

April 18, 1961

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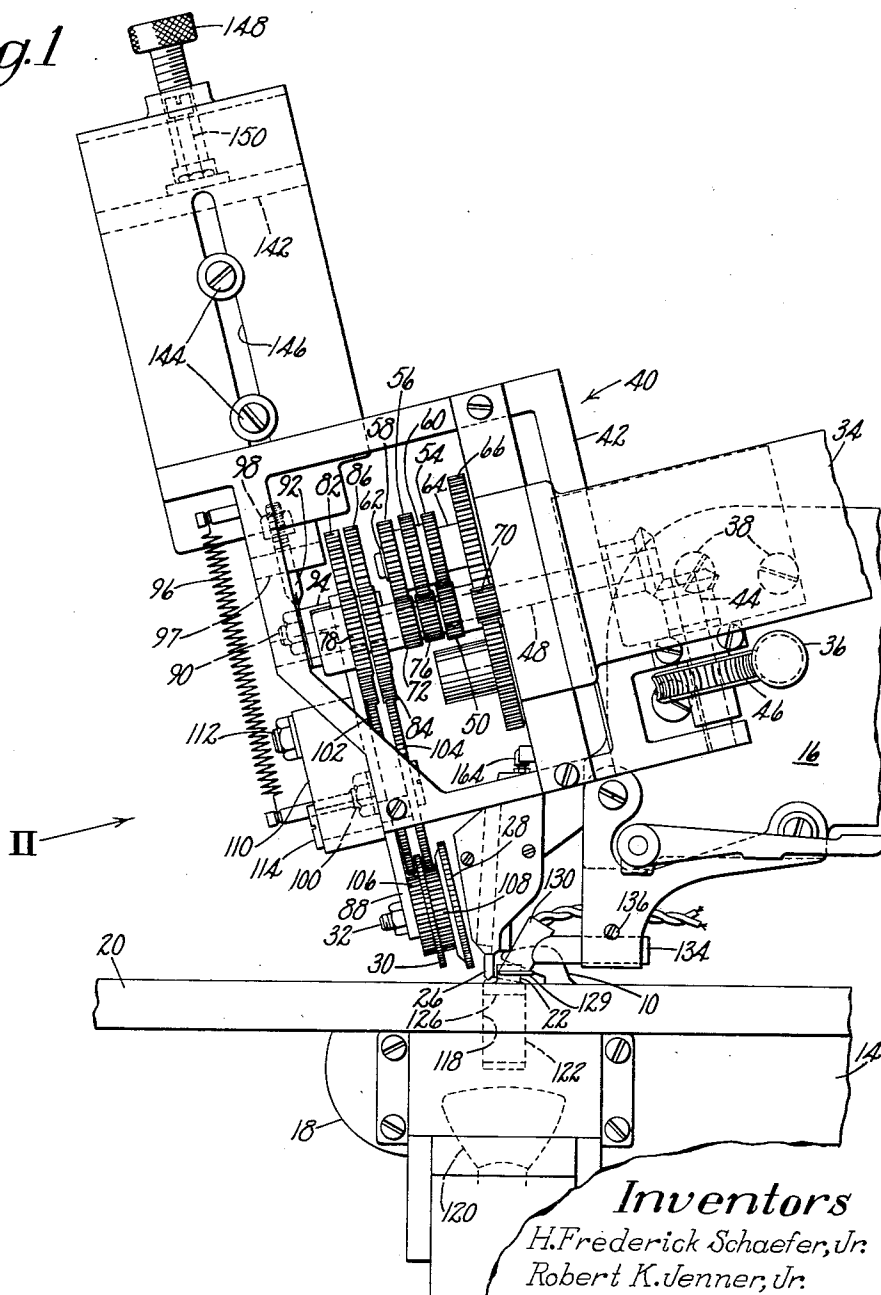
2,979,745

WORK FEEDING AND GUIDING MEANS

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4 Sheets-Sheet 1

Fig. 1



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Fig.2

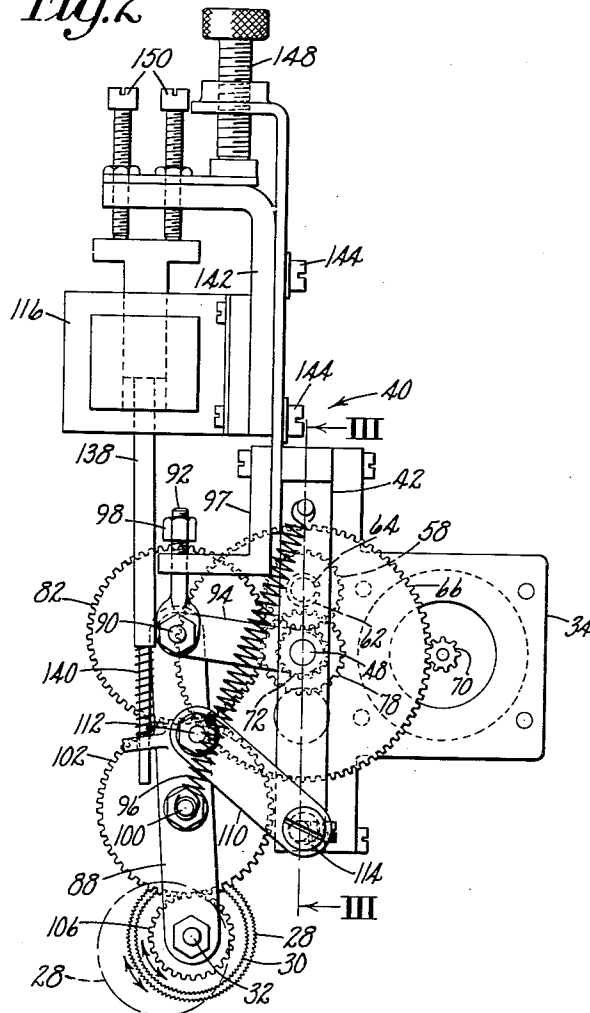
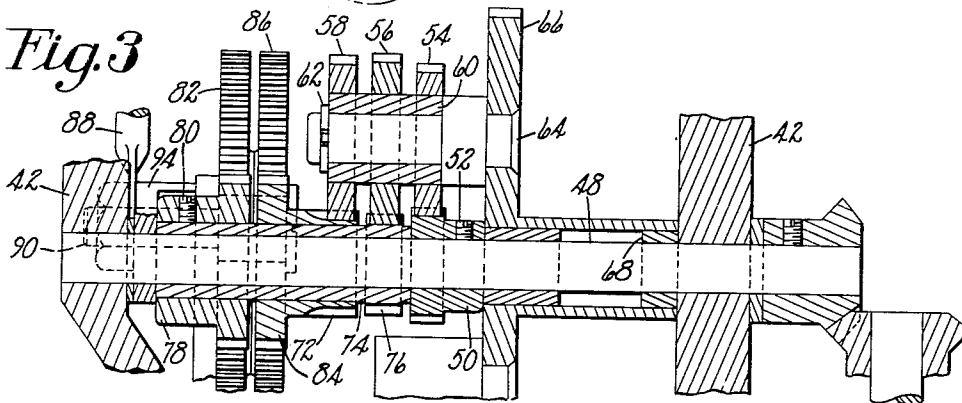


Fig.3



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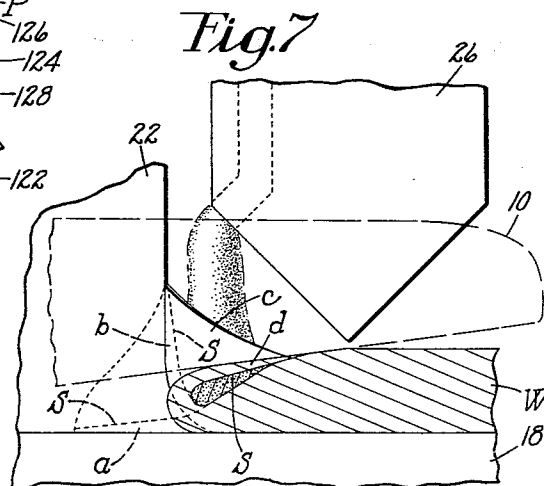
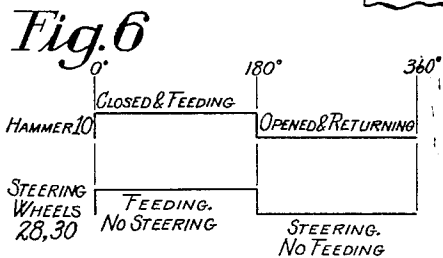
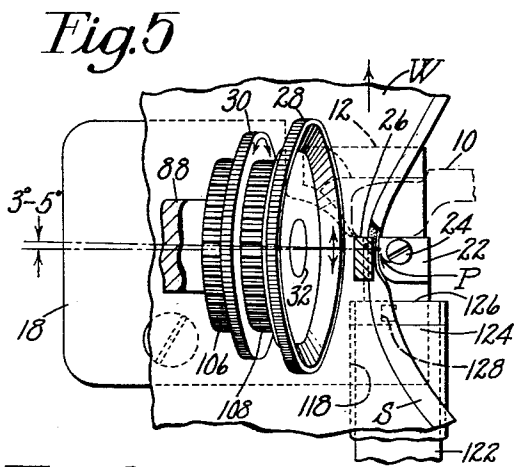
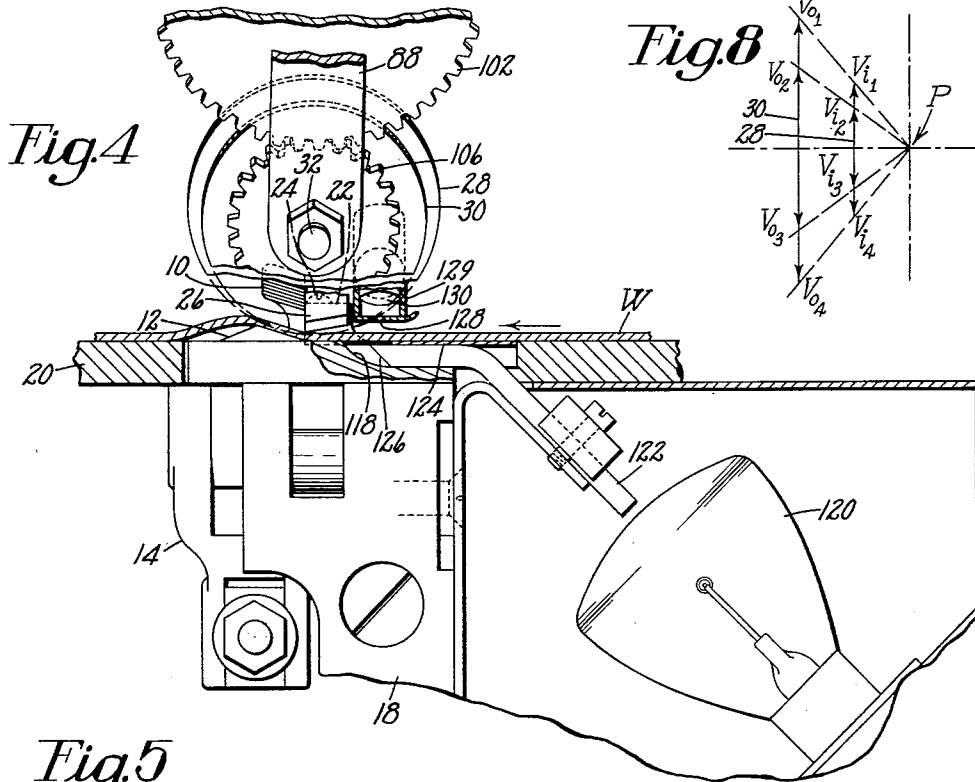
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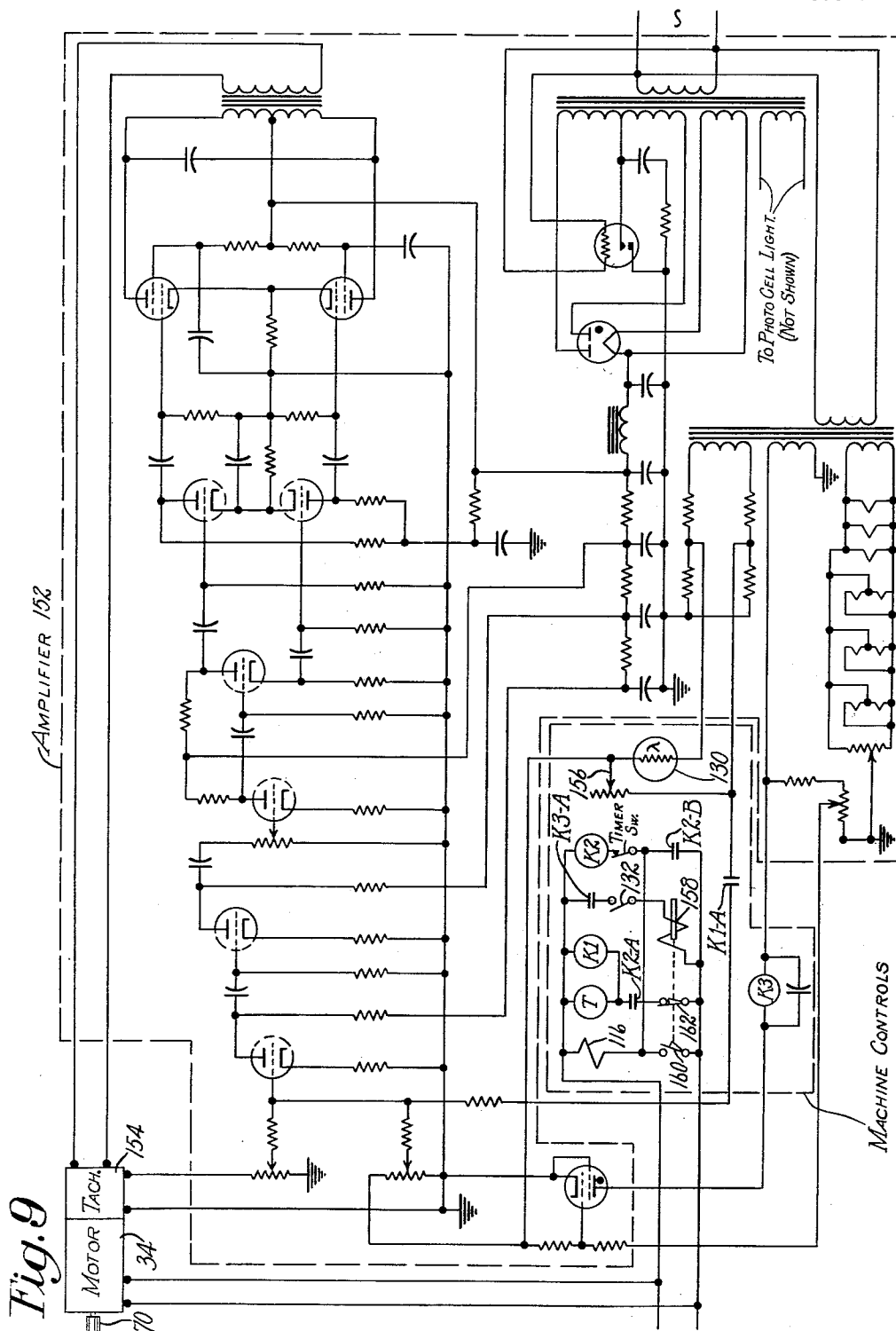
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WORK FEEDING AND GUIDING MEANS

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2,979,745

WORK FEEDING AND GUIDING MEANS

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28 Claims. (Cl. 12—55)

This invention relates to mechanism for feeding and guiding work pieces. More particularly the invention is concerned with providing improved means for automatically guiding the margin of a work piece, especially the edge portions of flexible sheet material, relative to a tool operative thereon. The invention is illustrated herein as being embodied in a machine, of the general type disclosed and claimed in United States Letters Patent No. 2,849,734, issued September 2, 1958, upon an application filed in the name of Roy V. McGahan, wherein the margins of leather work pieces are finished by instrumentalities including, for example, adhesive applying means and edge folding and pressing devices having essentially the same construction and operation disclosed in United States Letters Patent No. 2,765,768, issued October 9, 1956, upon an application filed in the name of Hans C. Paulsen. It is to be understood, nevertheless, that the invention is not restricted to the organization herein shown by way of example, and that indeed the invention is not limited in application to use on only a particular type of work piece or for use with operating tools of any specific character.

The machine referred to in the above cited McGahan patent employs a single intermittently driven wheel for feeding a work piece in synchronism with feeding movements of a hammer and anvil which cooperate to clamp a skived and adhesively coated margin which has just been folded. Provided that the work boundaries are of gentle curvature and fairly consistent to their wieldability this McGahan arrangement has been found quite satisfactory in commercial use, the machine being reliable and the finished product being generally pleasing in appearance. Each work piece is moved through the machine by an operator at a speed under his control, and there seems to be less displacing of an edge of a piece from proper engagement by the hammer and anvil than when the feed wheel is rotated continuously, as in the case in the previously designed edge folding machine disclosed in United States Letters Patent No. 2,526,691, issued October 24, 1950, on an application filed in the name of Milton H. Roske. For more uniform and continuous performance and especially where edges have smaller radii of curvature the patented constructions demand that operator guidance supplement that normally imparted to the work piece by the machine.

In view of the foregoing it is a primary object of this invention to provide an improved machine for treating and/or operating on the margins of work pieces, which machine shall, without any attendance on the part of the operator, after initial presentation of the work, automatically and uniformly guide the edge of each piece relative to the operating instrumentalities of the machine. Another and more specific objective of the invention is to incorporate in an edge folding machine of the general type referred to above, reliable control means for automatically steering a work piece, regardless of the curvature of its boundaries, about a common turning point

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which is herein shown as a fixed center of rotation at a turning post.

In keeping with these objectives, and in accordance with a novel feature of the invention, there is provided in combination with a tool for operating on the margin of a work piece, a work support, and means cooperative with the work support for causing the margin to be presented and guided relatively to the tool, said means including an abutment adjacent to the tool, a pair of control wheels differently spaced inwardly of the edge of the work piece for feeding it in contact with the abutment and progressively to the tool, and means for rotating one of the wheels in either of two directions with variable speed according to the curvature of the margin while rotating the other wheel in a corresponding direction with a speed in fixed ratio thereto to steer the work piece about a substantially fixed center of rotation.

It will be appreciated that the novel work guidance means disclosed herein may be employed in machines wherein the operating tools either do or do not additionally perform a work feeding function. As herein shown for purposes of convenience in illustration, the work guiding means of this invention, being adapted for embodiment in an edge folding machine of the McGahan type, comprises in addition to an edge gage abutment in the form of the usual turning post and an intermittently operative hammer and anvil which move in unison away therefrom for imparting step-by-step feeding movement of the work past the turning post, the pair of differentially driven wheels referred to, and electrical means for controlling the relative wheel speeds effectively to vary the direction of feed between the successive hammer and anvil feeding movements thereby to guide the edge of the work with respect to the operating devices. The electrical means is disclosed herein as a servo controlled circuit including a light source at one side of the work support, a photoelectric detector cell arranged at the other side of the support responsive to light from said source passing the edge of the work piece just ahead of the turning post, and a servo amplifier, including a servo motor and tachometer, responsive to transmitted light, i.e. to a corresponding voltage difference from a selected reference level, for reversibly operating the wheels at speeds appropriate to steer the work. Thus "error voltage" is fed to the input of the servo amplifier and, amplified, fed to the servo motor. This motor drives a mechanically controlled assembly and the tachometer, output voltage of the latter being fed back to the input of the servo amplifier for stabilizing purposes.

The illustrative arrangement is such that although the work control wheels, which are respectively rotated intermittently and in synchronism with the feeding movements of the hammer and anvil, are reversibly driven, they effectively exert a steering force on the work only when the hammer is out of work-gripping relation to the anvil, and the control wheels also tend to aid in feeding in the intervals when the work is being operated upon and fed by the hammer and anvil. Thus, in about one-half of a cycle, while the hammer is not clamped on the work, the servo motor is free to position it until the error voltage equals zero, the light passing then equaling a preset light level. The servo motor accordingly rotates the work about a point substantially on the turning post, the shaft of the motor being coupled by independent driving means to each of the control wheels always to insure turning of the work about only one point. Direction of rotation of the work is determined by the sign of the "error voltage," and the speed of rotation of the work is determined by the magnitude of that voltage. The control wheels are, in this illustrative embodiment, disposed slightly angularly, i.e. on a radius about 2-5° off from a plane normal to the direction of feed and passing

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through the work turning point, to cause the work margin to be progressively urged or "crowded" against the turning post in order to turn the edge of the work upward. In the other half of the cycle, the hammer closes on the upturned margin to fold it and then feed the work straight past the turning post while clamping the folded margin. During this latter half cycle the servo motor does not develop power sufficient to disturb the work, but motion derived from the motor governing the folding instrumentalities is in this interval also fed to the control wheels through a differential, equal motion then being imparted thereto to supplement the straight line hammer feeding.

The above and other novel features of the invention, including means by which the work control wheels are automatically moved into and out of feeding relation to the work, means for changing the width of fold, and other details of construction, will now be set forth in more particularity in connection with an illustrative embodiment thereof and with reference to the accompanying drawings, in which

Fig. 1 is a view in front elevation of novel work guidance mechanism together with operating elements of an edge folding machine of the general type more fully disclosed and described in the above cited McGahan and Roske patents, the parts being in their normal in-operative positions;

Fig. 2 is an end view of a pair of control wheels and their differential drive shown in Fig. 1 and looking in the direction of arrow II in Fig. 1;

Fig. 3 is a section taken on the line III—III of Fig. 2;

Fig. 4 is an enlarged end view of the control wheels and other adjacent parts in operating position;

Fig. 5 is a plan view corresponding to Fig. 4;

Fig. 6 is a schematic diagram illustrating the cyclic relation of feeding and steering functions;

Fig. 7 is a view enlarged (about eight to ten times) and somewhat diagrammatic, indicating in section a work piece being folded, pressed, and fed toward the reader;

Fig. 8 is a vector diagram of the control wheels; and

Fig. 9 is an electrical diagram of the servo amplifier system.

It will be understood that the device for operating on the margins of a work piece to be guided by the means afforded by this invention may be of various types and for different purposes, the ones herein shown conveniently being selected as exemplary. Thus, although the hammer and anvil serve dual purposes in feeding as well as folding, it will be appreciated that in other organizations wherein the present invention may likewise have considerable value other marginal operating tools may merely perform a single function without work feeding, in which latter case the novel automatic work guiding means herein to be disclosed might perform all of the feeding as well as guidance. It will, of course, be clear that application of the guidance mechanism disclosed herein is not limited to situations wherein a folding of the margin occurs, the mechanism cooperating with any suitable edge gage means whether turning post or otherwise.

The illustrative machine, including its hammer 10 and anvil 12 (Figs. 1, 4 and 5) together with their actuating mechanism, resembles in many respects that disclosed in United States Letters Patent 2,270,891, granted January 27, 1942, upon an application of Carl A. Newhall. Preferably the machine incorporates means for feeding thermoplastic adhesive in the form of rods or strips in the manner later taught by the Paulsen patent above cited. Accordingly the machine has a frame comprising a hollow base 14 (Figs. 1 and 4) affording an opening in which the hammer and anvil cooperate and an overhanging arm 16 (Fig. 1) on the base. Level with and surrounding a detachable end portion 18 of the base 14 is a removable supporting plate 20 across which work W (Figs. 5, 10) normally in the form of flexible sheet material

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such as leather, is to be automatically guided for, in this instance, edge folding. Unlike the McGahan construction, however, the plate 20 does not include an anti-friction rotary disk. As customary in edge folding machines, a turning post 22 is secured by a screw 24 to the portion 18 and has an upturned plow surface for deflecting the scarf S of the work piece upwardly. An adhesive applying nozzle 26 (Figs. 1, 5 and 7) depends from the arm 16 and its delivery end is disposed closely adjacent to the upturning surface of the turning post as indicated in Fig. 7, the melted adhesive thus flowing (under pressure and when a control valve, not shown, is open) onto the scarf passing between the post and the nozzle. Preferably the nozzle 26 is V-bottomed, its lower extremity nearly engaging the work piece to insure that its margin lies substantially flat at the locality where cementing, folding and guidance are progressing.

For automatically guiding the work W relatively to the mentioned feeding, folding and adhesive devices and about a substantially fixed point P (Fig. 5) normally located substantially on the turning post 22, in accordance with the requirements of marginal curvature, a pair of control wheels 28, 30 radially spaced inwardly of the work piece W from the point P is provided. These wheels are mounted for reversible, intermittent and independent rotation on a common shaft 32. This shaft, supported for heightwise movements as later explained, preferably is inclined to the horizontal plate 20 to enable the wheel perimeters frictionally to engage the work nearer its margin and proximate to the turning post 22 thus avoiding, or at least minimizing, possible distortion in a work piece being guided in the event it is flimsy material. The control wheels 28, 30 are differentially driven through gearing as later explained connecting them respectively to both the basic folding machine motor (not shown) and to a servo motor 34 (Figs. 1, 2 and 9).

As has been indicated the hammer and anvil are operated cyclically by the main motor just referred to in the manner of the prior patents to fold the scarf S upturned by the turning post 22, to grip the edge of the work piece and move in unison rectilinearly away from the post 22 (preferably about $\frac{1}{16}$ "), whereupon at substantially 180° of the cycle the hammer and anvil cease feeding and are opened and returned to their initial positions. Referring to Fig. 1, a worm 36 is intermittently driven from a main shaft (not shown) of the basic motor through operating connections including a pawl clutch (not shown) of the type disclosed in detail in United States Letters Patent No. 2,276,913, granted March 17, 1942, upon application of Fred Ashworth, these connections being shown and described, for instance, with relation to Figs. 4 and 7 of the above cited McGahan patent. (In that patent the worm designated 102 corresponds to the worm 36 herein, both having bearings in the machine head.) Secured by screws 38, 38 (Fig. 1) to the arm 16 is a self-contained unit generally designated 40 in Fig. 2. This unit has a frame 42 in which is journaled a shaft 44 carrying a worm wheel 46 meshing with the worm 36. The upper end of the shaft 44 has mitre gear connection with a shaft 48 (Figs. 1 and 3) parallel to the control shaft 32 and rotatable unidirectionally in spaced bearings formed in the frame 42. A sun pinion 50 (Figs. 1 and 3) affixed on the shaft 48 by a set screw 52 (Fig. 3) is arranged to mesh with a planet pinion 54. The latter, like adjacent planet pinions 56, 58 (Fig. 3), is press-fitted on a bushing 60 retained by a snap ring 62 on a stud shaft 64. The three planet pinions therefore rotate together, and their supporting stud shaft 64 is carried parallel to the shaft 48 by a relatively large gear 66 the hub of which is coaxially mounted on the shaft 48 by means of a collar bearing 68 thereon and a sleeve portion of the sun pinion 50. The gear 66 is coupled, for purposes later discussed, to an output pinion 70 (Figs. 1

and 2) of the servo motor 34 which is mounted on the frame 42.

Similar gear trains driven by the planet gears 56 and 58, respectively, are adapted as will now be described to drive the outer control wheel 30 and the inner control wheel 28. Thus the planet pinion 58 is disposed to mesh with a sun pinion 72 (Fig. 3) rotatable on a sleeve bearing portion 74 of a sun gear 76 rotatable on the shaft 48, and the planet pinion 56 is in mesh with the sun gear 76. A pinion 78 (Figs. 1, 2, 3) affixed on an end of the sleeve portion 74 by a set screw 80 (Fig. 3) is in mesh with a gear 82, and a pinion 84 formed coaxially and integrally with the pinion 72 is in mesh with a gear 86. In order to enable the control wheels 28 and 30 to be shifted heightwise into and out of operative relation to the work W by means later explained, the shaft 32 on which they are mounted is carried by the lower end of a depending arm 88. A shaft 90 parallel to the shaft 32 and carrying the gears 82 and 86 is supported in aligned bores formed in the upper end of the arm 88, in the lower end of a stop rod 92, and in one end of a link 94 the other end of which is pivotally mounted on the shaft 48. The arm 88 is normally urged to raise the control wheels 28, 30 to an inoperative position by a tension spring 96 (Figs. 1 and 2) connecting the arm 88 to the frame 42. The stop rod 92 freely extends through a vertical bore formed in a bracket 97 secured to the frame 42, a nut 98 threaded onto the upper end of the stop rod serving adjustably and positively to determine the lower or operating level of the control wheels 28, 30 according to the thickness and/or compressibility of the particular work pieces being guided thereby. A stud 100 in the arm 88 rotatably supports intermediate gears 102, 104, the former transmitting motion of the gear 82 to a gear 106 integral with the wheel 30, and the gear 104 transmitting motion of the gear 86 to a gear 108 (Figs. 1, 5) integral with the wheel 28.

For guiding heightwise movement of the control wheels 28, 30 a link 110 (Figs. 1 and 2) is pivoted at one end to the arm 88 by a stud 112, and adjustably secured at its other end by means of a screw 114 having an eccentric stem threaded into the frame 42. As will be apparent, rotation of the screw 114 thus conveniently enables the work engaging localities of the control wheels 28, 30 to be shifted in the direction of feeding and hence enables the turning point about which the work is to be turned to be moved relatively to the turning post 22. The wheels 28, 30 are automatically moved into work engaging positions by the energization of a solenoid 116 (Figs. 2 and 9) to overcome the spring 96. This normally occurs automatically in response to initial presentation of a work piece on the plate 20 so that the edge to be operated upon sufficiently overlies a light passageway or slot 118 (Figs. 1, 4 and 5) in the portion 18 and thereby interrupting the path of light being emitted from a source, such as a bulb 120, mounted in an enclosure beneath the plate 20. Preferably the light is conducted from the bulb by a bent lucite bar 122 (Figs. 1 and 4) having its upper portion masked by a strip 124 except for a gate end 126 of the rod which deflects the beam vertically upward, through an aperture 128 (Figs. 4 and 5) in a protective cap 129, to a photoelectric cell 130 (Figs. 1, 4, 5 and 9) on which the cap is mounted. As herein indicated in Fig. 9, the illustrated machine controls preferably include a master switch 132 which may, for instance, be manually closed at the beginning of a production run and remain so as a condition precedent to energization of the solenoid 116 but be opened quickly in the event of an emergency such as jamming of a work piece or parts. The cell is adjustable in a direction in and out of the machine by means of its stem 134 (Fig. 1) which slidably extends through a bore formed in the arm 16, the stem being secured in selected posi-

tion by a screw 136. On energizing the solenoid 116 its plunger 138 descends, causing a compression spring 140 thereon yieldingly to urge the arm 88 into operative position, the corresponding position of the control wheels 28, 30 being indicated by dash lines in Fig. 2. The solenoid 116 is secured to a bracket 142 which may initially be adjusted heightwise relatively to the frame 42 by clamping screws 144, 144 extending through a slot 146 formed in the frame. A stop stud 148 adjustably threaded through the frame 42 engages the bracket 142 endwise to hold it against relative upward movement. A pair of stop screws 150, 150 adjustably extend through the bracket to determine the upper limit of movement of the plunger 138 and hence of the control wheels 28, 30, and heightwise adjustment of the solenoid 116 by means of the stud 148 is effective to adjust the force with which the wheels engage the work.

The mechanical means just described for driving the work control wheels 28, 30 will be understood to be effective, as indicated in Fig. 6, in the first half of a cycle, their intermittent simultaneous movements occurring at the same speed to supplement the straight line feeding imparted to the work by the hammer and anvil. Following this step in feeding, when the work has been released from the hammer and anvil substantially midway in the cycle, guidance means next to be described automatically assumes sole control of the wheels 28, 30, not for the purpose of feeding the work, but to turn or steer it as determined by the curvature of its scarf S approaching the turning post 22 thus to insure that the edge of the work will be progressively presented in appropriate position to the turning post and to the cementing and folding devices. To this end the work is to be swung in the second half of a cycle about a substantially fixed center designated P (Figs. 5 and 8), in the appropriate direction and to a correct degree, by imparting appropriate velocities to the respective wheels 28, 30. This is accomplished through the above-described gear trains but as now driven solely by the pinion 70 of the servo motor 34 to rotate the gear 66 in either of two directions according to the sign of the error voltage of the light beam passing the work edge and directed through the aperture 128 for registering on the cell 130. Thus, immediately beneath the aperture 128 the edge of the work may be to the right or left of a position in which a reference level of light and the regulated voltage level corresponding thereto are zero, and hence turning of the work to shift its edge to the left or to the right to modify the light and voltage to "zero level" is required. The "error voltage" at any instant is fed from the cell 130 to the input of an appropriate, conventional servo amplifier 152 (Fig. 9) and, amplified, is fed to the servo motor 34 to rotate its pinion 70 in the correcting direction. Planet pinions 56, 58 consequently are reversibly driven but in the same direction at any instant, and, by reason of the gearing described, their motion is transmitted to the control wheels 30, 28, respectively, to drive the latter in velocities of fixed ratio. Thus, in Fig. 8, which relates only to this second half of the machine cycle, the vectors representing velocities of the inner wheel 28 are shown as always being directly proportional to the vectors representing corresponding velocities of the outer wheel 30. These vectors may likewise be considered to represent frictional forces being exerted by the wheels 28, 30 respectively on the work, and hence it will be apparent that their net effect is always to turn the work about the fixed center P until the error voltage equals zero. The arrangement is such that this steering influence due to light detection and imparted by the servo motor 34, while effective only in the second half of the cycle, is extant but of no effect during the first half due to its relatively insignificant torque as compared to that then exerted on the shaft 48 by the main motor. For purposes of stability in operation the servo motor also drives a tachometer 154 (Fig. 9), the output voltage of

the latter being fed back to the input of the servo amplifier in conventional manner.

Referring now more especially to Fig. 9, the machine includes in its controls means schematically shown at 156 which may take the form of a control knob for adjusting the regulated zero error voltage position. By this means the position of the work edge with respect to the turning post 22 at zero error may be varied, and hence the effect of adjusting the knob is to move the edge in or out, thus determining the width of fold effected by the hammer and anvil. In addition, the machine controls include a relay K3 energized by a thyatron of the amplifier 152 in response to partial interruption of the light path to the cell 130 by the initial presentation of the work. The relay K3 accordingly acts to close a contact K3-A whereby, assuming closure of the master switch 132, a cement control solenoid 158 is energized to close a switch 160 and open a switch 162, and also to open a valve 164 (Figs. 1 and 9) in the adhesive supply line. Resultant energizing of the solenoid 116 initiates automatic infeed and guidance of the work as above described. Simultaneously, a relay K2 is energized which closes a contact K2-B of a holding circuit for the solenoid 116, and also closes a normally open contact K2-A in a circuit that, when the switch 162 is closed, starts a Timer T and energizes a relay K1. After the work passes through the machine, the light path is no longer partly blocked by the work piece and consequent rising of the level of the light received by the cell 130 above the preset reference level automatically deenergizes the relay K3 to effect outfeed of the work from the machine. Thus, on resultant deenergizing of the solenoid 158 and closing of the switch 162, the cement valve 164 is at once reclosed, but the control wheels 28 and 30 are held in operating contact with the work for a predetermined time interval, while the operating timer T maintains the control wheel solenoid 116 energized. In this interval a signal through the now closed contact K1-A modifies input to the servo motor 34 causing the wheels 28, 30 to rotate at the same speed and to impart straight-line feed to the work piece, supplementing the feeding action of the hammer 10 and anvil 12. The work is accordingly feed directly out of the machine, timer T then permits the solenoid 116 to be deenergized, and the machine is restored to its initial inoperative condition.

From the foregoing it will be apparent that this invention provides automatic work guidance by safe and reliable means which, by its versatile nature, may readily be adapted for use in numerous other types of apparatus. These types may include, for instance, machines for edging, decorating, skiving, sewing, cutting, perforating, and the like. Their operators will be relieved of the need for exercising any particular skill, their only duty being that of presenting successive work pieces to the machine so that its guidance means may, in accordance with this invention, steer the work pieces as their contours individually require.

Having thus described our invention, what we claim as new and desire to secure by Letters Patent of the United States is:

1. A machine for progressively operating on or near the irregularly curved margin of a work piece comprising a work support, a tool, and means cooperative with the work support and engageable with the work piece for causing the margin of the latter progressively to be presented to the tool, said means including an abutment adjacent to the tool, a pair of movable work control members differently spaced inwardly of the edge of the work piece for feeding it against the abutment and relatively to the tool, and means for driving one of the members in either of two directions with variable speed according to the curvature of the margin while driving the other member in a corresponding direction with a speed fixedly proportionate thereto to steer the work piece about a common turning point.

2. A machine for progressively operating on or near the margin of a work piece comprising a work support, a tool engageable with the margin of the work piece, and means cooperative with the work support for causing the margin of the work piece progressively to be presented to the tool, said means including an abutment adjacent to the tool, a pair of rotatable wheels differently spaced inwardly of the edge of the work piece for feeding it against the abutment and relatively to the tool, and means for driving one of the wheels in either of two directions with variable speed controlled by changes in marginal curvature of the work piece while driving the other wheel in a corresponding direction with a speed fixedly proportionate to that of said one wheel to steer the work piece about a common turning point.

3. A machine as set forth in claim 2 and further characterized in that said driving means is controlled automatically by the curvature of successive increments of the margin of the work piece approaching said abutment.

4. In a machine having a tool for progressively operating on or near the margin of a flexible work piece, a work support, an edge gage on the support arranged marginally to be engaged by the work ahead of the tool, guidance means operable on the work at localities spaced on a radius extending through a turning center substantially on the gage, and means responsive to the curvature of the successive edge increments approaching said center for automatically controlling the operating speed and direction of the guidance means in swinging the work thereabout.

5. In a machine having a tool for progressively operating on or near the margin of a flexible work piece, a work support, an edge gage on the support arranged marginally to be engaged by the work ahead of the tool, an inner and an outer wheel rotatably engageable with the work at points lying on a radius extending substantially through a turning center adjacent to the gage, and electrical means for controlling the differential in speeds of the wheels when acting to turn the work about said center, said means being responsive to changes in curvature of the work margin as measured at a locality adjacent to the turning center thereby predeterminedly to position the margin with respect to the tool.

6. A machine as set forth in claim 5 and further characterized in that the electrical means comprises a source of light at one side of the work, a light detecting means disposed on the other side of the work for receiving the light beams emitted from said source and passing the work margin at said locality, a servo motor, and means controlling the motor for amplifying in terms of voltage the light level received by the detecting means with reference to a standard level corresponding to deviation of the work margin from said locality.

7. In a machine having a tool for operating progressively on or near the margin of a flexible work piece, a work support formed with an aperture and having a turning post adjacent thereto, said tool being arranged to operate on the work piece on the other side of the turning post from said aperture, a pair of work engaging wheels arranged to turn the work about a center substantially on the turning post, detecting means responsive to rays directed through the aperture and passing the edge of the work fed thereover, and servo amplifier means controlled by the detecting means for changing the differential velocity of said wheels in accordance with changes in edge curvature of the work.

8. In a machine having a tool for operating on a work piece, means engageable therewith for guiding the work piece relatively to the tool, said means comprising, at opposite sides of the work, a light source and sensing means responsive to the level of light passing the edge of the work piece in a locality just ahead of the tool, and servo amplifier means connected to the sensing means and responsive to reduction in said light below a predetermined level upon initial presentation of the work piece to

the tool for shifting the guiding means into operative position.

9. A machine as set forth in claim 8, and further characterized in that said servo amplifier means is further adapted, upon the level of light passing the work edge in said locality exceeding a predetermined level, to cause the guiding means to feed the work away from the tool.

10. In a machine having a tool for operating on a work piece, a gage arranged to be engaged progressively by the margin of the work piece ahead of the tool, means for causing the tool intermittently to engage and feed the work rectilinearly past the gage, means disposed to steer the work with respect to the tool and about a center adjacent to the gage, and automatic mechanism responsive to the curvature of the successive marginal portions approaching the gage and adapted to render said steering means effective in the intervals when the tool operating means is not operable to feed the work, the degree of steering corresponding with the degree of curvature.

11. In a machine having a work support and a tool adapted to operate on a work piece on the support, mechanism for intermittently operating the tool, means operatively connected to said mechanism for steering the work in translation, and curvature sensing means for causing the steering means to operate while the tool operating means is inoperative to turn the work on the support about a substantially fixed center.

12. In a machine having a work support and a tool adapted to operate on a work piece on the support, mechanism for causing the tool to impart step-by-step feeding movement to the work, a pair of reversible work control wheels frictionally engageable with the work at points spaced inwardly from the tool, means for operating the work control wheels including gearing independently interconnecting them with said mechanism, and servo control means operatively connected to the work control wheel operating means, said servo control means being responsive to changes in curvature of the edge of the work piece in a locality ahead of the tool for changing the velocity of the work control wheels whereby they steer the work when said feeding mechanism is inoperative.

13. A machine as set forth in claim 12, and further characterized in that said servo control means is of low power output compared with said feeding mechanism and arranged to cause the control wheels to supplement the feeding action of the mechanism when it is operative.

14. A machine as set forth in claim 12, and further characterized in that an edge gage is mounted on the work support, said work support is formed with an opening adjacent to the gage in a position to be traversed progressively by the edge of the work piece, a source of light is provided at one side of said opening, and means at the other side thereof is responsive to light from said source passing the edge of the work for energizing the servo control means.

15. An edge treating machine of the type having a work support provided with a turning post and members cooperative to feed the work intermittently past the post, said machine comprising automatic means engageable with the work for guiding its margin progressively with respect to the post and said members, and mechanism for effectively actuating the guiding means in the intervals when the work is not being fed and according to the curvature of its edge in the vicinity of said turning post.

16. In an edge folding machine of the type having a work support provided with a turning post and a hammer for folding successive marginal portions of a work piece on the support turned up by said post, means respectively engageable with the work piece at points spaced inwardly of its contact with the turning post to guide the work piece with respect to the hammer, and automatic mechanism for causing said guide means, when the hammer is disengaged from the work, to exert fixedly pro-

portionate steering forces at said points according to the curvature of the marginal portions approaching the post.

17. In an edge folding machine of the type having a work support provided with a turning post and a hammer for folding successive marginal portions of a work piece on the support turned up by said post, mechanism for causing the hammer intermittently to feed the work past the post, means respectively engageable with the work piece at points spaced inwardly of its contact with the turning post to guide the work piece with respect to the hammer, and automatic mechanism for causing said guide means, when the hammer is disengaged from the work, to exert fixedly proportionate steering forces at said points according to the curvature of the marginal portions approaching the post, said automatic mechanism being adapted to have no steering effect on the guide means when the hammer is engaging the work to feed it.

18. In an edge folding machine of the type having a work support, a turning post, and a hammer and anvil cooperative to fold and feed successive marginal portions of a work piece on the support past said post, means for thus intermittently operating the hammer and anvil, a pair of reversible work control wheels frictionally engageable with the work to swing it about a point substantially on the turning post in accordance with changes in curvature of the marginal portions adjacent thereto, and mechanism for rotating said control wheels effectively with variable speeds and fixedly proportionate velocities only in the intervals when the hammer and anvil operating means is inoperative.

19. A machine as set forth in claim 18, and further characterized in that independent mechanical driving connections are provided between the work control wheels and said hammer and anvil operating means, respectively, and said mechanism for rotating the control wheels is operatively connected to the independent mechanical driving connections by a servo motor of servo amplifier means responsive to said curvature.

20. In an edge folding machine of the type having a work support, a turning post, and a hammer and anvil cooperative to fold and feed successive portions of a work piece on the support past said post, means for thus intermittently operating the hammer and anvil, a pair of reversible work control wheels frictionally engageable with the work to swing it about a point substantially on the turning post, mechanical means for operating the work control wheels including gearing independently interconnecting them, respectively, with said hammer and anvil operating means, and electrical means operative when the last mentioned means is inoperative for rotating said control wheels with differential velocity proportionate to curvature of the marginal portions approaching the post, said electrical means including a source of light at one side of the support, and a photoelectric cell responsive to light from said source passing said marginal portions.

21. A machine as set forth in claim 20, and further characterized in that said electrical means comprises servo amplifier means including a servo motor connected to the photoelectric cell, the output of said motor being operatively connected to said mechanical means but of very much lower power.

22. In an edge folding machine of the type having a work support, a turning post, and a hammer and anvil cooperative to fold and feed successive portions of a work piece on the support past said post, a pair of work control wheels frictionally engageable with the work piece inwardly of its edge to change the direction of feed, mechanism including a drive shaft and gearing driven thereby for intermittently operating the hammer and anvil and said control wheels to feed the work piece in one direction, and electrical means operatively connected to said gearing and effectively operative when said mechanism is inoperative for causing the control wheels to exert a reversible moment for turning the work piece about a se-

lected turning center, said means being responsive to changes in curvature of the work piece edge as determined in a locality adjacent to the post.

23. A machine as set forth in claim 22, and further characterized in that said wheels differ in diameter, the wheels being mounted for independent rotation on an axis inclined to the work supporting surface of said support and lying in a plane substantially coincident with said turning center and normal to said surface.

24. A machine as set forth in claim 22, and further characterized in that said gearing comprises sun pinions carried by said shaft and coaxial planetary gears meshing with said pinions, respectively, the operative connection between said electrical means and said mechanism consisting of an output pinion of a servo motor for driving said planetary gears about the axis of said shaft.

25. A machine as set forth in claim 22, and further characterized in that means is provided for synchronously moving said work control wheels toward and from operating positions in which they cooperate with the work support frictionally to engage work pieces of different thickness, and said mechanism is adapted to continue its operative relation with the control wheels in their various positions whereby work pieces of different thickness and/or varying thicknesses may be accommodated.

26. A machine as set forth in claim 22, and further characterized in that said electrical means comprises a photo-sensitive means for detecting said changes in edge curvature, with reference to a preset light level and corresponding voltage level, and means for adjusting the just-mentioned levels to determine the width of fold to be effected by the hammer and anvil.

27. In an edge folding machine of the type having a work support, a turning post, and a hammer and anvil cooperative to fold and feed successive portions of a work

piece on the support past said post, a pair of work control wheels arranged for frictional engagement with the work piece at different distances from the locality where its edge is upturned by said post, said wheels being mounted for reversible rotation on an axis nearly coincident with a plane normal to the direction of feed and passing through said locality, mechanism for causing the hammer and anvil, together with said control wheels, to feed the work piece intermittently and rectilinearly, and photo-electric means responsive to the position of the edge of the work piece just ahead of where it is being upturned for varying and reversing the speeds of rotation of the control wheels while maintaining their velocities fixedly proportionate.

28. A machine for operating on sheet material comprising a work support, an edge gage thereon, a tool repeatedly engageable with the margin of work on the support progressively to perform a finishing operation, means independently mounting a pair of coaxial, reversibly rotative wheels for frictional engagement with the work at points substantially in a line with its locality of contact with the edge gage, and mechanism for operating said wheels with constant ratio velocity at speeds determined by the curvature of the margin approaching said gage, said mechanism effectively operating alternately with said tool to guide the work thereto.

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