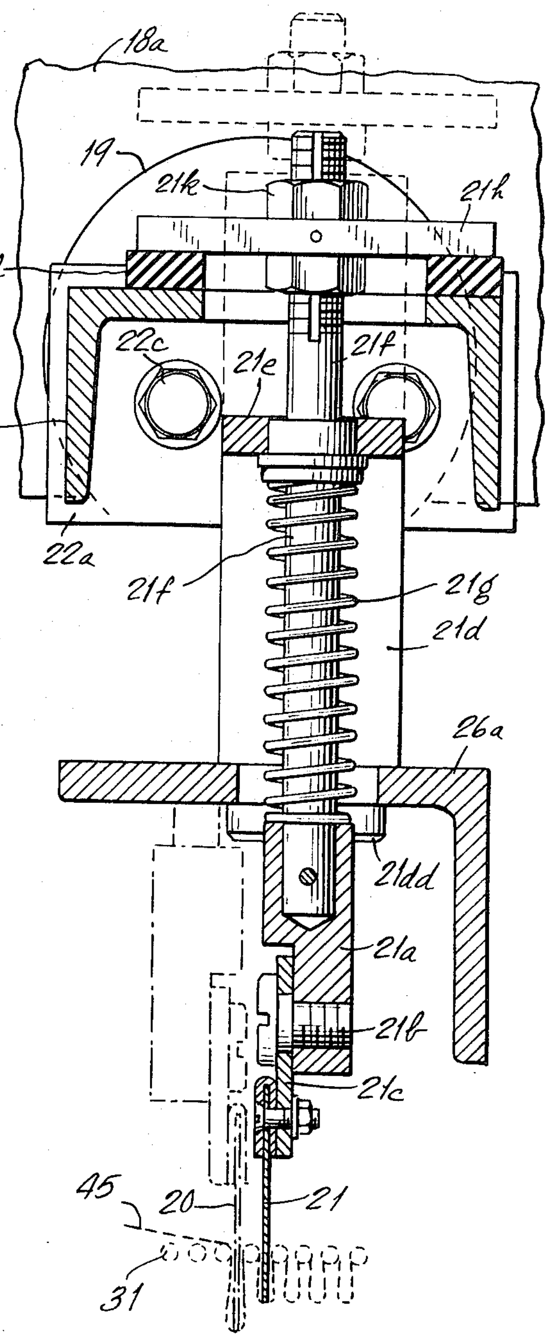

Fig. 7.

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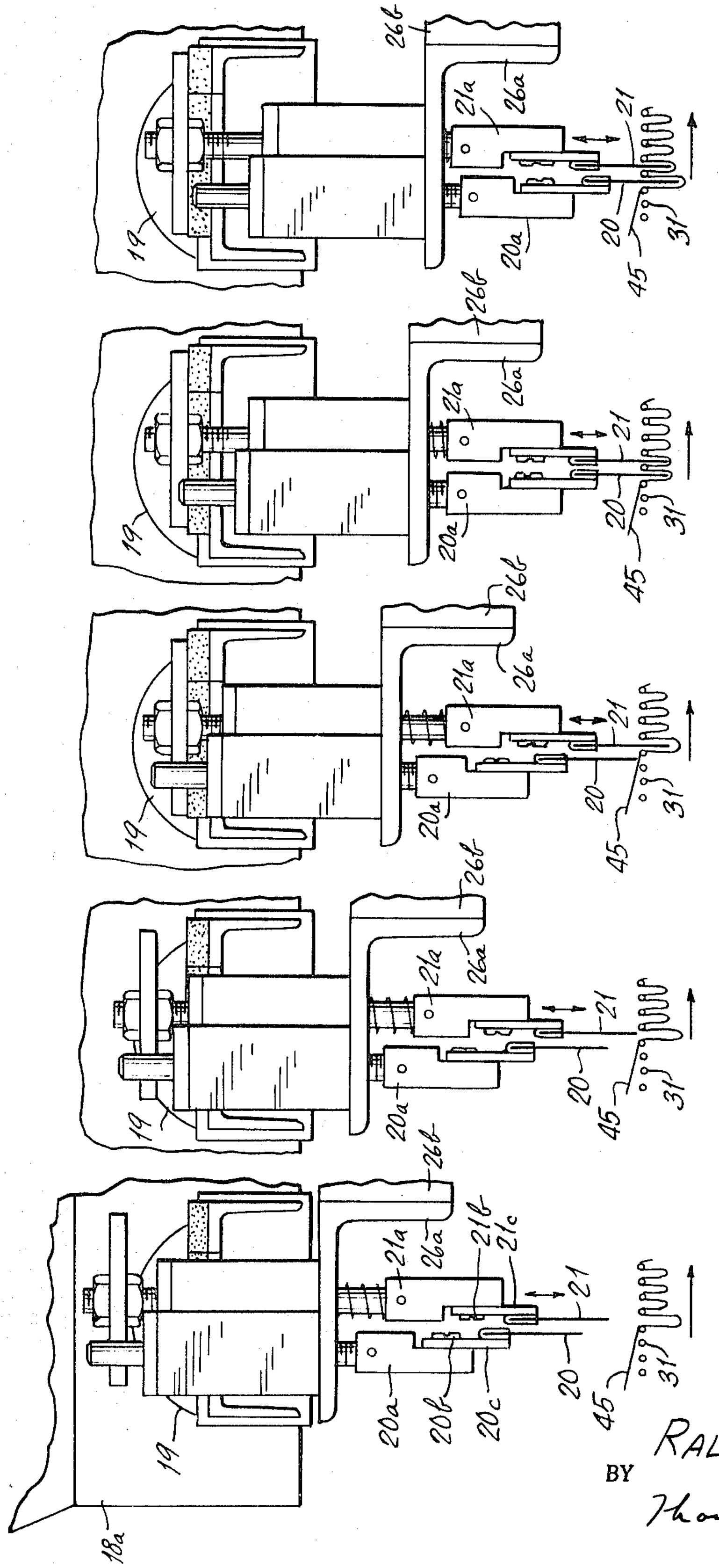

Fig. 8a.

Fig. 8b.

Fig. 8c.

Fig. 8d.

Fig. 8e.

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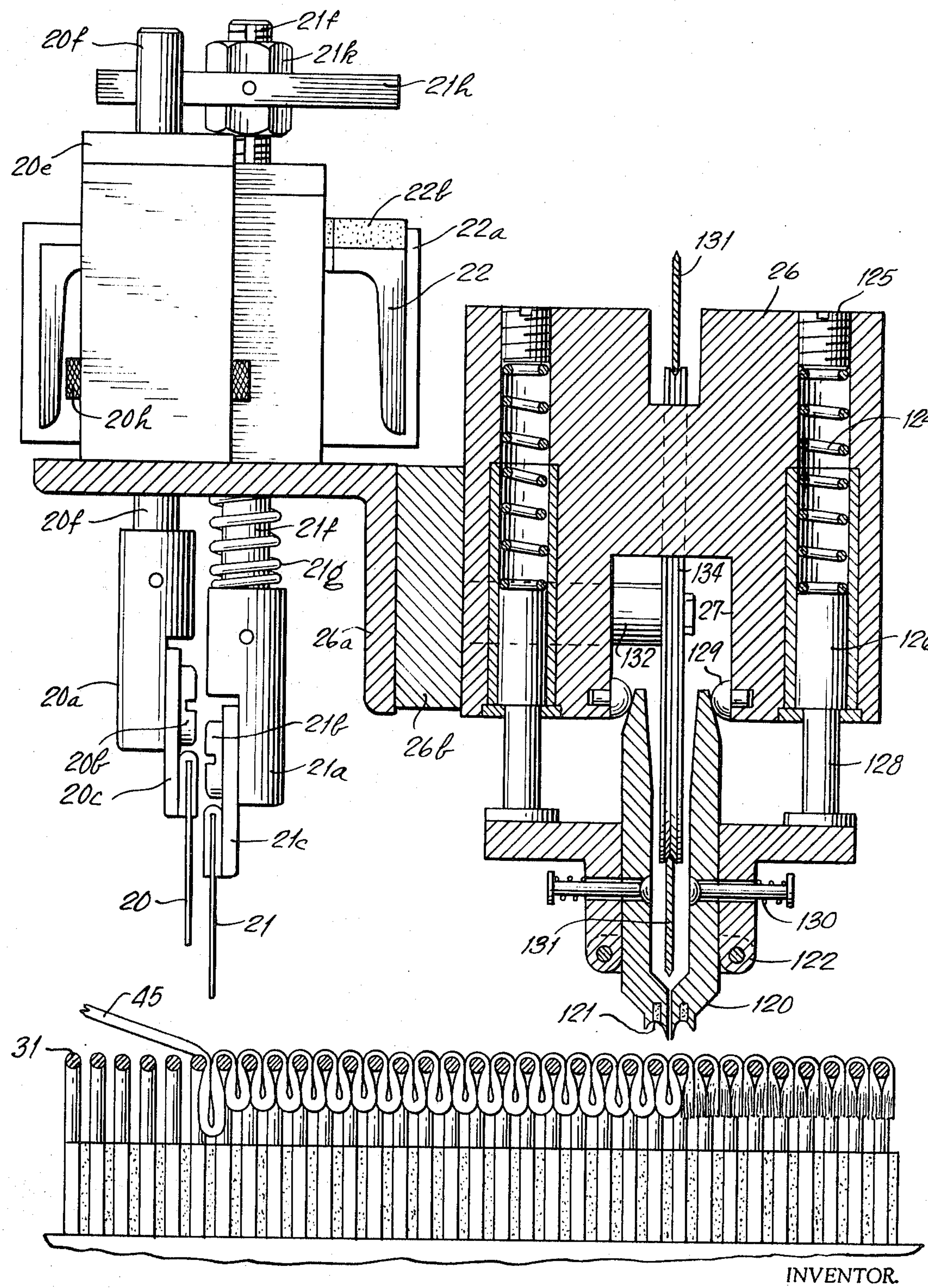

Fig. 9.

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Fig.10c

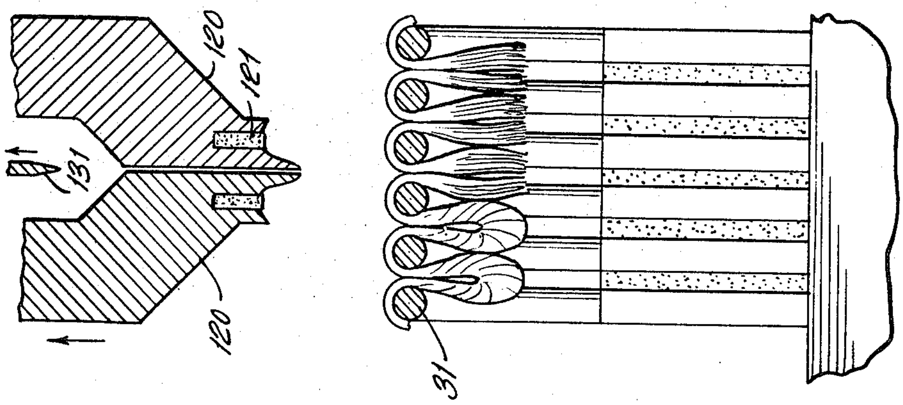


Fig.10b

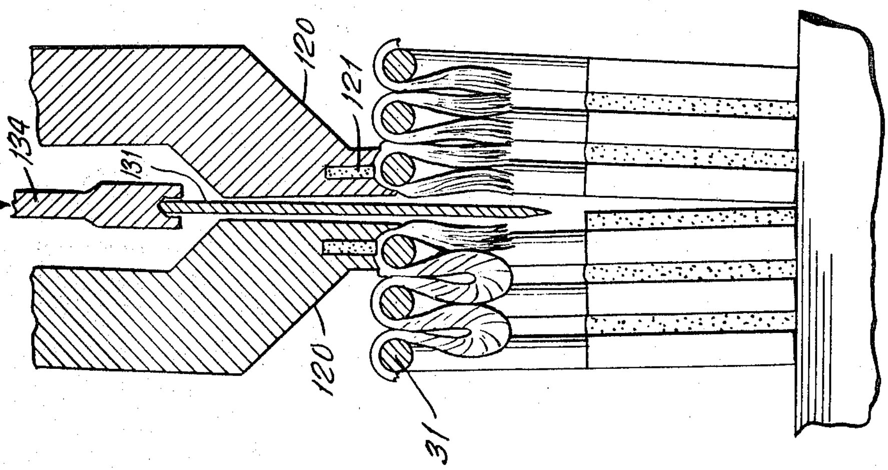
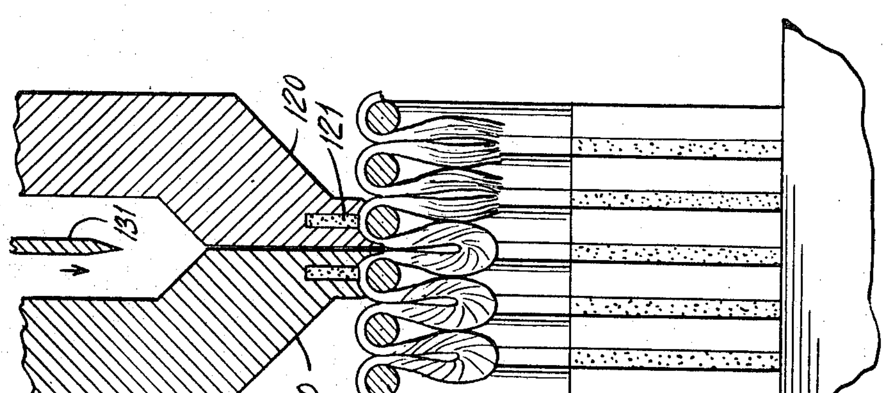


Fig.10a



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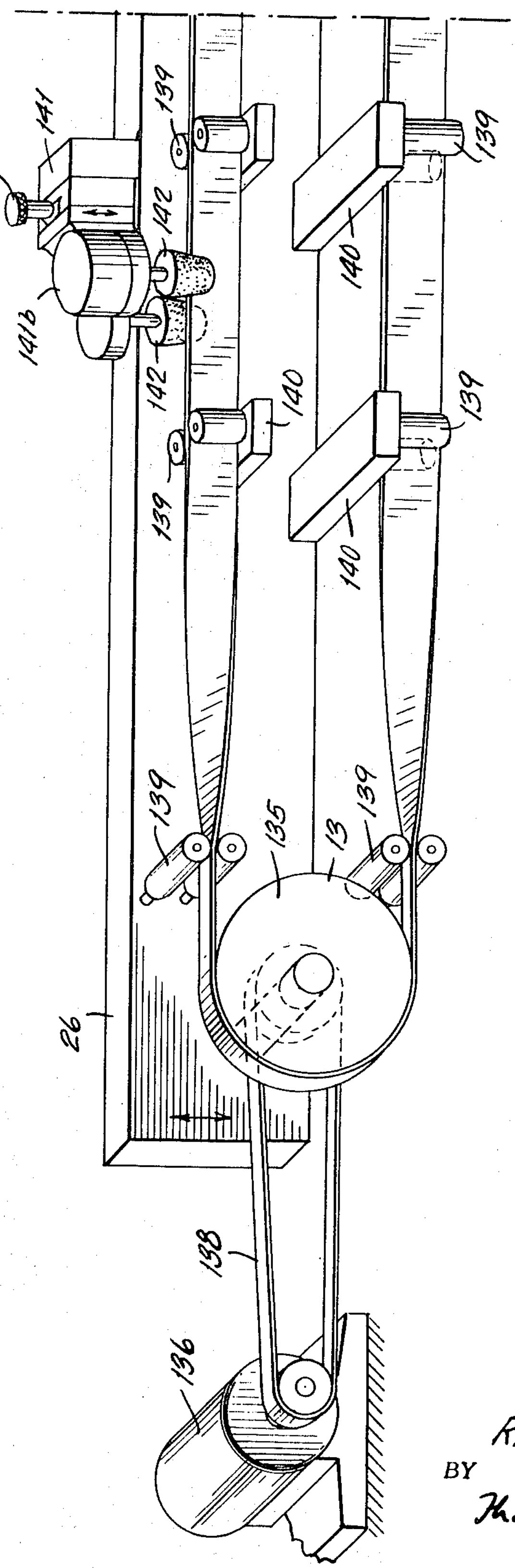

Fig. 11a

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Fig. 11b

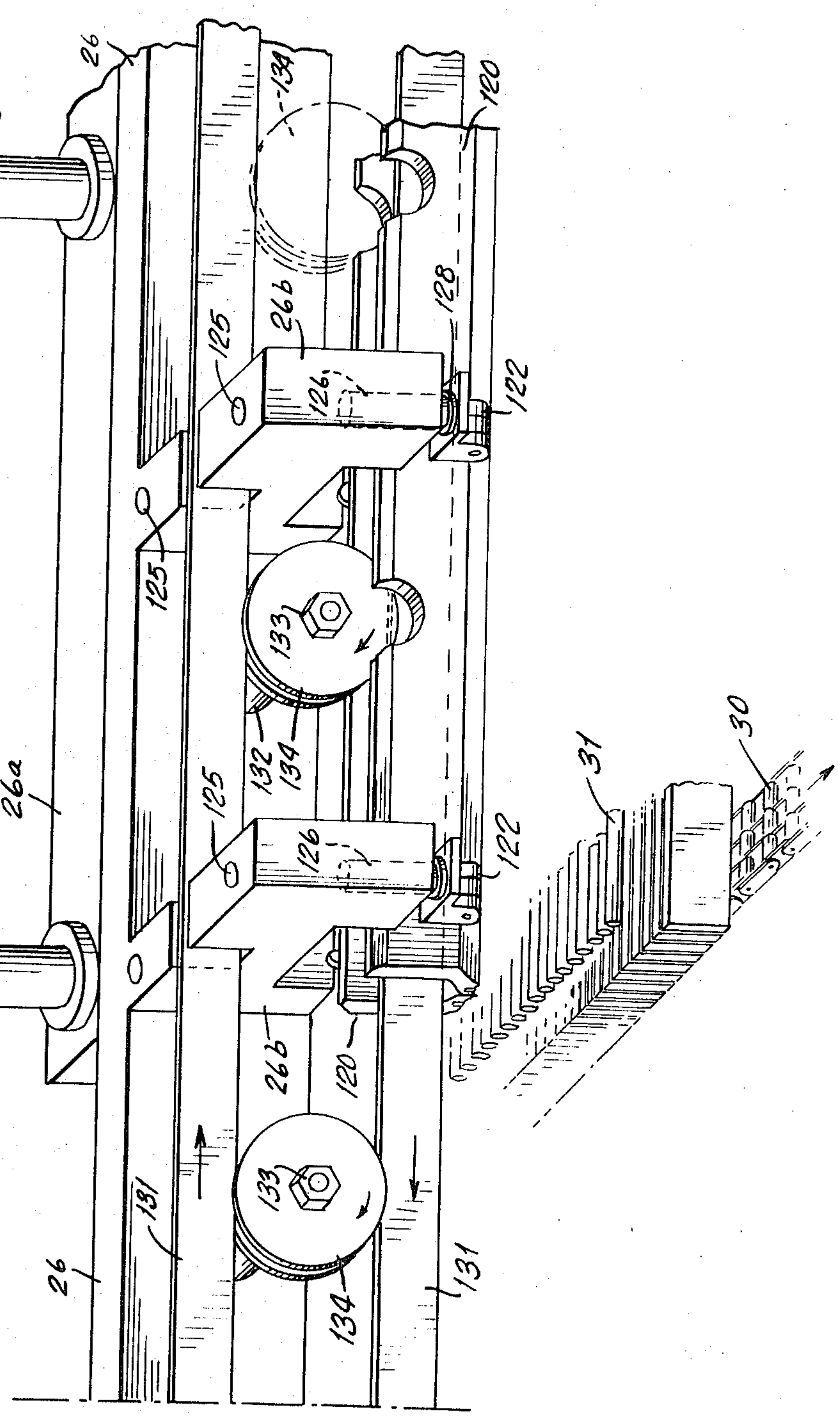

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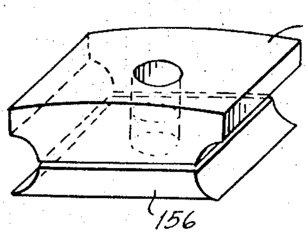
Fig.15



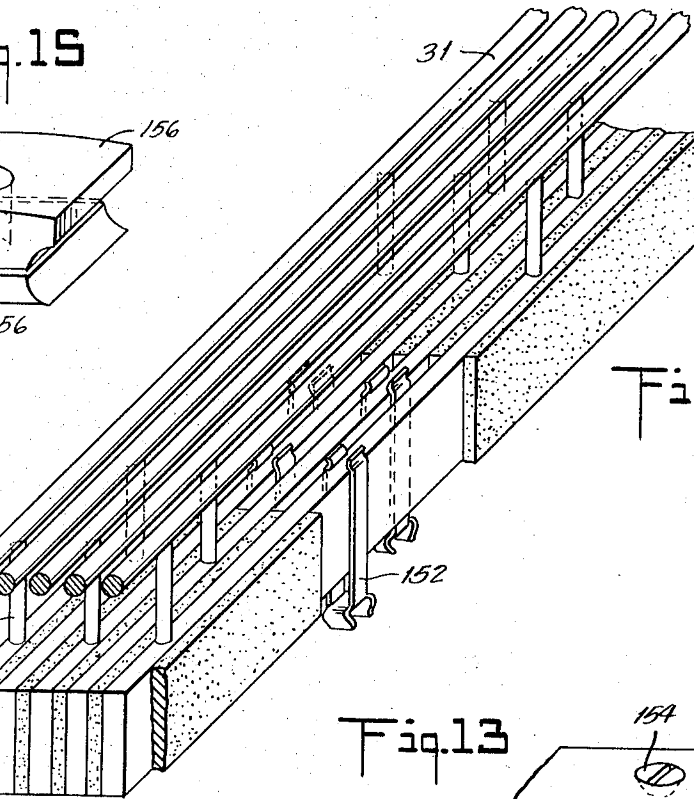
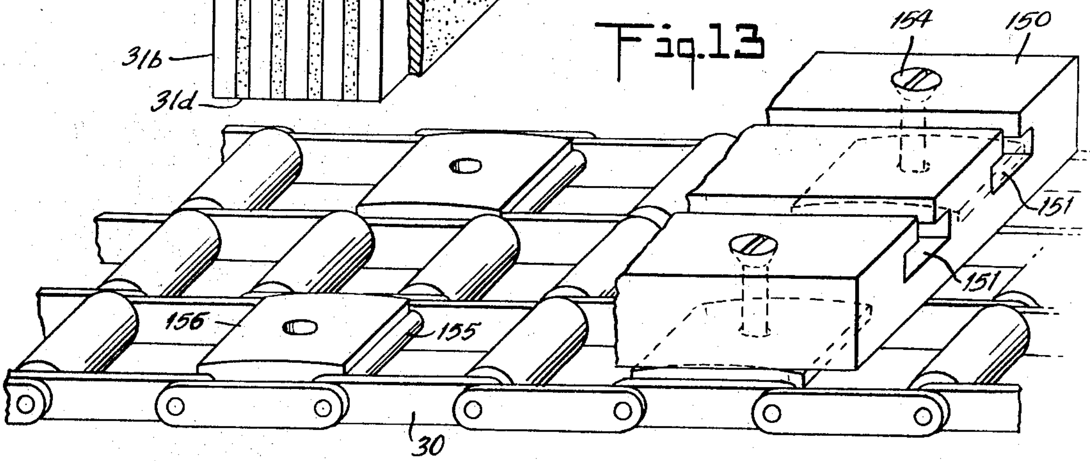


Fig.12

Fig.13



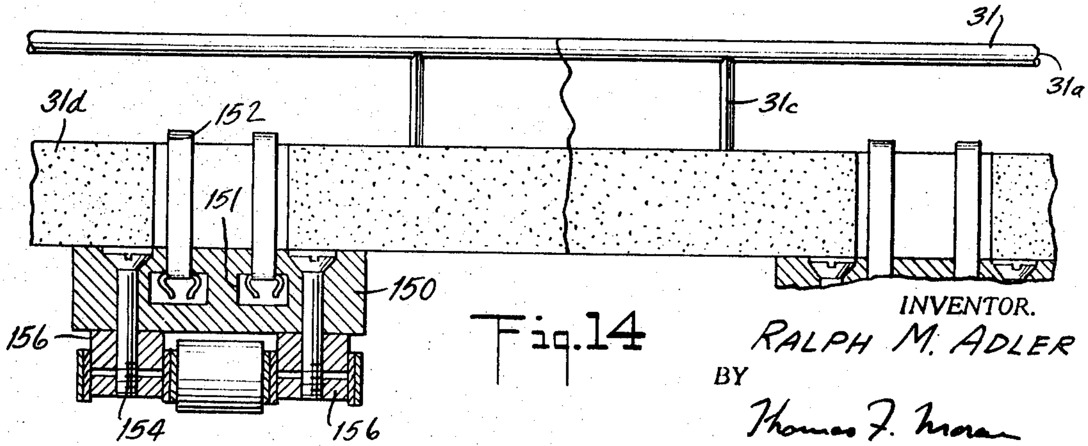


Fig.14

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APPARATUS FOR PRODUCTION OF PILE CARPETING

This application is a continuation-in-part of application Ser. No. 793,842, filed Jan. 24, 1969 which in turn is a continuation-in-part of my application Ser. No. 520,402 filed Jan. 13, 1966 entitled "Method and Apparatus for Production of Pile Carpeting and the Like," now U.S. Pat. No. 3,424,632. The disclosures of the above-identified patent application and patent are herein incorporates and made part of this disclosure.

This invention relates to pile fabrics. More particularly, this invention relates to pile fabrics, such as carpeting, rugs and the like, and to a method and apparatus useful for producing same.

Various methods and apparatus have been employed for the production of pile fabrics, such as carpeting and rugs. Those methods and apparatus employing a weaving technique are capable of producing quality pile fabrics having a dense pile and long service or wearing life. Woven pile fabrics, however, are relatively expensive to produce and as a result woven pile fabrics are costly.

Pile fabrics and carpeting have also been prepared by utilizing non-weaving techniques, such as by knitting and by tufting. Pile fabrics produced by such techniques, however, generally exhibit a relatively loose pile and are less pleasing in appearance. Such pile fabrics, however, are capable of being produced at a relatively high rate and are usually less expensive as compared with woven pile fabrics.

The textile industry, particularly that portion thereof involved in the production of pile fabrics, such as carpeting and rugs, has long been interested in a fast, practical, inexpensive method and apparatus for the production of pile fabrics having a relatively dense pile and exhibiting a long wearing life and simulating a woven pile fabric. Techniques employed and suggested heretofore for the manufacture of such non-woven fabrics, however, have not been entirely satisfactory.

Although techniques of making pile fabrics by forming loops of yarn between spaced, parallel, slat-like machine elements or loop-forming members have been investigated there has been relatively little commercial utilization of these techniques. Apparently the previously known and suggested techniques have failed to meet the very demanding requirements of a commercially acceptable operation. It would appear that in order to gain commercial acceptance methods and apparatus for the production of non-woven pile fabrics must be capable of rapidly and continuously producing pile fabrics from diverse materials, natural and synthetic fibers, and of spun, twisted or monofilament yarns and in a variety of controlled pile heights, densities and patterns without requiring extensive alteration of the apparatus and basic method.

Accordingly, it is an object of this invention to provide a method and apparatus for the production of pile fabric suitable for use as carpeting, rugs and the like and at a relatively high rate of production.

It is another object of this invention to provide an improved method and apparatus for the production of pile fabrics.

It is another object of this invention to provide a process and apparatus capable of producing pile fabric of uniform quality and at a production rate substantially in excess of that presently attainable for similar pile fabric.

In at least one embodiment of this invention at least one of the foregoing objects will be achieved. How these and other objects of this invention are achieved will become apparent in the light of the accompanying disclosure made with reference to the accompanying drawings wherein:

FIGS. 1*a*, 1*b* and 1*c* illustrate schematically and in partial cross section portions of an apparatus in accordance with this invention for the production of pile fabrics and the like;

FIG. 2 is an enlarged fragmentary cross sectional view of elements of the apparatus of this invention illustrated in FIG. 1*a*;

FIG. 3 illustrates in partial vertical cross section the actuating mechanism for the loop-forming blade and the gauge blade of the apparatus of this invention;

FIGS. 4 and 5 illustrate in partial cross section other views of the actuating mechanism for the loop-forming blade and the gauge blade in an apparatus in accordance with this invention;

FIGS. 6 and 7 illustrate in partial vertical cross section the operation of the loop-forming blade and the gauge blade, respectively, in an apparatus in accordance with this invention;

FIGS. 8*a*, 8*b*, 8*c*, 8*d* and 8*e* illustrate sequentially the loop-forming operation in an apparatus in accordance with this invention;

FIG. 9 illustrates in partial vertical cross section the loop-forming mechanism and the loop-cutting mechanism in an apparatus in accordance with this invention;

FIGS. 10*a*, 10*b* and 10*c* show fragmentary cross sectional views of the loop-cutting element in an apparatus in accordance with this invention and illustrate the sequence of operations of this element;

FIGS. 11*a* and 11*b* illustrate in fragmentary perspective views the loop-cutting element in accordance with this invention;

FIG. 12 illustrates in perspective and partial cross section an array of the loop-forming elements suitable for use in an apparatus in accordance with this invention;

FIG. 13 is a fragmentary view of the carrier structure for the loop-forming elements in an apparatus in accordance with this invention;

FIG. 14 is a fragmentary cross sectional view showing the disposition of the loop-forming elements in an apparatus in accordance with this invention; and wherein

FIG. 15 illustrates a supporting block in the carrier structure of the loop-forming elements in an apparatus in accordance with this invention.

In accordance with this invention there is provided a method and apparatus for the manufacture of non-woven pile fabrics useful as carpeting, rugs and the like. The pile of the fabric is produced by forming loops of yarn between slat-like loop-forming elements. The loop-forming elements are desirably arranged in a closed loop array in parallel side-by-side disposition. The loops formed between the loop-forming elements, are, if desired, cut and a backing material applied thereto. Thereupon, the resulting pile fabric is removed from the array of loop-forming elements.

Desirably, the array of loop-forming elements is moved continuously and as the array of loop-forming elements moves beneath a loop-forming station a blade-like member descends so as to press warp material, which is continuously supplied to said loop-forming station, between adjacent loop-forming members directly beneath the blade-like member. When the warp material is pressed by the blade-like member between the loop-forming members to form loops of warp material therebetween the blade is withdrawn and the loop-forming members retain the thus-formed loops.

Adjacent and cooperative with the loop-forming station is a gauge blade station which serves the purpose or function of determining the height of the pile in the resulting non-woven fabric or the length of the yarn loops between the loop-forming elements. In operation, before the loop-forming element is moved downwardly to form loops the gauge blade is moved downwardly and inserted between two adjacent loop-forming members containing the immediately previously formed yarn loops. The gauge blade descends thereinto a distance not grater than and preferably less than the length or depth of the yarn loop therein. When the gauge blade has entered into the previously formed yarn loops the loop-forming blade descends and produces newly formed yarn loops. In the instance where the gauge blade does not descend into the previously formed yarn loops to the full depth of the yarn loops, as the loop-forming blade descends some of the yarn material making up the previously formed yarn loops is taken away or "robbed" to make up the newly formed yarn loops as the loop-forming blade descends. In effect, therefore, the depth of the gauge blade determines the depth or length of the yarn loops. When the loop-forming blade has fully descended, preferably to a distance greater than the gauge blade, both the loop-forming blade and the gauge blade are removed. The above sequence of operations is carried out and results in the production of a continuous length of non-woven pile fabric, the height of the pile being determined by the distance the gauge blade penetrates into the loop-forming elements. The gauge blade may be profiled, if desired, to impart a sculptured effect or profile to the resulting pile fabric.

The thus-formed loops are securely retained by and between the loop-forming members as the array of loop-forming members moves. Subsequently, if desired, the loops are cut and an adhesive and/or backing material applied thereto. After a suitable length of travel the loops, now bound to the backing material, are removed from the array of loop-forming members as a substantially finished pile fabric.

The design, fabrication and operation of the array of the slat-like, loop-forming members to yield a commercially acceptable operation and a satisfactory product are difficult, particularly when it is realized that it is commercially desirable to produce continuous length pile fabric having a width of about 15 feet.

The slat-like, loop-forming members making up the closed array must be in closely arranged parallel relationship with the pitch or center-to-center distance between successive loop-forming members being approximately three-sixteenth inch, more or less, depending upon the thickness of the yarn. As a result it is apparent that when the slat-like, loop-forming members are long, thin members measuring approximately 15 feet in length they must have substantial depth to prevent sagging. Because of the construction and dimensions of the slat-like, loop-forming members and the resulting array, means must also be provided to provide proper support, alignment and transport of the loop-forming members and the array.

Also, means must be provided for synchronizing the arrival of the slat-like, loop-forming members at the loop-forming station so as to assure proper positioning of the loop-forming members relative to the blade which descends to press the warp material between adjacent loop-forming members to form loops of warp therebetween. If the loop-forming members are disposed and arrayed in a rigid, fixed, parallel, spaced relationship with respect to each other, at best, only a given thickness of warp material or yarn will be accommodated and satisfactorily retained therebetween. Thinner warp material or yarn will tend to leave or escape from between the loop-forming members. Thicker warp material or yarn would require excessive force to force the warp between the loop-forming members. Such excessive force would tend to cause yarn damage and breakage and the resulting formed loops would tend to force to wedge the loop-forming members apart into a non-parallel relationship which would become cumulative such that each succeeding slat-like, loop-forming member would arrive at the loop-forming station with a successively greater tilt until the space available between adjacent loop-forming members would become too narrow for continued operation. For example, in the manufacture of a commercially acceptable pile fabric, useful as carpeting, the pitch of the loop-forming members is approximately three-sixteenth inch with about 1/16 or ⅛ inch spacing between the loop-forming members. Such an arrangement would call for an array of about 68 slat-like, loop-forming members per linear foot of the array. Since the overall closed loop array in accordance with this invention would usually require over a thousand, even thousands, of loop-forming members it should be readily appreciated that even a small cumulative tilt would soon cause the overall apparatus to be inoperative. Even when the slat-like, loop-forming members are disposed in a hinged substantially parallel relationship, which arrangement would require force to be continuously applied to the array so as to retain the looped warp material between the loop-forming members, the total aggregate force required, if supplied from outside the structure by means of springs and the like, becomes enormous and substantially impractical of achievement by such means.

In accordance with this invention, however, the slat-like, loop-forming members are constructed and disposed such that the forces necessary to retain the loop-forming members in the desired array and also to retain the looped warp material therebetween are provided by the loop-forming members per se. Also, in accordance with this invention the slat-like, loop-forming members are capable of being readily spread apart to permit the forcing of the warp material therebetween by the descending blade at the loop-forming station and to yield resiliently and to accommodate various size warp material.

These features are achieved in accordance with this invention by imparting magnetic properties to the slat-like, loop-forming members. For example, the slat-like, loop-forming member is made of magnetic material or has magnetic material fixed or otherwise attached thereto such that the loop-forming member attracts adjacent loop-forming members with the result that the array of the loop-forming member is magnetically held together. The magnetic attraction of the loop-forming member to its adjacent loop-forming member provides the force for retaining the looped warp material therebetween. At the same time the magnetic attraction between adjacent loop-forming members permits these members to be, in effect, hingedly separated to readily accommodate the entry of the blade and looped yarn therebetween during the loop-forming operation. This feature of the invention, to which feature is attributable the advantages and the unique operation of the apparatus of this invention, is more clearly and precisely described hereinafter.

Referring now to the drawings, particularly FIGS. **1***a*, **1***b*, and **1***c*, which illustrate the apparatus and mode of operation of the invention and elements thereof, there is illustrated housing **10** disposed atop and transversely straddling the conveyor system, generally indicated by the reference numeral **11**, which is supported by frame **12**. Main shaft **14** is mounted and journaled for rotation within housing **10**. Eccentric **15** carried on shaft **14** is provided with cam groove **15***a* in which roller **15***b* rides. Roller **15***b* is carried on yoke **16** which pivots on shaft **16***a*. Shaft **14** is also rotatably fixed to cam **17** which is fixed to yoke **17***a* which in turn is fixed to yoke **16** by arm **17***b* and pins **17***c*.

The rotation of shaft **14** produces an up-and-down motion to rod **18** which is fixed to yoke **17***a* and at the same time imparts a slight side-to-side motion to rod **18** carried within lower portion **18***a* of housing **10**. Rod **18** is supported by shaft or cylinder **19** within lower portion **18***a* of housing **10** such that shaft **19** rocks slightly with rod **18** about location **19***a* within lower housing portion **18***a*. Push rod **18** is thereby caused to describe a compound motion in the form of a narrow ellipse with a major vertical axis for each complete rotation of main shaft **14** and a minor axis such that the horizontal component or velocity of push rod **18** from left to right as illustrated is relatively small. Loop-forming blade **20** and gauge blade **21**, as illustrated, are operatively connected to and fixed to push rod **18** for movement therewith.

Endless conveyor chain **30** carrying loop-forming members **31** is continuously moved by sprockets **32** which in turn are driven by main drive **34** by means of drive chain **35**. Sprockets **32** are driven at a uniform speed and move conveyor chain **30** carrying with it the array of loop-forming members **31** in the manner indicated.

Together with the array of loop-forming members **31** which has considerable weight conveyor chain **30** moves along support rail **36** of conveyor frame **12**. Support for the lower or returning section of conveyor chain **30** and the lower or returning section of the array of loop-forming members **31** is provided by support chain platform **38** which is shown in greater detail in FIG. **2** wherein support chain platform **38** is shown provided with platform sections **39** at each link **40**, thereby making up support chain platform **38**. Platform sections **39** assume a flat, planar conformation directly beneath and in contact with the lower or returning section or array of loop-forming members **31** to support the array and to maintain the loop-forming members **31** straight and without any sagging. Further, support chain platform **38** is mounted like main conveyor chain **30** and moves in synchronism therewith by means of sprockets **41** and drive chain **42**. Support chain platform **38** moves and is supported on rail **37** of frame **12** with the result that the weight of the conveyor system carrying the array of loop-forming members **31** is transmitted to frame **12**. Rollers **44** rotatably mounted on frame **12** support and guide the lower or returning section of support chain platform **38**.

Loop-forming blade **20** and gauge blade **21** are adapted and positioned to descend between adjacent loop-forming members **31** as they move continuously beneath loop-forming blade **20** and gauge blade **21** with the result that warp material **45** is inserted and held between loop-forming members **31** to form loops therebetween.

Warp material **45** is supplied from a suitable source, such as a creel or beam, not shown, through adjustable reed **46** along feed and guide rolls **48** and **48***a* and through final adjusting reed **49** and guide **50**. The synchronization of the downward movement of loop-forming blade **20** and gauge blade **21** with the motion and position of the loop-forming members **31** as they continuously move by the loop-forming station directly beneath loop-forming blade **20** and gauge blade **21** assures that warp material **45** is inserted downwardly by blade **20** between an adjacent pair of loop-forming members **31** and the immediately previously inserted or looped warp material is held between loop-forming members **31** by gauge blade **21** inserted thereinto. This synchronization may be effected by any suitable means.

As schematically illustrated in FIG. **1***a* main shaft **14** is shown driven by main drive **34** via chain **51**, differential gear box **52** and chain **54**. Main drive **34** is driven by a suitable means, such as electric motor **55**. To assist in maintaining the synchronism between downward movement and motion of loop-forming blade **20** and gauge blade **21** and the motion of loop-forming members **31** as they move past the loop-forming station to assure that blades **20** and **21** descend between loop-forming members **31** and to compensate for any variations in spacings between loop-forming members **31** in the moving array and to compensate for thermal expansion and the like, a compensating drive system is provided.

In the compensating drive system any additive or subtractive errors in the position of the loop-forming members **31** beneath blades **20** and **21** are detected by sprocket wheel **55** which engages in pinion-like fashion loop-forming members **31** a short distance before the loop-forming station. Sprocket wheel **55** through chain **56** drives rotating reference transducer **58**. Errors in the motion and/or position of loop-forming members **31** are detected by sprocket wheel **55** and cause changes in the output signal from transducer **58** proportional to the errors. Signals derived from transducer **58** may be a voltage signal, a frequency signal or variable quantity. The signal from transducer **58** is sent via line **57** to servocontroller **60** wherein it is compared with another signal received via line **61** and generated by transducer **62** which is actuated via chain drive **64** by the rotational speed of main shaft **14**. When the signals supplied to servocontroller **60** are identical in value the operation of the apparatus or machine in accordance with this invention is normal and the synchronism of the motion and position of loop-forming members **31** relative to the motion and position of blades **20** and **21** at the loop-forming station is correct or satisfactory. If the signals are not identical or do not match an appropriate correction output signal is generated by servocontroller **60** and sent via line **65** to servoamplifier **66** wherein it is amplified and sent to servomotor **68** and motor controller **69** to vary the output speed of differential gear box **52**. When the difference between the signals compared in servocontroller **60** is eliminated the corrective action ceases.

Rather than driving and controlling the motion and synchronism of the array of loop-forming members **31** and blades **20** and **21** for insertion between adjacent pairs of loop-forming members in the manner indicated hereinabove, blades **20** and **21** may be mounted for movement in a vertical direction only. Also, main shaft **14** may be mounted such that it does not continuously rotate but only rotates when space between loop-forming members **31** is available for the insertion of blades **20** and **21**. Such a system would comprise a photoelectric cell device of the reflective type including a light source and a detector which senses the presence of the loop-forming members and the spaces therebetween due to differences in the amount or other quality of the reflected light. The signal produced by such a photoelectric cell device could operate a relay system which in turn could energize an electromagnetic or other suitable clutch assembly operatively connected to main shaft **14**. When actuated, main shaft **14** could be caused to rotate at a high speed for a single rotation only. Blades **20** and **21** would then be actuated to form a single loop-forming cycle, following which they would return to their upper position and await the arrival of the next, successive spaces between loop-forming members **31**. Such an arrangement would correct for any errors or variations which may exist in conveyor speed or construction, etc., since the downward motion of blades **20** and **21** would be triggered only by the arrival and detection of available spaces between the loop-forming members **31** at the loop-forming station. By driving main shaft **14** at a sufficiently high speed for a single rotation the loop-forming operation would be completed in an extremely short period of time during which the movement of the array of the continuously moving loop-forming members **31** would be insignificantly small. If desired, however, the array of loop-forming members could be advanced intermittently beneath the loop-forming station in synchronism.

In the operation of the device illustrated in FIGS. **1***a*, **1***b* and **1***c* for the manufacture of pile fabric, yarn **45** from a suitable source, such as a beam or creel, not shown, is drawn through adjustable expansion cone or reed **46** and then over feed and guide rolls **48** and **48a** through adjustable expansion reed **49** and between guide plates **50** by the action of blades **20** and **21** which act in combination at the loop-forming station and intermittently descend between loop-forming members **31** to form loops therebetween. There is thus formed an array of loops from yarn **45** between loop-forming members **31** which moves along with the array of loop-forming members **31**.

The array of loops thus formed between the loop-forming members moves beneath carrier beam **26**. Carrier beam **26** is fixed to push rod **18** by angle bar **26***a* and plate **26***b*. Carrier beam **26** and angle bar **26***a* are adapted to move in synchronism with rod **18** such that as blades **20** and **21** descend to form a loop of yarn between loop-forming members **31** carrier beam **26** also descends and by means of cutting blade **13** cuts the loops previously formed between loop-forming members **31**. The operation of cutting blade **13** in association with carrier beam **26** is described hereinafter.

Following the formation and cutting of the loops, and referring now to FIG. **1***b*, suitable film-forming binder material, such as a plastisol, e.g. polyvinyl plastisol, or other thermoplastic material useful as a binder, is distributed by any suitable means such as hopper **71** via rotary distributor device **72** located at the bottom of hopper **71** to apply particle-form thermoplastic material **74** onto sifter or screen **75** or other applicator from which it falls onto the top surface of the array of cut yarns or loops. The resulting plastic coated cut yarns or loops, the top surface of which is covered with thermoplastic binder material **74**, such as polyvinyl chloride, including PVC plastisol, polyethylene or polypropylene-containing material and the like, then passes beneath bank **76** of infra-red ray heating elements **78**. As the thermoplastic material moves beneath bank **76** of heating elements **78** the thermoplastic material is softened and becomes fluent and tends to coat the top surface of the cut yarn loops with a fluent adhesive layer of plastic material.

Referring now to FIG. **1***c*, backing material **80**, such as burlap, is supplied from roll **81** through feed rolls **82** and guide roll **84** onto the hot fluent thermoplastic material on the top surface of the cut yarn loops. The backing material is then pressed into firm adhesive contact with the hot fluent thermoplastic material by means of pressure rolls **85** to form a firm bond between the backing material, the thermoplastic material and the cut yarn loops. Advantageously, pressure rolls **85** are also chilled to set or solidify the fluent thermoplastic adhesive material more quickly. Instead of chilled pressure rolls **85** a chilled pressure plate adapted to be moved in synchronism with the materials being processed can be employed. After a sufficient amount of chilling has been effected the chilled plate could then be returned to its original position to chill additional material being processed. The size of the chilled plate, the time the chilled plate is in contact with the material being processed and the movement of the material being processed being synchronized so that all the material undergoing processing, i.e. all the backing material, is pressed into contact with the thermoplastic adhesive material and the cut yarn loops. The resulting pile fabric structure **86** comprising cut yarn loops, a coating of thermoplastic material and a backing is removed from the array of loop-forming members **31** by passing under guide roll **88**. The pile of fabric is pulled by wind-up roll **89** which is driven in synchronism with sprocket **41** via chain drive **90**. Trimming rotary knife blade **91** removes excess pile fabric material and the trimmed pile fabric then moves over guide rolls **92** onto the take-up or wind-up roll **89** from which it is subsequently removed as a substantially finished pile fabric product.

Referring now to FIGS. **3**, **4**, **5**, **6**, **7** and FIGS. **8***a*, **8***b*, **8***c*, **8***d* and **8***e*, which illustrate the loop-forming operation and the elements thereof in a machine in accordance with this invention, as push rod **18** is moved up-and-down at the loop-forming station in the manner described hereinabove loop-forming blade **20** and gauge blade **21** which are carried on angle bar **26***a* fixed to push rod **18** are also moved up-and-down. As illustrated in FIG. **3** the lower portion **18***a* of housing **10** within which push rod **18** operates through cylinder **19** is fixed to housing **10** by screws **18***b*. Bushing **18***c* encloses push rod **18** within the lower portion **18***a* of housing **10** and provides around the upper portion thereof an annular space for the side-to-side rocking motion imparted to push rod **18**. The lower end of push rod **18** within the lower portion **18***a* of housing **10** is positioned therein relative to cylinder **19** by plates **19***b*.

As further illustrated in FIG. **3** yoke **16** pivots on shaft **16***a* which is adjustably fixed to plate **16***b* on the inside of housing **10**, plate **16***b* being fixed to the inside of housing **10** by strap **16***c* and screws **16***d*. Shaft **16***a* is adjustably fixed to plate **16***b* by means of threaded screw **16***e* which passes through split portion **16***f* of plate **16***b* to adjustably clamp or fix shaft **16***a* therein.

Referring now particularly to FIGS. **4**, **5**, **6** and **7**, as push rod **18** is moved up-and-down it carries with it angle bar **26***a* which is fixed to push rod **18** by collars **18***d*. In turn, angle bar **26***a* is operatively connected to loop-forming blade **20** and gauge blade **21**. Accordingly, as push rod **18** moves up-and-down loop-forming blade **20** and gauge blade **21** also move up-and-down. Loop-forming blade **20** is mounted on carrier **20***a* and gauge blade **21** is mounted on carrier **20***a*, being fastened thereto by screws **20***b* and **21***b* and plates **20***c* and **21***c*, respectively.

Carrier **20***a* is fixed to a supporting structure on the upper side of angle bar **26***a*. This supporting structure on the upper side of angle bar **26***a* for the support of carrier **20***a* and loop-forming blade **20** comprises posts **20***d* with support plate **20***e* fixed at the upper ends. Threaded rod **20***f* extends through plate **20***e* and is fixed to carrier **20***a*. Spring **20***g* is biased against knurled collar **20***h* which is adjustable along threaded rod **20***f* so as to maintain a firm response for the up-and-down motion of loop-forming blade **20** relative to the up-and-down motion of angle bar **26***a*, see FIG. **6** for greater detail.

Carrier **21***a* is fixed to angle bar **26***a* by means of a supporting structure similar to the supporting structure to which carrier **20***a* is fixed thereto. This supporting structure for carrier **21***a* to which gauge blade **21** is fixed is shown in greater detail in FIG. **7** of the drawings. The supporting structure on the upper side of angle bar **26***a* comprises posts **21***d* which are fixed to angle bar **26***a* by screws **21***dd*. Posts **21***d* are provided with a supporting plate **21***e* fixed to the top of posts **21***d* by screws, not shown. Threaded rod **21***f* extends through plate **21***e* and is fixed at its lower end to carrier **21***a*. Spring **21***g* surrounding that portion of threaded rod **21***f* between plate **21***e* and carrier **21***a* serves to maintain a firm response for the up-and-down motion of gauge blade **21** relative to the up-and-down motion of angle bar **26***a*.

The portion of threaded rod **21***f* above plate **21** is provided at the top thereof with plate **21***h* which is vertically adjustable along rod **21***f* by means of nut **21***k*. The end of the downward motion of rod **21***f* when moved downwardly by angle bar **26***a* is adjustably determined by the position of plate **21***h* along the upper portion of rod **21***f*.

Channel **22** is fastened to lower portion **18***a* of housing **10** by means of plate **22***a* which is fastened thereto by screws **22***c*. Channel **22** carries on its top resilient buffer pad **22***b*. The downward motion of rod **21***f* when angle bar **26***a* moves downwardly is terminated when plate **21***h* contacts buffer pad **22***b*. The continued downward motion of angle bar **26***a* after plate **21***h* contacts buffer pad **22***b* serves only to move plate **21***e* downwardly to compress spring **21***g*.

FIGS. **8***a*, **8***b*, **8***c*, **8***d* and **8***e* show the sequence of travel of loop-forming blade **20** and gauge blade **21** at the loop-forming station in the apparatus in accordance with this invention with the resultant production of loops of yarn **45** between loop-forming members **31**. As illustrated in FIGS. **8***a*, **8***b*, and **8***c*, gauge blade **21** precedes loop-forming blade **20**. Gauge blade **21** enters the pair of loop-forming members **31** which contain the immediately previously formed loops of yarn. Gauge blade **21** enters part of the way into the previously formed loops of yarn as shown in FIG. **8***c*. Loop-forming blade **20** follows and enters between the preceding pair of loop-forming members **31** to produce therebetween the next set of loops, as illustrated in FIGS. **8***d* and **8***e*. As loop-forming blade **20** enters it forms loops of yarn, and in the formation of the loops, yarn material is back-robbed or taken from the previously formed loops of yarn until the previously formed loops of yarn comes into contact with the bottom edge of gauge blade **21**. It is thus seen that the depth of penetration of gauge blade **21** between the loop-forming members determines the depth of the yarn loops formed between loop-forming members **31**.

FIGS. **9**, **10***a*, **10***b* and **10***c* illustrate the loop-cutting operation in the apparatus in accordance with this invention. As illustrated therein carrier beam **26** is fixed to angle bar **26***a* by means of plate **26***b* for movement in synchronism with angle bar **26***a*. On the downward stroke of angle bar **26***a* carrying with it carrier beam **26** pre-openers **120** which are provided with resilient inserts **121** are moved into contact with looped yarn on top of loop-forming members **31**. Pre-openers **120** are swingably mounted in pivot yokes **122**. Upon contact with the looped yarn on the top of loop-forming members **31** the downward movement of pre-openers **120** is arrested. The downward movement of carrier beam **26**, however, continues and compresses springs **124** which are adjustably set within carrier beam **26** by means of threaded plugs **125**. Springs **124** are compressed within carrier beam **26** as carrier beam **26** moves downwardly by the action of piston **126** which bears against the bottom of springs **124**. Piston **126** is fixed to rods **128** which bear on pivot yokes **122**.

The upper end of pre-openers **120** are beveled and extend within opening **27** provided within carrier beam **26**. Hardened steel ball inserts **129** are provided within opening **27** in carrier beam **26** within which pre-openers **120** project and bear upon the beveled surface of pre-openers **120**. As carrier beam **26** moves downwardly compressing springs **124** hardened steel ball inserts **129** ride upon the beveled surfaces of pre-openers **120** causing the lower ends of pre-openers **120** in contact with the looped yarns on loop-forming members **31** to swing outwardly against the urging of pre-loaded springs **130**, thereby separating or opening upon the adjacent looped yarn-covered loop-forming members **31** which are in contact with the bottom of pre-openers **120**.

As the bottom ends of pre-openers **120** swing out spreading apart loop-forming members **31** knife blade **131** enters the thus-opened space between the open adjacent loop-forming members in contact with pre-openers **120** and cuts the looped yarn therebetween. As illustrated knife blade **131** is carried on and moves with carrier beam **26** by means of shaft **132** and sheaves **134**. The sequence of pre-openers **120** contacting the yarn-covered loop-forming members **31** and spreading apart loop-forming members **31** to permit the entry of knife blade **131** therebetween and the withdrawal and subsequent upward motion of knife blade **131** from between loop-forming members **31** and pre-openers **120**, as carrier beam **26** moves downwardly and upwardly is illustrated in greater detail in FIGS. **10***a*, **10***b* and **10***c*.

As carrier beam **26** is raised knife blade **131** is raised from between loop-forming members **31** and the bottom portions of pre-openers **120** brought together as steel inserts **129** ride up pre-openers **120** to the beveled surfaces thereof. Upon continued upward movement of carrier beam **26** pre-openers **120** are lifted from contact with yarn-covered loop-forming members **31**. Carrier beam **26** upon completion of its upward movement is then in position to again move downwardly in synchronism with angle bar **26***a* so that the loop-forming and the loop-cutting operations are carried out substantially simultaneously during the next downward excursion of angle bar **26***a*.

FIGS. **11***a* and **11***b* illustrate one embodiment of the loop-cutting apparatus suitable for use in the apparatus in accordance with this invention. As already described herein the loop-cutting apparatus comprises carrier beam **26** which is mounted on and fixed to angle bar **26***a* which actuates the loop-forming and loop-cutting operations. Carrier beam **26** moves downwardly and upwardly in synchronism with angle bar **26***a* with the result that the loop-cutting operation performed by the apparatus associated with carrier beam **26** is carried out simultaneously with the loop-forming operation carried out by the apparatus associated with angle bar **26***a*, all as described hereinabove.

Carrier beam **26** extends transversely across the array of loop-forming members **31**, as illustrated, the array of loop-forming members **31** being carried on moving endless conveyor chain **30**. The actual loop-cutting is effected by endless knife blade **131** which is carried on guide sheaves **134** fixed to carrier beam **26** by means of shaft **132** and lock nut **133** and driven by drive sheave **135**. Drive sheave **135** is driven by motor **136** and flexible belt **138** made of suitable resilient material. Preferably, motor **136** is mounted on a stationary support although, if desired, it may be mounted by means, not shown, fixed to carrier beam **26** so as to move in unison therewith.

As illustrated, endless knife blade **131** driven by drive sheave **135** moves on guide sheaves **134** and between guide rollers **139** which are fixed to carrier beam **26** by suitable means, such as projecting lugs **140**. The upper portion of endless knife blade **131** moves through cut-out portions of carrier beam **26** and the lower portion of blade **131** moves between pre-openers **120**. Vertically adjustable mounting **141** provided with vertical setting control knob **141**a is provided on carrier beam **26** for holding and positioning conical grinding wheels **142** supported by holder **141***b* against the cutting edge of knife blade **131**, either continuously or intermittently, to effect sharpening of the cutting edge thereof.

Knife blade **131** is under sufficient tension to eliminate any objectionable sag. For example, in a machine calling for the production of endless pile fabric of 15 foot width an endless knife blade having the cross section dimensions 0.75 × 0.025 inch would require a tension of about 100 pounds to eliminate sag. Desirably, the lower portion of knife blade **131** is positioned so as to descend more deeply between loop-forming members **31** than loop-foming blade **20** and/or gauge blade **21** so as to assure cutting of all the loops formed between loop-forming members **31**. Since knife blade **131** is positioned laterally from loop-forming blade **20** and gauge blade **21** only a short, fixed distance, the system for assuring that loop-forming blade **20** and gauge blade **21** descend between adjacent spaced loop-forming members also assures the cutting blade **131** descends between adjacent loop-forming members since any pitch error over this small, fixed distance would be negligible.

As illustrated in FIG. **11***a*, in order to pass around reasonably small sheaves, knife blade **131** is rotated or twisted 90° when approaching and leaving each end sheave, such as drive sheave **135**, by means of free-turning guide rollers **139**.

FIGS. 12, 13, 14 and 15 illustrate the array and assembly of the loop-forming members in accordance with this invention. Loop-forming members **31** comprise an upper cylindrical element **31***a* and a lower slat-like element **31***b*. Upper element **31***a* is supported and spaced from lower element **31***b* by means of a plurality of post elements **31***c*. Lower element **31***b* which is shown as having a rectangular cross section is generally a slat-like or bar-like element and carries with it or comprises or is made up of magnetic elements **31***d* spaced along the length thereof. In a presently preferred embodiment loop-forming members **31** have magnetic elements **31***d* fixed or otherwise adhesively attached to one side of lower element **31***b*. With lower element **31***b* made up of magnetic, permeable material, such as magnetically permeable steel, it is thus seen that the array of loop-forming members **31** illustrated in FIG. **12** is magnetically held together without the need for any external force to keep the array in order. Accordingly, the array of loop-forming members **31** is, in effect, self-energizing.

A further feature is the use of post elements **31***c* to space the upper element **31***a* from the lower element **31***b* thereby providing between adjacent loop-forming members **31** ample space for the the looped yarn therebetween with the result that adjacent loop-forming members **31** can accommodate a wide variety of yarn thicknesses without causing overpacking between adjacent loop-forming members **31** during the loop-forming operation.

As illustrated in FIG. **12** the magnetic, self-energizing feature characterizing the array of loop-forming members is provided by means of adhesive plastic magnetic separator strips, such as Minute-man flexible magnetic strip material manufactured by Magnetic Aids, Inc. of New York, N. Y. Such magnetic strip material is made up of magnetic particles embedded in a flexible plastic matrix which is adhesively fastened to one face or side of lower element **31***b* of loop-forming members **31** with the result that the magnetic strip material or magnetic element **31***d* is, in effect, sandwiched between two lower elements **31***b* of loop-forming members **31**. The magnetically permeable material making up lower element **31***b* of loop-forming members **31** serves as a shunt to improve the magnetic forces which hold together the array of loop-forming members. If desired, to reduce weight, loop-forming members **31** may be made substantially only of lightweight metal, such as aluminum, which might be clad with a magnetically permeable material, such as steel, on the side surface thereof to which magnetic element **31***d* is attached.

In accordance with the arrangement illustrated in FIG. **12** each pair or adjacent loop-forming members are self-energizing with the magnetic attractive forces holding together adjacent loop-forming members and the whole array and serving to hold the looped yarn therebetween after the loop-forming operation has been carried out. Also, in effect, adjacent loop-forming members **31** act as though they were hingedly attached at the bottom during the loop-forming operation and accordingly accommodate during the loop-forming operation a wide variety of yarn thicknesses.

The array of loop-forming members **31** is mounted on channel strip member **150** encircling conveyor system **11** carrying the array of loop-forming members **31**. Channel strip member **150** is made of resilient, flexible material, such as nylon or high durometer neoprene or the like and is provided with channels **151** extending along the length thereof. Each loop-forming member **31** is keyed to channel strip member **150** by means of spring clip **152**, the upper portion of which is attached to bottom element **31***b* of loop-forming members **31** and the bottom portion of which is keyed within cooperating channel **151** of channel strip **150**. As indicated clip **152** can be snapped into position within channel **151** of channel strip **150**. Also, as indicated, the position of clip **152** keying alternate loop-forming members **31** is staggered. Also, desirably, as illustrated, the position of alternate post elements **31***c* of loop-forming members **31** is staggered. By this arrangement post elements **31***c* and clip **152** cause minimal interference with the looped yarns formed between loop-forming members **31** making up the array. Channel strip **150** is secured to two or more roller chains **30** depending upon the width of the pile fabric to be produced. Screws **154** fasten channel strip member **150** to roller chain **30** which comprises undersize rollers **155** and split clamps **156** which are provided with an arcuate upper contour similar to the arc made as split clamps **156** pass over drive sprockets **32**.

In the practice of this invention the warp material may include not only yarns made up of natural, synthetic or metallic fibers but also sheets or tapes of such materials, woven and/or non-woven. For example, the warp material may comprise sheet or tape material, such as woven cotton or wool or scrim or woven glass fibers and tapes. The warp material useful in the practice of this invention might also include sheets or tapes of non-woven fibrous material, such as the natural fibrous materials, e.g. cotton fibers, cellulosic fibers, e.g. paper, animal fibers, such as wool fibers, as well as synthetic organic, as well as inorganic fibrous materials, such as polyester fibrous material, e.g. Dacron, rayon fibrous material, cellulose acetate fibrous material, polyolefinic fibrous material, such as polyethylene and polypropylene fibrous materials, acrylic fibrous materials and the inorganic fibrous materials, such as mineral wool, glass fibers and asbestos fibers.

As will be apparent to those skilled in the art in the light of the foregoing disclosure, many modifications, alterations and substitutions are possible in the practice of this invention without departing from the spirit or scope thereof.

I claim:

1. Apparatus useful for producing a pile fabric comprising an array of loop-forming members, said loop-forming members being disposed in side-by-side relationship, means for supplying warp material transversely onto said array of loop-forming members and a loop-forming station in said apparatus, said loop-forming station comprising a loop-forming element adapted for up and down movement relative to said loop-forming members for inserting and pressing downwardly said warp material between a pair of adjacent loop-forming members to form loops of warp material therebetween and a gauge element associated with said loop-forming element, said gauge element also being adapted for up and down movement relative to said loop-forming members, for insertion between a pair of adjacent loop-forming members containing the immediately previously formed loops of warp material to a distance less than the distance said loop-forming element is inserted into said first mentioned pair of loop-forming members so as to maintain said previously formed loops of warp material in position and at a desired depth between said loop-forming members as said loop-forming element is inserted between another pair of said loop-forming members to form additional loops of warp material therebetween.

2. Apparatus in accordance with claim **1** including means for cutting the thus-formed loops of warp material.

3. Apparatus in accordance with claim **1** wherein said loop-forming members are adapted to be magnetically attracted to each other and held together in said array.

4. Apparatus in accordance with claim **1** including means for applying adhesive material to the exposed surfaces of said warp material on said loop-forming members, after said warp material has been depressed between said loop-forming members to form loops therebetween and subsequent to the insertion of said gauge element.

5. Apparatus for producing a pile fabric comprising a closed loop array of loop-forming members, said loop-forming members being disposed in said array in side-by-side relationship, means for continuously moving said loop-forming members in the path of said array, means for supplying warp material over and transversely with respect to said array of loop-forming members, a loop-forming station, said loop-forming station comprising a loop-forming element adapted for up-and-down movement relative to said loop-forming members for inserting and pressing downwardly said warp material between a pair of adjacent loop-forming members to form loops of warp material therebetween and a gauge element associated with said loop-forming element and adapted for up-and-down movement relative to said loop-forming members, for insertion between a pair of adjacent loop-forming members containing the immediately previously formed loops of warp material to a distance less than the distance said loop-forming element is inserted into said first mentioned pair of loop-forming members so as to maintain said previously formed loops of warp material in position and at a desired depth between said loop-forming members containing the previously formed loops of warp material as said loop-forming element is inserted between another pair of said loop-forming members to form additional loops of warp material therebetween.

6. Apparatus in accordance with claim **5** wherein said loop-forming element and said gauge element are blade-like elements.

7. Apparatus in accordance with claim **5** including means for cutting the thus-formed loops of warp material.

8. Apparatus in accordance with claim **5** wherein said loop-forming members are magnetically attracted to each other and held together in said array.

9. Apparatus in accordance with claim **5** including means for applying adhesive material to the exposed surfaces of said looped warp material on said loop-forming members after said warp material has been depressed between said loop-forming members to form loops of warp material therebetween and subsequent to the insertion of said gauge element.

10. Apparatus in accordance with claim **5** including means for applying binding material onto the exposed surfaces of portions of said looped warp material disposed and supported on said loop-forming members, the thus-applied binding material serving to bind together the looped warp material and means for removing the thus-formed bound loops of warp material from said array as said pile fabric.

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