United States Patent [19]

Sjostrom

[11] **3,754,750**

[45] **Aug. 28, 1973**

[54] **METHOD AND APPARATUS FOR FOLDING SHEETS**

[76] Inventor: **Robert L. Sjostrom,** 133 N.W. 16th St., Boca Raton, Fla. 33432

[22] Filed: **Feb. 24, 1970**

[21] Appl. No.: **13,277**

[52] **U.S. Cl.** **270/69,** 270/84

[51] **Int. Cl.** **B65h 45/04**

[58] **Field of Search** 270/66–69, 80–85

[56] **References Cited**

UNITED STATES PATENTS

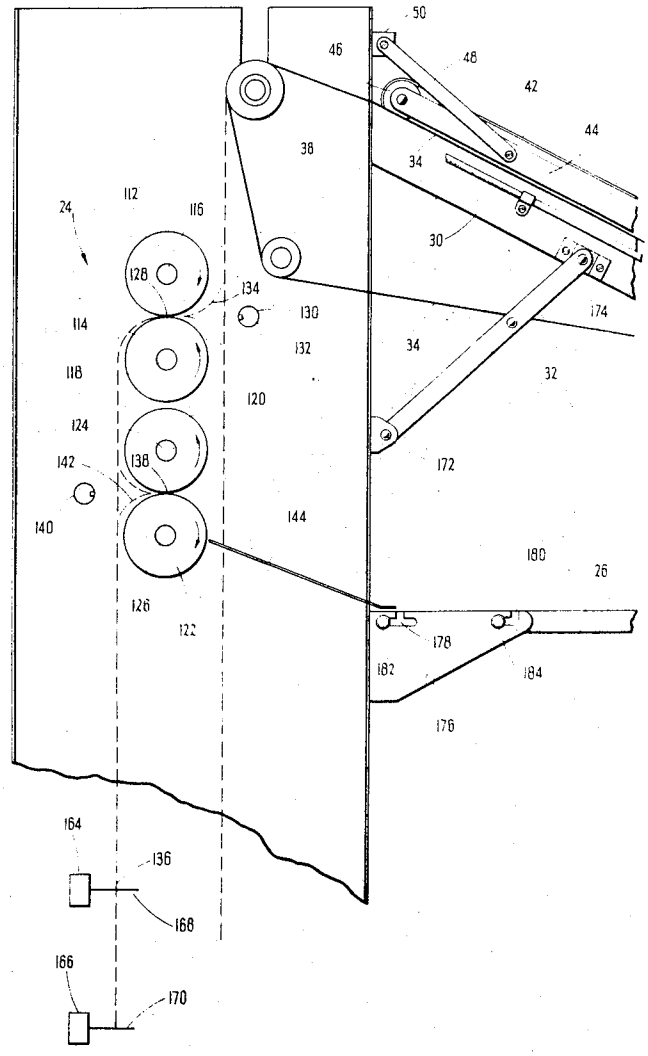
3,339,914	9/1967	Grantham	270/66
3,294,395	12/1966	Sjostrom	270/69
3,212,771	10/1965	Kerman et al.	270/69
3,437,334	4/1969	Maldonado	270/69
3,452,979	7/1969	Grantham	270/83 X
3,563,530	2/1971	Grantham	270/66
3,255,662	6/1966	Call	270/61 F
1,480,517	1/1924	Doolittle	270/79
3,485,492	12/1969	Iltis	270/69 X
2,813,714	11/1957	Herrick	270/68 A

Primary Examiner—Robert W. Michell
Assistant Examiner—L. R. Oremland
Attorney—Wolf, Greenfield, Hieken & Sacks

[57] **ABSTRACT**

A compact sheet folder for longitudinal folding of ironed or "no-iron" sheets, including means for feeding the unfolded sheet into the machine with one edge of the sheet leading the remaining portions of the sheet. The feeding device advances the sheet to a number of parallel horizontal rollers which are arranged in a generally vertical alignment. The sheet moves downwardly from the feeding arrangement to the rollers and is passed transversely and repeatedly through the rollers to effect a number of folds. The last fold is made by a pair of rollers which advance the sheet horizontally toward the side of the machine at which the sheet was originally fed in. This enables the operator to both load and unload the machine from the same operating station. A cross folding device may be located at the unloading station to receive automatically the longitudinally folded sheets. The folder may be connected to an automatic ironer which delivers ironed sheets to the feeding means.

21 Claims, 12 Drawing Figures



Patented Aug. 28, 1973 3,754,750

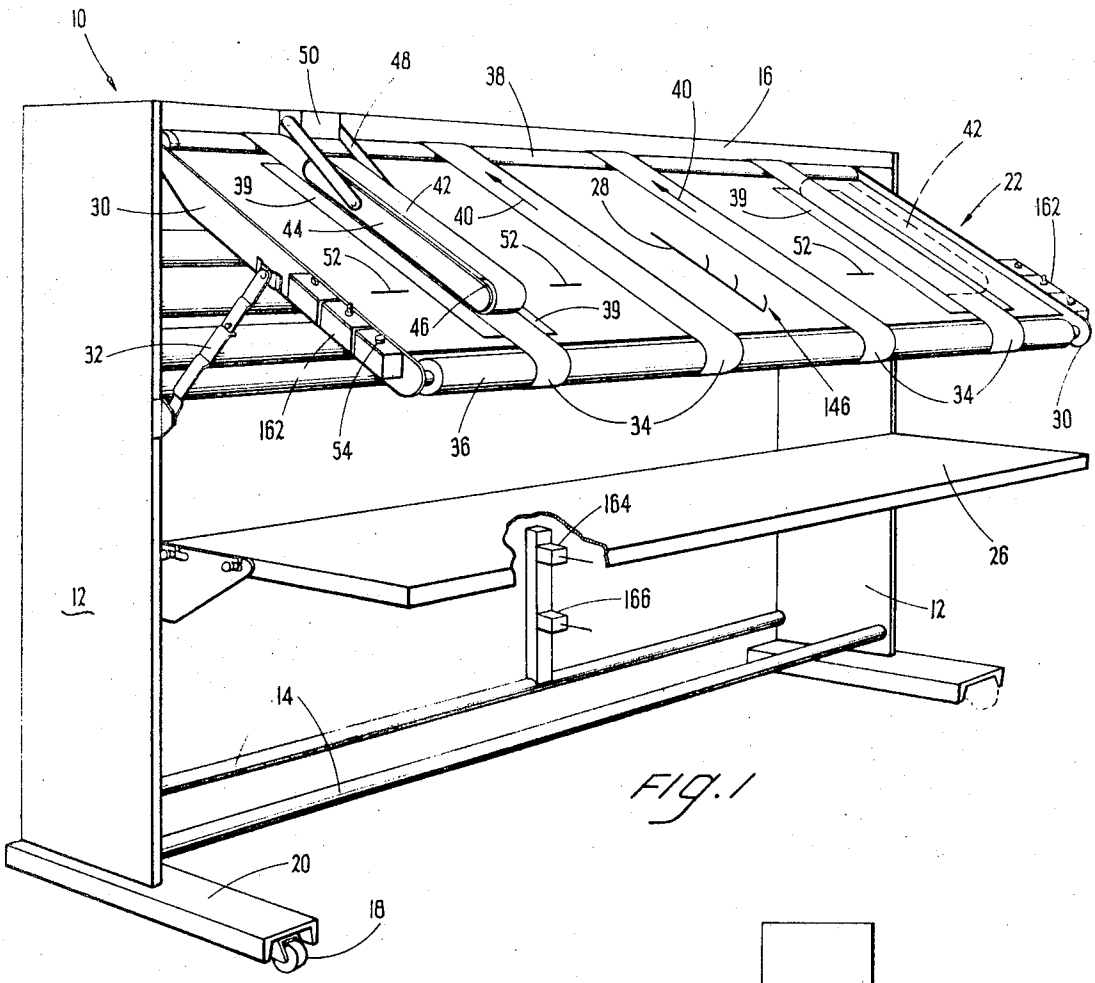


FIG. 1

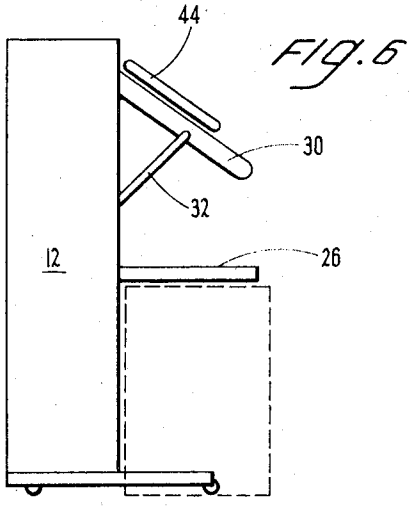


FIG. 6

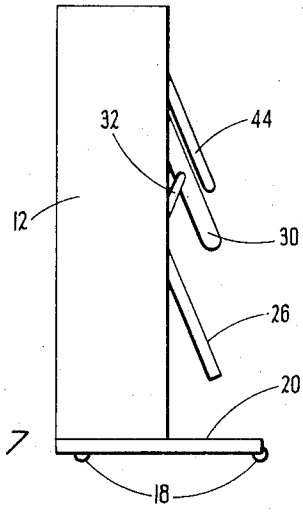


FIG. 7

INVENTOR
Robert L. Sjöström
BY
Wolf, Greenfield Hueken + Sacks

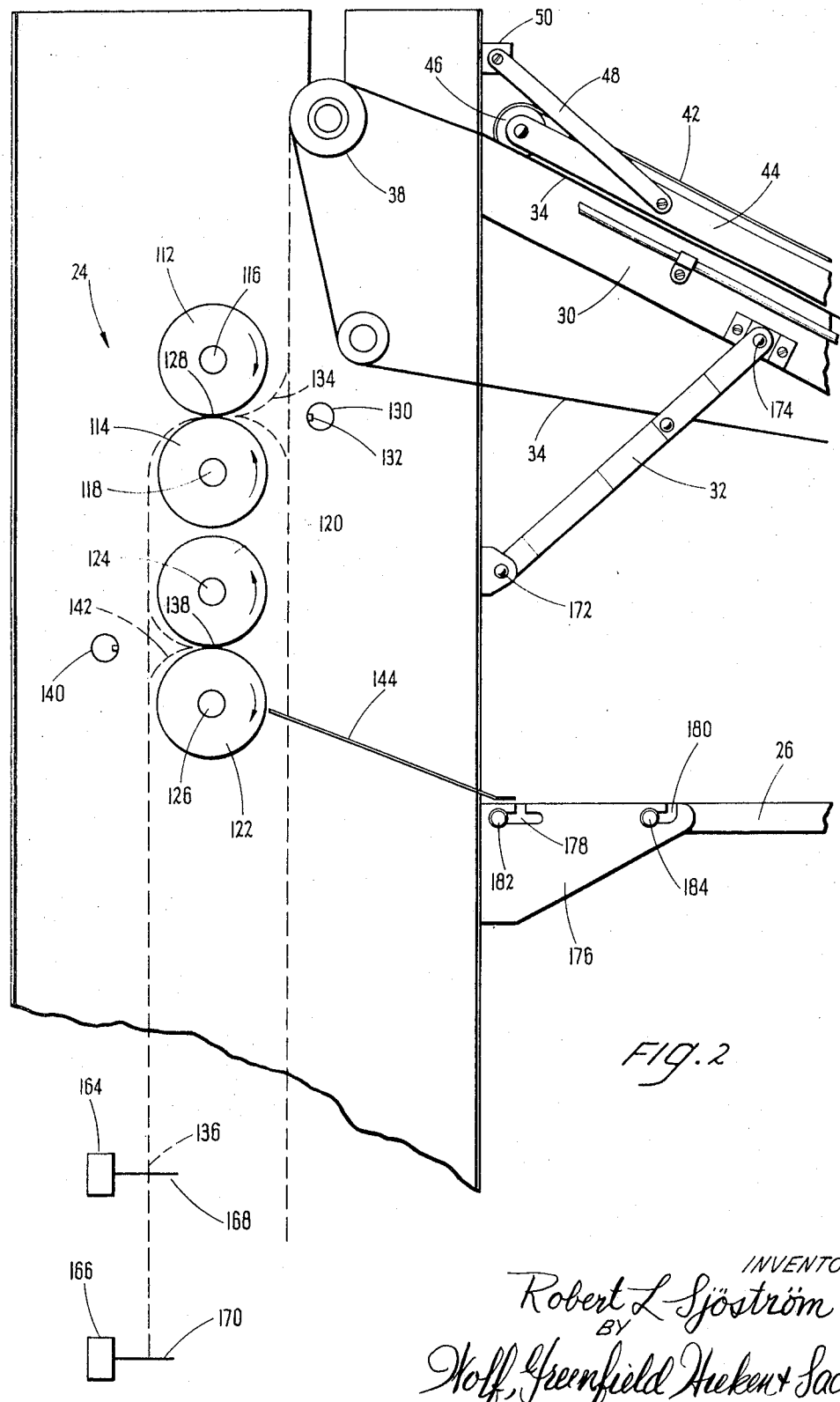


FIG. 2

INVENTOR
Robert L. Sjöström
BY
Wolff, Greenfield Hueken & Sacks

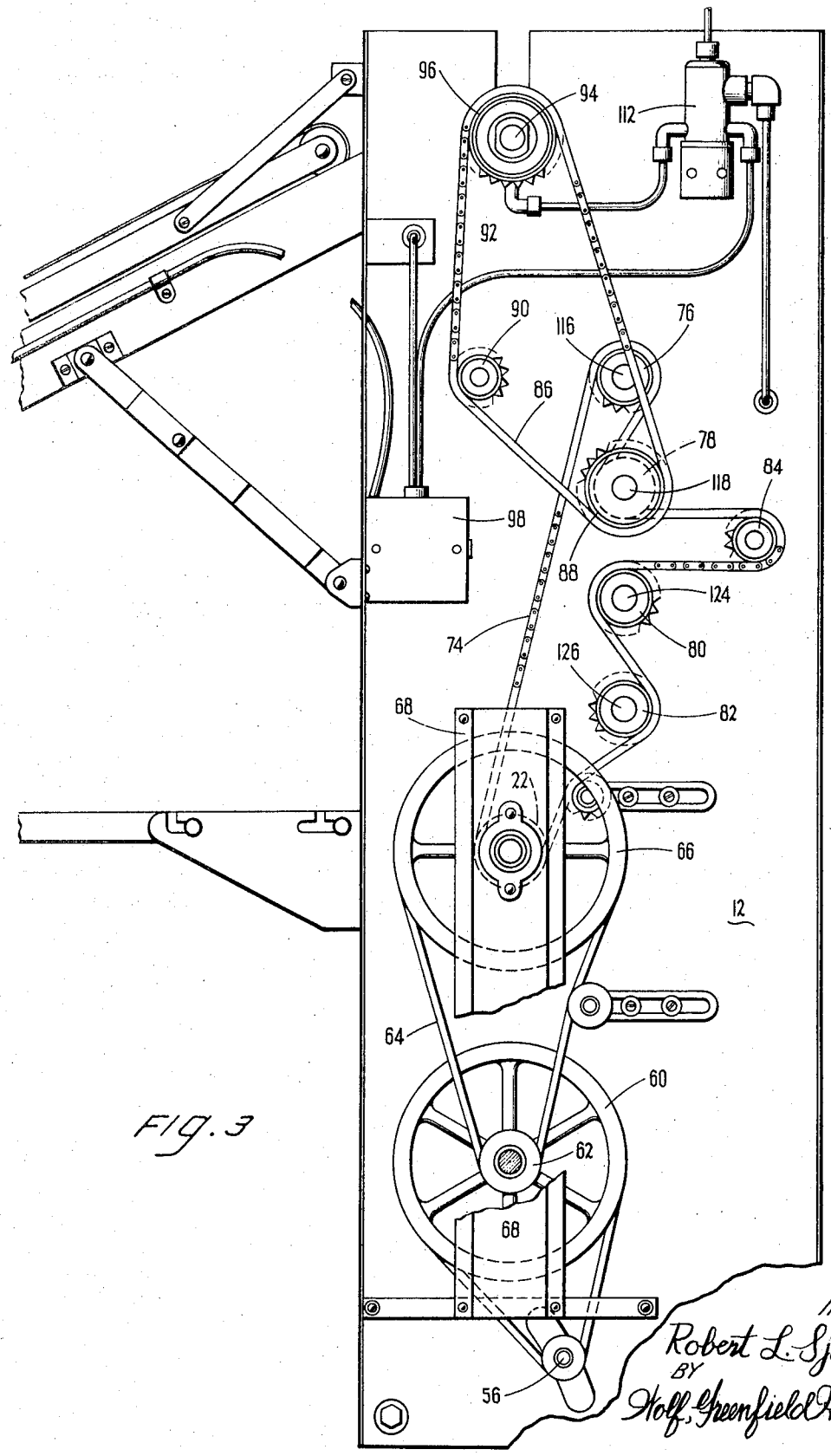


FIG. 3

INVENTOR
Robert L. Sjöström
BY
Wolff, Greenfield Hieken & Sacks

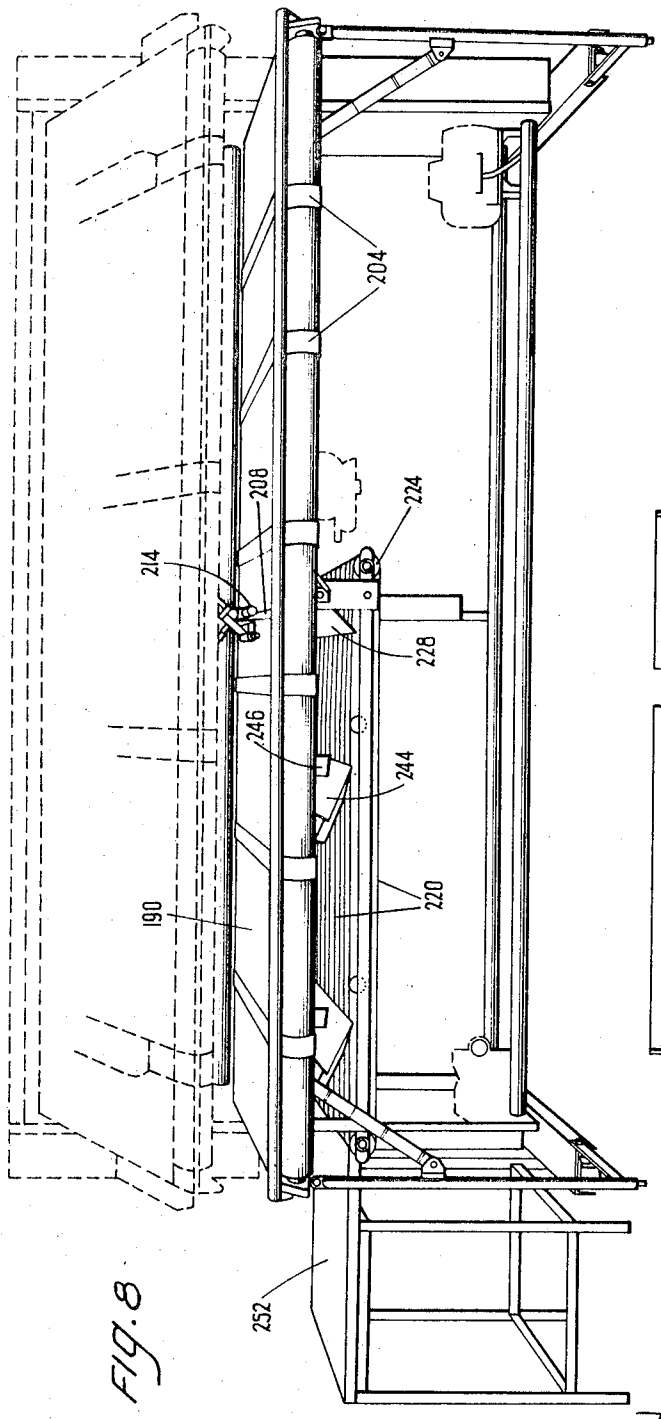


FIG. 8

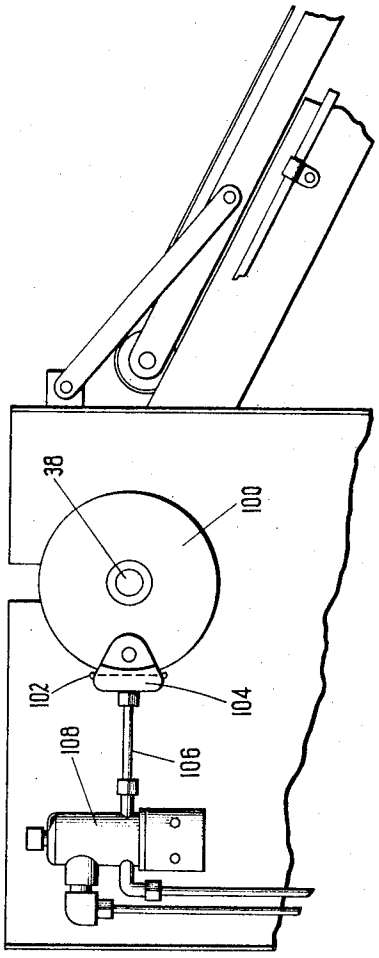


FIG. 4

INVENTOR
Robert L Sjöström
BY
Wolf, Greenfield, Hiekert & Sacks

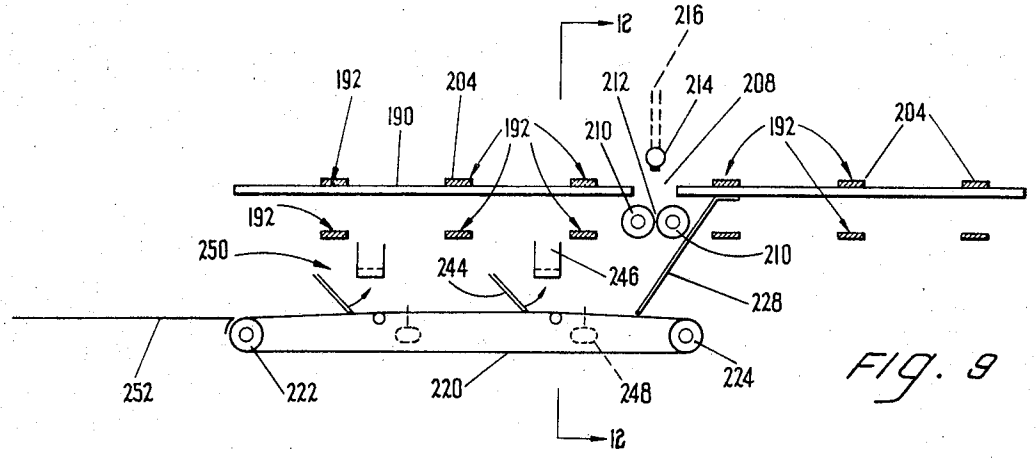


FIG. 9

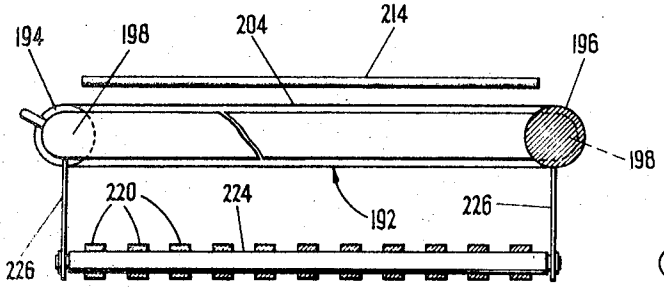


FIG. 12

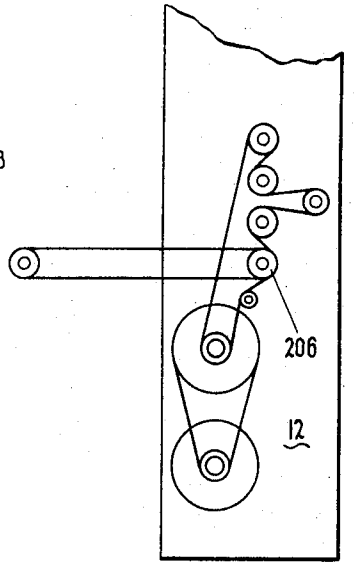


FIG. 11

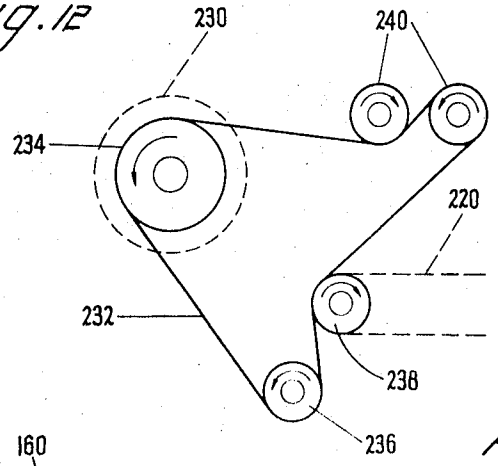


FIG. 10

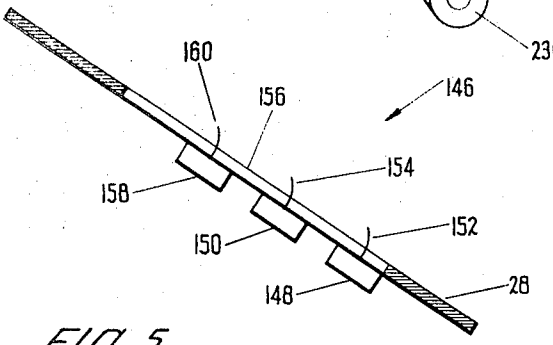


FIG. 5

INVENTOR
Robert L. Sjöström
BY
Wolf, Greenfield Hieken & Sacks

METHOD AND APPARATUS FOR FOLDING SHEETS

BACKGROUND OF THE INVENTION

This invention relates to sheet folders as might be used to fold bed sheets and the like. It is useful particularly in connection with bed sheets which have been treated so that they require no ironing and simply may be laundered, folded and then used. Bed sheets of this character have been used with increased frequency, particularly by institutions such as hospitals, hotels, motels, dormitory facilities and the like. Such institutions may maintain relatively extensive laundering facilities in order to provide the constant supply of fresh bed sheets which they obviously need. Before the development of "no-iron" sheets, the bed sheets had to be washed, dried, ironed and then folded. These operations generally are performed by machines specially adapted for these purposes. A typical arrangement includes an ironing machine which feeds the ironed sheets directly into a folding machine, this transfer being substantially automatic and mechanized. The increasing use of "no-iron" sheets, however, has eliminated the need for the ironing machine. The washed and dried sheet only requires folding. My invention relates to a folding machine which is suitable for use particularly with such "no-iron" sheets but which also may be used in connection with conventional sheets which first are passed through an ironing machine.

Although some of the institutions referred to above, such as large hospitals, may have their own complete laundering facilities, many of these institutions such as smaller hotels, motels, etc., may not find it economically feasible to maintain their own complete laundering facilities. This is due primarily to the relatively high cost of the necessary laundering machines, particularly the ironing and folding machines. Additionally, these machines are bulky and require considerable space. The sheet folder described herein is of relatively simple design, is uncomplicated, and may be fabricated and maintained at a considerably lower cost than heretofore available machines. Because of the economics inherent in my folding machine, it may be used economically by smaller institutions which normally would not do their own laundering. Additionally, the currently available folding machines are relatively bulky and cannot be moved about easily. The folding machine described herein occupies relatively little space, is quiet and, therefore, is more suitable to use in smaller institutions.

SUMMARY OF THE INVENTION

In brief, my sheet folder is of generally upright configuration and has a loading unit which feeds the sheets into the machine where they are folded by a folding unit and then delivered out of the machine to a receiving platform. The receiving platform is located below and on the same side of the machine as the feeding unit so that the operation may both load and unload the machine from the same position. This is contrasted with prior machines in which the sheets are fed in one end of the machine and delivered from a different portion of the machine.

The operator feeds the leading edge of the spread-out sheet onto the feeding unit which advances the sheet to the upper regions of the unit. As the sheet is fed into the machine, it then passes downwardly and through

the folding unit. In the illustrative embodiment of the invention the folding unit consists of a number of rollers which are arranged in generally vertical alignment. The rollers are arranged to provide a number of nip lines through which the sheet is passed in succession to make the folds. The nip lines and rollers are arranged so that the folds are made while the sheet is advanced in a generally horizontal direction. The last fold is made by a pair of follers which advance the sheet forwardly toward the operator while simultaneously making the fold. In general, the sheet, before each folding operation, is advanced in a direction which is substantially normal to the folding direction of the folding rolls. The leading edge of the sheet passes to one side of a pair of folding rolls until the center of the sheet is in alignment with the nip of those folding rolls. At that time, a feeding blade or a blast of air is employed to urge the mid portion of the sheet into the rolls thus effecting the fold.

Another aspect of the invention resides in the arrangement by which the sheet is fed into the machine. This includes a loading or feeding bed which projects forwardly. The feeding unit has a number of endless belts which pass over the upper surface of the loading bed and advance continually toward the machine. The sheet, when loaded, is placed on these belts and is maintained in engagement with these belts by hold down or pressure rollers or belts which cooperate with the feeding belts to grip the sheet firmly. The main feed belts are driven at their rearward ends by a roller which extends across the top of the machine. The sheet is fed by the belts over and about the roller and hangs downwardly from the roller. The leading edge of the sheet descends through the machine as the main feeding belts continue to advance the sheet into the machine. The leading edge descends past and to one side of the first pair of folding rollers until the mid portion of the sheet is located in registry with the nip line of the first two folding rollers. At this time, the mid portion of the sheet is injected transversely into the nip line of the first two folding rollers which grip and advance the sheet therethrough. Injection of the sheet into the nip line is controlled by a switch mounted strategically on the feeding bed and which is responsive to the passing of the trailing edge of the sheet. The switch is positioned so that the trailing edge of the sheet passes the switch just as the center of the sheet advances downwardly into registry with the nip line of the first two feed rollers. The once folded sheet exits from the first nip line of the first two rollers and then drapes downwardly from the first two rollers. The first folded edge continues to descend until the mid portion of the once folded sheet is in registry with the nip line of the second, lower pair of fold rolls at which time the mid portion of the once folded sheet is injected into the second nip line. Injection of the once folded sheet through the second nip line is controlled by reference to the leading, folded edge of the once folded sheet. The lower, second pair of fold rolls fold and advance the sheet forwardly back toward the operator, with the sheet being advanced onto the loading platform at the front of the machine.

One feature of the invention resides in the general vertical arrangement of the fold rollers which, among other things, permits the machine to be located in a relatively narrow space thus providing a compact arrangement.

An additional feature of the invention resides in the foldable construction of the feed bed and loading platform which, during use, extend forwardly from the body of the machine but which may be folded downwardly to reduce the effective width of the machine. Folding these beds down is advantageous particularly when shipping, moving or storing the machine.

An additional feature of the invention resides in the roller arrangement which delivers the folded sheet to the operator with selvage edge up, returns the folded sheet to a position convenient to the same operator feeding the machine, and which permits rapid feeding of "no-iron" sheets to the machine at the fastest rate an operator can work.

Another feature of the invention is that it permits the operator to use his time most efficiently in that after the sheet has been gripped by the feeding unit, the operator has some free time during which he can handle the previously ejected and folded sheet to either remove the sheet from the machine or effect further cross folds for the already quarter-folded sheet.

DESCRIPTION OF THE DRAWINGS

The various objects and advantages of the invention will be more fully apparent form the following detailed description thereof with reference to the accompanying drawings wherein:

FIG. 1 is a perspective illustration of the machine showing the front and sides thereof;

FIG. 2 is a side elevation, in section, illustrating the arrangement of fold rolls and feed unit and showing the path along which the sheet passes through the machine;

FIG. 3 is a side elevation of the right side of the machine showing the drive means for the various elements of the machine;

FIG. 4 is a side elevation of the other side of the machine showing the brake arrangement for the feed roller;

FIG. 5 is a sectional view taken through the feeding bed to illustrate the switches responsive to the trailing end of the sheet;

FIG. 6 is a side elevation of the machine when the feeding unit and loading platform are in an operating configuration;

FIG. 7 is a side elevation similar to FIG. 7 showing the feeding bed and loading platform folded down for compact storage; and

FIG. 8 is a somewhat diagrammatic illustration of the machine as used in conjunction with a cross folder located at the forward end of the machine.

FIG. 9 is a front elevation, in section, of the cross folder;

FIG. 10 is a somewhat diagrammatic illustration of the arrangement for driving the lower transverse belts of the cross folder;

FIG. 11 is a side elevation of the machine showing the arrangement for driving the upper belts of the cross folder; and

FIG. 12 is a side elevation, in section, of the cross folder as seen from the plane 12—12 of FIG. 9.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The invention is directed specifically to a means for folding sheets or large pieces as distinguished from towels, napkins or other small pieces. Large pieces or sheets as used herein are meant to define, as is usual in the trade, bed sheets or sheets of generally bed sheet dimensions as distinguished from the much smaller small pieces, napkins or towels. In this connection it should be understood that the problems inherent in folding and handling large pieces are quite different from folding small pieces.

FIG. 1 shows the machine having a frame, indicated generally by reference character **10**, which consists of side panels **12**, lower cross braces **14** and upper panel or cross brace **16**. The frame **10** preferably is mounted on rollers **18** to enhance the mobility of the unit. The rollers may be rotatably mounted to feet **20** which are secured to the bottom of the frame **10**.

When the machine is fed and controlled by an operator, he is intended to be positioned in front of the machine so that he faces the front of the machine shown in FIG. **1**. For ease of explanation, directions that are toward the operator will be referred to as "forward" with the opposite direction (from the operator toward the machine) being referred to as "rearward."

As shown in FIG. **1**, the machine includes a feeding unit indicated generally by the reference character **22** onto which the operator places the leading edge of the sheet. The feeding unit **22** grips and advances the sheet into the upper portion of the machine. A folding unit, indicated generally by the reference character **24** is supported within the frame to receive and fold the sheet introduced into the frame by the feeding unit **22**. The folding unit **24**, described in detail below, folds the sheet into quarters and then delivers the sheet forwardly onto a loading platform or table **26** located at the front of the machine below the feeding unit **22**. This arrangement enables the operator to load and unload the machine from the front end.

As shown in FIGS. **1, 3, 4** and **7**, the feeding unit **22** is generally rectangular in shape and includes a flat loading bed **28** which is fastened at its ends to the side braces **30**. The bed **28** and braces **30** are inclined upwardly and rearwardly of the operator, with the upper rearward ends of the braces **30** being pivoted to the side panels **12** of the frame **10**. When in use, the feeding unit is maintained in this inclined position by means of foldable side struts **32** which are pivoted to the mid portion of the side braces **30** and to the side panels **12** of the frame **10**. The struts preferably may be locked in the position shown in FIG. **1** to insure that the feeding unit **22** is properly supported in position.

The feeding unit **22** includes a number of endless feeding belts **34** which are wrapped about forward and rearward rollers **36, 38** extending transversely of the machine and being journaled to the forward and rearward ends of the side struts **32**. The upper run of each of the transversely spaced endless belts **34** passes over the loading bed **28**. The feeding belts **34** are drive in a feeding direction, indicated by the arrow **40**, by drive means connected to the rearward roller **38** as described below. The belts **34** are drawn tightly about the rollers **36, 38** and means may be provided for adjusting the tension of the belts **34** to insure that they are driven at all times and do not slip. Additionally, the rollers **36, 38** may be provided with a rubber or other high friction covering to enhance the grip between the feeding belts **34** and rollers **36, 38**. Additionally, the belts **34** should be fabricated from a material which may grip effectively the sheet and advance the sheet steadily through the machine. Canvas or rubberized materials may be selected for this purpose.

The sheet, which is placed on the feeding belts **34** by the operator, is gripped firmly by means of a pair of pressure belts **42** which cooperate with the most laterally disposed feeding belts **34.** Each of the pressure belts **42** is supported by a frame **44** which includes rollers **46** rotatably mounted to the ends of the frame **44.** The frame **44** is of substantial weight so that it may bear downwardly and directly against its associated feeding belt **34** to grip the sheet firmly therebetween. The rollers **46** and pressure belt **42** are not powered but advance with the sheet. The frames **44** and pressure belts **42** are supported in this position by means of connecting links **48** which are pivoted, at their ends, to the frame **44** and to the upper cross brace **16** by brackets **50.**

Guide means preferably are provided for the feeding belts to insure proper location of the belts in relation to each other and to the pressure belts **42** and pressure frames **44.** The guide means include elongate guidebars **39** disposed on each side of their associated belt. The guidebars **39** project slightly from the surface of the feeding bed, preferably no more than the thickness of the belt, to define a channel receptive to the belt. The guidebars **39** are effective particularly in connection with the most lateral belts to maintain these belts in registry with their associated pressure belts **42** and frames **44.**

When the operator loads the feeding unit **22** with a sheet, he selects the leading edge of the sheet and then takes one corner of the sheet at the leading edge, lifts up the forward end of one of the frames **44** and places that corner of the sheet between the pressure belt **42** and the feeding belt **34** associated with that pressure **42.** In order to facilitate this action, the frames **44** preferably are pivoted to the connecting links **48** near the upper and rearward end of the frames **44.** When the lower forward ends of the frames **44** are lifted they will pivot about a fulcrum which is located at the rearward upper end of the frame **44** thus giving the operator some leverage as he raises the front end of the frame. Once the sheet has been inserted beneath the frame **44,** the frame **44** is lowered to grip the corner of the sheet between the pressure belt **42** and its associated feeding belt **34.** The operator then takes the other corner of the sheet at the leading edge and inserts it, in the same manner, between the other pressure belt **42** and feeding belt **34.** When the operator is loading the sheet onto the feeding unit **22** the belts **34** are stationary and are not driven as will be described below. When placing a sheet in the feeding unit it is important that the leading edge of the sheet is aligned properly. The leading edge must extend transversely and substantially normal to belts **34** and substantially parallel to the various rollers in the machine. For this purpose, guides, such as the marks or indicia **52** may be provided on the loading bed adjacent the pressure belts **42** to facilitate proper registration of the leading of the sheet.

Once the leading edge of the sheet has been introduced and aligned into the feeding unit **22,** the operator presses a starting button **54** to activate the drive means for the rearward roller **38** and feed the sheet into the machine. The starting button **54** as well as other controls described herein preferably are mounted to the side braces **30** and are duplicated on each side brace so that the machine controls may be in easy reach of the operator at all times.

FIG. **3** shows the right side of the machine on which the primary drive mechanisms are located, including the drive mechanism for the rearward roller **38** of the feeding unit **22.** In the preferred embodiment a single electric motor is provided (not shown) which furnishes the power for all of the various rollers and other mechanisms. The drive shaft **56** of the motor is connected to and geared down through the belt **58,** pulleys **60, 62** belt **64** and pulley **66,** all of which are journaled firmly to a rigid support member **68** which, in turn, is secured rigidly to the frame **10.** A conventional idler pulley **70** may be adjustably mounted to the side panel to regulate the tension in the belt **64.**

A drive sprocket **72** is mounted to the pulley **66** for rotation in unison and drives the chain **74** which is wrapped about the fold roll sprockets **76, 78, 80, 82** and the idler sprocket **84.** The fold roll sprockets **76, 78, 80** and **82** are associated with the folding unit **24** as described more fully herein.

The driving power for the rearward roller **36** of the feeding unit **22** is taken from the feed roll sprockets by a feeding chain **86** which is wrapped about the meshes with a take-off sprocket **88** which is mounted for rotation in unison with the fold roll sprocket **78.** The tension of the feeding chain is regulated by and adjustable idler sprocket **90.** The drive sprocket **92** which is driven by the feeding chain **86** is connected to the shaft **94** of the rearward roller **38** through a pneumatic clutch **96.** Thus, although the various pulleys, belts, sprockets and chains are driven continuously by the drive motor, the operation of the rearward roller **38** and thus the feeding belts **34** may be controlled intermittently by the operator. The operator controls the clutch **96** so that when loading a sheet onto the feeding unit **22** the clutch is disengaged with the rearward roller **38** and feeding belts **34** remaining motionless. Once the sheet has been oriented in the machine and engaged properly between the feeding belts **34** and their associated pressure belts **42,** the operator engages the clutch to transmit power from the continually rotating sprocket **92** to the rearward roller **38** to advance the sheet upwardly and rearwardly into the machine.

The clutch may be selected from any number of commercially available pneumatic clutches. The control circuit for operating the clutch may include appropriate valves which may be operated by solenoids controlled by the starting button **54.** The various solenoids, valves, etc., preferably are housed within a single control box which may be mounted to the side panel **12** as shown at **98** in FIG. **3.** Although a pneumatic clutch is preferred, some uses may require that an electrically-operated clutch be substituted if compressed air is not readily available.

Means also are provided for locking the rearward roller **38** firmly into position immediately after the sheet has been fed into the machine so that the next sheet may be introduced to the feeding unit promptly with the feeding belts **34** stopped and in readiness to receive the next sheet. As shown in FIG. **4,** the braking arrangement includes a braking disc **100** which is secured to the end of the rearward roller **38.** The disc **100** is braked by a fluid powered braking pad **102** which is mounted in a bracket **104** for movement toward and away from the braking disc **100.** The braking pad **102** is powered by pressured fluid introduced through the conduit **106** which in turn is controlled through the valve **108.** The valve **108** may include a feedback con-

duit **110** which is associated with the valve **112** for the clutch **96** to insure that at any given time the rearward roller **38** is either driven or is braked.

FIG. **5** shows the folding unit **24** which consists of a number of rollers through which the sheet is passed. The folding unit **24** includes a first pair of fold rolls **112, 114** which are secured to shafts **116, 118** respectively. The fold rolls **112, 114** may be covered with rubber or a ruberized fabric or other material which is capable of gripping the sheet firmly therebetween. The folding unit **24** also includes a second pair of fold rolls **120, 122** are mounted on shafts **124, 126** respectively. The fold roll shafts **116, 118, 124** and **126** are journaled to the side panels **12** and are rotated by the driving arrangement shown in FIG. **3** in which the ends of the shafts are secured to the sprockets **76, 78, 80** and **82** respectively which are driven by the chain **74.** In the preferred embodiment the fold rolls are arranged in generally vertical alignment and are disposed rearwardly of the rearward roller **38** of the feeding unit **22.** The first pair of fold rolls **112, 118** are driven to grip and advance the sheet therebetween in a rearward direction while the lower second pair of fold rolls **120, 122** are arranged to grip and advance the sheet in a forward direction that is toward the operator. The fold rollers **112, 114, 120** and **122** extend substantially across the full width of the chain so that they may grip and fold the sheet passed therethrough along its full width.

As a sheet is drawn into the machine by the feeding unit **22,** its leading edge passes over and about the rearward roller **38** and then drapes and is advanced downwardly past the folding unit **24** in front of the fold rolls **112, 114, 120, 122.** The sheet advances in a direction that is substantially normal to the first nip line **128** defined by the first pair of fold rolls **112, 114.** When half of the sheet has been advanced past the first nip line so that the center of the sheet is in substantial widthwise registry with the nip line **128,** the central portion of the sheet is tucked along a widthwise extending line quickly into the nip line **128** between the first pair of fold rolls **112, 114.** This may be accomplished by conventional punch-blade mechanisms or, as shown in the illustrative embodiment, by an air blast ejected from an injection pipe **130.** The injection pipe or tube **130** is located in general alignment with the first nip line **128** and is mounted forwardly of the downward path of advancement of the sheet to be folded. The pipe **130** is connected to a source of compressed air (not shown) and includes a number of outlet orifices **132** which direct the air toward the sheet to inject the sheet into the nip line **128.** Control means (described below) are provided to actuate the blast of air from the injection pipe **130** at the precise time when the middle of the sheet is in registry with the nip line **128** of the first pair of fold rolls. The air blast lasts long enough to insure that the sheet is inserted into the first nip line **128** as shown in phantom at **134** in FIG. **5.** As the sheet is gripped between and advanced through the first fold rolls, a first longitudinal fold **136** is made and the first longitudinal fold **136** then becomes the leading edge of the half-folded sheet.

The half-folded sheet exits from the rearward side of the first pair of fold rolls and drapes downwardly and about the fold roll **114.** As the half-folded sheet advances downwardly, it is located rearwardly of the second pair of fold rolls **120, 122.** The half-folded sheet advances downwardly in this manner until its center is located in substantial registry with the second nip line **138** defined by the lower second pair of fold rolls **120, 122.** The central portion of the half-folded sheet then is inserted quickly into the nip line **138** by a second injection pipe which is located rearwardly of the downward path of travel of the half-folded sheet and which directs an air blast against the rearward half-folded sheet to inject the sheet into and between the fold rolls **120, 122** as shown at **142** in phantom. The second injection pipe may be of substantially identical construction of that of the first injection pipe **130.** Control means also are provided for actuating the blast of compressed air from the second injection pipe **140** to insure that the half-folded sheet is gripped properly by and between the second pair of fold rolls **120, 122.** The second pair of fold rolls **120, 122** thus fold the half-folded sheet into a quarter fold.

The second pair of fold rolls **120, 122** are arranged so that they effect the quarter fold and simultaneously eject the quarter-folded sheet forwardly toward the operator. Additionally, the rolls and path of movement of the sheet through the rolls is such that the ejected, quarter-folded sheet will be presented to the operator with the selvage facing upwardly and on top of the folded sheet. A transverse chute **144** is secured to the machine across and between the side panels **12** to receive and guide the quarter-folded sheet from the second nip line **138** downwardly toward and onto the loading platform **126.** The quarter-folded sheet simply slides down the transverse chute **144** to the front of the machine where the operator is stationed.

FIG. **1** shows the location of the means for controlling the operation of the first injection pipe **130.** This control includes sensing means indicated generally by the reference character **146,** located at the face of the loading bed **28** of the feeding unit **22.** The sensing means **146** is responsive to advancement of the trailing edge of the sheet and is positioned so that when the trailing edge moves past the sensing means **146,** the center of the sheet will be in registry with the first nip line **128** of the first pair of fold rolls **112, 114.** Thus, the distance as measured along the path of travel of the sheet between the sensing means and the first nip line is equal to one-half of the length of the sheet.

The sensing means **146** also is effective to control the duration of the blast of air through the first injection pipe **130.** A preferred arrangement for controlling the initiation and duration of the air blast is shown in FIG. **6.** This arrangement is responsive to advancement of the trailing edge of the sheet. It includes first and second microswitches **148, 150** which are secured to the underside of the loading bed **28.** The microswitches **148, 150** are spaced along the direction of advancement of the sheet and include light tripping filaments **152** and **154** respectively which protrude upwardly through a slot **156** formed in the bed **28** beyond the upper surface of the bed **28.** The microswitches **148, 150** control the operation of a valving arrangement (not shown) which is designed, according to well-known principles, to control the flow of air through the injection pipe **130.** When the sheet is placed on the bed **28** it will cover both filaments **152** and **154** and will trip them to actuate both microswitches **148** and **150.** The microswitches control the valving arrangement (not shown) so that when both microswitches **148, 150** are actuated compressed air does not flow through the in-

jection pipe **130.** As the sheet if fed into the machine its trailing edge advances over the filament **152** to trip the microswitch **148.** This controls the valves to introduce compressed air into the injection pipe **130** to direct the air blast toward the sheet and inject the sheet into the first nip line **128** of the first pair of fold rolls **112, 114.** The air blast continues while the sheet is simultaneously drawn through the first pair of fold rolls and also is advanced by the feeding unit **22.** The air blast continues until the trailing edge of the sheet passes over the filament **154** of the microswitch **150** to release the filament and trip that microswitch **150.** The microswitch **150** is incorporated into the control circuit for the valves to shut off the supply of compressed air to the injection pipe **130** and to terminate the air blast. Thus, the air blast will continue when the microswitches **148, 150** are in different positions but will be discontinued when both microswitches **148, 150** are in the same position. The spacing between the microswitches **148, 150** is sufficient to provide a blast of air which, in turn, insures that the midportion of the sheet will be injected firmly between the fold rolls **112, 114** to effect the first fold at the center of the sheet. The microswitches **148, 150** may be mounted adjustably to enable the spacing and location along the slot **156** to be adjusted if desired.

Because sheets are fabricated in more than one standard length, the location of the microswitches which control the initiation of the air blast through the injection pipe **130** will be useful only with a sheet of a particular selected length. For example, the microswitch **148** may be positioned so that it is usable with a sheet **81** inches long and is located so that when the center of the sheet is in registry with the nip line **128** the air blast will begin. In order to accommodate smaller sheets such as, for example, **72** inches long, a third microswitch **158** having a tripping filament **160** may be provided rearwardly of the microswitch **150.** The microswitches **150, 158** are integrated into the control circuit for the valving arrangement so that when the trailing edge of the sheet passes over the filament **154** the air blast is initiated and when the trailing end thereafter passes over the filament **160** the air blast is terminated. The microswitch **148** is not used with the shorter sheets and the microswitch **158** is not used when the longer 82-inch sheets are being fed into the machine. A control switch **162** is provided near the starting button **54** and is integrated into the control circuiting of the machine to enable the operator to select which pair of the three microswitches are to be used. The switch **162** normally would be a two-position switch in which one position renders the first and secon microswitches operative and the other position renders the second and third microswitches operative, the switch position being selected by the operator for the particular length of sheet.

Although the microswitch arrangement employed herein is preferred, other sensing devices which are responsive to advancement of the trailing edge of the sheet may be used to initiate and control the duration of the air blast.

The control for initiating the air blast through the second injection pipe **140** to urge the midpoint of the half-folded sheet into the second nip line **138** of the second pair of fold rolls **120, 122** is responsive to the position of the first fold **134** of the half-folded sheet which is the leading edge of the advancing half-folded sheet. As shown in FIG. **1** and **5,** this arrangement includes a pair of microswitches **164, 166** having tripping levers **168, 170** respectively. The microswitches **164, 166** are mounted in the machine so that their respective tripping levers **168, 170** are located along the downward path of travel of the leading edge of the half-folded sheet. The microswitch **164** is located closer to the second nip line than the microswitch **166.** The microswitch **164** is intended to be used with shorter sheets, **72** inches long, and the microswitch **166** is intended to be used with longer sheets **81** inches long. Only one of these microswitches is used at a time depending on the length of sheet being folded. Selection of either of these microswitches **164, 166** preferably is incorporated into the control circuitry of the machine to be responsive to the control switch **162.** The microswitches **164** are located so that the selected switch will be tripped just as the center of the half-folded sheet is advanced downwardly into registry with the second nip line **158** of the second pair of fold rolls. Actuation of either of these microswitches controls the valving of compressed air to the second injection **140** thus initiating the air blast of the half-folded sheet into the second pair of fold rolls. The duration of the air blast may be controlled by an independent timing device or may be controlled simply by the operation of the microswitch **164** or **166** itself. As soon as one of the microswitches **164** or **166** has been tripped by the downwardly advancing first fold **136,** the air blast from the second injection pipe **140** and the grip of the second pair of fold rolls on the half-folded sheet will cause the leading edge or first longitudinal fold **136** to reverse its direction of movement and be drawn upwardly, thus relieving that particular switch. The air blast may be controlled to terminate in response to release the particular microswitch **164** or **166** which was in operation.

The arrangement of the folding rolls and particularly the second pair of folding rolls **120, 122** insures that the quarter-folded sheet will be ejected from the machine toward the front where the operator is stationed. This provides highly economical operation in that the same operator may load and unload the machine. This arrangement of the final or second pair of fold rolls is most desirable. Although other arrangements for the first pair of fold rolls **112, 114** may be employed, the preferred arrangement, as shown in the illustrative embodiment, is to arrange all of the rolls in general vertical alignment. This permits the machine to be incorporated in a relatively narrow frame which occupies relatively little space. Additionally, because the sheet is loaded and unloaded from the same side of the machine, the machine may be located directly against a wall, corner or other relatively confined space. Additionally, the vertical arrangement of the fold rolls enables the path of advancement of the sheet as it is folded to be confined within a relatively small space. The sheet passes downwardly on one side of the fold rollers, is folded transversely through one of the pairs of fold rollers, continues downward movement on the other side of the fold rollers, and then is urged transversely through the last pair of fold rolls toward the operator. Thus, the folding unit includes an arrangement by which the sheet is advanced in a single direction at all times except when being folded, at which time the sheet is passed in a direction transverse to the advancing direction while making the fold.

When in use the loading platform **26** and loading bed **28** protrude forwardly from the frame of the machine as shown in FIGS. **1** and **7.** In the preferred embodiment the platform **26** and bed **28** are movably mounted to the frame so that they may be folded down to the position shown in FIG. **3** for compact storage, transportation and for moving the machine through relatively narrow doorways, halls and the like. This feature of the machine enhances considerably its mobility. For this purpose the side struts **32** are of a foldable construction and are pivoted to the side panels **12** and side braces **30** at the pins **172, 174.** When in use the loading unit may be swung into its forward and upward position shown in FIG. **1** and the strut **32** may be locked to maintain and support the loading unit in this position. The delivery platform **26** is supported during operation by brackets **176** which are secured to the side panels **12** and project forwardly of the panels **12.** The brackets **176** include a T-shaped slot **178** and an L-shaped slot, formed along the upper edges of the brackets **176.** The slots **178, 180** receive lateral projecting pins **182, 184** which are fastened to the lateral edges of the loading or receiving platform **26.** The platform may be swung to its downwardly extending compact position by pulling the platform forwardly until the pins **184** may be withdrawn through the slots **180.** The platform **26** then is drawn forward until the pins **182** engage the forward ends of the slots **178,** at which time the pins **184** are located beyond the forward projecting end of the brackets **176.** The loading platform **26** then may be lowered about the pin **182** with the pin **184** clearing the forward end of the brackets **176.**

The machine and the method of folding which it performs have been described thus far as being employed to quarter fold the sheet which, after delivery to the operator, may be cross folded by the operator. Although in many instances manual cross folding may be preferred, the machine described herein may be employed in conjunction with an automatic cross folding machine which receives the longitudinally quarter-folded sheet from the second pair of fold rolls. FIG. **8** shows a somewhat diagrammatic arrangement of the machine as it might be used with an automatic cross folder. The cross folder **186** is located at the front of the machine and may be substituted in lieu of the receiving platform **26** so that the cross folder **186** is located below the feeding unit **22.** The cross folder **186** preferably is designed to cross fold the sheet to more compact configuration. The cross folder **186** delivers the fully cross-folded sheet laterally on the machine to a receiving station **188.** By locating the receiving station **188** laterally of the cross folder, its presence does not interfere with the operator who is located at the front of the machine. This enables the operator to control the machine and feed the sheets into the machine without any hindrance or uncomfortable reaching manipulations.

FIGS. **9** through **12** show a cross folder as incorporated into the machine which receives the longitudinally folded sheet and then effects a number of cross folds to fold finally the sheet into its final configuration. The cross folder includes a receiving bed **190** which is substituted for the platform **26.** During operation, the receiving bed is disposed horizontally in front of the second pair of fold rolls to receive the forwardly ejected longitudinally folded sheet. The receiving bed **190** includes a number of transversely spaced endless belts **192** which are wrapped about forward and rearward rollers **194, 196.** The rollers **194, 196** are rotatably supported at the forward and rearward ends of the bed **190** by brackets **198** which are secured to the lateral ends of bed **190.** The rearward roller **196** also is journaled and supported within the side panels **12** to enable the entire bed to be pivoted from its horizontal position to a downwardly folded, out-of-the-way position for storage, etc., about the axis of the roller **196.** The forward end of the bed **190** is supported in its horizontal, operative position by a pair of legs **200** which may be folded upwardly against the underside of the receiving bed **190** for storage. The legs may be locked, during operation, in the downwardly extending position shown by struts **202.**

Each of the belts **192** is arranged so that the upper run **204** thereof is disposed above the bed **190** and is advanced in a forward direction that is toward the operator. The belts **192** receive the ejected longitudinally folded sheet and advance it into a central position over the receiving bed **190.** The belts **192** are driven by the rearward roller **196** which includes a shaft (see FIG. **12**) which projects through the side panel **12** and has a sprocket **206** which in turn is driven by the main drive chain **74.** The folded sheets which are ejected from the second pair of fold rolls thus are received and transported forwardly along the receiving bed **190** to a position in readiness for the cross folding operation.

In order to effect the cross folds, the receiving bed **190** is provided with a forwardly-rearwardly extending slot **208** at the midportion of the receiving bed **190.** A pair of cross fold rolls **210** are journaled to the underside of the receiving bed **190** and cooperate to define a nip line **212** below and parallel to the slot **208.** After the folded sheet has been advanced a predetermined distance forwardly along the receiving bed **190,** its midportion, which is disposed over the slot **208,** is injected downwardly through the slot and into the nip line **212** of the cross fold rolls **210** which grip the sheet and advance it downwardly beneath the receiving bed **190** thus forming the first cross fold. Injection of the midportion of a sheet through the slot **208** may be effected by an air injection pipe **214** or a knife injector **216** shown in phantom in FIG. **9.**

A sensing device **218** is disposed along the forward portion of the slot **208** to control actuation of the injection pipe **218** or knife injector **216** in response to the position of the forward, leading edge of the longitudinally folded sheet. The sensing device may be of the construction referred to above in regard to the sensing arrangement for sensing the advancement of the trailing edge of the sheet through the feeding unit **22** or may be of other design suited for the purpose. The sensing device **218** is effective to control the operation of the injection pipe **214** or knife injector **216** so that the injection device is operated for a time interval sufficient to urge the midportion of the sheet downwardly into firm engagement with the nip line **212** of the rolls **210.**

The cross fold rolls **210** advance and fold the sheet downwardly toward a mechanism for effecting subsequent cross folds. This mechanism includes a plurality of transverse, endless belts **220** which are wrapped about rollers **222, 224.** The rollers **222, 224** are rotatably journaled in brackets **226** which are suspended from the outside of the receiving bed **190.** The belts are driven so that their upper runs advance transversely toward one side of the machine (to the left as shown in

FIG. 9). The once cross-folded sheets are directed from the food rolls **210** smoothly onto the upper run of the belts **220** by a deflector **228** which is secured to the underside of the receiving bed **190** and which diverts the cross folded, leading edge of the sheet smoothly onto the upper run of the belts **220.** The belts **220** and the fold rolls **210** are driven by a motor **230** (see FIG. **10**) which is suspended underneath the receiving bed **190** and which drives the chain **232** through the drive sprocket **234.** The chain is wrapped about an idler sprocket **236** and then partly about the sprockets **238, 240** and **242** which drive the roller **224** and fold rolls **210** respectively. The motor is normally operative so that the belts **220** and fold rolls **210** are driven at all times.

After the once cross-folded sheet has been guided onto the upper run of the transverse belts **220,** they carry the sheet, cross-folded edge first, toward a subsequent cross folding device which includes a blade **244** which projects toward the advancing sheet so that the leading, cross-folded edge will ride up onto the edge of the blade **244.** In the preferred embodiment a lifting bar may be provided just below the belts **220** and in advance of the blade **244** to provide a slight hump in the upper run of the belts. This tends to raise the once cross-folded leading edge of the sheet in relation to the blade **244** and insures that the leading edge **244** of the sheet will ride onto the blade **244** smoothly. The blade is pivoted beneath the receiving bed **190** as by brackets (not shown) for upward pivotal movement toward a stationary gripping bar **246.** The upward pivotal movement of the blade **244** may be effected by conventional hydraulic or pneumatic cylinders which, in turn, are controlled by a sensing switch **248** which project upwardly between adjacent of the transverse belts **220** to sense the presence of the leading cross-folded edge of the sheet. As shown, the sensing switch **248** is located in advance of the leading edge of the blade **244** and appropriate delay devices preferably are associated with the switch **248** and motor for the blade **244** so that the blade will be pivoted upwardly toward the gripping bar **246** after the leading edge has advanced onto the blade edge. The leading edge thus is gripped firmly between the blade **244** and gripping bar **246.** Continued advancement of the belt **220** and the trailing portions of the once cross-folded sheet causes the trailing portion to pass beneath the grip, now stationary, leading edge of the sheet. This forms a new leading edge defined by the second cross fold and also folds the once-folded sheet in half again. The blade **244** is released after the sheet has been folded in half and the first cross fold then is located at the trailing edge of the twice cross-folded sheet. A subsequent cross folding unit **250** may be disposed further along the path of advancement of the belts **220** to effect still another cross fold. The fully folded sheet then is delivered to a table **252** and has been folded completely for proper subsequent disposition by the operator.

The entire cross folding unit is pivotal about the axis of the rearward roller **196** which enables the entire unit to be pivoted downwardly to a remote compact position similar to that shown in FIG. **7** which is useful particularly when storing or transporting the device.

Although the machine is useful particularly with "no-iron" sheets, it may also be used in association with a conventional ironing machine with regular sheets. The ironing machine may be arranged to feed the leading edge of the ironed sheet directly onto the feeding unit **22,** the operation of the folding machine being the same as described herein.

It should be understood that the foregoing description of my invention is intended merely to be illustrative thereof and that other modifications and embodiments will be apparent to those skilled in the art without departing from its spirit.

Having thus described the invention, what is claimed is:

1. A sheet folder comprising:
a frame;
means mounted to said frame for effecting a plurality of parallel folds in said sheet;
means mounted to said frame and on one side thereof for drawing an unfolded sheet, leading edge first, along a path which is directed towards said folding means;
means for guiding said sheet downwardly from said sheet drawing means and along a substantially vertical path;
means for diverting a portion of said sheet from said substantially vertical path to and along a transverse path, said folding and diverting means being effective to fold said sheet while said sheet is diverted along said transverse path;
means for thereafter enabling said folded sheet to again advance downwardly along a substantially vertical path and for thereafter again diverting said sheet transversely while effecting a subsequent fold;
the last of said means for diverting said sheet in a transverse direction being arranged to divert and eject said sheet toward said one side of said machine; and
means wherein each of said fold is effected while said sheet is being diverted in a transverse direction, each successive transverse direction being opposite to that of the preceding transverse direction of diversion.

2. A sheet folder comprising:
a frame;
means for guiding an unfolded sheet into said frame and through said frame along a substantially vertical, downward direction;
a folding unit mounted to said frame adjacent to the downward path of travel of said sheet, said folding unit including a first pair of fold rolls rotatably mounted to said frame along longitudinal axes parallel to the plane of said guided sheet, said first fold rolls cooperating to define a first nip line therebetween, said first fold rolls and first nip line being spaced from the plane of advancement of said sheet whereby said sheet may advance downwardly past said first nip line;
means for urging a width-wise extending line of said sheet transversely toward and into engagement with said first nip line whereby said first fold rolls may grip and advance said sheet transversely through said first fold rolls to effect a first fold, said once-folded sheet exiting from said first fold rolls and thereafter advancing downwardly along a substantially vertical path;
said fold unit further including a second pair of fold rolls disposed below said first pair of fold rolls, said second fold rolls being rotatably mounted to said frame in parallel to said first fold rolls and said

plane of advancement of sheet, said second fold rolls cooperating to define a second nip line therebetween, said second fold rolls and second nip line being spaced from the plane of advancement of said sheet whereby said sheet may advance downwardly past said second nip line; and

means for urging a width-wise extending line of said once-folded sheet transversely toward and into said second nip line whereby second fold rolls may grip and advance said sheet transversely through said second fold rolls to effect a second fold, said twice-folded sheet exiting from second fold rolls.

3. An apparatus as defined in claim **2** further comprising:

said second fold rolls being arranged to eject said twice folded sheet in a selected direction and away from said frame.

4. an apparatus as defined in claim **2** wherein said first fold rolls advance said sheet transversely in one direction and wherein said second fold rolls advance said once folded sheet transversely in the opposite direction.

5. An apparatus as defined in claim **4** wherein said sheet is fed and guided into said frame from a loading station disposed in front of said frame, said first fold being effected transversely and in a rearward direction, said second fold being effected transversely and in a forward direction to eject said twice-folded sheet toward the front of said frame.

6. An apparatus as defined in claim **5** wherein each of said fold rolls are in general vertical alignment and wherein said substantially vertical path of said sheet before engagement thereof with said first fold rolls is located in front of said first fold rolls and wherein said substantially vertical path of said one-folded sheet from said first fold rolls to said second fold rolls is located rearwardly of said second fold rolls.

7. An apparatus as defined in claim **2** further comprising:

first sensing means for sensing the advancement of the trailing edge of said sheet past a predetermined position; and

means responsive to said first sensing means for actuating said means for urging said sheet into said first nip line.

8. An apparatus as defined in claim **7** wherein the distance between said first sending means and said first nip line as measured along the direction of travel of said sheet comprises one-half the length of said sheet.

9. An apparatus as defined in claim **7** further comprising:

second sensing means for sensing the downward advancement of the folded leading edge of said once-folded sheet; and

means responsive to said second sensing means for urging said once-folded sheet into said second nip line.

10. An apparatus as defined in claim **8** wherein said distance between said second sensing means and said second nip line as measured along the direction of travel of said once-folded sheet comprises one-half the length of said once-folded sheet.

11. An apparatus as defined in claim **9** further comprising:

first sending means for sensing the advancement of the trailing edge of said sheet past a predetermined position; and

means responsive to said second sensing means for actuating said means for urging said sheet into said second nip line.

12. An apparatus as defined in claim **2** wherein said means for guiding said unfolded sheet onto said frame comprises:

endless belt feeding means adapted to support said sheet and draw said sheet into said frame and in the upper region of said frame above said folding unit, said belt means including a roller rotatably mounted across said frame for rotation along a longitudinal axis paralleling that of said folding rolls, said endless belt being wrapped about said roller, said roller defining the rearward and upper extremity of said endless belt whereby said sheet passes over and about said roller and thereafter hangs downwardly therefrom;

said roller being disposed within said machine so as to support said hanging portion of said sheet in said spaced relation to said fold rolls and said nip lines thereof.

13. An apparatus as defined in claim **12** further comprising:

a feeding bed including a substantially rigid plate supported beneath the upper run of said feeding belts to support said feeding belts;

means mounted to said feeding bed for sensing the advancement of the trailing edge of said sheet past a predetermined location; and

means responsive to said first sensing means for actuating said means for urging said width-wise extending line of said sheet transversely into said first nip line.

14. An apparatus as defined in claim **13** wherein said means for urging said sheet into said nip line comprises:

an injection tube substantially paralleling said first fold rolls and being disposed on the other side of said downwardly advancing sheet, said injection tube including orifice means adapted to direct a jet of compressed air toward said sheet to urge said sheet into said first nip line;

means connecting said ejection tube to a source of compressed air;

valve means for controlling the admission of compressed air into said ejection tube; and

means connecting said sensing means to said valve means for controlling the initiation and duration of said ejected air blast.

15. A method of folding sheets comprising:

advancing said sheet in a generally planar configuration along a first predetermined direction with the edge of said sheet leading, said path of advancement of said sheet extending past one side of and in transverse, spaced relation to a first folding unit to advance a selected region of said sheet intermediate its ends into registry with a first folding station;

diverting said region of said sheet transversely toward said first station when said region is in registry with said first station and folding said sheet along said selected region while passing said sheet transversely through said station to form a first fold line, said first fold line thereafter defining the leading edge of said once-folded sheet;

continuing advancement of said once-folded sheet along said first predetermined direction past and to one side of a second folding unit to advance a se-

lected region of said once-folded sheet intermediate its ends into registry with said second folding station;

diverting said region of said once-folded sheet transversely toward said second station when in registry with said second station and folding said once-folded sheet along said selected region while passing said once-folded sheet transversely through said second station to form a second fold line; and

said sheet being diverted in opposite directions as it is passed through said first and second folding stations.

16. A method as defined in claim **15** wherein said sheet initially is introduced along said first predetermined direction from a loading station and wherein said direction of diversion of said sheet toward and through said second station is directed toward said loading station.

17. A method of folding sheets as defined in claim **15** further comprising:

said selected region of said unfolded sheet being located at the midportion of said unfolded sheet; and

said selected region of said once-folded sheet being disposed along the midportion of said once-folded sheet whereby said sheet is folded in quarters.

18. A method of folding sheets as defined in claim **17** further comprising:

means for presenting and diverting said once-folded sheet toward and through said second folding station so that after said twice-folded sheet emerges from said second folding station the selvage of said twice-folded sheet will be located at the top of the folded sheet.

19. A method of folding sheets as defined in claim **15** further comprising:

sensing the advancement of the trailing edge of said sheet past a predetermined location; and

diverting said sheet transversely toward said first folding station when said trailing edge of said sheet is located at said sensing station.

20. A method of folding sheets as defined in claim **19** further comprising:

sensing the advancement of said leading edge of said once-folded sheet to a predetermined location; and

diverting said once-folded sheet transversely toward said second folding station when said folded leading edge of said once-folded sheet is located at said second sensing location.

21. A method of folding sheets comprising:

advancing said sheet in a generally planar configuration along a first predetermined direction with the edge of said sheet leading, said path of advancement of said sheet extending past one side of and in transverse, spaced relation to a first folding unit to advance a selected region of said sheet intermediate its ends into registry with a first folding station;

diverting said region of said sheet transversely toward said first station when said region is in registry with said first station and folding said sheet along said selected region while passing said sheet transversely through said station to form a first fold line, said first fold line thereafter defining the leading edge of said once-folded sheet;

continuing advancement of said once-folded sheet along said first predetermined direction past and to one side of a second folding unit to advance a selected region of said once-folded sheet intermediate its ends in registry with said second folding station;

diverting said region of said once-folded sheet transversely toward said second station where in registry with said second station and folding said once-folded sheet along said selected region while passing said once-folded sheet transversely through said second station to form a second fold line; and

said first predetermined direction being generally downwardly and said first and second folding stations being located in general vertical alignment with each other, said sheet being disposed on one side of said folding stations prior to diversion of said sheet toward said first folding station and being disposed on the opposite side of said folding stations after said sheet has passed transversely through said first folding station but before said sheet has been diverted transversely through said second folding station.

* * * * *