United States Patent

Funk et al.

[15] **3,698,705**

[45] **Oct. 17, 1972**

[54] **APPARATUS FOR FOLDING FLEXIBLE SHEETS**

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[73] Assignee: **R. Funk & Co., Inc.**, Doylestown, Pa.

[22] Filed: **March 5, 1971**

[21] Appl. No.: **121,568**

Related U.S. Application Data

[63] Continuation of Ser. No. 737,934, June 18, 1968, abandoned.

[52] **U.S. Cl.**.....**270/62,** 270/67

[51] **Int. Cl.**.....**B65h 45/12,** B65h 45/18

[58] **Field of Search**.....270/62, 63, 67, 68, 81

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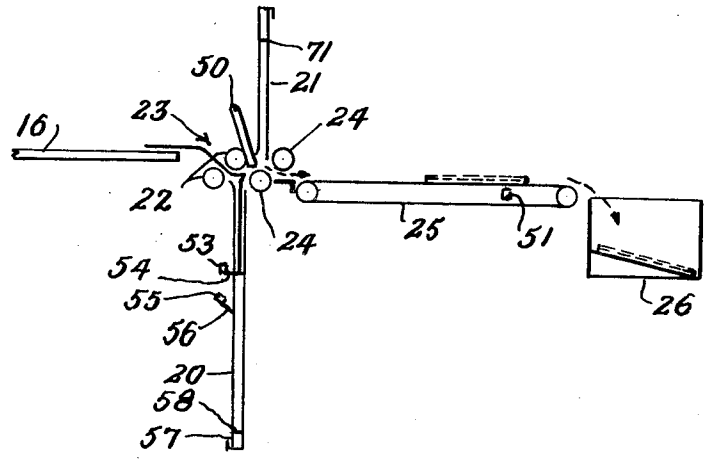
Primary Examiner—Lawrence Charles
Attorney—Synnestvedt & Lechner

[57] **ABSTRACT**

Apparatus which handles flexible sheets, typically blue-prints or the like, for folding them, is adapted to handle sheets, not only of uniform size but also an intermix of sheets of differing sizes, and to fold them selectively, along one or more fold lines, each into a folded packet having perdetermined standardized length and width dimensions; and the apparatus comprises high-speed normally continuously-operating sheet transport means with associated sheet-folding mechanism having a plurality of elements adapted to cooperate in the folding operation, at least some of the elements being selectively rendered operative according to sheet size whereby to fold the sheet on one or more lines of fold so related as to form the sheet into a folded packet of the predetermined standardized dimensions, regardless of the initial size of the sheet; there being a programming system for such selectively operative elements, controllable, in accordance with sheet size, to select simultaneously the required group of said elements, without retarding the sheet transport means or interfering with the normal flow of work through the apparatus. Above certain sheet sizes, the folding includes certain folds at right angles to one another. At least some of the elements to be selected for operation are automatically selected by means sensing certain sheet dimensions, but manual operation is also provided for, as to certain folding functions, by devices readily accessible to and quickly actuable by an operator, and typically the programming system includes an electrical mechanism governed at least in part by interlocking switches, or the like, disposed in a removable and replaceable console. Certain parts of the apparatus may function as transport means and/or as folding means. Regardless of the number, direction and spacing of the folds, and whether or not the initial sheet configuration involves dimensions which are even multiples of the final folded packet dimensions, the packet has no external irregularities; and a certain corner of each sheet handled appears at a given external corner of the folded packet. After initial folding, the sheet, depending upon its original size, may be discharged into a receiver from a particular station, or it may be arrested at that station, without stopping the transport means, and then given one or more additional folds and transported from that station to a different receiver. Power means for the apparatus may normally operate continuously, but may be interrupted at will, and a jogging operation and/or a manual operation may be introduced.

21 Claims, 23 Drawing Figures



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SHEET 1 OF 7

Fig. 1

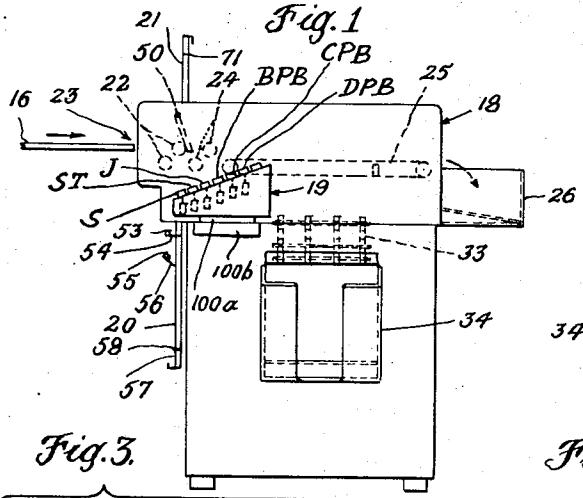


Fig. 2.

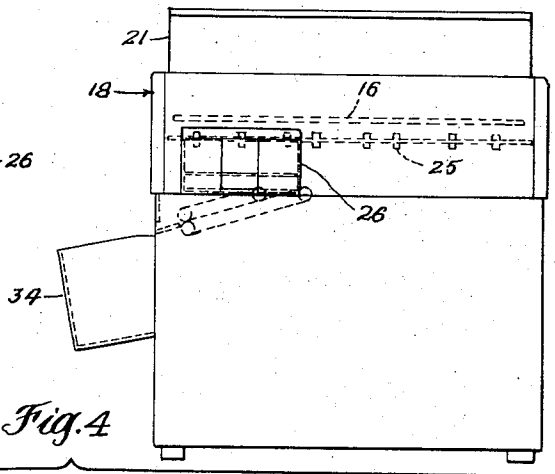


Fig. 3.

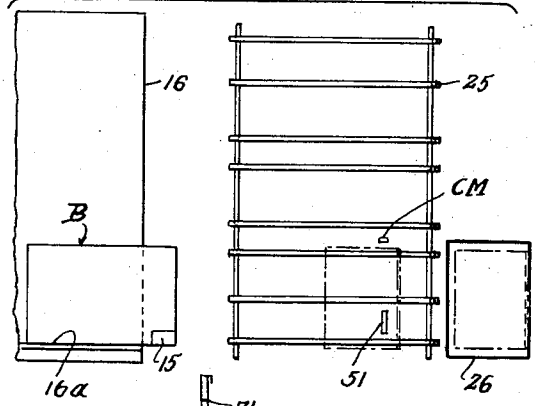
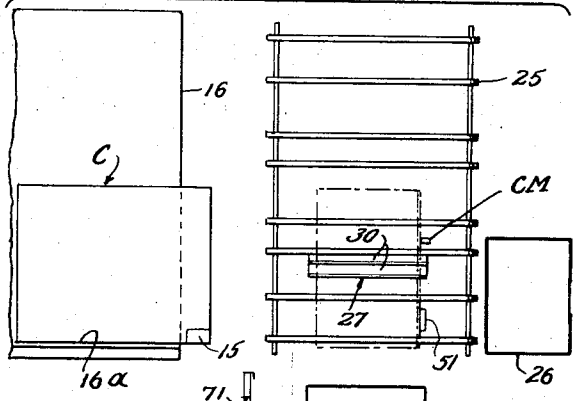


Fig. 4



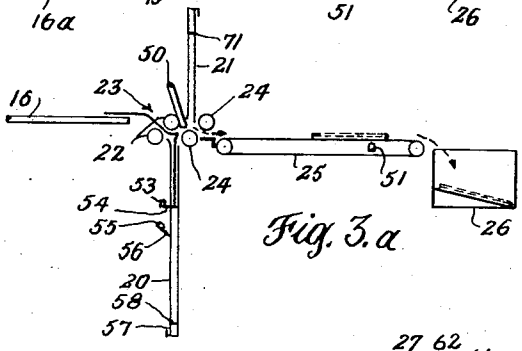


Fig. 3.a

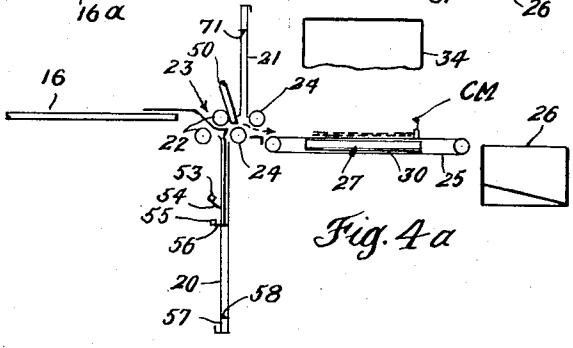
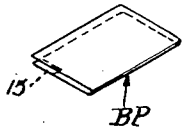


Fig. 4a

Fig. 3b.



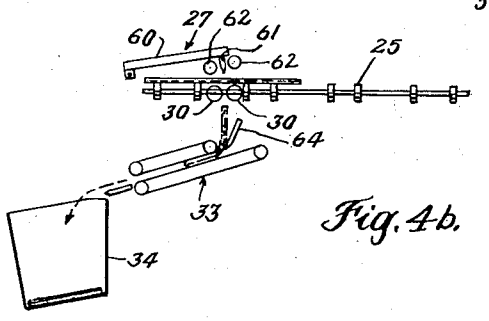


Fig. 4b.

Fig. 4c.

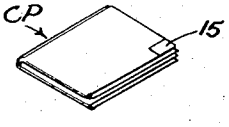


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Fig. 5.

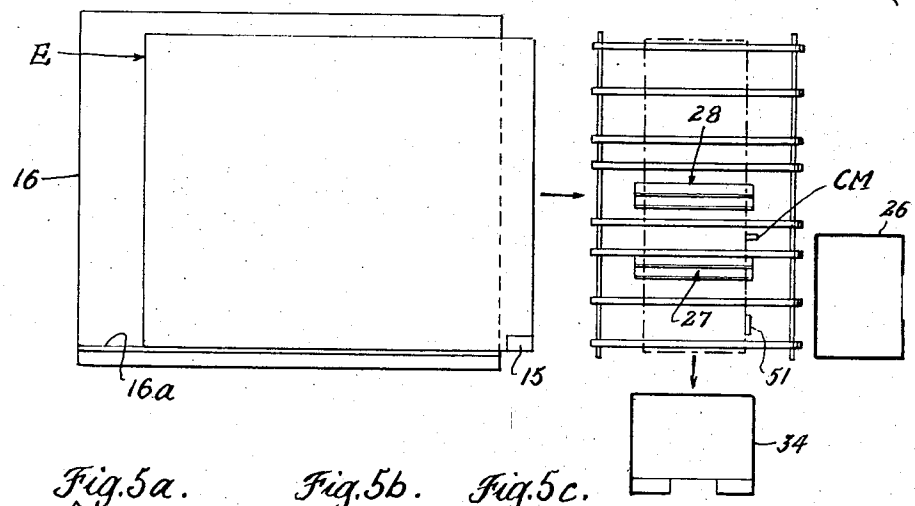


Fig. 5a.

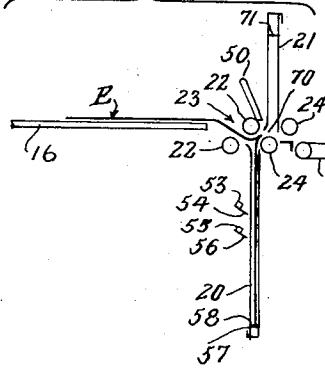


Fig. 5b.

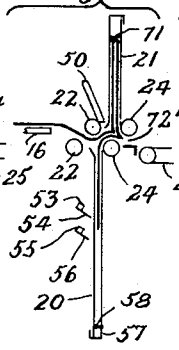


Fig. 5c.

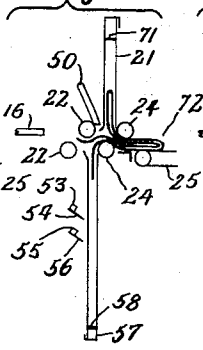


Fig. 5d.

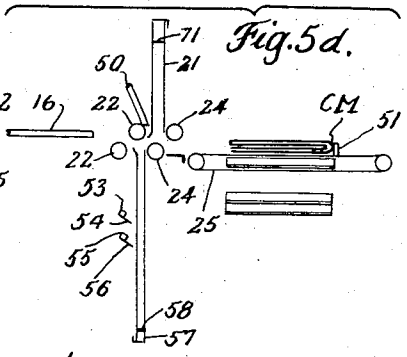


Fig. 5e.

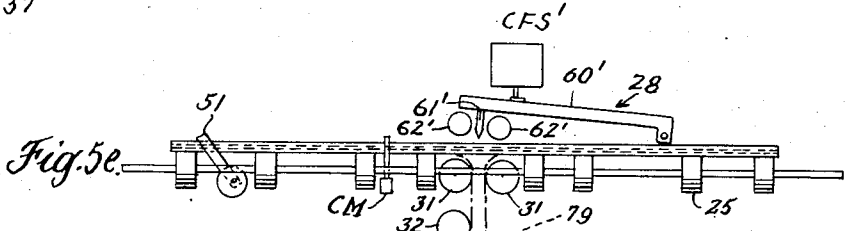


Fig. 6.

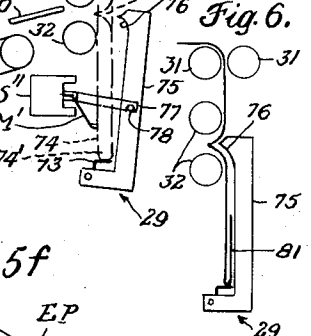
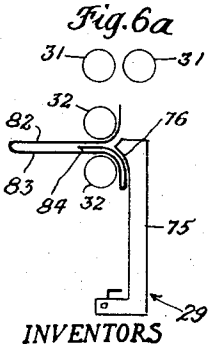


Fig. 6a



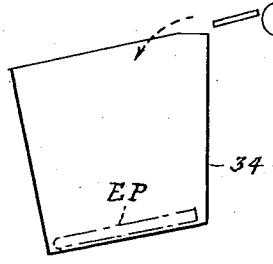
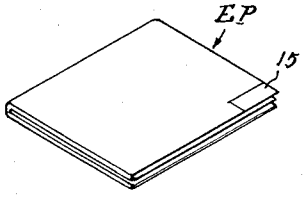


Fig. 5f



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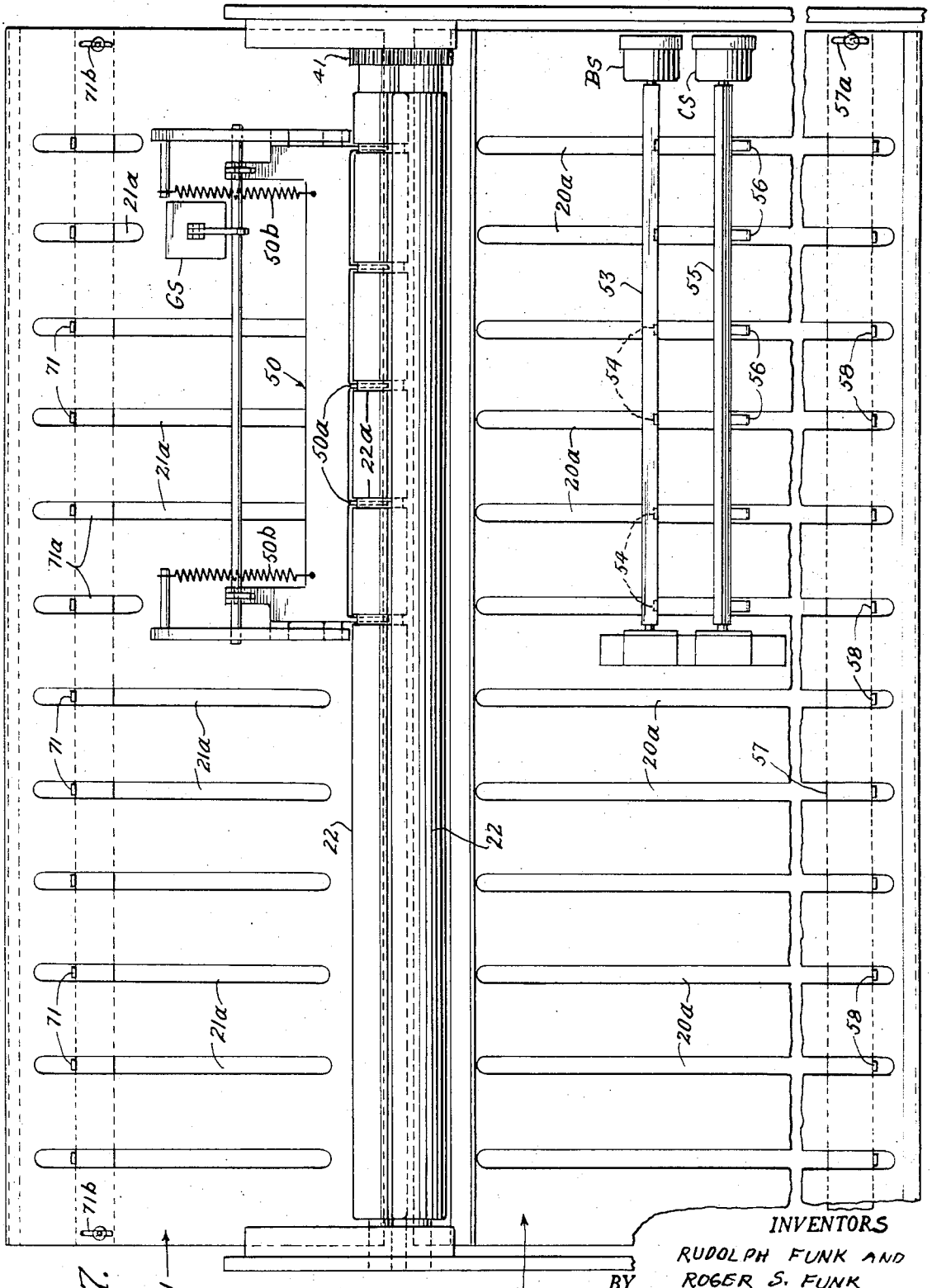

Fig. 7.

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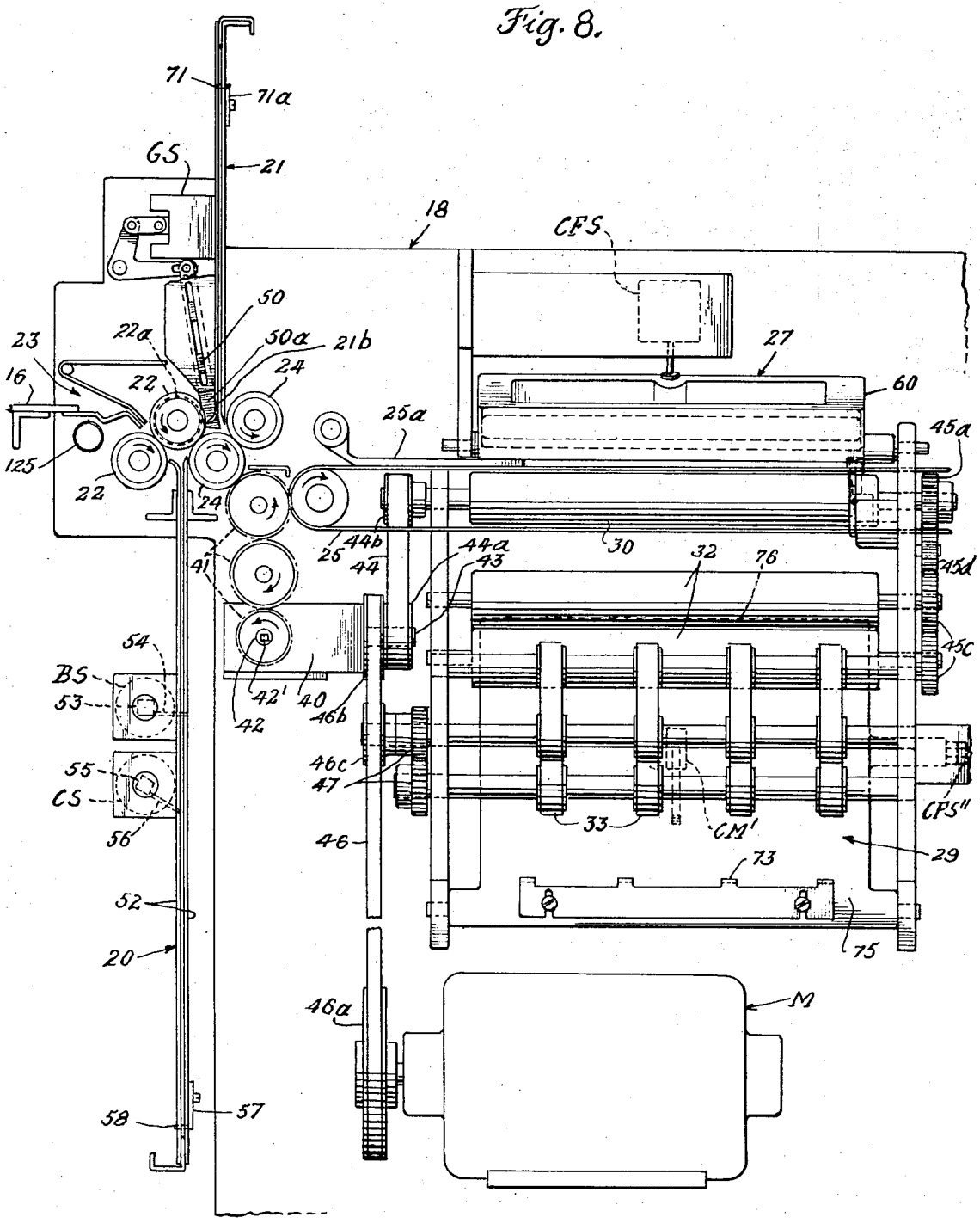
Fig. 8.



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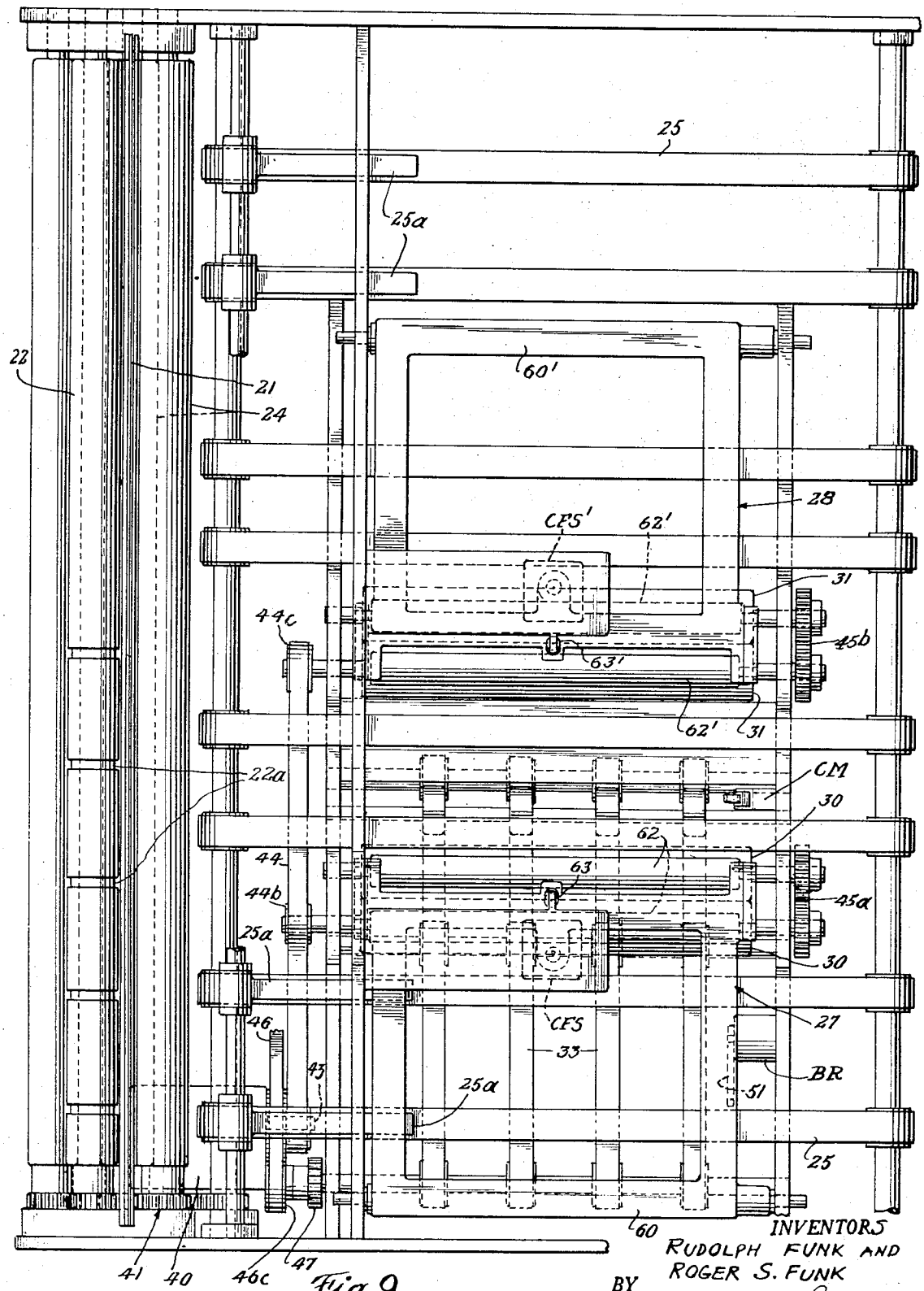

Fig. 9.

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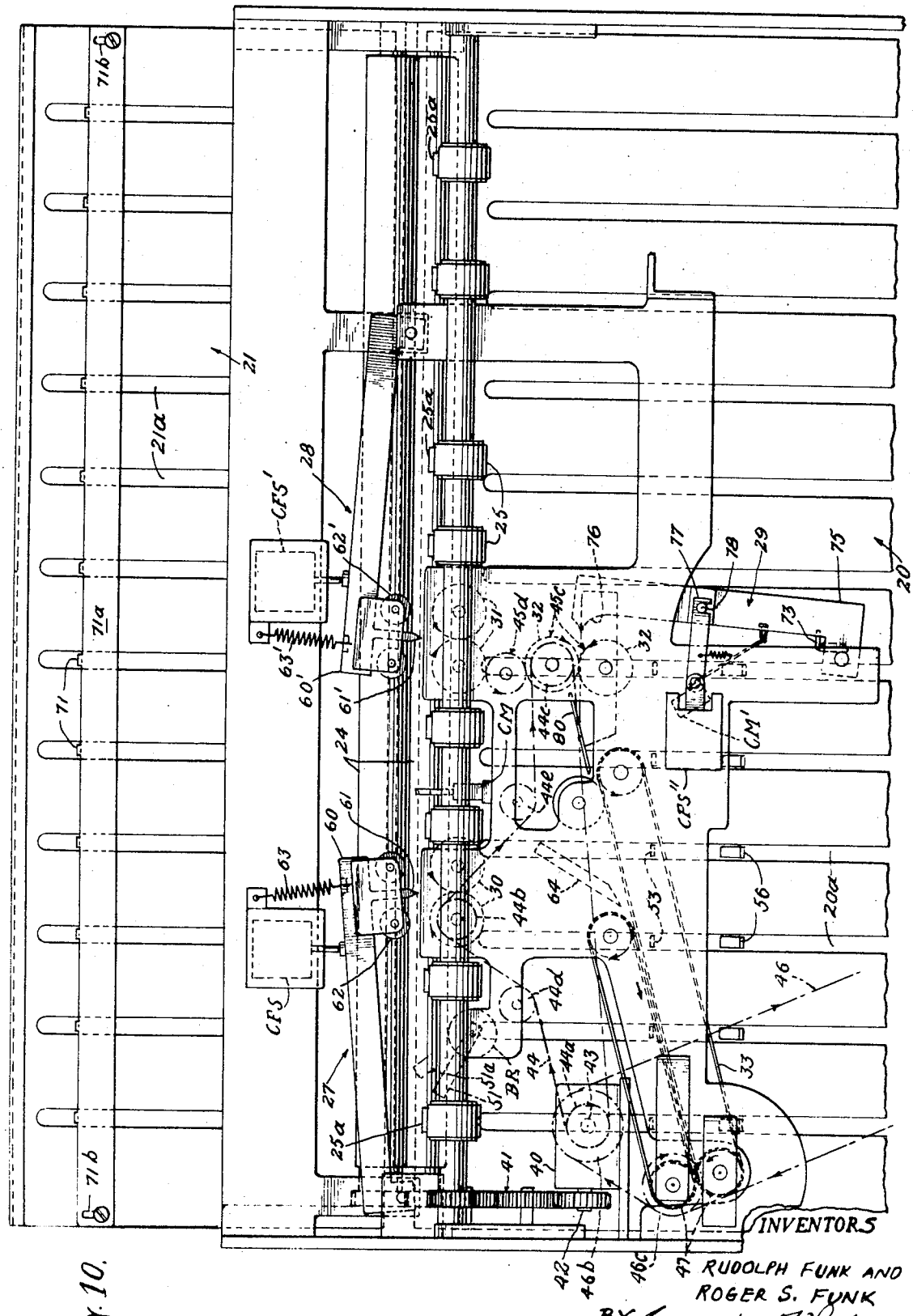
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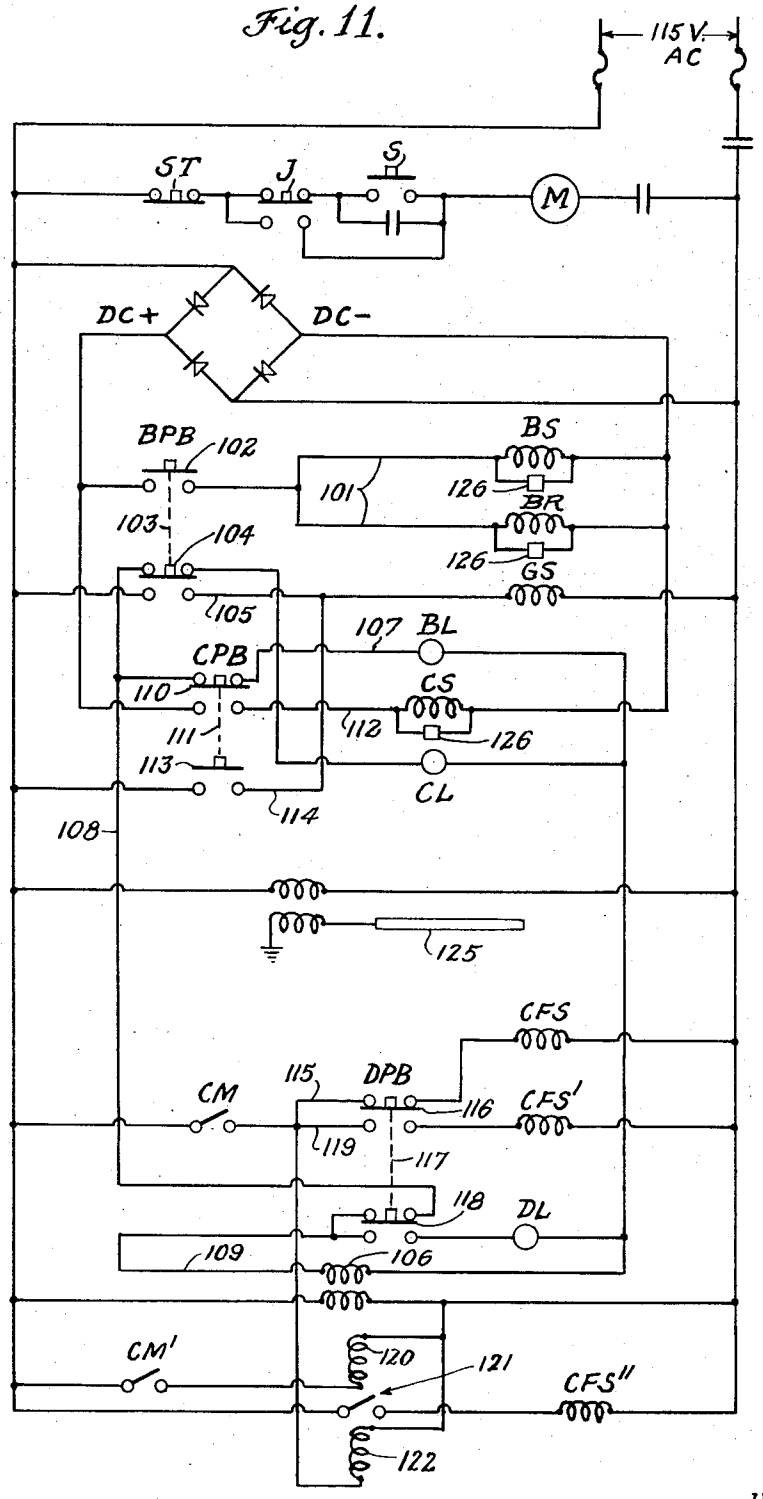
Fig. 10.

Fig. 11.



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APPARATUS FOR FOLDING FLEXIBLE SHEETS

This application is a continuation of application Ser. No. 737,934, filed June 18, 1968, now abandoned.

This invention relates broadly to apparatus for folding flexible sheets into compact packets, and to apparatus for folding sheets of various sizes and/or proportions into packets of a given size and proportions, such apparatus being particularly useful for such folding of blueprints, and the like, of various lengths and/or widths.

The principal object of the invention is to improve sheet-folding apparatus, in one or more of the following respects: simplicity of construction and/or operation, speed of operation, reliability of operation, versatility in the folding of an intermix of sheets of varying sizes and/or proportions, virtual elimination of set-up time when changing sheet sizes, facility of control, ease of adjustment and of maintenance, and neatness and compactness of the apparatus whereby it may be housed in a protective and dirt-excluding cabinet so as to constitute a unitary machine, occupying a minimum of space. In all these respects the invention represents a substantial improvement over various known types of sheet-folding apparatus.

Some of the advantages of the present invention are akin to those partially obtained with apparatus such as disclosed in U.S. Pat. Nos. 3,052,464 and 3,117,777, but the present invention involves substantial improvements thereover, especially as to speed, reliability, versatility and facility of operation.

In effecting the above-stated principal object of the invention, according to the presently preferred embodiment, we provide simple and effective selective control means of such character as to require a minimum of training of an operator to run the apparatus to fold any or all of an intermix of sheet sizes to a desired packet of standard length and width, and with corner blocks (in the case of prints) uniformly located on an outer corner face of the packet.

The invention further contemplates the folding of discrete flexible sheets, primarily by mechanism adapted to effect one or more initial transverse folds of the individual sheet (i.e., transverse the length thereof) and/or transverse folds at variable distances from a margin of the sheet, and secondarily (when required by sheet dimensions) by mechanism adapted to effect one or more cross-folds of the transversely-folded sheet (i.e. crosswise of the first folds), under automatic and/or manual regulation, according to sheet dimensions, and more particularly by means of stops, gates, guides, pivoted arms and other elements, actuated in whole or in part by solenoids or the like, under the control of electrical circuits selected and/or modified by automatic means such as intercept switches engageable by sheets of various dimensions and/or by manual means such as selector switches in a console which is positioned for ready actuation by an operator, and also for ready removal and replacement, for maintenance and repair.

Still further, the invention contemplates folded-sheet delivery or transport means incorporated in, or forming conveyors associated with, the folding mechanisms, which, in the case of the transverse-folding mechanism, delivers a folded sheet, via one station or location, directly to a packet-receiver, or alternatively to said

station or location, whereat the cross-folding mechanism imposes a first cross-folding operation on the sheet, or, alternatively, a plurality of cross-folding operations are carried out, preferably one at the level of said station and another at a lower level, from either of which levels the folded sheet is automatically placed upon a conveyor which delivers the folded packet to a second packet-receiver; the first packet receiver being preferably at the back of the machine and the second at one end thereof; and the first conveyor being adapted to move a folded sheet horizontally, at right angles to the line of transverse fold, whereas the second conveyor is adapted to move a folded sheet at right angles to the first conveyor and to the line of cross-fold of the sheet.

Additionally, the invention contemplates accomodation and operation of this apparatus to folding of sheets having one or more dimensions other than exact multiples of standard folded-packet dimensions, in such manner that odd areas of a sheet, which are fractions of an area determined by said standard dimensions, are automatically folded into the packet, preferably into an inside position therein; and in this operation, as well as other of the operations of the apparatus, the invention contemplates the use of feed rolls and of creasing rolls (the latter also serving a feeding function), certain of which cooperate with pockets and/or gates or guides in effecting folds, especially buckle-folds, of a sheet, and others of which cooperate with pivoted arms carrying stops and/or guides and tucking blades in effecting folds, such as cross-folds of an already transversely-folded sheet.

The invention also involves powered operation of the apparatus, generally continuously at one speed, but alternatively in an intermittent way, and, when needed, a manual operation.

In accordance with another aspect of the invention, an electrical control system of simple design employing a minimum number of electrical components is provided whereby sheets of various sizes can be processed in random size order without the necessity of time consuming set-up operations and adjustments, and by the simplest selective actuation of a group of marked and illuminated push-buttons.

Other objects of the invention have to do with the simplicity and effectiveness of design of various operating components of the apparatus, and the reduction of maintenance time and costs to a minimum.

How the foregoing and other objects and advantages of the invention are attained will be clear from the following description, referring to the drawings which illustrate a preferred form of apparatus embodying the invention, in which drawings:

FIG. 1 is a general outside end elevational view of the apparatus, in the form of a unified, compact machine;

FIG. 2 is a general elevational view looking at the rear of the machine, i.e., as viewed from the right in FIG. 1;

FIGS. 3 and 3*a* are diagrammatic views, showing parts of the machine, and illustrating the sequence of operations in folding a sheet of small size;

FIG. 3*b* is an isometric view of the folded sheet resulting from the operations illustrated by FIGS. 3 and 3*a*;

FIGS. 4, 4*a* and 4*b* are diagrammatic views, showing parts of the machine, and illustrating the sequence of operations in folding a sheet of an intermediate size;

FIG. 4*c* is an isometric view of the folded sheet resulting from the operations illustrated by FIGS. 4, 4*a* and 4*b*;

FIGS. 5, 5*a*, 5*b*, 5*c*, 5*d*, and 5*e* are diagrammatic views, showing parts of the machine, and illustrating the sequence of operations in folding a sheet of still larger size (FIG. 5*e* being on a scale twice that of the other Figures of this group);

FIG. 5*f* is an isometric view of the folded sheet resulting from the operations illustrated by FIGS. 5–5*e*;

FIGS. 6 and 6*a* are diagrammatic views illustrating certain steps in the folding of sheets of other sizes;

FIG. 7 is a partial front elevational view of the apparatus;

FIG. 8 is an end elevational view of the apparatus as seen from the right of FIG. 7 with the end frame plate removed;

FIG. 9 is a plan view of FIG. 8 with certain parts omitted;

FIG. 10 is a rear elevational view with certain drive elements diagrammatically indicated; and

FIG. 11 is a schematic wiring diagram of the electrical selector and control system of the apparatus.

Before describing the apparatus in detail, we will refer to a typical field of use; and the general arrangement of the main components of the apparatus will be dealt with and various components will be designated by terms suitable for convenient use in this specification.

By way of example, but not limitation, the apparatus will be described for the folding of 11 × 17 inch, 17 × 22 inch, 22 × 34 inches and 34 × 44 inches sheets into folded packets of 8½ × 11 inches size. For convenience of description the 11 × 17 inches sheets will be referred to as of B-size, the 17 × 22 inches sheets as of C-size, the 22 × 34 inches sheets as of D-size, and the 34 × 44 inches sheets as of E-size. These sizes are types are typical of many shop or other working drawings, from which blueprints or other prints are made.

In connection with the folding of blueprints or the like, it is noted that it is customary to provide title blocks **15** at the lower right hand corner of the prints, and in the operation of the preferred apparatus embodying the present invention, the folding of the prints is accomplished in such a way that the title blocks in all sizes of prints will be on an outer face of the completed packet so that the print can be identified without having to unfold it.

The general arrangement of the apparatus is best seen in FIGS. **1**, **2**, **3**, **7**, **8**, **9** and **10**, and the physical relationship of some of the main components will now be generally described.

The apparatus includes a table **16** on which the sheet (such as a print) to be folded is placed, against a guide **16***a*. The table **16** is disposed at the front of the cabinet **18**. A control console **19** is positioned at the right-hand end of the cabinet, near the front, where it is readily accessible to the operator, who is preferably stationed near the right front corner of the machine. At the front of the cabinet there is a lower pocket **20** for initiating a transverse buckle fold; an upper pocket **21**, also for effecting a buckle fold; a pair of feed rolls **22**, **22**, located at the inlet throat **23** of the cabinet **18**, (see FIG. **8**); and a second pair of rolls, **24**,**24**, termed creasing rolls. Actually, the upper feed roll **22** and the lower creasing roll **24** coact as creasing rolls when a buckle fold is initiated by the lower pocket **20**, whereas both rolls **24** serve as creasing rolls when a buckle fold is initiated by the upper pocket **21**. As best seen in FIGS. **1**, **8** and **9**, there is a horizontal conveyor **25** extending from the vicinity of the creasing rolls rearwardly to the back of the cabinet. A packet receiver or tray **26** is located at the back, in position to receive folded sheets from the conveyor **25**.

Also within the cabinet, (as seen in FIGS. 5*e*, **8**, **9** and **10**), the machine is provided with first, second and third cross-folding units **27**, **28** and **29**, having associated pairs of creasing rolls **30**, **31** and **32**; a downwardly inclined discharge conveyor **33**, associated with the cross-fold units; and an end packet receiver or tray **34** for receiving folded sheets or prints discharged by the discharge conveyor **33** (see also FIG. 4*b*).

Referring particularly to FIGS. **8**, **9** and **10**, it will be seen that the drive system of the apparatus includes a gear motor M and a transmission (in a right-angle gear-box **40**) driven by the gear motor M through a drive belt **46** and pulleys **46**a and **46**b.

A train of gears **41** (FIG. **8**) is driven from an output shaft **42** of the gear box **40**, and has driving connection with the feed rolls **22**, the creasing rolls **24**, and the conveyor **25**, the directions of rotation of these driven members being indicated by the arrows in FIG. **8**. The creasing rolls **30**,**31** and **32** of the cross-folding units **27**,**28** and **29** are driven from a second output shaft **43** of the gear box **40** by a belt **44**, cooperating with drive pulleys **44***a*, **44***b* and **44***c*, and idlers **44***d* and **44***e*, and suitable gearing **45***a*, **45***b*, **45***c* (on the shafts of said rolls) and idler gear **45***d*. The discharge conveyor **33** is driven from motor M by the drive belt **46**, pulley **46***c* and gearing **47**, clearly shown in FIGS. **8**, **9** and **10**.

Considering first the folding of an 11 × 17 inch or B-size sheet into an 8½ × 11 inches packet as shown in FIG. 3*b*, and with particular reference to FIGS. **1**, **3**, 3*a*, 3*b*, **7**, **8** and **9**, among the chief functioning components are the feed and creasing rolls **22**, **24**, the lower pocket **20**, a solenoid-actuated gate **50** located between the upper rolls **22**,**24**, the conveyor **25**, and the rear packet tray **26**. The gate **50**, comprising sheet-guiding fingers **50***a*, positionable in grooves **22***a* in the upper feeding and creasing roll **22**, may be lowered into such position by the gate solenoid GS (FIGS. **7** and **8**) or may be raised by springs **50***b* to the position shown in FIGS. 5*a* to 5*d*.

The lower pocket **20** comprises a pair of closely spaced plates **52**,**52** (FIG. **8**) providing a sheet-receiving pocket. The effective depth of this pocket is adjustably determined by stops which may be set to project into the pocket through slots **20***a* FIGS. **7** and **10**), as will now be described.

An upper horizontally pivoted stop bar **53** has a plurality of spaced-apart projecting stops **54**; a second horizontally pivoted stop bar **55**, positioned below the stop bar **53**, has similar projecting stops **56**; and third, normally-fixed, stop bar **57** has projecting stops **58**. The bottom stop bar **57** may be adjusted vertically, as by fasteners in slotted openings **57***a*. Similar vertical

adjustment means (not shown) may be provided for the pivoted stop bars **53** and **55**.

Continuing with the technique of folding a B-size sheet: The stop bar **53** is rocked to its stop position, as shown in FIGS. **1**, **3***a* and **8**, upon energization of a rotary spring-loaded solenoid BS so that the stops **54** project through slots **20***a* into the pocket **20** to lie in the path of an entering sheet to stop its downward movement at a pre-determined level. The feed rolls continue to feed the sheet, causing it to buckle between and be folded by the upper roll **22** and the lower roll **24**, as indicated in FIG. **3***a*, (8½ inches from the leading edge), and then to be fed under the lowered gate **50** to be pinched by and fed through both creasing rolls **24,24**, and finally onto the driven conveyor **25** and past the retracted rear stop **51** for delivery into the rear packet tray **26**. As seen in FIGS. **8**, **9** and **10** suitable hold down fingers **25***a* are provided to hold the sheet down on the horizontal conveyor **25** as it is fed thereto.

It will be observed from FIG. **3***a* that the stops **54** are so located vertically of the pocket **20** as to cause the 11 × 17 inches sheet to be folded in half in passing through the creasing rolls **22,24**, (i.e. it is folded on a line midway of the ends of its 17 inch dimension), thus forming a once-transversely-folded packet BP as shown in FIG. **3***b*, which packet is 11 × 8½ inches in size, with the title block exposed on an outside panel thereof.

The gate **50**, as above-mentioned, is actuated by a solenoid GS FIGS. **7** and **8**) which, when energized, moves the spring-loaded gate down to the position shown in FIGS. **1** to **3a** and **8**, to prevent upward diversion of the buckled sheet, and to guide it directly to the pinch of the creasing rolls **24**. (It will be noted that the pointed lower ends of the gate fingers **50***a* then extend down through slots in the flared lower edge **21***b* of the front plate of pocket **21**, to keep the sheet from being diverted up into said pocket.) The solenoid-actuated stop **51** is retracted so as not to arrest the folded B-size sheet, as it travels on conveyor **25** to the tray **26** (FIG. **3***a*).

As the description proceeds it will be apparent that since a number of different sized sheets are to be processed in the apparatus, in random size order, certain components which are active when one size of sheet is processed must be blanked out, so to speak, when a different size sheet is processed. How such control is accomplished in a simple and effective manner for a variety of sheet sizes, without the need of time-consuming set-up operations and adjustments, will fully appear hereinafter in connection with the description of the electrical system.

Considering now the folding of a 17 × 22 inches or C-size sheet into an 8½ × 11 inches packet, and with particular reference to FIGS. **4**, **4***a*, **4***b*, **4***c*, and **7–10**, among the chief functioning components are the feed rolls **22**, the lower pocket **2** (with stops **56** effective), the gate **50**, the creasing roll pair **22,24**, the conveyor **25**, the rear stop **51**, a cross-fold micro-switch CM, the cross-fold solenoid CFS, the first cross-fold unit **27**, the inclined discharge conveyor **33** and the end packet-receiving tray **34**.

The upper stops **54** of the lower pocket are retracted from the pocket upon de-energization of the solenoid BS, and the second stop bar **55** is rocked to its stop position as shown in FIG. **4a** by energization of a rotary spring-loaded solenoid CS so that the stops **56** project through slots **20***a* into the pocket **20**. The feed rolls **22** feed the sheet down into the pocket and when the sheet contacts the stops **56** it buckles into and through the crease roll pair **22,24**, as indicated in FIG. **4***a* and is then fed under the guiding fingers of the gate **50** through the pinch creasing rolls **24** and then onto the conveyor **25**. It will be observed from FIG. **4a** that the stops **56** are so located vertically of the pocket **20** as to cause the 17 × 22 inch sheet to be folded in half in passing through the creasing rolls **22,24**, (i.e. it is folded on a line midway of the ends of its 22 inch dimension), thus forming a once-folded sheet, having the folded dimensions 17 × 11 inches, as seen in FIG. **4***a* and at the right of FIG. **4**.

The once-folded sheet travels along the conveyor **25** until its leading edge contacts the rear stop **51** (FIGS. **4**, **4***a*, **9** and **10**) which was raised into its stop position in the path of the advancing sheet by solenoid BR as shown in dotted lines at **51***a* in FIG. **10**. The sheet also engages the cross-fold micro-switch CM (FIGS. **4**, **4***a* and **9**).

The sheet is next cross-folded by means of the first cross-fold unit **27**, (FIGS. **4***b*, **8**, **9** and **10**) after which it is deposited in the receiving tray **34** by the discharge conveyor **33**. The cross-fold unit **27** comprises a pivoted arm **60** carrying a creasing blade **61**, and a pair of hold-down rolls **62,62**, an actuating solenoid CFS controlled by micro-switch CM, and a pair of associated driven creasing rolls **30,30**, arranged as shown in FIG. **10**. The arm **27** is spring loaded by a spring **63** so that it is raised to its normal inoperative position when the solenoid CFS is de-energized. Upon energization of the solenoid CFS the hold-down rolls **62**, with the cooperation of the blade **61**, cause the sheet to be drawn into and be creased by the creasing rolls **30,30**, to cross-fold the sheet and feed it downwardly, this cross-fold being on a line midway between the ends of its 17 inch dimension. In its downward feed the cross-folded sheet engages a guide plate **64** and is guided onto the sloping discharge conveyor **33** and discharged into the end receiving-tray **34** as a completely folded 8½ × 11 inch packet CP, having one transverse fold and one cross-fold as shown in FIG. **4***c*.

In connection with the cross-fold micro-switch CM it is noted that this switch is so located that it is by-passed by the B-size sheet as seen in FIG. **3**.

Before considering the folding of a D-size sheet, or other intermediate sheets, we will now consider the folding of a 34 × 44 inch E-size sheet into an 8½ × 11 inch packet. With particular reference to FIGS. **5** to **5f**, among the chief functioning components are the feed rolls **22**, the lower pocket **20** with bottom stops **58**, the upper pocket **21** with stops **71**, the creasing rolls **22,24**, and **24,24**, the conveyor **25**, the rear stop **51**, the cross-fold micro-switch CM, the cross-fold solenoid CFS′, the second cross-fold unit **28**, the cross-fold solenoid CFS″, the third cross-fold unit **29**, the discharge conveyor **33** and the end packet-receiving tray **34**.

The upper and lower stops **54** and **56** are retracted from the lower pocket **20**, and the feed rolls **22** initially feed the leading portion of the sheet downwardly into the pocket until the leading edge engages the lowermost stops **58** of the pocket, with the trailing portion of the sheet remaining on the table and with the sheet

buckling as shown in FIG. 5*a*. For a 34 × 44 inch sheet the stops **58** are so located vertically of the pocket as to buckle-fold the sheet in half at **70** (i.e. on a line midway between the ends of its 44 inch dimension) this being the first transverse-fold of the sheet.

The gate **50** (as seen in FIGS. 5*a* to 5*d*) is retracted upwardly from the position of FIG. 3*a* so as to enable the once-folded sheet to feed upwardly into the upper pocket **21** until the first folded edge engages a series of upper stops **71**. The stops **71**, on bar **71***a*, extend into pocket **21** through slots **21***a*, the vertical position being adjustable as shown at **71***b* in FIGS. **7** and **10**. This engagement of the sheet with stops **71** again buckles the sheet (i.e. on a line midway of the folded 22 inch dimension of the previously folded sheet) to form a second or double-transverse fold, seen at **72** in FIG. 5*b*. As feed continues, the thus-folded sheet is fed through the creasing rolls **24** (FIG. 5*c*) onto the conveyor **25**. As shown in FIG. 5d, the sheet, now with the three transverse folds and now measuring 11 × 34 inches, is fed by the conveyor **25** until its leading double-folded edge engages the upraised stop **51** and also the cross-folding micro-switch CM. Engagement of the micro-switch CM energizes the cross-fold solenoid CFS′ of the second cross-fold unit **28**. The unit **28** is similar to the above-described first cross-fold unit **27** and includes a pivoted arm **60′**, a creasing blade **61′**, hold-down rolls **62′** and spring **63′**.

The hold-down rolls **62′** and cooperating blade **61′** force the folded sheet into the creasing rolls **31,31**, to cross-fold the previously-folded sheet in half, (i.e. to a 17 × 11 inch size) and feed it downwardly until its leading edge engages a bottom stop **73** of the upwardly disposed cross-fold unit **29**, the partially-completed packet appearing in dot-and-dash lines at **74** in FIG. 5*e*.

The cross-fold unit **29** comprises a pivoted arm **75** having a smoothly curved upper blade or tucking portion **76**, an actuation solenoid CFS″, a micro-switch CM′, the bottom stop **73** and a pair of associated creasing rolls **32,32**. A spring-loaded latch **77** (FIG. **10**) coupled to solenoid CFS″ and cooperating with a pin **78** of the arm **75**, is adapted to hold the arm **75** in its operative relation to the creasing rolls **32** (by action of the solenoid) but is readily releasable to allow the arm to swing away from the rolls to enable quick removal of a sheet in the event it should become jammed.

The downwardly-traversing fold **74′** engages and actuates micro-switch CM′, energizing the solenoid CFS″ thus moving the arm **75**, so that the cross-folded sheet is forced into the nip of the creasing rolls, **32,32**, by the blade **76** of said arm **75**, as diagrammatically indicated in dot-and-dash lines at **79** in FIG. 5*e*, and the sheet is thus cross-folded at its mid-line (i.e. to an 8½ inch dimension) and then the creasing rolls **32,32**, feed the double-cross-folded sheet underneath a guide plate **80** and onto the discharge conveyor **33** for delivery into the receiving tray **34** as a completely folded 8½ × 11 inch packet EP having three transverse-folds, as shown in FIG. 5*f*.

Referring now to the folding of a 22 × 34 inch D-size sheet, and in fact any size sheet ranging from 22 × 34 inches D-size to 34 × 44 inches E-size, the transverse folds and cross-folds are accomplished in the same manner as described above in connection with a 34 × 44 inches E-size sheet, noting in particular the important feature that in making the last cross-fold the arm **75** of the cross-fold unit **29** is held in its cross-folding position shown in FIGS. **6** and **6***a* by means of a latching relay, later described, during the feed of the sheet into the creasing rolls **32,32**, and is released upon unlatching of the relay when the next sheet is entered into the apparatus.

With intermediate sheet sizes, where the dimensions are not direct multiples of the ultimate packet measurements of 8½ × 11 inches, there will be odd-sized areas to be taken care of. Where this occurs in the cross-folding operation, it is typically cared for as in FIGS. **6** and **6***a*. As above-indicated, by holding the arm **75** "in" (see FIG. **6**), the odd area, or short portion **81** of the sheet, is smoothly led to the nip of the creasing rolls **32,32** by the smooth curved tucking portion **76** of the arm **75** and neatly tucked between the folds **82** and **83** as shown at **84** in FIG. **6***a*. This advantageous arrangement prevents damage or crumpling of the area **81** of the sheet.

The procedure in operating the apparatus and the electric circuits will now be described in connection with the schematic wiring diagram of FIG. **11**, from which it will be observed that no special set-up operations or adjustments of the components are necessary as sheets of various sizes are introduced for folding in random-size order, thus ensuring speed of operation. It will be seen that the mere pressing of a pushbutton, designated to be for the size of sheet being processed, automatically sets a minimum number of solenoid-actuated stops in order to effect folding of the sheet into a folded packet of predetermined size.

The control console **19** comprises a control switch assembly having suitable known lock-out characteristics, selective push-buttons, signal lights, and plug-in means **100***a* for plugging the console into a suitable terminal block **100***b* whereby the entire switch assembly can be readily removed either for replacement or repair in the event of failure, thus greatly reducing maintenance time and costs. The switches are of a type known as bail lock-out switches, interlocked in such a way that with one push-button switch for each of several selective control circuits, only one of that group of buttons will remain down at one time, and if a different button of the group is depressed it releases the button (and switch) previously depressed. The sheet size selector-switch buttons may bear legends such as B, C and D; and in the present embodiment, the third might well carry the legend D–E since the same circuit may be employed for both D-size and E-size prints, as will later appear.

In starting the apparatus, the operator presses the "on" button S to start the motor M to drive the various rolls and conveyors described above in continuous drive. To stop the motor, "off" or stop button ST is pressed. For test observations, if desired, the "Jog" button J is pressed.

Instantaneous conditioning of the machine for folding a B-size sheet into a folded 8½ × 11 inch packet is achieved by pressing push button BPB to close the circuit **101** controlled by the upper portion **102** of double switch **103**, and thus to energize the rotary stop solenoid BS to move the stops **53** of lower pocket **20** into stop position and simultaneously energize the rear rotary stop solenoid BR to retract the stop **51**

downwardly out of the path of the advancing sheet allowing it to be deposited into the rear packet **26**. At the same time, the lower portion **104** of switch **103** closes the circuit **105** to energize the gate solenoid GS to lower gate **50**, thus causing the sheet to by-pass the upper pocket **21** and directing it to the conveyor **25** as described hereinbefore.

The depressed push button BPB is illuminated by a lamp BL supplied with current by a low voltage transformer **106** in the closed circuit **107**, **108**, **109** of the locked-out push buttons CPB and DPB.

In this connection it is pointed out that only one of the three push buttons can be pressed at a time and that subsequent pushing of another push button releases the button initially pressed. Thus two push buttons cannot be down at the same time, and this enables use of the switches of idle push buttons to establish contact for the indicator light of the pressed push button as just described.

If, after folding one or more B-size sheets, a different size sheet is to be folded, for example a 17 × 22 inch C-size sheet, the corresponding push button CPB is pressed, which immediately releases the previously pressed push button BPB and opens the circuit **101** to de-energize stop-solenoids BS and BR (FIGS. 7 and 9) and also opens the circuit **107** of the indicator lamp BL of push button BPB. De-energization of the solenoid BS causes the stops **54** to retract out of the pocket **20** and de-energization of the solenoid BR causes rear stop **51** to move up into the path of sheets advanced by the conveyor **25**.

Release of push button BPB also causes the lower section **104** of its switch **103** to close a circuit from the low voltage transformer **106** to the indicator lamp CL of the push button CPB to illuminate it.

Pressing of the push button CPB causes the upper section **110** of its switch **111** to close a circuit **112** and energize stop-solenoid CS to move the stops **56** of the lower pocket **20** into stop position and also causes the lower section **113** of switch **111** to close a circuit **114** to the gate-solenoid GS to again lower the gate **50**.

When the sheet advanced by the conveyor **25** reaches the rear stop **51** the cross-fold micro-switch CM is closed, which closes a circuit **115** to energize the cross-fold solenoid CFS of the first cross-fold unit. It is noted that the closed contacts of the upper section **116** of the switch **117** of push button DPB are included in the circuit **115**.

The pressing of push button CPB therefore effects the transverse folding and cross-folding of the C-size sheet as hereinbefore described.

If now a 34 × 44 inch E-size sheet is to be folded, push button DPB is pressed which immediately releases the previously pressed push button CPB and opens circuit **114** of the gate-solenoid GS and the C stop-solenoid CS (FIG. 7) causing the gate **50** to be spring raised to the position shown in FIG. 5a and causing the stops **56** of the lower pocket **20** to be retracted out of the pocket. Pressing of the push-button DPB moves the lower section **118** of its switch **117** down to open the circuit **108** of the indicator lamps BL and CL and to close the circuit **109** of the D indicator lamp DL. The upper section **116** of the switch **117** opens the circuit **115** of the first cross-fold solenoid CFS, and, when the cross-fold micro-switch CM is closed by the advancing sheet, a circuit **119** of the cross-fold solenoid CFS′ is closed to energize said solenoid and effect cross-folding of the sheet by the cross-fold unit **28** (FIGS. 5*e* and 10).

The leading edge of the cross-folded sheet closes the switch CM′ (FIGS. 8 and 10) of cross-fold unit **29** which energizes the latching coil **120** of the latching relay **121** to close the relay contacts to in turn energize the cross-fold solenoid CFS″ of cross-fold unit **28**. This effects a second (and final) double-crossfold of the sheet as hereinbefore described. The mechanical latch of the relay holds the relay contact closed and consequently keeps the solenoid CFS″ energized until a succeeding sheet actuates the cross-fold micro-switch CM to pulse the unlatching coil **122** of the latching relay **121** to reset the circuit for another final cross-fold.

The folding of sheets of any size from the 22 × 34 inch D-size to the 34 × 44 E-size is accomplished by pressing the push button DPB and the folds take place in the same manner as just described for the E-size sheet. However, since sheets of certain intermediate sizes have a "short area" **81**, so to speak, when the sheet is advanced into the final fold unit **29** as seen in FIG. 6 provision is made, as explained hereinbefore, to smoothly tuck this end between the folds **82** and **83** as shown at **84** in FIG. 6*a*.

The apparatus includes a tubular static eliminator **125** located in the inlet throat **23** of the cabinet as shown in FIG. 8 and connected in the electrical circuit as shown in the wiring diagram of FIG. **11**.

Each of the rotary solenoids BS, CS and BR has a known type of arc-suppressor across it as indicated at **126** in FIG. **11**, to minimize the effect of the high reverse voltages generated by the collapsing magnetic field of the solenoids when de-energized. This protects the switching contacts of the control circuitry and substantially extends the life of the contacts.

By way of illustration and amplification, but not of limitation, we will now point out some further features and advantages of the invention.

The coordinated drive of the feed rolls and creasing rolls, conveyor **25** and conveyor **33**, and the rapid and accurate selection and actuation of the several folding mechanisms, stops and associated parts, help to make possible a high-speed operation, when folding a given standard size of print, or when folding an intermix of standard sizes, or when folding prints of odd or non-standard sizes and shapes or a mixture of odd and standard sizes.

Considering simply the linear speed of the conveyor belts and the roll surfaces, it is quite practical to operate these continuously at a speed, for example, of 150 feet per minute, which is approximately double the speed of some known folding machines heretofore in use. In this regard it may be noted that the rolls are desirably surfaced with rubber or Neoprene. The belts of the conveyors are typically of a woven endless fabric or tape having a good surface friction characteristic.

The selection of stops, gates and folding units, and thus of the number and location of fold lines (both as to transverse-folds and as to cross-folds), through the medium of quickly-identifiable push-buttons, spring returned solenoids, controls tripped by sheets of certain dimensions, and related elements, renders the operation of the machine quick, easy and reliable, and

simplifies the training of personnel to operate it. For Example, as an intermix of standard prints of B, C, D and E sizes (or any two or more of them) are received at the operator's station, the operator, recognizing the size, simply presses the corresponding push-button, positions the print against the guide **16a** with the corner block **15** at the location shown in FIGS. **3**, **4** and **5**, and slides the print endwise into the throat **23** (FIG. **8**), whereupon the feed rolls **22** take over, and those mechanisms made effective by the circuits controlled by the selected push-button then operate upon the print to produce the uniformly-dimensioned packet and to deliver it, either to the rear receiver **26** (in case of a B-size print) or to the end receiver **34** (in case of larger prints).

When a print of an odd (non-standard) size comes along, if it is of a width (for example) between the 17 inch width of a C-size print and the 34 inch width of an E-size print, the operator presses the D–E push-button, and when the print reaches the cross-folding unit **29** (see FIGS. **6** and **6***a*) the odd area, over and above what would have been folded as a direct multiple of the final 8½ inch dimension of the packet, will have been folded in, automatically, as shown for instance at **81** and **84** in those Figures. At **84**, it is seen that the odd area is positioned at the interior of the packet.

Similarly, when an odd (non-standard) print comes along, having, for example, a lengthwise dimension intermediate the 17 inches length of a B-size print and the 22 inches length of a C-size print, the operator presses the C push-button, and in the transverse-folding unit **20**,**24**, etc. (FIG. **4***a*) the odd area, not conforming with what would be folded as a direct multiple of the final 11 dimension of the packet, will have been folded in, automatically, during the buckle-folding operation; and, when the cross-fold has taken place, the odd length area will be on the inside of the packet, just as in the case with the odd width area (**84** in FIG. **6***a*).

In short, when a print is of dimensions between two standard-size sheets for which the machine has been set-up, the operator simply presses the push-button for the larger of those two standard sizes, and the apparatus automatically folds into the packet the sheet area which is in excess of the area of the smaller of said standard sizes.

The facility, speed and reliability of operation of this apparatus make it quite feasible to fold prints or other sheets at such rates per hour that the folded packets can be delivered in such quantities as: over 1,200 per hour (if B-size prints); over 1,100 (**C-size**); **over** 900 (D-size); over 700 (E-size); over 800 (with a typical random intermix). The reliability, speed and output constitute substantial improvements over all prior print-folding machines of which we are aware. It should further be understood that similar results may be obtained by our machine when made or adjusted for other sheet sizes, for example: 12 × 18 inch, 18 × 24 inches, 24 × 36 inches, **36** × **48** inches, and odd intermediate sizes.

Turning again to the electrical system disclosed and claimed herein: typically, though not by way of limitation, the 115-volt A.C. power (see FIG. **11**) may be used for the motor M and for the linear solenoids, while the rectifier diagrammatically-shown may deliver a 100-volt D.C. output to the rotary solenoids, and the lights may be operated with 5-volt A.C. from the transformer **106**.

The lights are desirably so placed as to give interior illumination to the push-buttons, which may be translucent so that the legends thereon show up clearly. Only one (the depressed) button is illuminated at any one time. This tends to avoid errors in operating the machine.

The known interlocked switches may be of any suitable commercially-available type, having a selective operation such as is commonly employed today in various radio receivers, business machines, data processing equipment, etc., where each push-button operates a switch to select a given circuit and automatically releases the other switches. One example is the Honeywell known as the "Kb" Micro Switch.

Besides the normal control, adapted to effect continuous power-driven operation of the folding and conveying mechanism at high speed, the "jog" button permits intermittent operation (under power) in order to check out the machine, or to take out a partially-folded sheet if desired, or to clear a jam. In addition, the apparatus may be operated slowly, by hand, by applying a wrench to the squared socket **42'** of shaft **42** of the gear-box (see FIG. **8**), for instance to extract a crumpled sheet, if for any reason there should be a malfunction.

Various changes may be made within the scope of the invention herein disclosed and claimed. For example, but without limitation, differently located stop devices or stops additional to stops **54**,**56**, **58** and **71**, might be employed, by which additional fold patterns could be programmed.

With respect to various feed and creasing rolls, such as **22**,**24**, **31** and **32**, these are shown as separated (for clarity) in the diagrammatic portions of the views of FIGS. **1**, **3***a*, **4***a*, **4***b*, **5***a* to **5***e* inclusive, **6** and **6a**, but it will be understood that their actual relationships are as shown in FIGS. **7** to **10**.

We claim:

1. Apparatus adapted to handle an intermix of flexible sheets of differing sizes and to fold them, selectively, along one or more fold lines, each into a folded packet having predetermined standardized length and width dimensions, comprising high-speed normally continuously-operating sheet transport means with associated sheet-folding mechanism, said mechanism having a plurality of elements adapted to co-operate in the sheet-folding operation, at least some of which elements may be selectively rendered operative according to sheet size whereby to fold the sheet on one or more lines of fold so related as to form said sheet into a folded packet of the aforesaid predetermined standardized length and width dimensions, regardless of the initial size of the sheet, and a programming system for said selectively operative elements, controllable, in accordance with sheet size, to select simultaneously the required group of said elements for operation, without retarding said sheet transport means or interfering with the normal flow of work through the apparatus.

2. Apparatus according to claim **1**, wherein certain elements of the sheet-folding mechanism also constitute part of the sheet transport means.

3. Apparatus according to claim **1**, wherein parts of the sheet transport means are adapted to act also in a sheet-folding capacity.

4. Apparatus according to claim 1, wherein the sheet transport means includes sheet-folding rollers.

5. Apparatus according to claim 4, wherein the transport means also includes constantly-moving conveyor means positioned and operating to receive a folded sheet and pass it to a selecting station.

6. Apparatus according to claim 5, wherein routing means are associated with the said conveyor means at said electing selecting and are adapted to route a sheet to a receiver or alternatively to arrest a sheet at said station for further folding and for routing to a different receiver, according to initial size of the sheet, without retardation of said conveyor means.

7. Apparatus according to claim 6, wherein certain elements of the sheet-folding mechanism are located at said station and are constructed and positioned to effect cross-folding of an arrested sheet.

8. Apparatus according to claim 7, wherein a second constantly-moving conveyor means is positioned to receive and transport the cross-folded sheet to another station.

9. Apparatus according to claim 1, wherein the sheet-folding mechanism includes elements constructed and operating to fold the sheet on transverse parallel lines of fold.

10. Apparatus according to claim 1, wherein the sheet-folding mechanism includes elements constructed and operating to fold the sheet selectively on one, or more, transverse lines of fold, depending upon sheet size, parallel to one edge of the sheet, and also includes elements constructed and operating to fold the sheet on one or more cross-fold lines, depending upon sheet size, at right angles to said transverse line or lines of fold.

11. The apparatus of claim 1, wherein the sheet-folding mechanism is adapted not only to fold a sheet having a dimension which is a multiple of one of said standardized dimensions into panels each having a dimension which substantially equals said one dimension, so as to fit a standardized packet dimension, but wherein said sheet-folding mechanism also incorporates means adapted, in the case of a sheet having a dimension greater than but differing from said multiple, to fold into the inside of the packet such remaining fragmentary portion of the sheet as is in excess of said multiple but of a dimension less than said one standardized dimension.

12. The apparatus of claim 11, wherein said means includes a sheet guide having a curved surface configured and operative to tuck said fragmentary portion of the sheet between normal folds of the sheet.

13. Apparatus for folding an intermix of flexible sheets of various sizes by transverse-folds and cross-folds to form, in each instance, a folded packet of the same predetermined size, comprising sheet-folding components, and continuously-moving high-speed sheet-conveying means between said components, and an electrical selection system including a plurality of electrical circuits for setting the various folding components of the apparatus to accomplish the necessary folds for any size sheet within the capacity of the apparatus, and means for variously selecting different particular circuits to activate differing groups of the folding components necessary for the transverse- and cross-folding of differing particular sizes of sheets to be folded.

14. Apparatus according to claim 13, having a selector console controlling said circuits.

15. The apparatus of claim 14, wherein said console comprises a plurality of manually-operated mutually inter-locked switches.

16. The apparatus of claim 15, having a receptacle into which said circuits extend and said selector console being adapted to be readily pulled out of said receptacle for replacement.

17. Apparatus adapted to handle an intermix of flexible sheets of different sizes and to fold them, selectively, along one or more fold lines, depending upon sheet size, and operative for successive transverse-folding and cross-folding, so that, by successive operations, sheets of differing sizes may each be folded to produce a folded packet having predetermined standardized length and width dimensions, said apparatus comprising high-speed normally continuously-operating sheet transport means with associated sheet-folding mechanism, said mechanism having a plurality of elements adapted to co-operate in a sheet-folding operation, at least some of which elements may be selectively rendered operative according to sheet size whereby to fold the sheet on one or more lines of fold related to the initial size of the sheet, and a programming system for said selectively operative elements, controllable, in accordance with sheet size, to select quickly and simultaneously a group of said elements for operation to produce one or more folds paralleling an edge of the sheet without retarding said sheet transport means.

18. Apparatus according to claim 17, wherein the sheet-folding mechanism includes elements constructed and operating to fold the sheet selectively on one or more transverse lines of fold, depending upon sheet size, parallel to one edge of the sheet, and also includes elements constructed and operating to fold the sheet on one or more cross-fold lines, depending upon sheet size, at right angles to said transverse line or lines of fold.

19. The apparatus of claim 17, wherein the programming system comprises manually-actuable means quickly controllable by an operator to condition the system for effecting a selection of folding elements in accordance with a sheet dimension.

20. The apparatus of claim 17, wherein the programming system comprises automatic sensing means operative in response to a sheet dimension.

21. The apparatus of claim 17, comprising power drive means therefor, a control for normally establishing continuing operation of said apparatus by said power drive means, a control for jogging said apparatus into an intermittent operation by said power drive means, and means for operating said apparatus slowly by hand.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,698,705
DATED : October 17, 1972
INVENTOR(S) : Rudolph Funk, Jamison; Roger S. Funk, Holicong, both of Pa.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In column 3, line 42, "are types" should be deleted

Signed and Sealed this

Eighteenth Day of *October 1977*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

LUTRELLE F. PARKER
Acting Commissioner of Patents and Trademarks