Oct. 29, 1957 J. E. TOWNSEND ET AL 2,811,196

METHOD AND APPARATUS FOR DELIVERING SHEET MATERIAL

Filed March 15, 1952 5 Sheets-Sheet 1

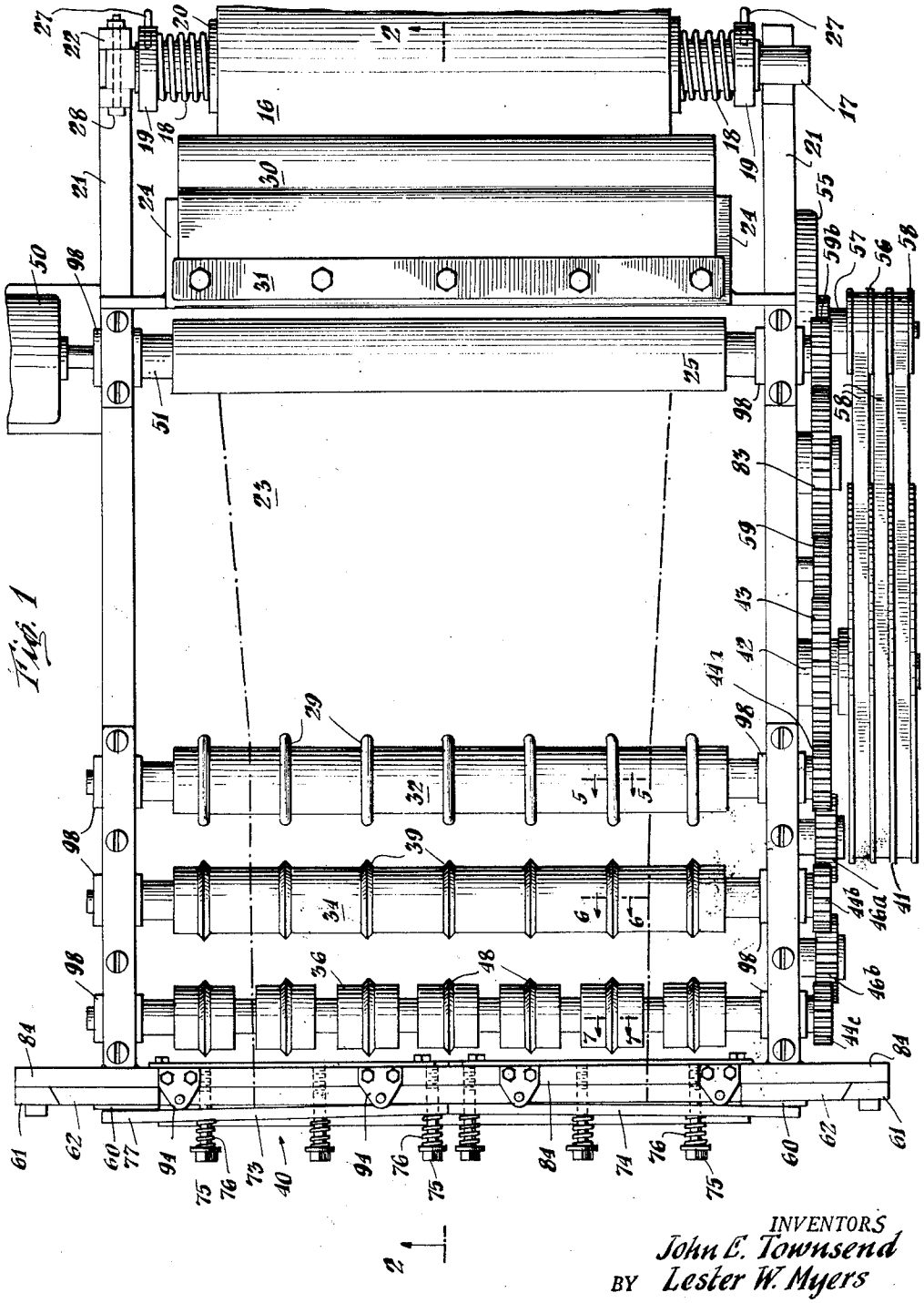

Fig. 1

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Fig. 2

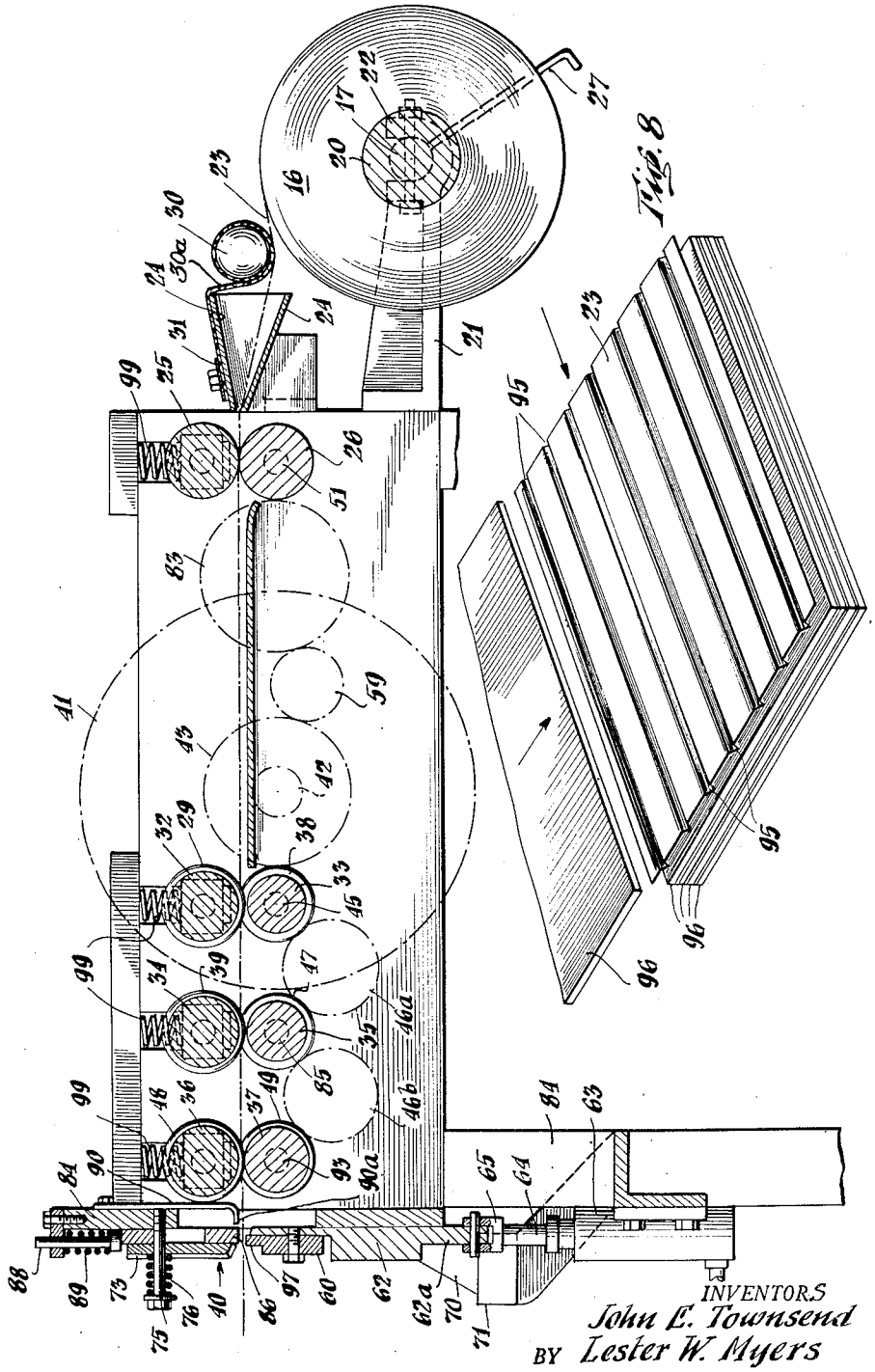

Fig. 8

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Fig. 3

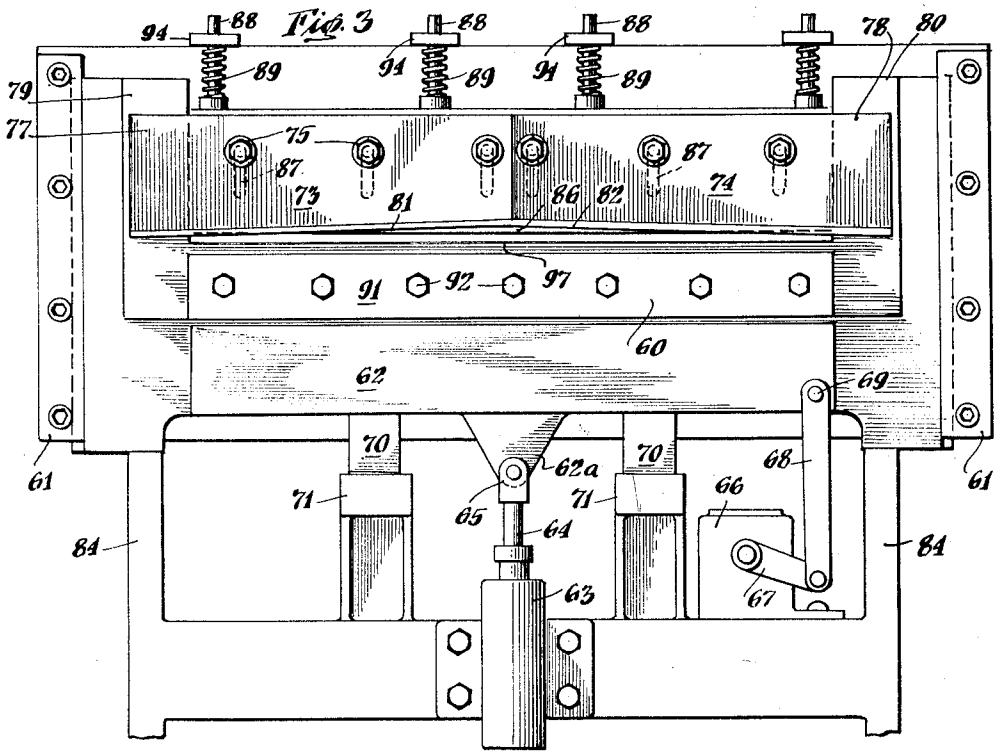
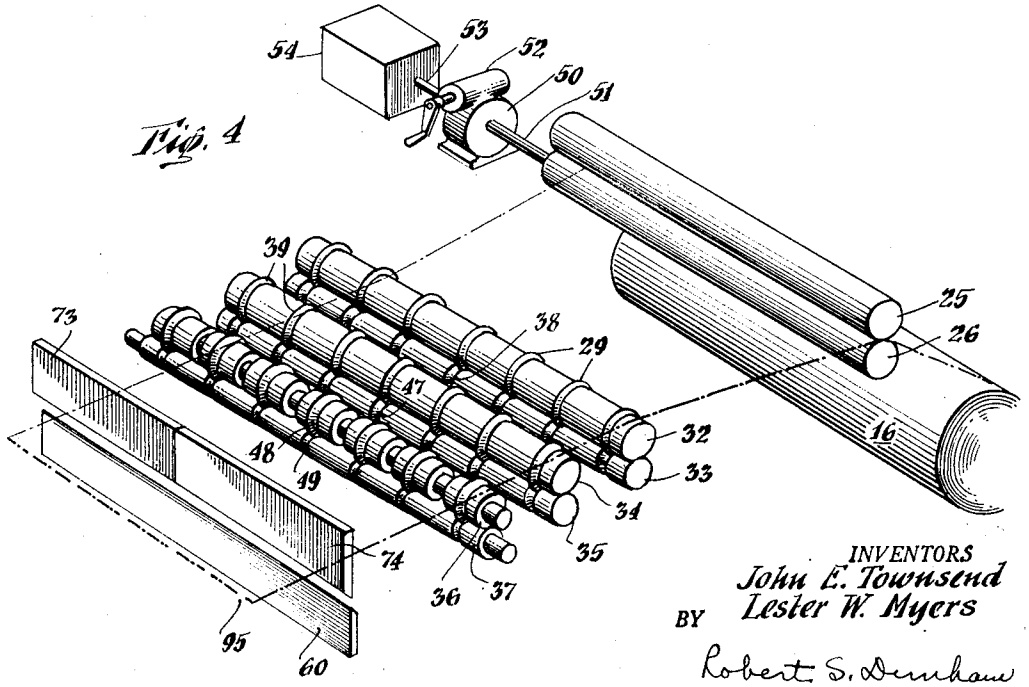


Fig. 4



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METHOD AND APPARATUS FOR DELIVERING SHEET MATERIAL

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Fig. 9

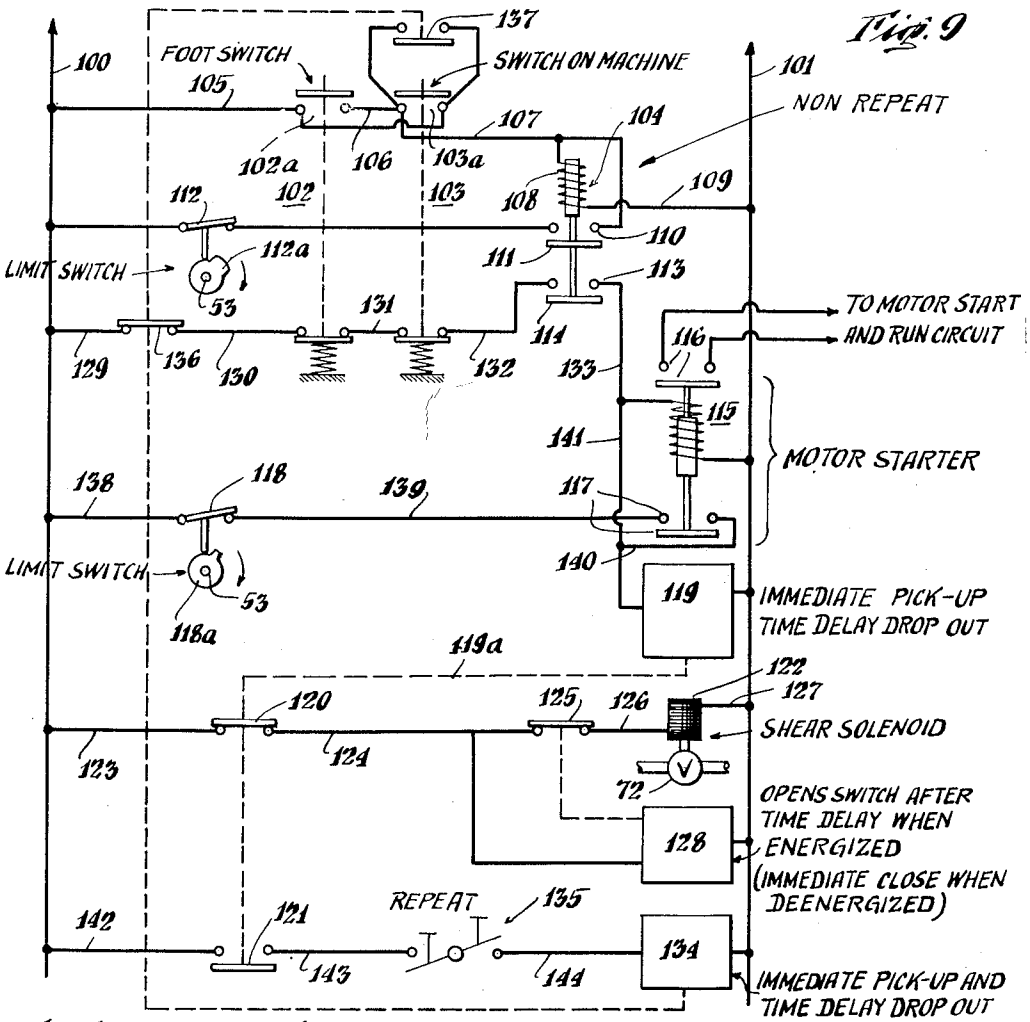


Fig. 5

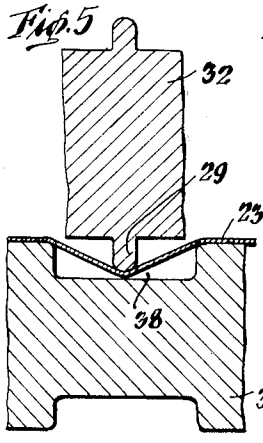


Fig. 6

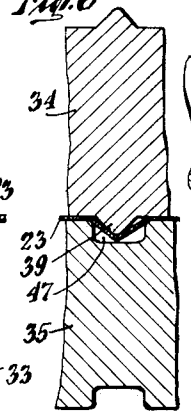
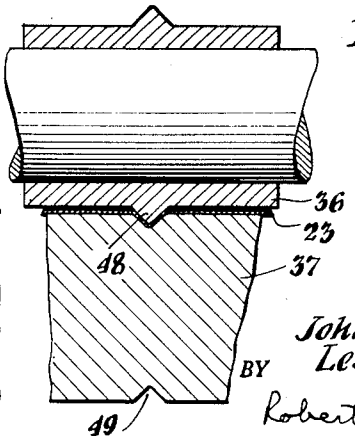


Fig. 7



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METHOD AND APPARATUS FOR DELIVERING SHEET MATERIAL

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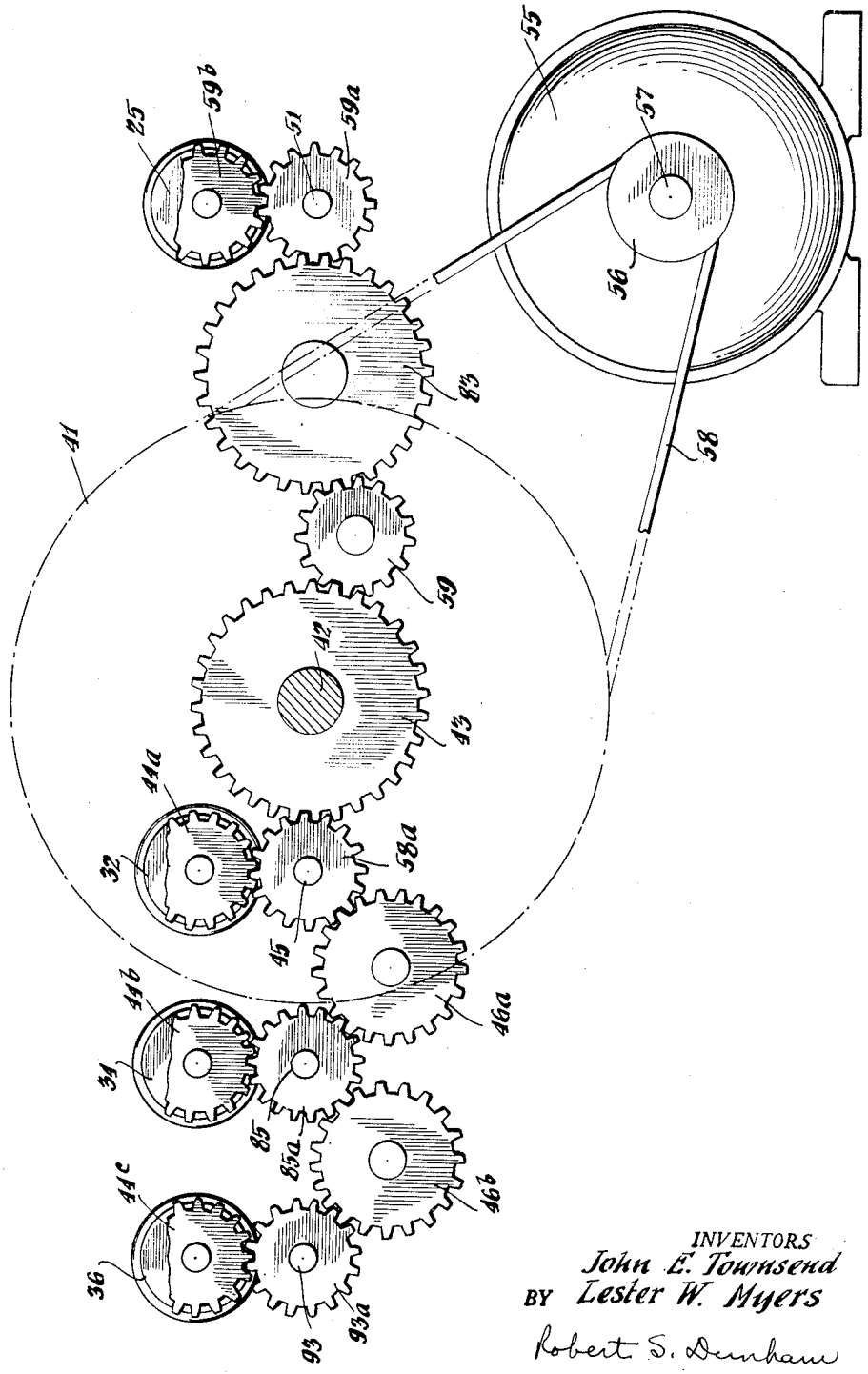
Fig. 10



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United States Patent Office 2,811,196 Patented Oct. 29, 1957

2,811,196

METHOD AND APPARATUS FOR DELIVERING SHEET MATERIAL

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Application March 15, 1952, Serial No. 276,888

9 Claims. (Cl. 154—30)

Long sheets or strips of thin material, such as paper or the like, are not easily handled because they are apt to buckle or bend, particularly when efforts are made to advance or locate such a sheet or web otherwise than by pulling it across a flat supporting surface. These problems are especially acute when it is desired to feed out a long strip of such material from a supply roll. An important instance of an operation of the type here contemplated, is in feeding large lengths of paper to constitute separator sheets in the stacking of sheet metal or equivalent articles.

For example, in the production of sheets of stainless steel or other metal, having a polished or specially finished surface which should not be scratched or marred, it is desirable to lay a sheet of separator paper upon each of the metal sheets while the latter are being stacked. The resulting pile then has paper interleaved between the metal faces, for the desired protection. The insertion of the paper, however, has been a laborious and time-consuming operation, not only because of the large size of the paper sheets (for example, up to two or three feet or more in width and ranging in length to eight or ten feet or so) but also because the necessary handling of the metal sheets in the stacking operation would be interfered with by any mechanical arrangement for pulling and guiding a paper strip across the stack.

It is, therefore, an important object of this invention to overcome these difficulties of both general and specific nature, and to provide apparatus and procedure whereby long strips or sheets of paper or similar thin material may be fed out by feed rolls from one end only of the material, without difficulty from buckling, crumpling, tearing, or the like. A specific object is to afford novel and effective apparatus which will appropriately handle long paper strip so as to push it out endwise, e. g. from a supply roll, onto a receiving surface, without need for any device to engage or pull the leading edge of the strip.

Another object of the present invention is to provide new and improved methods and apparatus for feeding out strips of paper-thin material to a predetermined length, and cutting them off.

A further object of this invention is to provide apparatus which will automatically feed out wide strips of paper-thin material, cut them to a predetermined length, and continuously repeat such operation as many times as desired.

A still further object is to provide novel control means, advantageously embodied in an electric circuit for controlling the desired sequence of operations involved in using apparatus, such as that disclosed herein, for feeding out strips of paper-thin material.

An additional object of the invention is the provision of new methods and means for automatically feeding out strips or sheets of paper-thin material to act as protective layers between sheets of heavier material, e. g. highly polished steel. It is further contemplated that such operation may be incorporated with a stacking of the sheets of material to be protected.

To these and other ends, the novel features and principles of the invention will be most readily explained in connection with the following description and accompanying illustration, by way of example, of one satisfactory form of the new paper feeding apparatus.

In the drawings:

Fig. 1 is a plan view of the paper feed-out machine and shear;

Fig. 2 is a side view chiefly in vertical section taken along the line **2—2** in Fig. 1;

Fig. 3 is a front end elevation view showing the shear blades and operating mechanism therefor;

Fig. 4 is a schematic view in perspective showing the material being fed via the feed rolls through the processing rolls and the shear. Also included in this figure is a showing of the limit switch mechanism and a gear ratio changing device;

Fig. 5 is an enlarged sectional detail view showing the action of the paper at the gathering roll, taken along the line **5—5** of Fig. 1;

Fig. 6 is an enlarged sectional detail view of the first creasing roll showing the action of said roll on the paper, taken along the line **6—6** in Fig. 1;

Fig. 7 is an enlarged sectional detail view showing the action of the final creasing roll on the paper, taken along the line **7—7** of Fig. 1;

Fig. 8 is a perspective view showing a stack of thick material sheets alternating with layers of paper supplied by the machine;

Fig. 9 is a wiring diagram of an electrical circuit controlling the automatic operation of the apparatus; and

Fig. 10 is a side view on a reduced scale, of the driving gear train.

The specific embodiment of the device which is illustrated in the various figures will be described with reference to the use of paper as the very thin material being fed out. It will be appreciated, as stated above, that with very thin material of the character and of the order of thickness of paper, buckling, bending and crumpling easily occur. Such buckling is especially troublesome where it is attempted to feed out large strips of such material of any appreciable length relative to the width of strip being fed out; the difficulty is likewise increased when it is sought to deliver or project the paper strip at a relatively high speed of travel. For interleaving between polished stainless steel sheets or the like, the paper must not only be soft, highly purified and entirely free from grit, specks or similar foreign matter, but is also usually very thin and pliant, indeed tissue-like, so that it is exceptionally hard to handle. It will become apparent that the device of this invention in some cases may be used to feed materials other than paper, especially materials having physical properties similar to paper, and in such instances, or indeed sometimes in the case of paper, the configuration of the grooves or crimps which the apparatus is adapted to make in the material (in the manner and for the purpose described below) may be changed suitably as desired.

Briefly, the illustrated machine embodying the invention consists (Figs. 1, 2 and 4) of feed rolls (**25, 26**), gathering rolls (**32, 33**), crimping rolls (**34** to **37** inclusive), and a shear (**40**). By the operation of these instrumentalities (as will be explained in detail) not only is paper advanced from a supply roll and cut off in the desired long lengths, but in accordance with the invention, it is continuously provided with a longitudinal ribbed or crimped structure which makes possible the desired endwise feeding without buckling or other damage. That is to say, it has now been discovered that by continuously imparting such a structure to the paper, preferably in the form of a plurality of parallel ribs or channels running lengthwise of the sheet and spaced across it, the

paper is sufficiently reinforced or stiffened as to permit its being pushed out endwise to a relatively great length, for example, over and onto the uppermost one of a stack of metal sheets that are to be interleaved with paper as they are piled up. It has further been found, as will become apparent below, that despite the use of relatively thin and pliable paper, longitudinal ribs or crimps may be continuously and rapidly embodied in it, with the apparatus herein described, and in a sufficient manner for the purpose of self-support against crumpling or buckling. Moreover, the resulting configuration of the paper sheet, e. g. with ribs of the character illustrated in the drawings, is not found to interfere with the desired interleaving operation; indeed, the sheet may tend to flatten somewhat as soon as it is deposited, and when prepared in the preferred manner shown, flattens completely and smoothly under the weight of a metal sheet placed over it. When the paper used is of the exceptionally soft and pliant variety mentioned above and although even then the V-shaped creases may be considered "permanent" for the desired stiffening purpose in projecting the strip onto the stack, the creases may almost completely disappear of their own accord while the severed piece is settling and momentarily awaiting the deposit of the next metal sheet.

To accomplish the feeding and crimping operations with the apparatus shown, paper from the supply roll is fed by the feed rolls to the gathering rolls where it is gathered in, reducing its width to gain sufficient paper in the form of preliminary ribs, for forming the desired creased ribs or crimps. Then it is passed through two sets of crimping rolls specially designed to cooperate, in succession, for setting in the creases or crimps, and from the crimping rolls the paper is ejected (in the desired, relatively self-supporting or stiffened manner) on through the shear which is operable to cut off the ejected strip to any desired length. In this manner, the apparatus may be used to feed out and insert layers of paper as separator-protectors, for example, in a stack of highly polished sheets of steel.

An illustration of a method of inserting paper between layers of any material, such as sheets of steel, is had in Fig. 8. As here shown, sheets of paper **23** are being fed out from the machine (not seen in this illustration) in the direction of the arrow which is parallel to the longitudinal ribs or crimps made by the machine. Specifically, V-shaped crimps **95** are formed in the sheet of paper as it is being fed out across the top of a sheet of steel or whatever material is being stacked. As indicated above, these crimps or creased ribs give sufficient stiffness so that the paper may be rapidly fed out full length from the feed-out or trailing end only, and then cut off to length. In this way, sheets of paper may be supplied as rapidly as sheets of steel, and no delay will be caused in piling up a stack of steel sheets by reason of the operation of inserting the paper protector layers. In the illustration, sheets of steel **96** are being introduced from one side; it is obvious that they may be introduced from any position as convenient.

Referring to Figs. 1 and 2, there is a supply roll of paper **16**, which is to be crimped and fed out for use. A rod **17** supports the roll **16** and also carries means to apply friction to the roll for damping effect, such that little or no overrun will occur as the paper is drawn off by the machine. Such friction means may consist of springs **18** and collars **19** for applying friction to a core **20**, upon which the paper is rolled. Collars **19** are secured in position against the spring tensions by means of set screws **27**. In order to prevent the rod **17** from rolling, it is supported at one end by a through bolt **28** which also serves as a pivot about which to raise the rod **17** in order to change rolls of paper. The rod **17** is supported on the machine by means of arms **21** which have U-shaped members **22** at the extremity of these arms.

The paper, indicated by the reference character **23** is fed off the roll **16** through a guide **24** and between feed rolls **25** and **26**. To apply further frictional effect for preventing overrun, there is a roll of canvas or a canvas-covered weighted roller, or the like, **30**, which is suspended by an extended portion **30***a* of its canvas covering that is in turn fastened by means of a metal strip **31** bolted to the top of guide **24** as indicated. The paper proceeds from the feed rolls **25** and **26** through a considerable space to the first set of processing rolls, which are the gathering rolls **32** and **33**. Here the width of the paper strip is reduced the required amount to gain sufficient paper for a crimping process to follow. This gathering action is accomplished by means of spaced ridges **29** on the upper gathering roll **32**, which ridges roll in correspondingly spaced grooves **38** in lower gathering roll **33**. For further illustration of the structure and function of these parts, see Figs. 4 and 5.

The paper is next fed through a first pair of crimping rolls **34** and **35** where a preliminary crimp is applied at each ridge **39** which rolls in its groove **47**. These ridges and grooves (**39** and **47**) are spaced the same distance apart (center to center) as are the ridges and grooves on the gathering rolls which preceded these crimping rolls in the progress of the paper through the machine. Also, the ridges and grooves of the crimping rolls are lined up with those of the gathering rolls, i. e. in the direction of travel of the paper. The action at the first crimping rolls (**34** and **35**) consists of forming the paper into preliminary V-shaped crimps preparatory to a final creasing of the paper to make the ribs or crimps stay. A further illustration of this action may be had by reference to Fig. 6. Although there is no intentional stretching of the paper in any of these operations and although the present method and apparatus are especially designed for material of the character of paper, it may be noted, in passing, that they are usefully applicable, when desired, to materials that are or can be stretched.

The final forming operation is applied at rolls **36** and **37** (through which the strip next passes) where the action is to press in the crimps under pressure. This step positively creases the paper and hence gives the crimps a lasting quality, e. g. a sufficiently permanent deformation of the paper, which produces the desired stiffness or reinforcement in the sheet. At these final rolls **36** and **37**, there are ridges **48** and grooves **49** respectively, which are lined up with the ridges and grooves of the preceding crimping rolls **34**, **35**, and also with the ridges and grooves of gathering rolls **32**, **33**. In order to gain the creases desired, the grooves **49** exactly match the shape of their corresponding ridges **48**. Further illustration of this creasing action by the fully conforming rolls **36**, **37**, may be had by referring to Fig. 7. Note that, as shown in Fig. 7, the ridges **48** are slightly higher than the depth of the grooves **49**, so that the localities of the paper which are to be crimped are tightly seized between the ridges **48** and the grooves **49**, while the intervening localities of the paper, which lie between the cylindrical portions of the rolls **36**, **37** are not closely confined between the rolls. On the contrary, these intervening localities of the paper pass between sections of the rolls having substantial clearance which permit local movements of the paper either laterally of the sheet or in a direction perpendicular to the general plane of the sheet. Such movements may be required to accommodate smoothly the change of form of the sheet from the relatively broad, open grooves of Fig. 6 to the narrower, sharp-edged grooves of Fig. 7.

After the paper leaves these final crimping rolls **36** and **37**, it is fed out between the blades of a shear generally indicated by **40**, the sheet being now sufficiently reinforced to be self-supporting as it is pushed, even across some space, to the top, say, of a stack of sheet metal, and then along the latter to a relatively great length (e. g. many feet) without buckling, folding under, or other difficulty. When the paper has been fed out a desired amount, the feeding operation is arrested while the

shear **40** is operated to cut off a strip of the selected length.

For effectuating the advance of the paper through the rolls, means are provided for positive drive of all of them, including the gathering and crimping rolls. It will be understood that any of a variety of types of drive may be used, and that the illustrated arrangement is simply disclosed by way of example. In such arrangement, power for driving these rolls is supplied by a suitable source such as an electric motor **55** which is shown only in Figs. 1 and 10, and which may be located at a lower part of the machine. Motor **55** carries a multiple belt pulley **56** on its shaft **57**, and by means of belts **58** drives a multiple belt pulley **41**, which in turn is carried by a shaft **42** (Figs. 1, 2 and 10). The shaft **42** also carries a gear **43** which is thus rotated by the pulley **41**. The gear **43** meshes with a pinion **58***a* (Fig. 10) which is carried at the end of a shaft **45** which in turn carries the lower gathering roll **33**. The positional relationship of this train of gears, being described now, is shown in Fig. 10 and is also in part indicated by dotted lines in Fig. 2. The large pulley **41** is likewise shown, to help identify the gears. As explained, the gear **43** not only turns the pinion **58***a* but also meshes with an idler pinion **59**, which in turn meshes with an idler gear **83**. The gear **83** is in mesh with a pinion **59***a* on the end of the shaft **51** which carries the lower feed roll **26**. Since the shaft of the upper feed roll **25** also carries a pinion **59***b* that meshes with the pinion **59***a*, it will now be seen that the feed rolls **25**, **26** are positively driven through the train described above.

The shafts **85** and **93** of the lower crimping rolls **35** and **37** respectively carry pinions **85***a*, **93***a*, which are driven in the same direction as the pinion **58***a* by intermediate idler gears **46***a*, **46***b*, the gear **46***a* being in mesh with the pinions **58***a* and **85***a* and the gear **46***b* being in mesh with the pinions **85***a* and **93***a*. The shafts of the upper gathering roll **32** and the upper crimping rolls **34** and **36** respectively carry pinions **44***a*, **44***b* and **44***c* which mesh with the described pinions **58***a*, **85***a* and **93***a* on the shafts of the corresponding lower rolls. In consequence of this further train of pinions and idler gears, all of the gathering and crimping rolls are positively driven from the gear **43**, in appropriate synchronism with each other and with the feed rolls **25**, **26**.

The machine includes a variable-ratio speed reduction transmission **50**, which may be of a conventional character (e. g. using friction or other gearing or other suitable transmission elements) and which for brevity is here identified as a gear reduction box. The box or unit **50** (only partly shown in Fig. 1) is connected to the end of the shaft **51** which carries the lower feed roll **26** as previously pointed out. Reference is made to Fig. 4, wherein the complete gear reduction box is schematically illustrated and where it will be noted that the unit includes a means **52** (e. g. of conventional character for such devices) for changing the ratio of speed reduction. The output of this gear reduction box is represented by the shaft **53** which drives a limit switch device **54** as schematically illustrated, the device **54** embodying, for example, a pair of cam contact devices which are functionally shown in Fig. 9 and there recognized by reference to their common driving shaft **53**. These elements, i. e. the transmission unit **50** and the switch unit **54**, may each take any known form of such devices, as will accomplish the desired purpose herein explained. The illustrated combination of the devices is to be used in connection with the electrical control circuit which will be described in detail below. It is sufficient now to point out that when the paper is fed out, the length of strip will be dependent on the number of revolutions made by feed roll **26** and its shaft **51**. Then by means of the reduction gearing **50**, a limit switch of suitable type (in the device **54**) may be driven by the output shaft **53** so that after a desired length of strip has been fed out the limit switch will operate and stop the motor **55** which is feeding out the strip. The gear reduction ratio changer is provided in order to be able to vary the length of strip to be fed out, as desired.

Attention is directed to Figs. 1, 2 and 3 for details of the shear which is of a unique construction whereby it may be subjected to long continued use without substantial loss in ability to operate easily and to make a sharp and clean cut every time. Such beneficial results are gained by a construction which provides an action similar in effect to that of hand operated shears, a basic principle of such arrangement being that the shear blades are spring-biased into contact with one another, in such a manner that their tips overlap until the shears are closed. It should also be noted that hand shears do not cut along the whole length of their blades at once but make a single "point" shear or cut which progresses from the heel of the blades to the tip. This action is also realized in the shear arrangement of the present invention.

The shear consists of a U shaped lower blade **60** (having two wings or vertical extensions **79**, **80** best seen in Fig. 3, and a horizontal, straight-line cutting edge **97**) and two approximately rectangular upper blades **73** and **74** which are each about one half the length of the lower blade and are arranged end to end above it. The lower blade **60** is fastened to the face of a U shaped support **62** by means of bolts **92** which are tightened against a thickened reinforcing section **91** of the lower shear blade. The support **62** at the sides of its upright arms, is carried in guide members **61** which are bolted to a framework **84** in a vertical position. These guide members **61** have inwardly sloping edges abutting the sides of the U shaped support **62**, while the sides of the support have a corresponding outward slope or bevel, i. e. to match the slope of guide members **61**, in such a manner as to hold the support **62** and the lower shear blade **60** against the framework **84**. Thus the guides **61** provide a trackway in which the support may slide vertically.

The support **62** is also movably supported by a lower foot **62***a*, as described below. That is to say, the support and blade are raised vertically by means of an air operated piston enclosed in a cylinder **63** and connected to the foot **62***a* by a shaft or piston rod **64** and a pin and clevis coupling **65** as illustrated. For indicating the number of operations of the shear and thus the number of sheets of paper delivered over a given time, there is a counter **66** which is actuated by its arm **67** and a link **68** attached to the lower shear blade support by means of a pin **69**. When the shear blade and support are in their lower position, as shown, the support rests on and is supported by blocks of absorbing resilient material **70** which are carried in cup-like supports **71** as clearly illustrated in Figs. 2 and 3.

The supply of air under pressure for the air operated cylinder **63** is controlled by means of a solenoid operated valve **72** which is schematically illustrated in Fig. 9, its physical location being unimportant to the operation of the device, so long as it is suitably connected to control the supply and exhaust of air for the cylinder. It will also be understood that the valve element is only diagrammatically shown in Fig. 9 and may in fact be of suitable conventional construction for controlling the elevation and return of a movable device (such as the shear blade **60**) by an air operated cylinder. It will likewise be apparent to those skilled in the art that other types of fluid-operated means, for example, a hydraulic cylinder, may be used to actuate the shear and may be similarly controlled by a solenoid valve. Similarly it will be apparent to those skilled in the art that the lower blade might be motor operated, dispensing with a fluid cylinder entirely.

The upper blades of the shear **40**, namely **73** and **74** previously mentioned, are attached in a generally flatwise but floating manner to the framework **84** of the shear assembly by means of bolts **75** and spring **76**, a plurality of the bolts being arranged to pass through each blade into

the framework behind it, and each blade being adapted to move on its supporting bolts, i. e. axially of the latter. The springs 76 act between the upper blades 73, 74 and washers under the heads of the bolts 75, to bias the upper blades inwardly against the lower shear blade 60 and against a stripping bar 86 which will be more fully described hereafter. In order to gain progressive shear action, the cutting edges 81 and 82 of upper shear blades 73 and 74 respectively are sloped relative to the horizontal, in such fashion that shearing action will commence at the heels (i. e. outer ends) of the upper blades and work toward their abutting tips. In other words, as seen in elevation the upper blade edges form a shallow inverted V, such that the cutting action will begin at the edges and work toward the center of a strip of paper.

Attention is also directed to the fact that end portions 77 and 78 of upper blades 73 and 74 respectively, overlap vertical extensions 79 and 80 (Fig. 3) of the U shaped lower shear blade 60, the portions 79 and 80 being plate-like faces of the upright arms of the lower blade. Since the portions 79, 80 project slightly from the face of the stripping bar 86 toward which the upper blades 73, 74 are urged by the springs 76, the blades actually engage the bar (when the lower blade is down) only at their abutting ends, i. e. at the center of the assembly (as viewed in Fig. 3); each of the upper blades is thus held at a slight angle, when seen in plan (Fig. 1), so that together they form a shallow V which extends inwardly across the lower blade and from which they are adapted to be displaced (against the springs 76) into a straight line relation when the lower blade rises. In the described fashion, with the upper blades spring biased across the center of the cutting edge 97 of the lower blade 60, the cross-tipped action of hand shears is achieved; when the lower blade ascends, it progressively forces the upper blades outwardly (to the left in Figs. 1 and 2) while it progressively engages their edges from the outer ends toward the center. It will be understood, of course, that the overlapping end portions 77, 78 of the upper blades 73, 74 are so positioned by the supporting faces 79, 80 as to insure that the end portions of the rising lower blade will pass behind the outer end portions of the upper blades, to commence the progressive shearing action at both ends of the assembly. That is to say, the end portions of the upper blade edges are positively held (by parts 79, 80 of the lower blade structure) from crossing over the lower blade edge and jamming the shear.

The stripping bar 86 previously mentioned, acts to remove paper from the upper blades following the operation of the shear. This bar is in structure a flat plate having slots 87 to allow it to move vertically with respect to bolts 75. The bar or plate 86 is spring biased into its lower position as shown by a plurality of plungers 88, and springs 89, each having its head downwardly pressed against the upper edge of the bar by a coil spring 89. That is to say, the springs 89 are thus disposed in compression between the heads of the plungers and corresponding brackets 94 which are bolted to the top of the framework 84 at intervals and which thus serve to carry the plungers. When the shear 40 is operated the lower shear blade 60 is raised and comes in contact with the stripping bar 86, carrying it up to the top of the stroke, i. e. moving the bar upward until the lower blade has passed the central, highest region of the upper blade edge assembly (Fig. 3). Thus the inner or remaining edge of the paper strip (after the cut) is stripped from the upper blades and is free to fall (or to be carried by the stripper bar) to a position below them when the lower blade returns to its lower or open position.

There is also a guide member 90 (best shown in Fig. 2), in the shape of thin plate or sheet metal structure having a face 90*a* which extends completely across the path of the paper and which cooperates (e. g. with the stripper bar) to insure that the paper feeds smoothly through the opening made by the shear blades.

It has been made clear that power to drive all eight of the feed and processing rolls (25, 26, and 32–37) is directly coupled to each of them by means of gearing on their respective shafts. It should also be pointed out that the ends of the shafts of the upper roll of each pair (25, 32, 34 and 36) are mounted in bearing boxes 98 (only one of the two boxes for each roll being seen in Fig. 2), each of which is spring biased downwardly to maintain desired pressure between the upper and lower rolls of each pair, by a spring 99 as shown. The ends of the shafts of the lower rolls (26, 33, 35 and 37) may likewise be carried in bearing boxes (not shown) similar to the upper boxes 98, in order to facilitate maintenance.

In order to review the operation of the device, reference is made to Fig. 4 where it is generally shown that paper is fed out from the roll 16 by means of the power driven feed rolls 25 and 26, and proceeds to be fed through the gathering rolls 32 and 33 where the paper is gathered in, reducing its width sufficiently to gain enough paper to form the longitudinal ribs or crimps 95. Formation of these crimps is accomplished by the crimping rolls 34–37.

As explained above, these creased ribs or crimps have been found remarkably effective in imparting sufficient stiffness to permit feeding the paper out in long strips without buckling or other derangement. The advantages thus gained will be particularly apparent when it is recalled that one important specific use for the machine is that of feeding strips of paper or other light-weight sheets of material between layers of polished steel or other such material which is to be protected in stacking. Another specific feature of the invention is the use of a plurality of sets of processing rolls (for example three, as shown) which cooperate in succession to provide the relatively permanent deformation of the paper along laterally spaced longitudinal paths, without undue strain, tearing or irregular or incomplete creasing. While in some cases other configurations can be used, the ultimate V-shaped section of the ribs or channels, each creased at its apex and lower edges, is unusually satisfactory for the present purposes, and thus constitutes a further feature of special preference. Simply by way of example, successful feed of paper upwards of 20 to 30 inches wide, out to lengths of many feet, has been achieved with ribs or crimps mutually spaced (center to center) by 2¾ inches, the V-shaped ribs 48 in the final roll 36 having a base width of one-fourth inch and having their sides inclined at 45°. It will be understood, of course, that considerable variation is possible in the dimensions and other values just recited, to suit various conditions and requirements that may be encountered in the practice of the invention.

While the configurations of ridges and grooves on the various rolls may vary with requirements, it should be noted that specially advantageous results are obtained in the machine as shown. Here the ridges 29 of the gathering roll 32 are narrow flange-like ribs, while the cooperating annular, rectangular grooves 38 in the roll 33 are at least several times as wide. Likewise, there is appreciable clearance between the base of each triangular ridge 39 on the first crimping roll 34 and the mouth of the cooperating rectangular groove 47 on the lower roll 35. Finally the operative surface of the upper, final crimping roll 36 is preferably provided by a series of separate sleeves (see Figs. 1 and 7) which are adapted to slide on the supporting shaft as shown, so that accurate spacing and self-alignment (with the grooves in the unitary lower roll 37) can be achieved. Indeed the clearance of the rolls 33 and 35 and the described construction of the roll 36 are of special manufacturing convenience, in permitting unavoidable variation of centers in machining the several ridges and grooves.

The contours of the grooves and recesses in the applicants' first set of rolls is best seen in Fig. 5. It may there be seen that the sheet material is not tightly gripped between the ridge 29 on the upper roller and the recess

38 on the lower roller. On the contrary, the recess is several times wider than the ridge, and is slightly deeper than the sum of the height of the ridge and the thickness of the sheet material. Consequently, the portion of the sheet material within the groove **38** is not rigidly gripped between the rollers, and the material approaching the rolls is thereby allowed to move laterally and gather to form slack regions in which the grooves will be formed by the subsequent rolls.

This improvement, i. e., the freeing of the groove forming material from restraint by the gathering rolls is also used in a modified way in the second set of rolls, shown in Fig. 6. The groove **47** in that figure is considerably narrower than the groove **38** in the first set of rolls, but it is nevertheless wider than the ridge **39**, and is also somewhat deeper than the combined height of the ridge and the thickness of the material.

It is only in the applicants' final set of crimping rolls that the material gathered for forming the grooves is tightly gripped between the ridged roll **36** and the recessed roll **37**, as best seen in Fig. 7. Furthermore, in those rolls, the material between the grooves is freed from restraint by virtue of the clearance between the rolls.

It is contemplated that the machine may be used with an electric motor drive to feed out a predetermined length of paper automatically and thereafter cut it off without further attention from an operator. This operation may also be caused to repeat continuously without attention, so long as it is desired. One embodiment of an electrical circuit by which such results may be had is illustrated in Fig. 9, where the automatic feeding out and cutting off of a predetermined length of paper will be first described. It will be understood that the several elements of the circuit may individually be of known and conventional construction, including the relays and the time delay switches having the specific functioning characteristics mentioned below; hence, these devices are shown only in diagrammatic form.

A source of electric power may be introduced by means of wires **100** and **101**, which may thus extend to any appropriate and available source (not shown). Operation of the feed out machine is initiated by either a foot switch **102** or a hand operated switch **103** which may be located on the machine itself. It will be observed that each of these switches is spring biased to the position shown and has a double set of contacts such that one circuit is opened and the other is closed when (and only so long as) the switch is operated against the spring. Operation of either of these switches completes a circuit for a relay **104** (conveniently called the non-repeat relay) to line wires **100**, **101**, such circuit extending through wire **105**, upper contacts **102***a* of switch **102** (or alternatively, the upper contacts **103***a* of the switch **103**), wire **106**, wire **107**, then through the solenoid **108** of the relay **104** and to the other power line **101** via wire **109**. When the relay **104** is energized, it closes a holding circuit by means of its contacts **110** and **111** through limit switch **112** shown. The relay **104** also closes its contacts **113** and **114** when it is energized, whereby a circuit to energize the motor starter relay **115**, will be closed. This circuit may be traced from line wire **100** to wire **129**, contacts **136** (of the time delay operated switch **134**), wire **130**, lower contacts of foot switch **102**, wire **131**, lower contacts of hand switch **103**, wire **132**, contacts **113**, **114** of relay **104**, and wire **133**, to the winding of motor starter relay **115**, the other side of which winding is connected directly to line wire **101**. This circuit is not closed, however, until release of the specific switch used, i. e. foot switch **102**, or manual switch **103**. Upon such release, the circuit just traced will be closed, which will energize the motor starter relay **115**.

It is to be understood that both relays **104** and **115** are shown in their de-energized condition. When energized, they each will pick up their armatures and close their two sets of contacts; as indicated, the relays are energized in succession, respectively upon depression and release of the foot (or hand) switch **102** (or **103**). One set of contacts **116** of relay **115** controls energization of the driving motor **55** (Figs. 1 and 10) of the machine, it being understood that in a suitable circuit, extending if necessary through conventional motor starting instrumentalities (not shown), closure of the contacts **116** starts the motor **55**, and that the motor and the several feeding and processing rolls driven by it thereafter continue to run until the contacts **116** are opened by deenergization of the relay **115**. An extra set of contacts **117** will also be closed when the relay **115** is energized, these contacts being embodied in a holding circuit for the motor starter relay **115**. This holding circuit is completed by means of a limit switch **118**, shown closed. It may be explained that upon termination of a previous cycle of motor operation (as likewise upon each subsequent cycle) the high spot of the operating cam **118***a*, being only 2°, will have momentarily opened limit switch **118**, then moved past due to inertia of the machine, closing limit switch **118** again. When limit switch **118** thus momentarily opens after a predetermined number of revolutions of the motor **55**, it deenergizes relay **115** stopping the motor. This determines the length of paper to be fed out before shearing action takes place. Also, the auxiliary contacts **117** on relay **115** will open, breaking the holding circuit through limit switch **118** to relay **115**. This prevents motor relay **115** from being energized again when limit switch **118** recloses after being momentarily opened, since relay **104** has been deenergized by the action of cam **112***a* as will presently appear.

The motor having a shunt brake will stop at approximately the same number of revolutions after relay **115** is de-energized by the high spot of the cam limit switch **118**, but the cam limit switch **118** having a variable relation with motor R. P. M. (because of the variable speed reduction box **50**) the high spot will vary in the distance past limit switch **118**. This variable means nothing to the operator in relation to length of cut because the gear reduction ratio changer **52** is merely adjusted by the operator until he obtains the length of paper required.

The holding circuit for motor starter relay **115** may therefore be traced as follows: from line wire **100**, to wire **138**, limit switch **118**, wire **139**, contacts **117**, wire **140**, wire **141**, to winding of relay **115** which is already connected to the other line wire **101**. Since the motor starter relay is now held closed, the motor continues to run, i. e. even though the first circuit to the motor starter relay is opened as now to be explained. Thus, after paper has been fed out a certain distance, the limit switch **112** is actuated (by the high spot, which is about 80°, of its cam **112***a*, carried on the shaft **53**, Fig. 4) to break the holding circuit for relay **104**, thereby setting up circuit conditions for a manually repeated operation after completion of one cycle. The limit switch **112** is thus opened some little time before the limit switch **118** opens (to stop the motor), but both switches re-close together.

It will be noted that a time delay switching means **119** is energized simultaneously with motor starter relay **115**, since these two elements are connected in parallel. Time delay switch means **119** is a type of time delay switch that picks up its contacts immediately upon energization and holds its contacts in this position during energization and for a predetermined time after deenergization of the switch device. Switch contacts **120** and **121** are operated by this time delay switch device **119** as indicated by the dashed line **119***a*; thus upon energization of the time delay device **119**, simultaneously with the relay **115**, the contacts **120** shift to open position (from their closed position shown) and the contacts **121** shift to closed position (from their open position shown), both sets of contacts remaining in the shifted positions so long as the motor is running and for the predetermined delay thereafter.

That is to say, when the limit switch 118 is operated (by the high spot of its cam 118*a*, also on the shaft 53, Fig. 4) after a predetermined number of revolutions of the motor, the holding circuit for relay 115 is broken and this relay is released, stopping the motor. Also the time delay switch means 119 is de-energized. Hence after a predetermined delay time, switches 120 and 121 drop out to the position illustrated in Fig. 9, and a circuit is complete to the shear solenoid 122. This circuit is readily traceable from line wire 100, over wire 123, switch contacts 120, wire 124, switch contacts 125 (normally closed), wire 126, solenoid 122, wire 127 to the other line wire 101.

When shear solenoid 122 is energized it actuates solenoid operated valve 72, which in turn causes the shear blade 60 to be raised and shear off the strip of crimped paper 23 at the predetermined length. After time for this action to take place, time delay switch 128 is actuated, opening its contacts 125 which then deenergizes solenoid 122 and so returns the shear blade to its lower or open position.

In other words, upon the energization of the motor starting relay 115 and the corresponding operation of the motor, the contacts 120 become open and the device 128 deenergized, closing its contacts 125, this condition persisting as long as the motor runs and until the end of the delay period of the device 119 (which gives time for the motor to stop). In consequence, the shear solenoid circuit will be completed upon the then closing of switch contacts 120 (i. e. at the end of the delay period of the device 119), since the contacts 125 were already closed by reason of the previously de-energized condition of the delay device 128 and will remain closed after energization of the device 128 (by closure of contacts 120), i. e. until termination of the delay period of the device 128. It is explained at this point that the time delay switch device 128 is connected to wire 124 (between switches 120 and 125) and to the line wire 101. Therefore, it will now be clearly appreciated that during the time when the motor was energized and the time delay switch means 119 consequently was also energized, the switch 120 was opened, and hence the time delay switch means 128 was de-energized and its switch contacts 125 stayed closed. The shear was not operated, however, since the contacts 120 (also in the shear control circuit) were open. Following this condition, when the motor was de-energized, as was also the time delay switching device 119, the switch 120 was eventually closed after time for the machine to stop, and at the latter time a complete circuit was made for the shear solenoid 122. Following the energization of shear solenoid 122, which causes the shear to be actuated (by supplying air under pressure to the lower end of the cylinder 63 and elevating the piston rod 64, Fig. 3), the time delay switch device 128 after a predetermined delay opens its contacts 125 and allows the shear to return to an open or inoperative position. This completes a single cycle of automatic feeding out and cutting off operation.

If it is desired to have the machine operate continuously, repeating the above cycle, without necessity for attention by the operator, a further circuit, now to be described, will be put into operation. Further time delay switch means 134, which has immediate pick up and time delay drop out (to the position shown) may be put into operation by means of a toggle switch 135, designated the repeat switch.

It is pointed out that all manual switches, limit switches, time delay switch contacts and relay contacts are shown (in Fig. 9) in a state of rest with no power on line wires 100 and 101.

Continuing with a description of repeated operation without manual starting each time: after switch 135 is closed (thereafter remaining closed until it is manually opened) a cycle of operation, such as previously described, is begun. That is to say, either the foot switch 102 or the hand switch 103 is operated, by pushing it down and letting up on it, to get the machine started; the initial energizations of relays 104 and 115 are thus successively effected, providing the first starting of the motor and in due season, energization of the time delay switch device 119, all as explained above. The switch 121 will be closed by energization of the time delay switch device 119 since the switches 120 and 121 are actuated together as is indicated by the dashed line 119*a* connecting them with the device 119. Closing this switch 121 completes a circuit, as illustrated, to energize the time delay switch device 134. This circuit may be traced as follows: from line wire 100, to wire 142, switch 121 (now closed), wire 143, toggle switch 135 (now closed), wire 144, to the time delay switch device 134 which is directly connected to line wire 101.

Promptly upon energization of the switch 134, its switch contacts 136 and 137 will be actuated, e. g. to open switch 136 and close switch 137. Closing of switch 137 will re-close the original or main energizing circuit for the relay 104 and therefore contacts 113 and 114 of the relay 104 will be closed irrespective of actuation of the limit switch 112. Specifically, the relay 104 remains continuously energized during a time of automatically repeated operation: the holding circuit through contacts 110—111 is temporarily interrupted by the limit switch 112 only at times when the main energizing circuit for the relay 104 is closed by the switch 137, so that upon the re-closing of the switch 112 (which, like the re-closing of switch 118, occurs just after the motor stops and before the end of the delay period of relay 119) the holding circuit is always reestablished (to continue the energization) before the switch 137 is opened. At the time of its operation following energization of the relay device 134, the switch 136 will be opened as above indicated, however, and therefore the motor starter relay 115 and time delay switch means 119 will continue energized only by means of the holding circuit through the limit switch 118. Thus, when the limit switch 118 is finally opened (to stop the motor and initiate operation of the solenoid 122 of the shear solenoid valve 72) as previously described in a single cycle of operation, the time delay switch means 119 will be de-energized and as a result, the switch 121 will ultimately be opened. Opening switch 121 will de-energize the time delay switch device 134, so that after a predetermined delay time, the switch 136 will close and a new cycle will be commenced.

It is to be noted that the time delay following de-energization of this device 134, i. e. as determined by it, must be such as to allow sufficient time for operation of the shearing to be completed so that when a following cycle is commenced, the shear will be in its inoperative or open position. That is to say, since the closing of the switch 120 initiates the shear operation which is terminated only at the end of the delay period of the device 128 and since the switch 121 opens to de-energize the device 134 at the same time that the switch 120 closes, the delay period afforded by the device 134 (for closing the switch 136 to re-energize the motor relay 115 and to start a new paper feeding cycle) should be somewhat longer than the delay period of the device 128. Under such circumstances, the shear will have ample time to return to open condition before the new cycle is automatically started.

To stop the machine during a period when it is running in the described automatically repeating manner, the toggle switch 134 is merely shifted to open position. Thereupon, after not more than one further cycle of operation, the machine will come to rest, the final cycle having been duly completed and the parts being restored to the position they occupy at the end of any cycle of non-repeating operation.

As indicated above, sheet material feeding apparatus such as shown herein is capable of many uses, especially for inserting long pieces or strips of paper or the like between sheets or plates being stacked by manual or au-

tomatic operation. It will likewise now be appreciated that the machine of the present invention is readily adapted for timing with automatic piling apparatus, as well as for effective cooperation with other equipment in a production line. Although if desired there can also be manual or automatic arrangements for progressive elevation of the machine or for progressive depression of the pile under supply (as by means conventional for other but similar purposes) to keep a fixed distance between the paper pass line and the top of the pile, satisfactory delivery of paper has been obtained upon surfaces considerably below as well as close to the pass line with the machine which is shown herein and which fully embraces the features of our invention. Finally, it should again be noted that in all cases, the present method and apparatus are eminently suited for attainment of their primary advantage, namely an effective endwise delivery or feeding of very long sheets or strips of flexible material such as relatively thin paper, e. g. pliable material which is creasable, i. e. capable of at least a temporarily continuing deformation from a plane sheet by pressure, and which is materially stiffened by such creasing or deformation, such material (of which examples other than paper are some metal foils and paper-thin, pliant plastic sheets) preferably having the same inherent pliability as paper, especially in that in its plane, uncreased state the material cannot be projected or propelled in a plane (i. e. pushed horizontally flatwise) out across an unsupported region of more than, say, a few inches without bending steeply downward around a transverse axis.

A specific embodiment of the invention has thus been shown and described by way of example but it is not to be taken as limiting in any way the scope of our invention, as defined by the appended claims.

We claim:

1. The method of forming, in a moving sheet of material, a multiplicity of laterally spaced grooves parallel to the direction of movement of the material, comprising, at one laterally extending region along the path of the moving sheet, simultaneously and continuously gathering substantial amounts of the sheet material at the intended laterally spaced localites of all the grooves, by deflecting said groove localities from the general plane of the sheet material while holding in said plane other localities of the material spaced from, parallel to, and between said groove localities, and simultaneously freeing from restraint, in a direction perpendicular to the plane of the material, those localities of the material intermediate said groove localities and said other localities.

2. The method defined in claim 1 for forming grooves in sheet material, in which said groove localities are deflected from the general plane of the sheet material by applying deflecting forces to the sheet material on only one surface thereof, while leaving the opposite surfaces at said localities unconfined.

3. The method defined in claim 1 for forming a multiplicity of parallel grooves in a moving sheet of material, comprising subsequently, at a second laterally extending region along the path of the moving sheet, simultaneously and continuously forming the gathered material at all said groove localities to provide the multiplicity of parallel grooves therein, by closely confining both surfaces of the material at all said groove localities, while leaving the material between said localities unconfined on at least one surface.

4. The method of forming, in a moving sheet of material, a multiplicity of laterally spaced grooves parallel to the direction of movement of the material, comprising: at one laterally extending region along the path of the moving sheet, simultaneously and continuously gathering substantial amounts of the sheet material at the intended laterally spaced localities of all the grooves, by deflecting said groove localities from the general plane of the sheet material, while holding in said plane other localities of the material spaced from, parallel to and between said groove localities, and simultaneously freeing from restraint, in a direction perpendicular to the plane of the material, those localities of the material intermediate said groove localities and said other localities; at a second laterally extending region farther along the path of the moving sheet from said one region, further gathering the gathered material by widening said other localities and correspondingly narrowing said intermediate localities; and at a third laterally extending region farther along the path of the moving sheet from said second region, simultaneously and continuously confining both surfaces of the gathered material at all said groove localities to form said multiplicity of parallel grooves therein.

5. Apparatus for forming, in a moving sheet of material, a multiplicity of laterally spaced grooves parallel to the direction of movement of the material, comprising a pair of opposed gathering rolls extending laterally of the path of movement of the material for engaging opposite sides of the material, one of said rolls having a plurality of ridges spaced by cylindrical surfaces of smaller diameter than the ridges, and the other of said rolls having a plurality of recesses aligned with, substantially wider than and cooperatively receiving said ridges and spaced by cylindrical surfaces of greater diameter than the recesses, said ridges and recesses cooperating when the ridges engage the material to deflect the intended localities of all the grooves from the general plane of the sheet material, while said cylindrical surfaces cooperate to hold in said plane other localities of the material spaced from, parallel to, and between said groove localities, the spacing between the sides of the ridges and recesses being effective to free from restraint, in a direction perpendicular to the plane of the material, those localities of the material intermediate said groove localities and said other localities.

6. Apparatus as defined in claim 5, comprising a pair of opposed crimping rolls engaging said material after it passes said gathering rolls, the one of said crimping rolls on the same side of the material as said one gathering roll having a plurality of ridges sharper than the ridges on said gathering roll and aligned therewith, the other of said crimping rolls having a plurality of recesses substantially wider than the ridges on said one crimping roll but substantially narrower than the recesses on said other gathering roll, said crimping rolls cooperating to narrow and sharpen the depression formed by said gathering rolls.

7. Apparatus as defined in claim 6, comprising a second pair of opposed crimping rolls engaging said material after it passes said first pair of crimping rolls, the one of said second pair of crimping rolls on the same side of the material as said one gathering roll having a plurality of ridges having substantially the same contour as those on said one of said first-mentioned pair of crimping rolls and aligned therewith, the other of said second pair of crimping rolls having a plurality of recesses aligned with, closely conforming to and cooperatively receiving said ridges on said one of said second pair of crimping rolls, said second pair of crimping rolls cooperating to narrow further and to sharpen the edges of the depressions formed in the sheet material by the first-mentioned crimping rolls to change said depressions into sharp-edged grooves, the ridges on said one of said second pair of crimping rolls being higher than the depth of their cooperating recesses, so that the localities of the sheet material between said ridges and recesses are closely confined, and the intervening localities are relatively unconfined.

8. Apparatus as defined in claim 5, in which each said groove is at least several times as wide as its cooperating ridge.

9. Apparatus as defined in claim 5, in which each said groove is wide enough only to provide appreciable clearance between the sides of the ridge and the sides of the groove.

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