# United States Patent [19]

**Daniels**

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[54] **N.C. AUTOMATIC FOLDING MACHINE**


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[52] **U.S. Cl.** ..... **72/7,** 72/320, 72/461

[51] **Int. Cl.** ..... **B21d 41/02**

[58] **Field of Search** ..... 72/7, 319, 320, 321, 322, 72/420, 461



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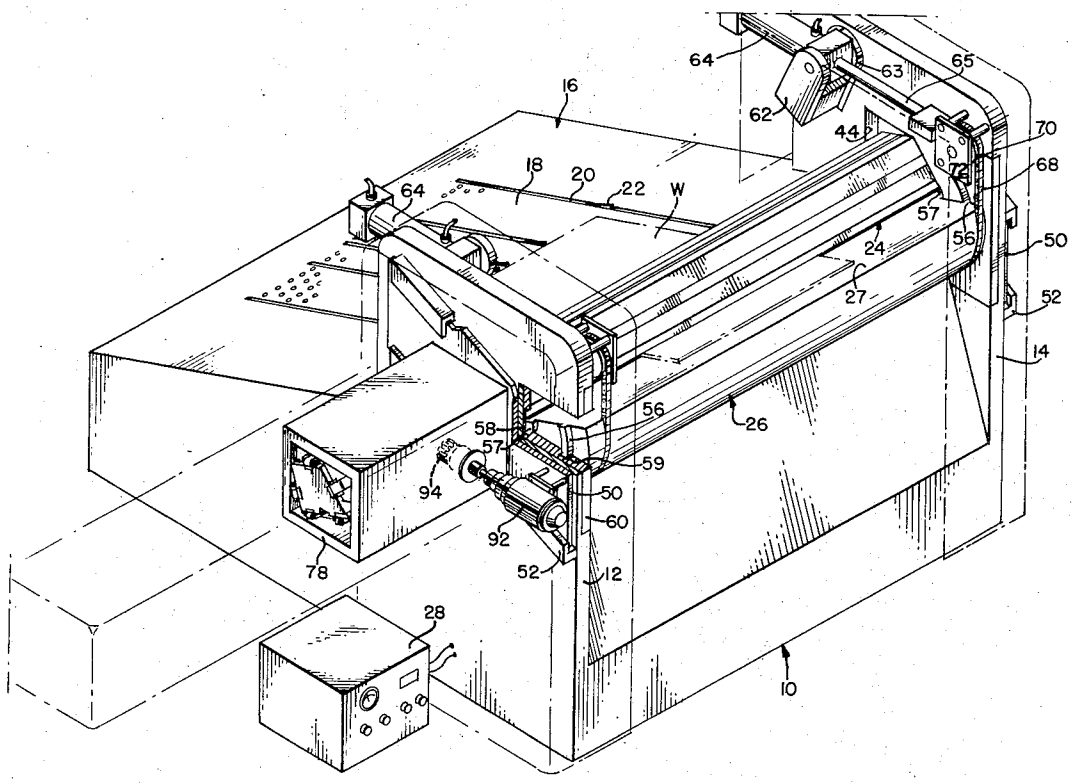
[57] **ABSTRACT**

An N.C. automatic folding machine provides programmed positioning of the workpiece, multiple folding, and removal of the workpiece upon completion of the folds. Movement of the workpiece is assisted by a cushion of air. Apparatus and a method of automatically folding and handling sheet material from point of storage to point of ejection of the folded object. A folding die and punch assembly includes a folding die that clamps the workpiece against a supporting surface and a pivotally mounted folding punch that bends the workpiece around the folding die. The folding die is retracted laterally of the supporting surface to strip the workpiece from the die.


**22 Claims, 7 Drawing Figures**



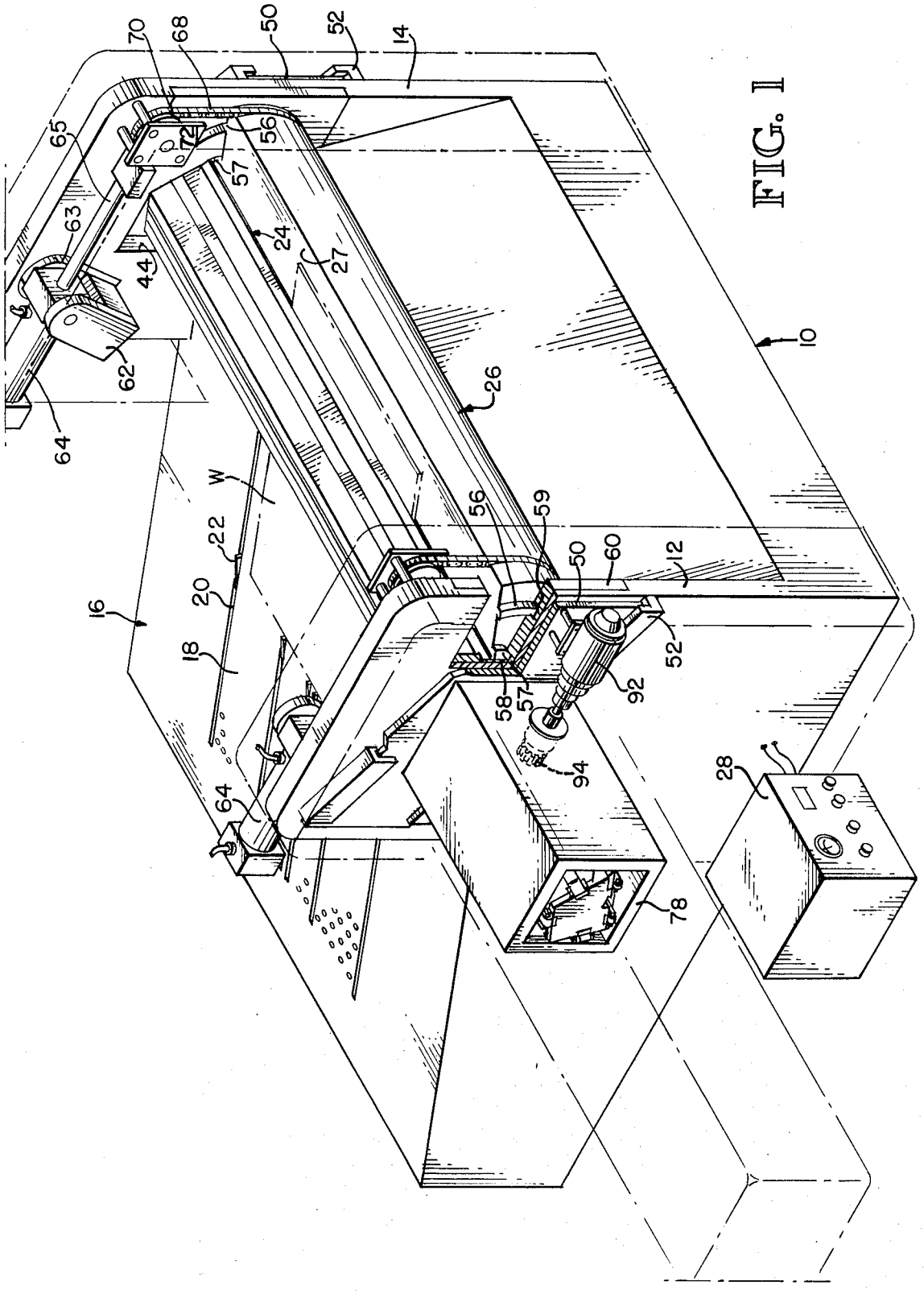

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FIG. 1

FIG. 2

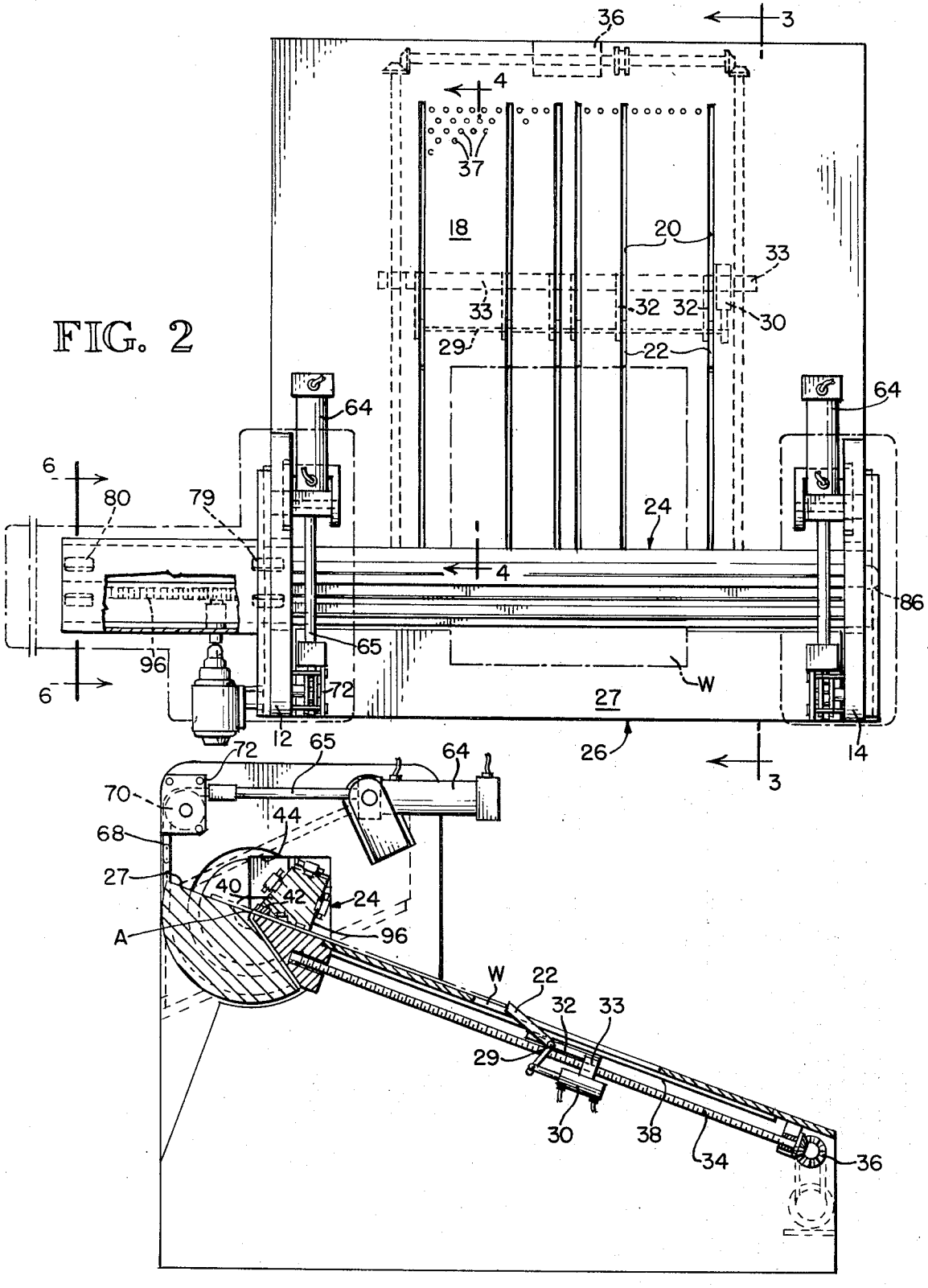
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FIG. 3

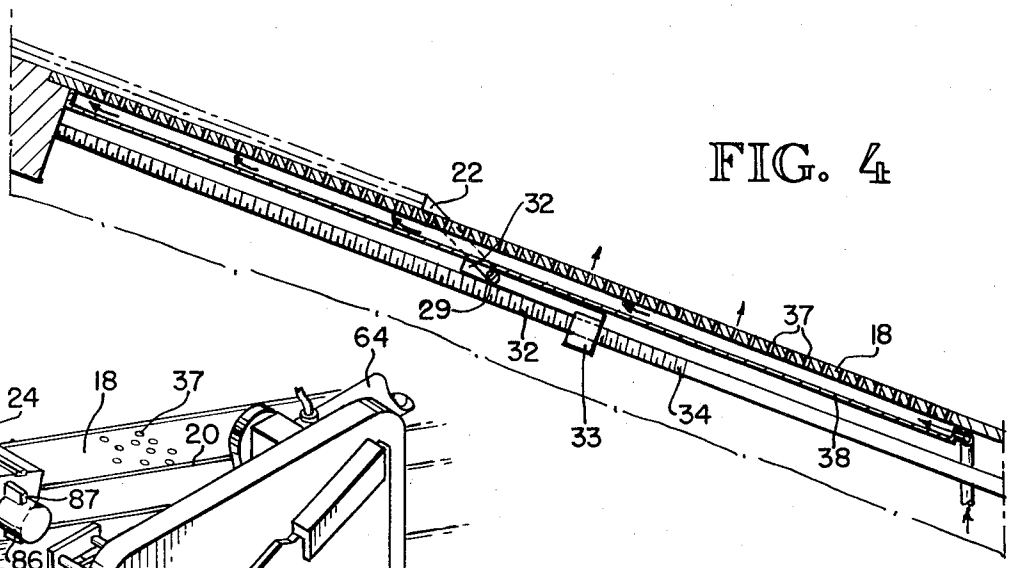



FIG. 4

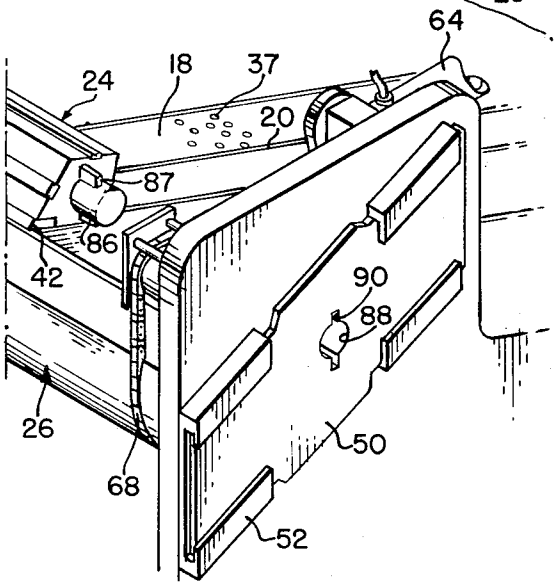



FIG. 5

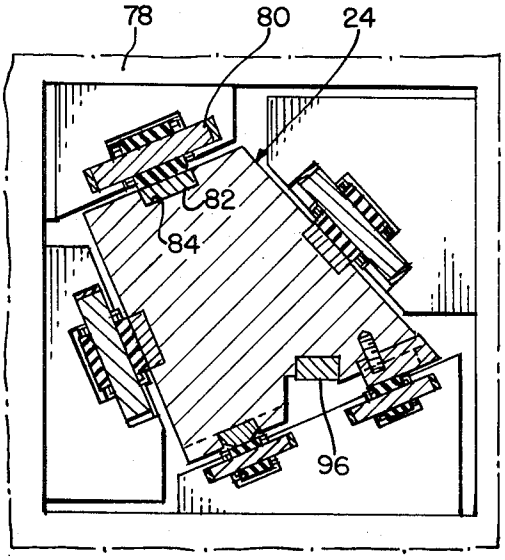
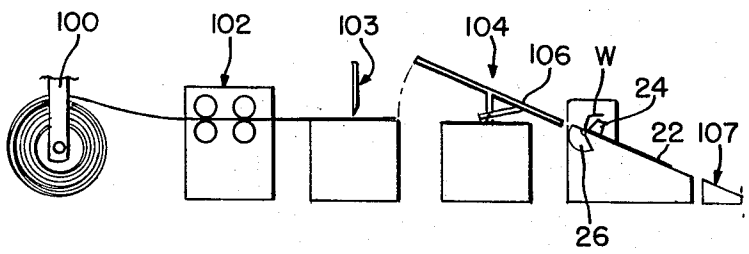



FIG. 6

FIG. 7



# N.C. AUTOMATIC FOLDING MACHINE

## BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to methods and apparatus for automatically handling sheet material for a folding operation, numerically controlled (N.C.) automatic folding machines, and folding die and punch assemblies.

2. Description of the Prior Art

Heretofore multiple-folds on sheet-metal forming machines were made by manually measuring the workpiece after each fold was completed and shifting the workpiece manually for the next fold. Folding machines have also heretofore required complicated mechanisms for stripping the workpiece from the folding die such as the use of a gate or some other opening in the sidewall of the machine to pull or slide the work off the folding die. Still further no system for automatically delivering, folding, and removing the folded object has been used heretofore — all previous systems employing extensive use of manual labor.

## SUMMARY OF THE INVENTION

It is an object of this invention to provide a folding machine which operates automatically from a numerically controlled or other programming device to provide multiple folds in the workpiece without the need for manual measurement or positioning of the workpiece.

It is another object of this invention to provide a preprogrammed automatic numerically controlled folding machine which automatically positions the workpiece and automatically strips the workpiece from the folding die after the completion of the folds.

Another object is to provide an inexpensive easily maintained folding die and punch assembly.

Another object of this invention is to provide a unique folding die and punch assembly which utilizes complementary clamping and folding forces so that an increase in one provides an increase in the other.

It is another object of this invention to provide a folding die retractable laterally of the workpiece supporting surface to leave the workpiece on the supporting surface as the workpiece is stripped off the folding die.

Still another object is to provide apparatus and a method for automatically delivering an elongated strip of sheet material, cutting it to a predetermined size, transferring the cut material, folding it, and ejecting the folded object. All operations may be controlled automatically by an N.C. program or the like.

These various objects are best accomplished by providing a supply of sheet material delivered automatically by a roller feed system to a flying shear, and next to a folding apparatus in which the sheet material is given multiple folds and ejected.

The folding apparatus includes a bed mounted on a frame and workpiece supporting means on the bed. A folding die serves to clamp the workpiece against the supporting surface and in conjunction with a folding punch acts as an anvil to bend the workpiece. Adjustable stops initially position the workpiece relative to the folding die and subsequently reposition the workpiece for making additional folds. The workpiece is stripped from the folding die by retracting the die. All



operations are automatically performed, preferably according to a prearranged N.C. program.

Another broad feature of the invention is the unique folding die and punch assembly comprising a one-piece integral folding die having a clamping surface for holding the workpiece against the workpiece supporting surface and a folding punch mounted for pivotal movement towards the folding die for bending the workpiece therearound.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an isometric of a folding apparatus employing the principles of the invention.

FIG. **2** is a plan of the folding apparatus shown in FIG. **1**.

FIG. **3** is a vertical sectional view taken along the line **3—3** of FIG. **2**.

FIG. **4** is a fragmentary vertical sectional view taken along the line **4—4** of FIG. **2**.

FIG. **5** is a fragmentary perspective of a portion of the folding apparatus of FIG. **1**.

FIG. **6** is a fragmentary vertical section taken along the line **6—6** of FIG. **2**.

FIG. **7** is a schematic elevation of an automated sheet material handling system embodying the principles of the invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As best shown in FIG. **1** the folding apparatus includes a base frame **10** having side frames **12** and **14** which support a bed **16** having a workpiece supporting surface **18.** The workpiece supporting surface is provided with a plurality of transversely spaced slots **20** in which are positioned a plurality of adjustable stops or positioning members **22.** A folding die and punch assembly includes a folding die **24** mounted within the side frames **12** and **14** for both movement toward the workpiece supporting surface **18** to clamp a workpiece W against the supporting surface and for lateral movement for stripping the workpiece off the folding die. A folding punch **26** is pivotally mounted between the side frames to move upwardly against the folding die and includes a folding surface **27** to bend the workpiece around the die. The operations of the machine are controlled by an N.C. programming device **28** of any conventional design. A basic program from the numerically controlled device **28** is to initially set the stops **22** to position the workpiece on the workpiece supporting surface, then advance the stops to move the workpiece between the folding die **24** and the workpiece supporting surface, clamp the workpiece, pivot the folding punch at each location at which a fold is desired, and finally move the folding die laterally across the supporting surface leaving the workpiece for automatic ejection from the supporting surface.

The adjustable stops **22** ride within the slots **20** and are keyed to a common shaft **29** which is pivoted by a conventional two-position pneumatic actuator **30** to raise the stops above the supporting surface or lower them for removal of the workpiece. The common shaft **29** is journaled in blocks **32** joined to a cross-shaft **33** having a pair of transversely spaced feed nuts. Advancing screws **34** driven by a conventional drive mechanism **36** advance and return the stops through the nuts and cross-shaft **33** along the supporting surface. The supporting surface is perforated as at **37** to receive air

from a pressure chamber **38** attached to the underside of the workpiece supporting surface. Air supplied from the chamber **38** provides an air layer or cushion along the top of the supporting surface to reduce the friction between the workpiece and the supporting surface and thus permits effortless sliding of the workpiece either for initially placing the workpiece on the supporting surface, advancing it during a folding operation, or removing it by gravity upon completion of the folding operation as will be described.

The folding die **24** includes an anvil **40** provided with a replaceable folding edge **42.** Each end of the folding die is mounted for reciprocation toward and away from the supporting surface **18** within enlarged openings **44** in the side frames **12** and **14.** The ends are rigidly secured in slides **50** mounted in guide tracks **52** which are fixed to the side frames **12** and **14.** As is readily apparent, downward movement of the slides **50** will draw the folding die toward the supporting surface **18** to clamp the workpiece in a desired position. Upward movement of the slides will release the workpiece so that it may be repositioned.

The folding punch **26** is pivotally mounted between the side frames **12** and **14.** For this purpose each end of the punch is provided with an outer ring segment **56** and an inner shaft segment **57.** The shaft and ring segments glide in corresponding inner and outer annular recesses **58** and **59** formed in bronze bearing plates **60** that are secured to the side frames **12** and **14.** The inner and outer annular recesses on the bearing plates are concentric to a pivot axis A located adjacent the forward edge of the folding edge **42.** As is thus readily apparent, an upward force on the folding punch will pivot the punch about the folding edge **42** and the weight of the punch when the upward force is removed will allow it to return to its lower position shown in FIG. **3.** In the lower position the folding surface **27** is in the same plane as the workpiece supporting surface **18** and thus forms an extension thereof. As will be described in more detail below, this extension of the workpiece supporting surface uniquely serves to assist in automatically delivering a piece of sheet material to the workpiece supporting surface in a completely automated folding system.

The means for lowering the folding die **24** to clamp the workpiece against the workpiece supporting surface **18** and the means to pivot the folding punch **26** upwardly to bend the workpiece are in the preferred embodiment of this invention uniquely combined to complement one another, thus simplifying the number of mechanisms required to perform these two functions. For this purpose brackets **62** are secured through oversized openings **63** in the side frames **12** and **14** to the slides **50.** Accordingly, movement of the brackets **62** will produce a corresponding movement of the slides **50** in the guide tracks **52.** Each bracket pivotally mounts a conventional two-position pneumatic ram **64,** having a piston rod **65.** The free end of each rod **65** is secured to a chain **68** which is entrained about a sprocket **70** pivotally secured to a side frame. The chain is fixed at its free end to the folding punch **26.** Thus, simultaneous retraction of the two piston rods **65** on each side of the folding punch **26** will first draw tight the chains **68,** next move the slides **50** downwardly to move the folding die **24** tightly against the workpiece W, and finally continued retraction of the piston rods **65** will cause the folding punch to pivot about the axis A and bend the workpiece. Extension of the piston rod **65** will relieve the tension in the chain **68** so that the folding punch will drop to its position shown in FIG. **3.** Further extension of the piston rods will bring their free ends into abutment with stop plates **72** so that the brackets **62** will be moved upwardly, thus moving the slides and the folding die away from the workpiece supporting surface.

As mentioned earlier, a unique feature of this invention is that the folding die **24** may be retracted laterally of the workpiece supporting surface **18** to strip the workpiece off the die. For this purpose a rigid rectangular housing **78** is welded or otherwise fixed to the slide **50** on the side frame **12** of the machine. The housing mounts an inner bearing set of five conventional roller or needle bearings **79** (FIG. **2**) and an identical outer set of five roller or needle bearings **80** (FIG. **6**). The bearings ride on bearing plates **82** seated in grooves **84** of the folding die **24.** The two sets of bearings cantilever the folding die **24** over the workpiece supporting surface as it is moved laterally. In order to position and support the folding die in the opposite side frame **14** the folding die is provided with a bullet-shaped pin **86** having a pair of diametrically opposed locating fins **87.** The pin and fins fit within a corresponding bore **88** in the slide **50.** The bore **88** is provided with diametrically opposed slots **90** to seat the fins. The pin extends further than the fins so that as the folding die approaches the side frame **14** the tapered nose of the pin **86** will first engage the recess **88** centering the folding die in the recess **88** and finally guide the fins **87** into the diametrically opposed slot **90** to accurately position the end of the folding die in the slide **50.** The folding die is moved laterally by a conventional electric or pneumatic motor **92** that drives a gear **94.** The gear **94** meshes with a gear track **96** running along the length of the folding die so that rotation of the gear **94** will reciprocate the folding die in the rigid housing **78.** As is, of course, obvious control of the motor **92** may also be obtained through the N.C. device **28** so that retraction of the folding die may also be preprogrammed and completely automated.

It is by now apparent that the entire operation of the folding machine may be carried out completely automatically by the N.C. device **28.** This automated folding machine can therefore be used in a completely automated delivery system so that a conventional coil or other container of sheet material can be connected through various automated pieces of equipment to enable a completely automated folding method from delivery of material in bulk to the removal of the folded workpiece. A typical apparatus is illustrated in FIG. **7.** Sheet material delivered in a coil is supported for free rotation in a conventional cradle **100.** The free end of the coil will be fed between straightening and feed rollers **102** of a conventional design. The straightened sheet material leaving the feed rollers will pass across a conventional flying shear **103** where it is cut to the desired size. The material will then be delivered to a transfer table **104.** The transfer includes a tiltable top **106** that is movable between the horizontal position where it is aligned with the flying shear **103** to an angular position as shown in FIG. **7** where it is aligned with the folding surface **27** of the folding punch and the work supporting surface **18** of the folding machine. The table **106** also includes an air receptable and a perforated top so that the table will have a layer or cushion

of air for freely sliding the sheet material thereover. Finally a conveyor **107** is provided at the lower end of the workpiece supporting surface so that the completed workpiece when stripped from the folding die can be carried away for subsequent forming operations.

In operation the sheet material will be fed through the feeding and straightening rollers **102** and from there on will be automatically controlled. Each of the units of the system, namely, the straightening and feeding rollers **102,** the flying shear **103,** transfer table **104,** the folding machine, and conveyor **107** all are controlled automatically by the N.C. device. Thus, once the program has been established to determine the size of the workpiece and folding requirements the feeding roller will be suitably energized to advance a prescribed length. The cut material will then be pushed from the flying shear onto the transfer table **104** by the next oncoming piece of sheet material or other suitable means. The sliding will be facilitated on the top of the transfer table by the cushion of air. Next the top **106** will be raised so that the workpiece W is free to slide off the top onto the workpiece supporting surface of the folding machine. During transfer of the workpiece it is initially guided by the folding surface **27** of the folding punch **26.** When the workpiece hits the stops **22,** which have been preset to initiate the folding operation, the workpiece will come to rest. Next the folds will be made in the workpiece and when the last fold is made, the folding die will be stripped from the workpiece. The cushion of air on the workpiece supporting surface will allow the workpiece to then slide down onto the conveyor **107.**

While the preferred form of the invention has been illustrated and described, it should be understood that modifications will be readily apparent to one skilled in the art. Accordingly, the invention is not to be limited to the specific forms illustrated and described, but rather is to be limited solely by a literal interpretation of the claims appended hereto. For example, although the invention has been described for use with a preprogrammed control, it is obviously equally advantageously used with manually operated controls.

What is claimed is:

**1.** An automatic or programmable folding machine for sheet metal material or the like workpieces each having side and end surfaces, comprising;

workpiece supporting means on said base frame,

powered workpiece stop means continuously engaging during advancing and folding an end surface of said workpiece and movable to initially position the workpiece end surface on the workpiece supporting means and subsequently advance the workpiece end surface after each fold so that the location of each fold on the workpiece is determined by the position of the end surface engaging stop means,

means for clamping the workpiece on the supporting means for holding the workpiece during folding,

anvil means for defining an edge about which the workpiece is folded, said edge facing away from said stop means and toward an unrestricted opening through which a folding punch can pass, said anvil means having a relatively short forward surface adjacent said anvil edge and having a top surface and a rear surface of relatively short dimensions for allowing the workpiece to be bent around on itself rearwardly of said rear surface,

a powered folding punch for forming the workpiece over the anvil means,

means for removing the workpiece from said anvil means, and

wherein said powered stop means, clamping means, folding punch and workpiece removing means can be actuated to make multiple folds in the workpiece automatically.

**2.** The machine of claim **1,** including means for automatically ejecting the workpiece from said workpiece supporting means.

**3.** The machine of claim **1,** said folding punch being mounted for pivotal movement, said means for pivotally mounting said folding punch comprising bearing plates secured to each said side frame, said bearing plates each including an annular outer recess spaced from the pivot axis of said folding punch and an inner recess spaced between the pivot axis and said outer recess, said inner and outer recesses being concentric with said pivot axis, and said folding punch including an outer ring segment and an inner shaft segment extending laterally of each end of said folding punch and slidably received in said inner and outer recesses respectively.

**4.** The machine of claim **1,** said workpiece supporting means including means for providing a layer of air along the top thereof for reducing the friction beneath the workpiece and the workpiece supporting means.

**5.** The machine of claim **2,** said workpiece supporting means being at an angle with respect to the horizontal and said workpiece ejecting means including means for providing a layer of air along the top of said workpiece supporting means to reduce the friction between the workpiece and the supporting means, and means for lowering said adjustable stop means beneath the supporting means for permitting the workpiece to slide freely off the supporting means.

**6.** The machine of claim **1,** including means for holding a roll of sheet material, means for straightening the material, means for automatically cutting the material into sheets of predetermined size, and means for automatically transferring the cut material to said workpiece supporting surface and against said adjustable stops.

**7.** The method of automatically forming sheet material objects comprising moving an elongated strip of sheet material along a path, straightening the material as it travels in said path, automatically cutting the material into lengths with forward and rearward end edges in accordance with a prearranged numerically controlled program, moving the cut material out of said path and onto a material folding surface automatically folding the material at a first location on the material measured a first distance from the rearward end edge of the material in accordance with said prearranged numerically controlled program, automatically moving the material along the material folding surface and folding the material to provide additional folds at locations again measured from the rearward end edge of the material in accordance with said prearranged numerically controlled program, said steps of automatically folding and advancing including continuously engaging the rearward end edge of the cut length of sheet material during advancing and folding through a series of folding steps, and automatically moving the folded material off the material folding surface.

8. An automatic folding machine for sheet metal material or the like comprising; a base frame, workpiece supporting means on said base frame, adjustable stop means automatically positionable for initially positioning the workpiece on the supporting means and advancing it in predetermined increments, means for automatically clamping the workpiece on the supporting means for holding the workpiece during the folding, anvil means for defining an edge about which the workpiece is folded, a folding punch automatically actuated for forming the workpiece over the anvil means, means for removing the workpiece from said anvil means, and wherein said adjustable stop means, clamping means, folding punch and workpiece removing means are automatically actuated whereby multiple folds are made in the workpiece automatically, said means for clamping the workpiece and said anvil means being combined as an integral folding die mounted for movement toward and away from said workpiece supporting means, said folding punch and said means for clamping the workpiece being operatively interconnected for clamping the workpiece against the workpiece supporting means with the same force transmitting means employed to actuate the folding punch for forming the workpiece so that an increase in folding force results in an increase in clamping force, said base frame including transversely spaced side frames, said means for moving said folding die toward and away from said workpiece supporting means including a guideway on each side frame and a slide reciprocably mounted in each guideway, said slides being secured to opposite ends of said folding die, said workpiece removing means including means for retracting said folding die laterally of the workpiece supporting means whereby the folding die is stripped off the workpiece leaving the workpiece on the supporting means.

9. An automatic folding machine for sheet metal material or the like comprising; a base frame, workpiece supporting means on said base frame, adjustable stop means automatically positionable for initially positioning the workpiece on the supporting means and advancing it in predetermined increments, means for automatically clamping the workpiece on the supporting means for holding the workpiece during the folding, anvil means for defining an edge about which the workpiece is folded, a folding punch automatically actuated for forming the workpiece over the anvil means, means for removing the workpiece from said anvil means, and wherein said adjustable stop means, clamping means, folding punch and workpiece removing means are automatically actuated whereby multiple folds are made in the workpiece automatically, said means for clamping the workpiece and said anvil means being combined as an integral folding die mounted for movement toward and away from said workpiece supporting means, said folding punch and said means for clamping the workpiece being operatively interconnected for clamping the workpiece against the workpiece supporting means with the same force transmitting means employed to actuate the folding punch for forming the workpiece so that an increase in folding force results in an increase in clamping force, said base frame including transversely spaced side frames, said means for moving said folding die toward and away from said workpiece supporting means including a guideway on each side frame and a slide reciprocably mounted in each guideway, said slides being secured to opposite ends of said folding die, and said folding die moving means for clamping the workpiece including ram means mounted on brackets secured to each of said slides, each ram means having a piston rod secured at its free end to a chain, said chains being secured at their free ends to the opposite ends of said folding punch, said folding punch being mounted for pivotal movement into engagement with said folding die whereby retraction of said piston rods first effects movement of said folding die toward said workpiece supporting means to clamp the workpiece and subsequently pivots said folding punch toward said folding die to form the workpiece on the anvil of said folding die.

10. The machine of claim 9, said means for pivotally mounting said folding punch comprising bearing plates secured to each said side frame, said bearing plates each including an annular outer recess spaced from the pivot axis of said folding punch and an inner recess spaced between the pivot axis and said outer recess, said inner and outer recesses being concentric with said pivot axis, and said folding punch including an outer ring segment and an inner shaft segment extending laterally of each end of said folding punch and slidably received in said inner and outer recesses respectively.

11. A folding mechanism for a folding machine having a support frame with a workpiece supporting surface, the improvement comprising a one-piece integral folding die having a clamping surface for holding the workpiece against the supporting surface and a folding anvil, a folding punch mounted for pivotal movement toward the folding anvil for bending the workpiece around the folding anvil, means for moving said folding die toward said supporting surface to clamp the workpiece therebetween, means for pivoting the folding punch toward and away from said folding anvil, and means for removing the workpiece from said folding die, said workpiece removing means including means for moving said folding die laterally of said workpiece supporting surface, and means for stripping the workpiece from the folding die as it is moved laterally.

12. The folding mechanism of claim 11, one of said slides including a bearing housing having two sets of bearings for supporting the folding die as it is moved laterally, the opposite end of said folding die including a tapered pin having diametrical keys, the slide adjacent said tapered pin having an opening and diametrical keyways for receiving said pin and keys wherein the folding die is supported by the slides during a folding operation.

13. The apparatus of claim 11 said anvil having a relatively short forward surface adjacent said edge and having a top surface and a rear surface of relatively short dimensions for allowing the workpiece to be bent around on itself rearwardly of said rear surface.

14. A folding mechanism for a folding machine having a support frame with a workpiece supporting surface, the improvement comprising a one-piece integral folding die having a clamping surface for holding the workpiece against the supporting surface and a folding anvil for bending the workpiece around the folding anvil, means for moving said folding die toward said supporting surface to clamp the workpiece therebetween, means for pivoting the folding punch toward and away from said folding anvil, and means for removing the workpiece from said folding die including spaced side frames secured to said support frame, said means for moving the folding die toward the workpiece support-

ing surface and said means for pivoting the folding punch including guideways on said side frames, slides in said guideways movable toward and away from said workpiece supporting surface, ram means secured to said slides and each having a piston rod extendable therefrom, chains secured to said piston rods and to the ends of said folding punch wherein retraction of said piston rods draws said folding die toward the supporting surface to clamp the workpiece and subsequently pivots the folding punch toward said folding anvil to form the workpiece.

**15.** The folding mechanism of claim **14,** said side frames including bearing plates each having an annular outer recess spaced from the pivot axis of said folding punch and an inner recess spaced between the pivot axis and said annular outer recess, said inner and outer recesses being concentric with said pivot axis of said folding punch, and said folding punch including an outer ring segment and an inner shaft segment extending laterally of each end of said folding punch and slidably received in said inner and outer recesses, respectively, a bearing housing rigidly secured to one of said slides and including two sets of spaced bearings for supporting the folding die as it is moved laterally, the opposite end of said folding die including a tapered pin provided with a pair of diametrical keys, the slide adjacent said tapered pin having an opening and diametrical keyways for receiving said pin and keys wherein the folding die is supported by the slides during a folding operation.

**16.** A folding mechanism for a folding machine having a support frame with a workpiece supporting surface, the improvement comprising a one-piece integral folding die having a clamping surface for holding the workpiece against the supporting surface and a folding anvil, a folding punch mounted for pivotal movement toward the folding anvil for bending the workpiece around the folding anvil, means for moving said folding die toward said supporting surface to clamp the workpiece therebetween, means for pivoting the folding punch toward and away from said folding anvil, and means for removing the workpiece from said folding die, said means for moving the folding die toward said supporting surface to clamp the workpiece and said means for pivoting the folding punch being interconnected so that the punch and die are moved interdependently toward one another by a common connection whereby the clamping force on the workpiece is directly related to the folding force applied by the folding punch, said workpiece removing means including means for moving said folding die laterally of the workpiece supporting surface, and means for stripping the workpiece from the folding die as it is moved laterally.

**17.** An automatic or programmable folding machine for sheet metal material or the like comprising;

a base frame,

workpiece supporting means on said base frame,

powered workpiece stop means positionable for initially positioning the workpiece on the supporting means and advancing it over the supporting means,

means for clamping the workpiece on the supporting means for holding the workpiece during folding,

anvil means for defining an edge about which the workpiece is folded,

a powered folding punch for forming the workpiece over the anvil means, means coupling the folding punch with the clamping means for increasing the clamping force in response to an increase in folding force applied on the folding punch, means for removing the workpiece from said anvil means, and wherein said powered stop means, clamping means, folding punch and workpiece removing means can be actuated to make multiple folds in the workpiece automatically.

**18.** The machine of claim **17,** said base frame including transversely spaced side frames, said means for clamping the workpiece on the supporting means including a guideway on each said side frame and a slide reciprocably mounted in said each guideway, said slide being secured to opposite end of said anvil means.

**19.** A folding mechanism for a folding machine having a support frame with a workpiece supporting surface, the improvement comprising a one-piece integral folding die having a folding anvil and a clamping surface for holding the workpiece against the supporting surface, a folding punch mounted for pivotal movement toward the folding anvil for bending the workpiece around the folding anvil, and interconnecting means for pulling the punch and die toward one another whereby the clamping force on the workpiece is increased directly in response to an increase in the folding force applied on the folding punch.

**20.** An automatic or programmable folding machine for sheet material or the like workpieces each having an end surface comprising a base frame, workpiece supporting means on said base frame, powered workpiece stop means continuously engageable with said end surface during advancing and folding and positionable for initially positioning the workpiece on the supporting means and advancing it over the supporting means after each fold, means for clamping the workpiece on the supporting means for holding the workpiece during the folding operation, anvil means for defining an exposed edge facing away from said stop means about which the workpiece is folded, said anvil means having a relatively short forward surface adjacent said anvil edge and having a top surface and a rear surface of relatively short dimensions for allowing the workpiece to be bent around on itself rearwardly of said rear surface, a powered folding punch for forming the workpiece over the anvil means, and wherein said powered stop means, clamping means, folding punch and workpiece removing means can be acutated to make multiple folds in the workpiece automatically.

**21.** An automatic or programmable folding machine for sheet material or the like workpieces having side and end surfaces, comprising, a base frame, workpiece supporting means on said base frame, powered workpiece stop means positionable for initially positioning the workpiece on the supporting means and advancing the workpiece, said stop means including means for engaging an end surface of the workpiece so that all movements of the workpiece are based on the position of the end surface of the workpiece, means for clamping the workpiece on the supporting means for holding the workpiece during folding, anvil means for defining an edge about which the workpiece is folded, said edge facing away from said stop means and toward an unrestricted opening through which a folding punch can pass, said anvil means having a relatively short forward surface adjacent said anvil edge and having a top sur-

face and a rear surface of relatively short dimensions for allowing the workpiece to be bent around on itself rearwardly of said rear surface, a powered folding punch for forming the workpiece over the anvil means, means for removing the workpiece from said anvil means, wherein said powered stop means, clamping means, folding punch and workpiece removing means can be actuated to make multiple folds in the workpiece automatically, including means for holding a roll of sheet material, means for straightening the material, means for automatically cutting the material into sheets of predetermined size, and means for automatically transferring the cut material to said workpiece supporting surface and against said means for engaging an end surface of the workpiece, said transferring means including a table having a tiltable top, means for providing a layer of air along the top of the table for reducing the friction between the sheet material and the table, and means for tilting the table into an inclined plane to slide the material off the table, said workpiece supporting means of said machine lying in said inclined plane, means for providing a layer of air along said supporting means for raising the workpiece off the supporting means to reduce the friction between the workpiece and the supporting means whereby the sheet material is automatically transferred from the transfer table to said supporting surface by sliding along said inclined plane.

**22.** The method of automatically forming sheet material objects comprising moving an elongated strip of sheet material along a path, straightening the material as it travels in said path, automatically cutting the material into lengths with forward and rearward end edges in accordance with a prearranged numerically controlled program, moving the cut material out of said path and onto a material folding surface, automatically folding the material at a first location on the material measured a first distance from the rearward end edge of the material in accordance with said prearranged numerically controlled program, automatically moving the material along the material folding surface and folding the material to provide additional folds at locations again measured from the rearward end edge of the material in accordance with said prearranged numerically controlled program, and automatically moving the folded material off the material folding surface, said step of moving the cut material out of said path and onto said material folding surface including lifting the material into an inclined path, raising the material on a layer of air and sliding it onto an inclined material surface, said step of moving the material along the material folding surface including raising the material on a layer of air and sliding the material up said surface, and said step of moving the folded material off the folding surface including raising the material on a layer of air and sliding the material down said inclined material surface.

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