Dec. 11, 1956 J. B. FULK 2,773,688

WEB MANIFOLDING METHOD AND APPARATUS

Filed June 5, 1951 4 Sheets-Sheet 1

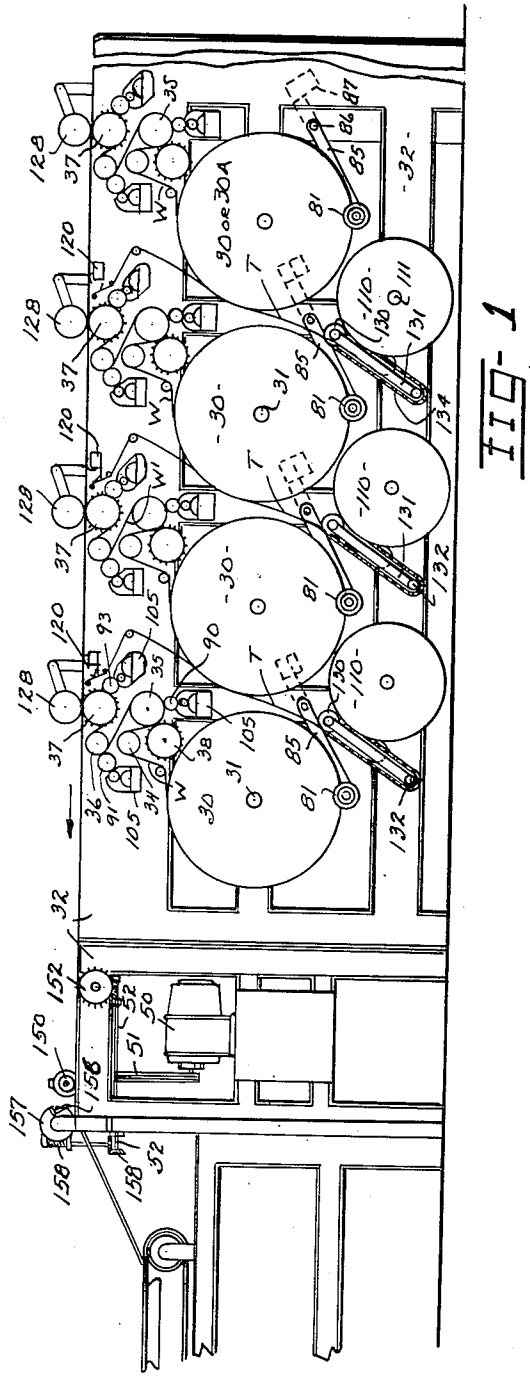


FIG. 1

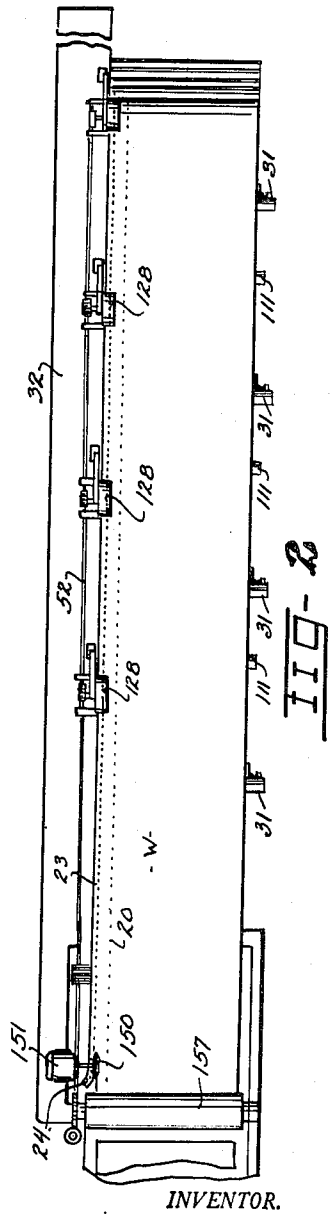


FIG. 2

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WEB MANIFOLDING METHOD AND APPARATUS

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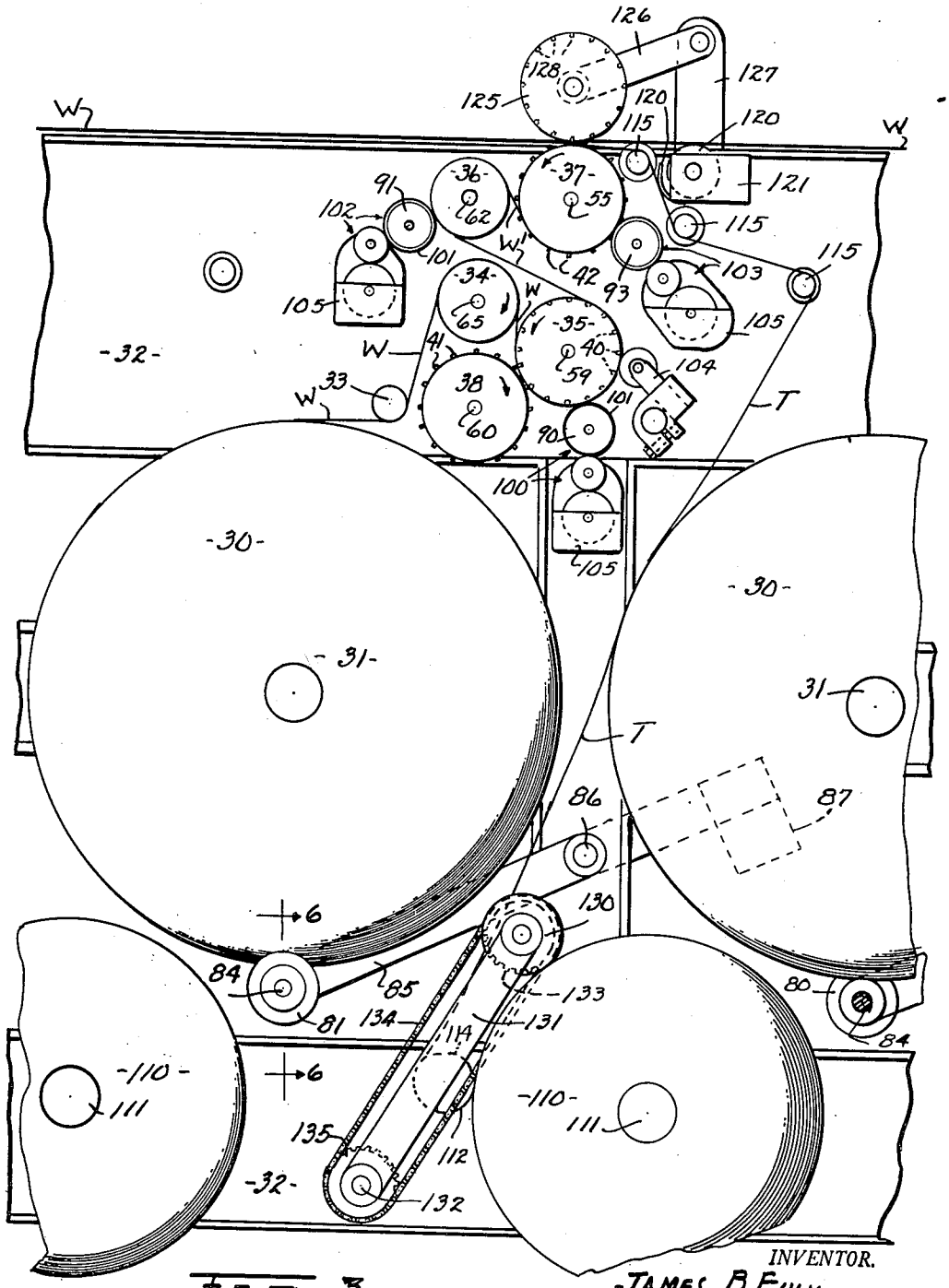


FIG. 3

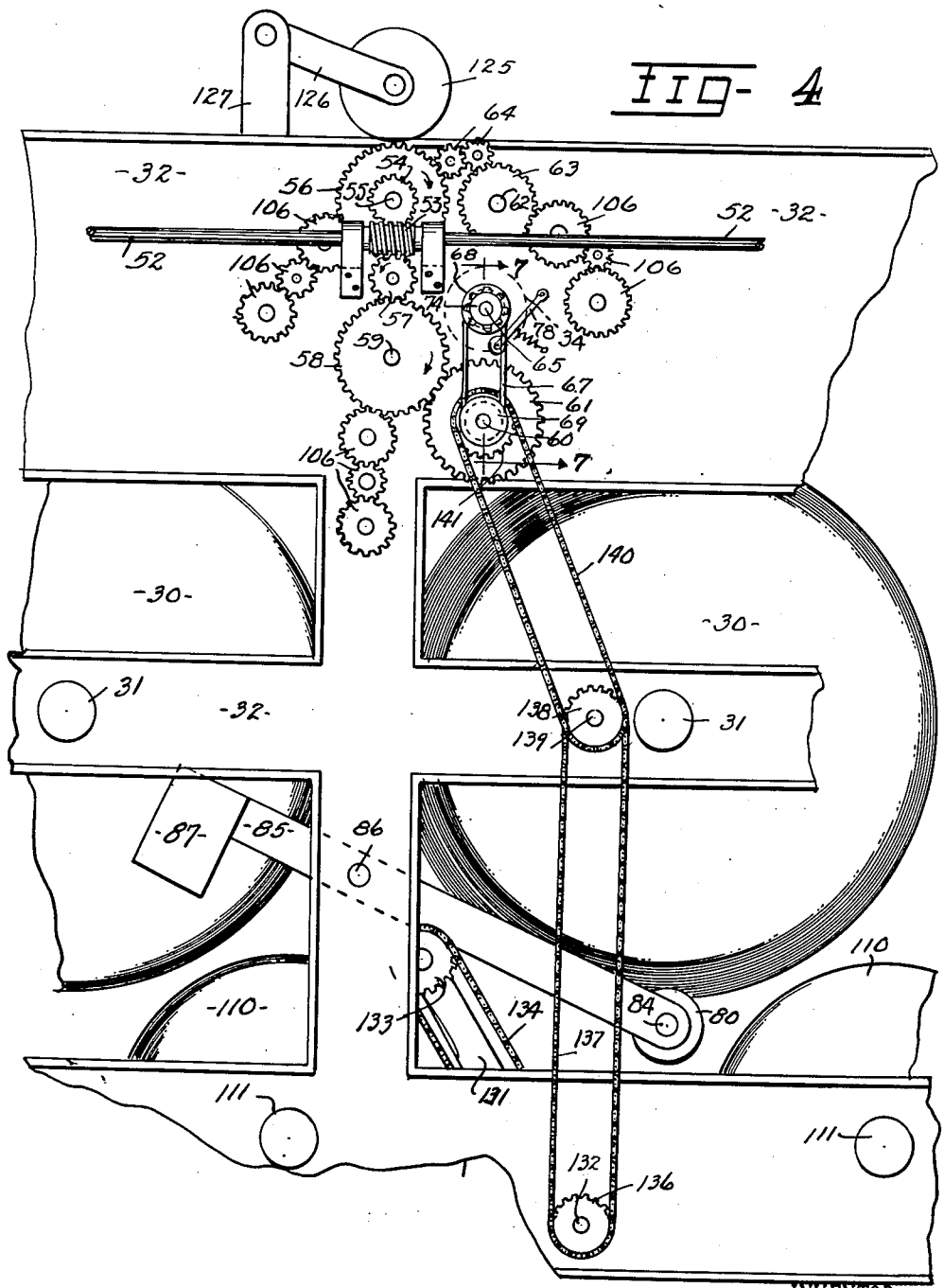
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WEB MANIFOLDING METHOD AND APPARATUS

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Fig. 4



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WEB MANIFOLDING METHOD AND APPARATUS

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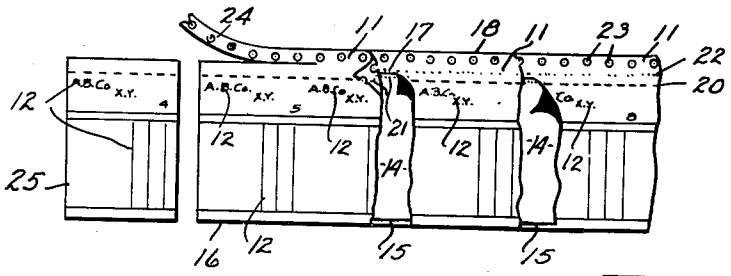


FIG. 5

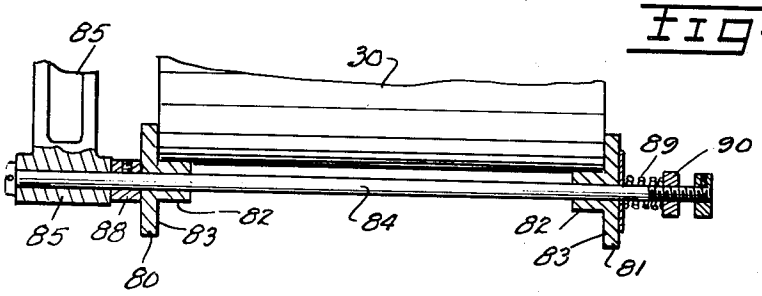


FIG. 6

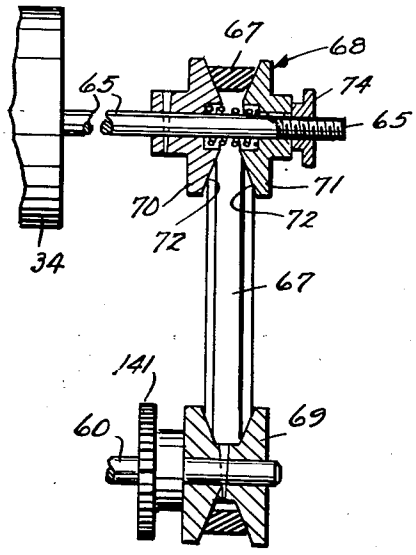


FIG. 7

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2,773,688

WEB MANIFOLDING METHOD AND APPARATUS

James B. Fulk, Los Gatos, Calif., assignor, by direct and mesne assignments, of one-half to Fred A. Ross, Green Bay, Wis.

Application June 5, 1951, Serial No. 230,008

5 Claims. (Cl. 270—18)

This invention relates to an improved method and apparatus for making manifold register forms or packs in which carbons may be utilized for making a record on superimposed printed record strips.

Manifold packs of the general nature and character of the present invention, generally comprise a plurality of sheets of record strips, having transfer strips interleaved therebetween and secured together to form a single unit. These manifold packs may take the form of a plurality of webs, at least two of which have a series of repeated imprints thereon. The imprints on associated webs may be identical or they may vary. In either event the imprints on one web must be superimposed in accurate registration with the imprints on other webs, so that when transfer strips are interleaved between the webs and the forms used to receive further data as for instance by typing on the top strip in registration with the imprint thereon, the transfer strips will transfer such typed data to the strips therebelow in accurate registration with their imprints.

These manifold forms may be severed into individual packs for use, each pack containing a plurality of attached strips having one imprinted form thereon. However, the forms may comprise an elongated strip composed of a plurality of superimposed webs having repeated imprints thereon. Elongated forms may be supplied in rolls or fanfolded stacks. The forms may be provided with a series of equi-spaced holes along one or both edges to receive the coacting pins of a tabulating mechanism.

It is important that the imprint on one web be in accurate registration with the imprints on the other webs. Generally such forms are imprinted in an elongated strip which receives many consecutive imprints. It is obvious that the "lengths" of the forms be identical, and to this end the imprints on one web must be spaced accurately and such spacing must be identical on all webs which are to be collated to form the pack. Even a minute variation in this "length" or spacing is serious because it creates an error which increases in amount with each imprint made. This is true even though the forms, as used, comprise individual packs, because such packs are generally formed by first making a continuous strip of collated webs and then severing the strip into individual forms.

One form of apparatus heretofore developed for making such a manifold pack is illustrated in Patent No. 2,143,107, issued to George L. Fulk, January 10, 1939. Such apparatus utilized relatively large horizontally spaced rolls of previously printed paper webs, each having a row of registration openings along one side thereof. The webs were guided upwardly from the rolls to respective drums positioned generally above the rolls and having projections or pins which coacted with the row of openings of such strip. The pin drums were spaced from each other with their projections aligned horizontally. The webs were collated by advancing them horizontally across the pin drums of other webs while maintaining registration of one web relative to the other by engagement with the registration openings.

It has been found in the use of such apparatus that the distance between the holes and the imprints on a previously printed strip or web often varies slightly from the corresponding distance on other webs. This is due in part to differences in weight or kind of paper, and partially to differences in climatic conditions at the time the strips are printed and perforated and the condition existing at the time the strips are collated. This, together with the fact that the collating drums are spaced a considerable distance apart, has made it exceedingly difficult to maintain accurate registration of the previously printed webs so that they may be collated or secured together to form a manifold pack in which the printed portions of the web are superimposed directly above the corresponding printed portions of other webs. These difficulties have been made more serious due to present demands for the provision of webs having differing colors and weights.

Heretofore various methods have been used, and others proposed, for assembling the previously printed and punched webs or strips to correct misalignment due to variations such as those in weight of paper and climatic conditions above mentioned. I have found, however, that despite the great care used in assembling such previously printed and perforated strips, the maintenance of accurate registration of the imprints previously made on one strip with imprints previously made on other strips has been extremely difficult, and has presented serious problems in construction of the collating apparatus which have, to a great extent, limited the speed at which the assembly of the strips may take place, particularly in view of the present demands for the use of various types of paper in the same pack.

An object of the present invention is to provide an improved method and apparatus for making a manifold pack from substantially continuous webs of material at a relatively high rate of speed and in such a manner that the difficulties heretofore experienced in maintaining accurate registration of the imprints upon the superimposed webs may be eliminated.

A further object of the present invention is to provide an apparatus for making a manifold pack or the like which will facilitate the production of packs of a wide range of sizes without necessitating complicated adjustments and which will eliminate troubles encountered with prior mechanisms due to variations in paper lengths, thickness, poor registration holes and misalignment of the imprints.

According to the present invention the registration openings are made in the web and the web is imprinted in the assembly or collating machine and as close to the point of assembly as is practicable. The apparatus also includes means whereby the webs are individually tensioned while being provided with registration openings and this tension is maintained while receiving the impression but is released prior to the assembly operation. Mechanism is also provided whereby the tension on each web may be varied to facilitate the increase or decrease of the "length" of the pack and thus accurately control the size of the individual sheets and of the pack.

Other objects and advantages of my invention will become more apparent from the following description referring to one embodiment of the invention illustrated in the accompanying drawings. The essential features of the invention will be summarized in the claims.

In the drawings, Fig. 1 is a side view of a machine embodying my invention; Fig. 2 is a top plan view of the machine; Fig. 3 is a fragmentary side view of the machine on a substantially enlarged scale; Fig. 4 is a view similar to Fig. 3 but looking at the opposite side of the machine; Fig. 5 is a view illustrating the manner of assembly of the webs and illustrating a finished pack; and Figs.

6 and 7 are sectional details the planes of the sections being indicated by the correspondingly numbered lines on Figs. 3 and 4 respectively.

The manifold pack 10 with which the present machine may be used may hold any desired number of record strips such as, for example, those illustrated in Fig. 5 at 11. Each strip carries an imprint 12 which is superimposed upon a corresponding or coacting imprint on the strip or strips therebelow. Suitable transfer or carbon strips 14 are interposed between the record strips. In the form illustrated, the bottom edges 15 of the transfer strips terminate short of the bottom edges 16 of the record strips 11, while the top edges 17 of the transfer strips 14 terminate below the top edges 18 of the record strips. Ordinarily the record strips may contain a weakening line 20 which is disposed beneath the top edges 17 of the transfer strips and also beneath a line 21 of adhesive material which connects the transfer strip to the record strip. There is an additional line 22 of adhesive material which connects the record strips together beyond the upper edge of the transfer strip and below a line of registration openings 23. The openings 23 in the record strips are used for maintaining the strips in registration during the manufacture of the packs, but are not required in the finished pack. Hence a narrow strip 24 containing the perforations 23 is severed from the pack before the assembly of webs are cut transversely into individual packs 25. The weakening lines of perforations 20 are provided to facilitate the detachment of the record strips one from the other by the user.

To make the pack 25 illustrated in Fig. 5, a plurality of supply rolls 30 of web material W is mounted on respective supports such as bars or rods 31 in a manner such that the rolls are freely movable on the bars. These bars or rods 31 are spaced horizontally one from the other and are illustrated as extending laterally from an elongated frame structure 32. The rolls correspond in number to the number of record sheets required to form the desired pack.

The webs or strips W are each extended from their respective rolls 30 upwardly around an idler roller 33 to a respective withdrawing roll or drum 34. These withdrawing rolls are supported by the frame 32 and are individually rotated at variable speeds as will hereinafter be more fully described. Each web W extends around its withdrawing roll 34 and downward to a respective roll or drum 35, around such a roll and upward around a respective drum 36 to a respective roll or drum 37. Each roll 35 is provided with a series of equi-spaced inwardly extending female punch members 40 which coact with respective male punches 41 carried by an adjacent roll or drum 38. The punches 40, 41 serve to provide each web with a series of equi-spaced registration openings 23 heretofore mentioned described as extending adjacent one edge of the web. Each drum 37 is provided with a plurality of equi-spaced accurately positioned outwardly extending pins 42 arranged to enter the registration openings 23 formed by the punches 40 and 41.

The various drums and rolls are all drivingly mounted on respective shafts which are journalled in and extend outward from the frame 32. The drums 35, 36, 37 and 38 are all driven at the same peripheral speed and preferably from a single source of power. As indicated in Fig. 1, a motor 50 is mounted on the frame 32 and is drivingly connected by a driving belt or chain 51 with a line shaft 52. This line shaft (Figs. 2 and 4) carries a plurality of worm gears 53 which mesh with respective worm wheels 54 drivingly secured to shafts 55 which support respective pin drums 37. Each drum shaft 55 also carries a gear 56 meshing with an idler gear 57 which drives a gear 58 drivingly secured to a shaft 59 supporting the respective punch drum 35. The other punch drum 38 is shown as being drivingly secured to a shaft 60 carrying a gear 61 which meshes with the gear 58. The drums 36 are supported on shafts 62 carrying gears 63 which are driven by the pin drum gears 56 by idler gears 64.

The imprinting, numbering, and perforating operations are performed on portion W^1 of each web which extends between the point of engagement with the punches 41 and disengagement of the web by its pin drum 37. As heretofore mentioned, one of the difficulties previously encountered has been registration of the imprints made on one web with imprints made on another web. Previous pack assembly mechanisms utilized webs which had been imprinted prior to the introduction of the web in the assembly machine. Some of the difficulties in registration were caused by using previously printed supply rolls which were perforated and imprinted under different climatic conditions. When such rolls of record strips were placed in the assembly machine it was found that although the spacing of the registration openings and imprints on one roll at the time of punching and imprinting was exactly the same as the spacing of corresponding openings and imprints on other rolls, such spacing due to shrinkage of the webs, varied at the time of assembly. Further, the use of different grades and thickness of paper resulted in these distances varying from roll to roll. The present invention eliminates some of these differences by punching, imprinting, numbering and performing all similar operations on the webs in the assembly or collating machine. Other of these differences, such as those resulting from differences in grade and weight of papers, are compensated for by the present invention by performing such operations on tensioned portions of each web and by individually regulating or adjusting the tension on respective webs so that compensation is made by individually controlling the stretching of the respective webs during the performance of such operations. I have found that most paper stocks are sufficiently stretchable to facilitate such compensations to be made. To this end the apparatus is constructed to enable a relative fine degree of control of the tension of the web from the time it is engaged by the perforating punches 40, 41 until it is released by its pin drum 37, during which period the various operations, requiring registration, are performed on the webs. I have found that this tension may be regulated by individually regulating the peripheral speed of each web withdrawing roll 34 and by independently adjustably retarding the rotation of respective web supply rolls 30.

The withdrawing rolls 34 are preferably driven with the same source of power as the various other rolls, but through a mechanism which will permit a fine degree of adjustment of the peripheral speed thereof relative to the peripheral speed of the other rolls or drums.

I have found the mechanism generally indicated in Figs. 4 and 7 to be suitable for driving the withdrawing rolls 34. As there shown each withdrawing roll 34 is drivingly mounted on a shaft 65 which is drivingly connected with the punch drum shaft 60 by a changeable speed drive mechanism. As shown, such mechanism includes a V-shaped drive belt 67 which is looped about a pair of sheaves 68 and 69 mounted on respective shafts 65 and 60. The sheave 68 comprises a pair of discs 70, 71 having tapered belt coacting surfaces 72. One of these discs, for instance, the disc 70 is rigidly secured to the shaft 65 while the other disc 71 is slidable axially of such shaft. The disc 71 is retained in an adjusted position relative to the disc 70 by a nut 74 carried by the shaft and by a spring 75, which is interposed between the two discs and serves to maintain them spaced. Thus, as the nut 74 is tightened the V belt is forced radially outwardly along the inclined surfaces 72, whereas if the wing nut is loosened the belt moves toward the axis of the disc. Thus by tightening the nut 74 the peripheral speed of the withdrawing roll 34 may be reduced whereas if the nut is loosened the peripheral speed of the drum 34 will be increased as desired. A suitable spring controlled take-up member 78 may be provided to maintain the tension on the belt 67. Accordingly, the peripheral speed of each withdrawing

roll 34 may be adjustably and individually decreased relative to the peripheral speed of the drums 35, 36, 37 and 38. By adjusting the drive of the withdrawing roll 34, as above described, to control the difference between its peripheral speed relative to that of the other rolls, the tension on the web may be increased or decreased as desired. This increase or decrease of the tension of the portion W^1 of the web extending between the drums 35 and 37 controls the length of the web therebetween and compensates for variations of the thickness of the web of the various rolls 30. Likewise by varying the peripheral speed of each roll 34 independently of the other rolls 34, one web may be tensioned to a greater degree than another, thus compensating for variations in grade or stretchability of the different webs.

The rotation of the punch drums 35 and the pin drums 37 at a greater peripheral speed than that of the respective withdrawing drums 34 tensions the portions of each web extending between its withdrawing drum 34 and its pin drum 37, which includes the portion W^1. The punch members 40 and 41 are so spaced on their respective drums that each web is free from engagement by its male punch members 41 for an interval of time between each successive punching operation. Accordingly, as the webs extend around the drums 35 which carry the recessed or female punch members 40, the entire stretch of each web extending from its withdrawing drum 34 to its pin drum 37 is tensioned.

Each web is maintained in contact with its respective withdrawing roll 34 and the portion W thereof extending between such roll and the associated supply roll 30 is maintained taut. This is accomplished, as shown in Figs. 3 and 6, by pairs of spaced guide rollers or collars 80 and 81, the hubs 82 of which engage the periphery of their respective rolls 30, and inner faces 83 of the flanges of which engage the sides of such roll. Each pair of collars 80, 81 is mounted on a rod 84 which is carried at one end of an arm 85. This arm is pivoted to the frame 32 as at 86 and is counterweighted as indicated at 87 to maintain the collars in contact with their respective roll 30 as the diameter of the roll decreases due to the withdrawal of the web therefrom. The collars 80 and 81 are rotatably mounted on the rods 84. Axial movement of each collar 80, from the adajcent side of its roll 30, is prevented by a sleeve 88 which is pinned to the rod 84. The other collar 81 is resiliently urged axially toward the other side of the roll 30 by a spring 89 interposed between the collar and a nut 90 threaded on the rod. Thus the roll is gripped resiliently between the two collars. The pressure of the collars on the roll may be increased or decreased as desired, thus regulating the tension on the web. In many instances the tension of the portion W^1 of the web, which extends between a withdrawing roll 34 and a pin drum 37, may be controlled satisfactorily by adjusting the peripheral speed of the withdrawing rolls 34 to compensate for differences in thickness of webs, and by adjusting the pressure of respective collars 80, 81 on the respective rolls 30, the tension may be adjusted to compensate for differences in stretchability of the webs.

Each web W is imprinted, perforated and numbered after it passes from the punches 40, 41 and before it leaves its respective pin drum 37. As shown in Figs. 1 and 3 the face of each web is imprinted a relative short distance and only inches from the point of punching. Indeed the faces of the webs are imprinted before they leave the punch drums 35 by a form roll 90 of a printing unit 100. The reverse side of the web is imprinted by a form roll 91 of a printing unit 102, which coacts with the web as it passes around the drum 36. The drums 35 and 36 thus act as platen rolls for their respective form rolls 90 and 91. The pin drum 37 provides a platen which coacts with a form roller 93 of a numbering device 103, which acts on the face of the web. The punch drum 35 acts as a backing roll for one or more perforators 104 which provide the web with one or more rows of perforations such as to provide the weakening line 20 heretofore described in connection with Fig. 5.

The printing units 100, 102, and the numbering device 103 are more or less diagrammatically shown. Any well known type of rotary printing or numbering device may be used. Likewise a printing unit may be substituted for the numbering device if desired and the web provided with a multicolored imprint.

As indicated in the drawings, the pattern roll or impression drum of each printing unit preferably has a pattern or printing form 101 extending entirely around its circumference. The printing and numbering units are each mounted on and extend outward from the frame 32. Each unit is provided with a suitable inking mechanism generally indicated at 105 as being supported by the frame 32. As indicated in Fig. 4, the printing units 100, 102 and the numbering device 103 are driven from their respective platen drums 35 or 36 by individual gearing units 106.

Transfer or carbon strips may be inserted between the record strips as they pass across the pinned drums 37. As illustrated in the drawings, I have shown carbon transfer strips T as being stored on supply rolls 110 which are journalled on suitable rods or shafts 111 carried by the frame 32. The web T from each transfer roll 110 extends downwardly forming a loop 112, within which a suitable weight generally indicated at 114 may be cradled. Each strip T extends from its loop 112, upwardly between the rolls 30 over guide bars or rollers 115 until it passes between the adjacent webs W of record strips as they pass over the pin drums 37.

The transfer record strips may be secured together by an adhesive material which is adapted to be applied by paste applying units 120 mounted in paste containers 121. Each paste container 121 has two paste applying members. One of the members 121 coacts with its respective transfer strip to provide the adhesive line 21 which secures the transfer member in place in the pack, while the other contacts one of the webs W and provides the adhesive line 22 (Fig. 5) which secures adjacent record strips together. The paste unit may be driven by suitable gearing or merely by frictional contact with the respective webs. Such paste units are well known in the art, hence a detailed description thereof need not be given here.

The transfer strips T are unwound from their respective supply rolls 110 at the same surface speed as that of the record strip. To this end it is preferable to unwind the transfer strips by frictional contact against the outer surface of their supply rolls. Each transfer strip is unwound by a roller 130 which is journalled in an arm 131 pivotally mounted on a shaft 132 journalled in the frame 32. Thus each roller 130 is held in contact with the outer surface of its respective roll 110 of transfer material T by gravity. Each roller 130 carries a sprocket wheel 133 which is drivingly connected by a chain 134 with a similar sprocket wheel 135 secured to the pivot shaft 132. A second sprocket wheel 136 on such shaft is drivingly connected by a drive chain 137 with a sprocket wheel 138 mounted on a shaft 139 rotatably journalled in the frame 32 and which is driven by a chain 140 connecting it with a sprocket wheel 141 which is secured to the punch drum shaft 60 heretofore described.

The drums 37, as heretofore mentioned, are spaced a predetermined distance apart, and each drum is maintained in engagement with the registration openings in the webs by a respective roller 125. These rollers are journalled at one end of respective arms 126 the other ends of which are pivoted to frame brackets 127 so that gravity maintains the rollers in contact with the webs W. The rollers 125 are provided with suitable recesses 128 to receive the pins of the respective drum 37.

The tension on the webs W between the assembly or pin drums 37 is readily controlled by the distance therebetween. It has been found preferable to so space the drums 37 that the tension applied to the webs for performing the punching, printing, perforating and numbering

operations is released before the web is engaged by the pin drum of the adjacent web.

After the record strips W and the interposed transfer strips T have been completely assembled and secured together as above described, the portions **24** of the record strips carrying the line registration openings **23** which were utilized for maintaining the record strips W in accurate registration may be removed by a shearing operation. This shearing operation may be performed as indicated in Figs. 1 and 2 by a rotary cutter **150** driven by a motor **151**. A suitable pin drum **152** which is drivingly connected with the power shaft **52** progresses the webs to the cutters **150**.

After the portion **24** of the record strip carrying the registration openings **23** has been severed as above described, the assembled web composed of record strips and interposed transfer strips may be cut to form individual packs, each of which contains a plurality of secured sheets. These packs are severed from the assembled web by a suitable cutting mechanism, which may comprise a rotating shear blade **156** carried by a drum **157** rotatably mounted in a frame **32** and arranged to be driven in synchronism with the progress of the collated webs through the machine by gearing **158** connecting it with the drive shaft **52**. One type of shearing mechanism particularly well adapted for use in shearing the web is illustrated and described in detail in Patent No. 2,144,331 issued to G. L. Fulk, January 17, 1939. Reference to such patent may be had for a detailed description thereof.

As above described, the invention contemplates the simultaneous punching, printing, perforating and collating of a plurality of webs while maintaining continuous progress of the webs through a single machine. However, the invention has the added advantage in that it may be used to collate one or more previously punched and printed webs with one or more webs which are punched and printed while moving through the collating mechanism. For instance, the roll **30A** of Fig. 1 may comprise a previously punched, printed and perforated record strip. The associated punch drum **38** may be disabled by moving it away from its coacting punch drum **35** as, for instance, by the use of eccentric bushings (not shown) which may be associated with the shaft **60**. Likewise the associated impression drums **90**, **91** and **93** together with the perforator **104** may be disabled, either by moving them out of contact with their respective platens in a similar manner or by removing the forms **101** therefrom. The remaining rolls **30** may then comprise unpunched and unprinted stock on which the various operations, such as printing and punching are performed as heretofore described and while tensioning such webs to cause them to register with the web withdrawn from the previously punched and printed roll **30A**.

I claim:

1. The method of making manifold forms, comprising providing a plurality of supply rolls of webs of stretchable material, individually withdrawing the webs from the respective supply rolls, passing each withdrawn web to and through a respective pair of rotary drums having a plurality of equi-spaced male and female punches to provide each web with a longitudinally extending row of identically spaced registration openings at least along one edge thereof, passing each web from its punch carrying drums, to a drum having a peripheral row of spaced pins to engage the registration openings, collating the webs by passing them from their respective pin drums across other webs while such other webs are engaged by their respective pin drums, imprinting at least one of the webs in the region of the web extending from the point of the withdrawing operation to the point of departure of such web from its pin drum, rotating the punch and pin drums at the same rate of peripheral speed, individually varying the rate of speed of passage of each web to its respective punches, whereby the webs of varying degress of stretchability may be simultaneously imprinted, and then collating the webs in a relaxed condition with their imprints in registration.

2. The method of making manifold forms according to claim 1, including securing the webs together with an adhesive and interleaving the webs with a transfer material as the webs pass over the pin drums.

3. An apparatus for making manifold forms, comprising a frame, means to support a plurality of rolls of paper, a withdrawing unit to withdraw said paper from said rolls, there being one such unit for each roll, each unit including a withdrawing drum supported by said frame and arranged to receive the web from its respective roll, a pair of punch equipped drums to receive the web from the withdrawing roll and supply it with a continuous row of registration openings, a pin drum spaced from each pair of punch equipped drums and having an annular row of pins to engage the registration openings in the web as it passes to such drum from the punch drums, said pin drums being spaced one from another, whereby one web may be extended from its pin drum into engagement with the pins of the pin drum of another web, means to drive all punch drums and pin drums at the same rate of speed, a single source of rotative power for said last named means, and individual means connected with said source of power to drive the withdrawing rolls, each of said last named means being individually adjustable to vary the rate of speed of withdrawal of its respective web, an individual brake means for each roll of material, and individual imprinting means mounted on said frame and acting on said web stretches between the withdrawing rolls and the pin drums.

4. An apparatus for forming manifold forms by printing and collating a plurality of continuous webs of stretchable materials, comprising a frame having means to individually support a plurality of rolls each comprising a web of stretchable material, means to withdraw material from said webs comprising a plurality of pairs of coacting drums having male and female punches respectively to simultaneously withdraw respective webs and provide each web with an identical continuous row of equispaced registration openings, together with a plurality of individual pin drums mounted in said frame having outwardly projecting pins to engage the registration openings in the web, said pin drums being positioned sequentially in a row, whereby the webs may be collated by passing each web from its pin drum to the pin drum of the succeeding web, imprinting means carried by said frame and acting on at least one web in the stretch extending from a point adjacent the punching operation to the point of departure of such web from its pin drum, and means acting on each roll to retard the withdrawal of the web therefrom, said means including a rod, means pivotally connecting each rod with said frame for movement toward the periphery of its respective roll, means to urge each rod toward its respective roll, each rod having a pair of spaced flanged collars at least one of which is movable axially of its rod, whereby said flanges may engage opposite ends of a roll, resilient means acting to move said collars toward each other and into engagement with the roll, and means to individually adjust the pressure of each of said resilient means.

5. An apparatus for printing a web of material in accurate registration with a row of punched holes extending along one edge thereof comprising a frame constituting a support for a roll of material, a withdrawing drum rotatably supported on the frame and having the web wrapped therearound, a pair of coacting drums carried by the frame and arranged to engage the web after it leaves the withdrawing drum and having means thereon to punch a row of holes at regular intervals on the web, another drum carried by the frame and having pins in the periphery thereof spaced for engagement with the row of perforations in the web, said web being wrapped around the last-named drum, there being a predetermined fixed distance between the punching drums and the pin drum,

means for rotating the punching drums and the pin drum at the same peripheral speed, means for adjusting the speed of rotation of the withdrawal drum so as to vary the rate at which the web is fed into the punching drums, whereby a substantially uniform length of web is maintained on that portion of the strip between the point of punching and the point of engagement with the pin drum.

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