

**April 13, 1937.**

M. ROMAINE

**2,076,865**

# MANUALLY CONTROLLED COPYING MACHINE

Filed Dec. 28, 1935

3 Sheets-Sheet 1

Fig. 1

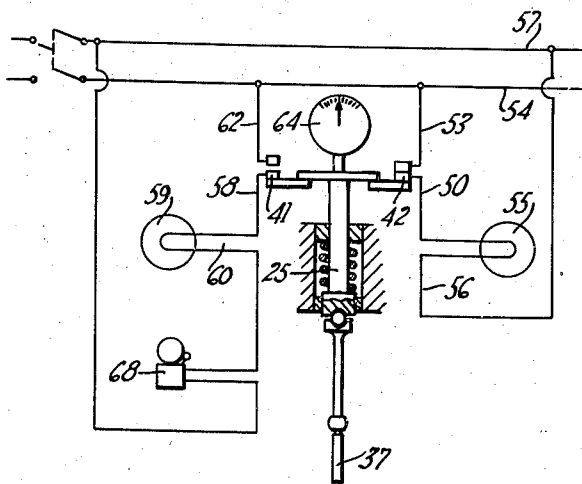
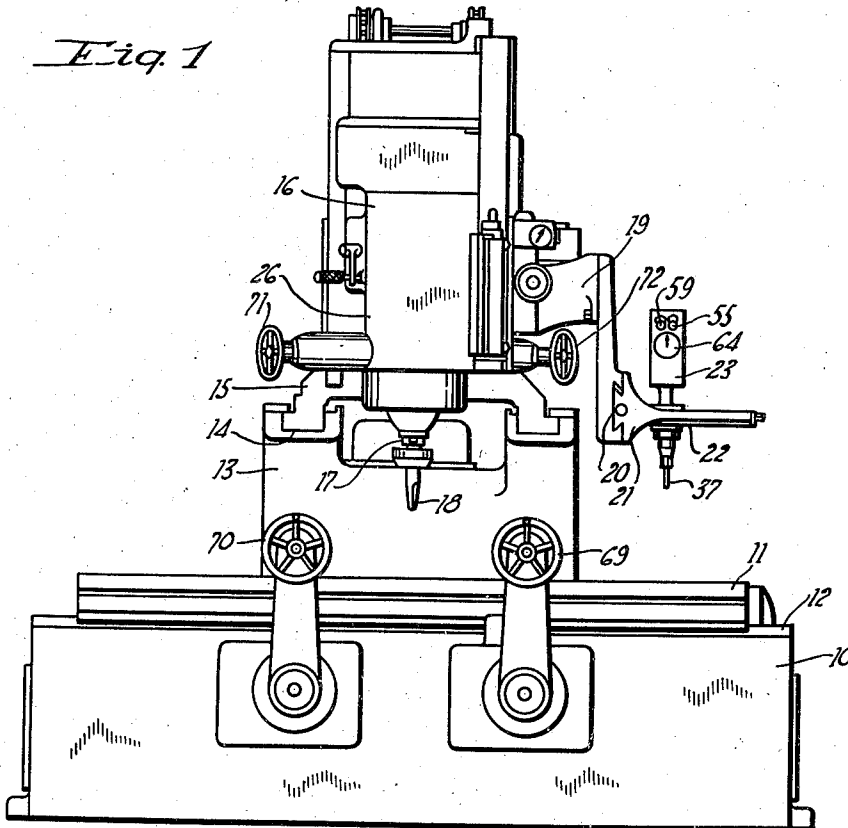


*Fig. 4*

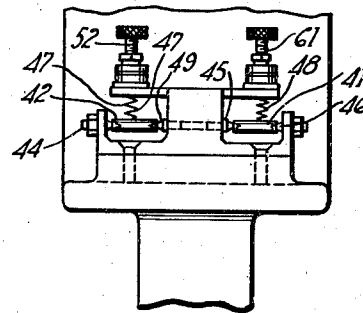


*Fig. 5*

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3 Sheets-Sheet 2

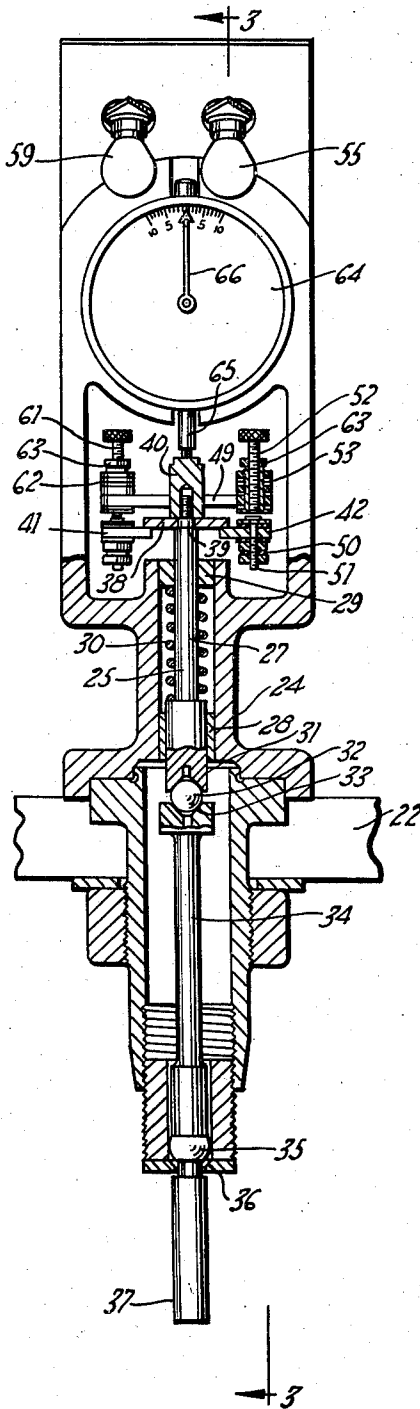


Fig. 2

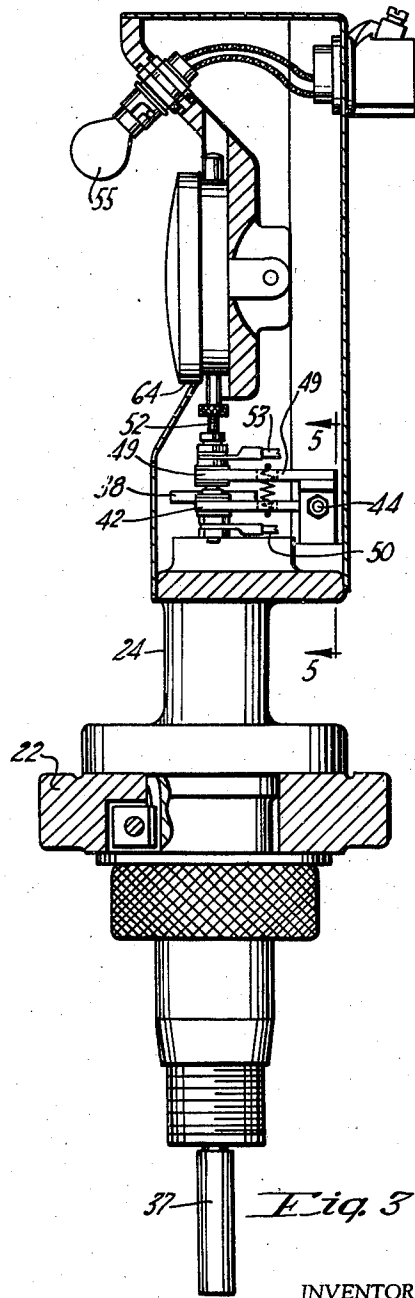


Fig. 3

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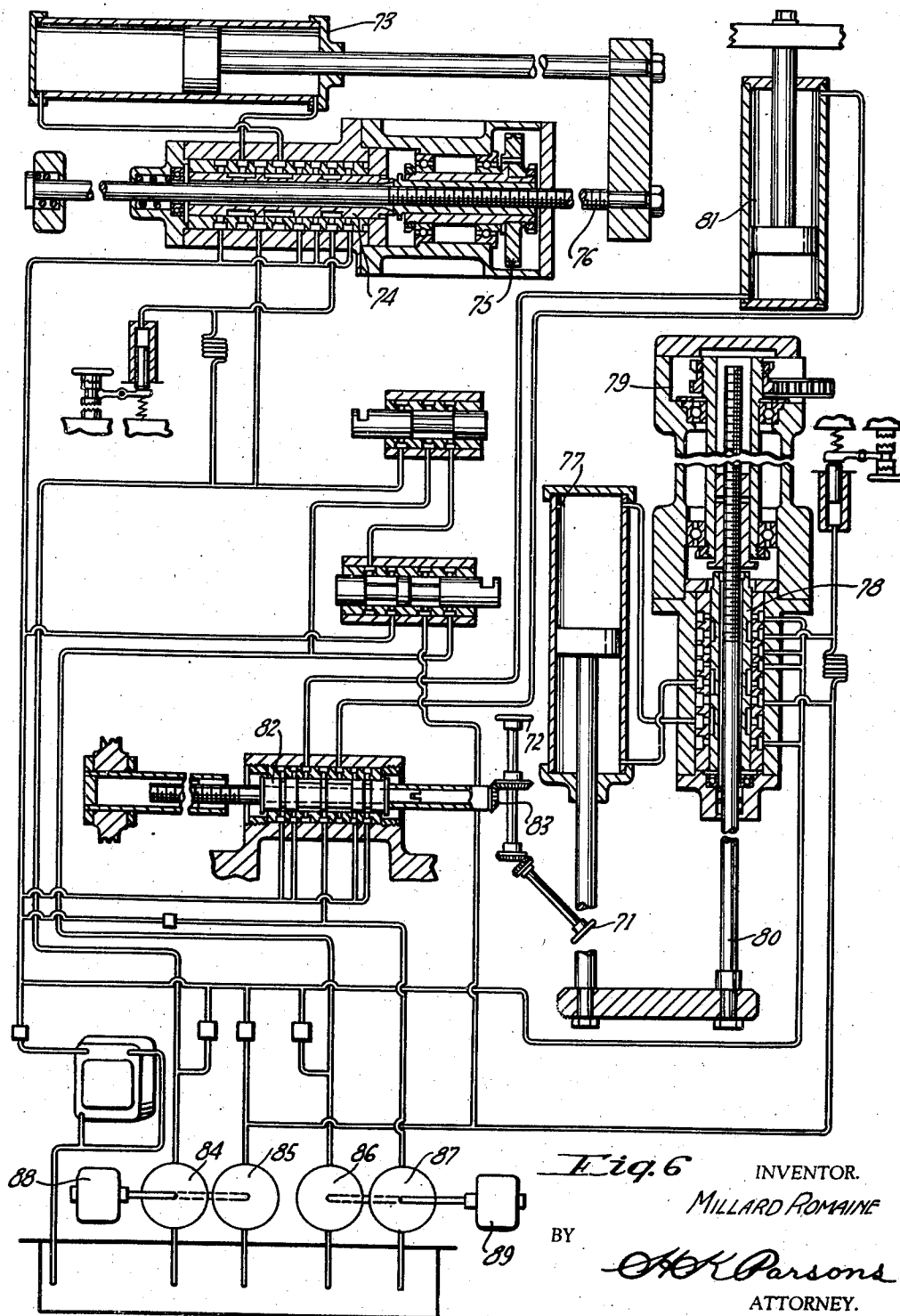
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MANUALLY CONTROLLED COPYING MACHINE

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3 Sheets-Sheet 3



## UNITED STATES PATENT OFFICE

2,076,865

MANUALLY CONTROLLED COPYING  
MACHINE

Millard Romaine, Cincinnati, Ohio, assignor to  
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Ohio, a corporation of Ohio

Application December 28, 1935, Serial No. 56,579

12 Claims. (Cl. 90—62)

This invention relates to machine tools and more particularly to improvements in copying machines of the non-automatic type.

One of the main objects of this invention is to provide an improved form of piloting means for machines of the character described.

Another object of this invention is to provide improvements in machines of the character described which will improve the accuracy of reproduction thereof.

A further object of this invention is to improve the construction and operation of such machines so as to reduce the effort on the part of the operator.

An additional object of this invention is to improve the construction and operation of machines of the character described so that mechanical advantage means may be utilized between the manual controls and the parts controlled thereby which will reduce the effort on the part of the operator without loss of reproduction accuracy.

A still further object of this invention is to improve the construction and control of copying machines of the non-automatic type whereby lighter pressures between the tracer and pattern are rendered possible so that other than metal patterns may be utilized in such machines.

Other objects and advantages of the present invention should be readily apparent by reference to the following specification, considered in conjunction with the accompanying drawings forming a part thereof and it is to be understood that any modifications may be made in the exact structural details there shown and described, within the scope of the appended claims, without departing from or exceeding the spirit of the invention.

Referring to the drawings in which like reference numerals indicate like or similar parts:

Figure 1 is a front elevation of a machine tool embodying the principles of this invention.

Figure 2 is a vertical section through the tracer head.

Figure 3 is a section on the line 3—3 of Figure 2.

Figure 4 is a diagram of the electrical control circuit.

Figure 5 is a section on the line 5—5 of Figure 3.

Figure 6 is a diagram of the operating and control circuit of the machine.

In a conventional form of copying machine of the non-automatic type known in the art as a profiling machine, a first slide is provided which carries a tool and tracer, and a second slide is provided which carries the work and pattern.

The tracer in this machine is merely a rigid member depending from the slide and having a suitably shaped end of equal diameter to the cutter for engaging the pattern, and by means of manual controls the end of the tracer is kept in engagement with the pattern during relative traversing movement between the slides, whereby a surface is produced by the cutter having a geometrical outline which is congruent to the outline of the pattern.

The disadvantages of this type of machine are that the tracer must be held with considerable pressure against the pattern in order that the cutter may be held to the work, which necessitated the use of metal patterns; the cutting force has to be applied by the operator; and a mechanical advantage means of any real effective type cannot be used because the operator has to depend, to a certain extent, upon his sense of touch in order to determine if the tracer was in proper contact with the pattern.

In a non-automatic type of machine, such as this, it will be evident that the tracer, pattern, and the effect produced by the two upon the sense of touch of the operator, constitute a piloting means which is utilized and interpreted by the operator to guide the tool over a desired path. In other words, there is no direct connection between the piloting means and the controls whereby one automatically controls the other.

The term "piloting means" is thus used in this specification in the sense of a means for determining the tool's position; the course or courses over which the tool is to be moved; and when a change in course should be made so that the summation of all the courses represented by the completed path of the tool will produce a finished outline which is congruent to the outline scanned by the tracer.

In this invention the machine is provided with an improved form of piloting means which makes possible other improvements in the machine with the net result that the labor of operating the machine is materially reduced; that precision accuracy may be obtained; that patterns of softer material than metal can be utilized; and that a saving in time per piece may be effected.

In Figure 1 is an exemplary embodiment of the machine, the principal elements of which comprise a base or bed 10; a table 11 reciprocally mounted on guideways 12 formed on the bed; and a portion 13 upstanding from the bed and having guideways 14 upon which is reciprocally mounted a horizontally movable ram 15. A spindle carrier 16 is vertically guided in the

forward end of the ram 15 for up and down movement and this carrier has a tool spindle 17 journaled therein for rotating a tool or cutter 18.

A bracket 19 is attached to the side of the carrier 16 and has a horizontal extending dovetail guideway 20 for receiving and supporting a slide 21. This slide supports a second slide 22 for adjustment in a horizontal direction at right angles to the direction of movement of the slide 21. The slide 22 supports a piloting means indicated generally by the reference numeral 23.

Referring now to Figures 2 and 3, the piloting means includes a tracer head 24 having a vertical axis 25 which is parallel to the vertical axis 26 of the cutter spindle and these axes normally lie in a vertical plane which is parallel to the direction of movement of the table 11. For duplicating purposes, the pattern and work piece are positioned on the table with corresponding starting points spaced apart the same distance as the spacing of the aforementioned axes.

The tracer head 24 has a vertically movable plunger 27 which is guided at 28 and 29 and is continually urged downward by a spring 30. The lower end of the plunger has a conical-shaped depression 31 which engages a ball 32, the ball resting in a conically-shaped depression 33 formed in the upper end of a tracer arm 34. The tracer arm has a spherically-shaped portion 35 by which it is supported in the end 36 of the tracer head for universal movement. A tracer or stylus 37 is integrally attached to the lower end of the tracer arm for engagement with the pattern.

From the foregoing it will be noted that the tracer is supported for lateral movement or deflection and that the spring 30 acting through the vertical plunger 27 and the ball 32 act to normally maintain the tracer in a vertical position, that is, with its axis parallel to the cutter spindle axis. The tracer head has indicating means associated therewith which signal to the operator the manner in which he should operate the controls of the machine, and this indicating means is operated by the tracer and therefore it is necessary that the tracer be supported for movement by the pattern so that a motivating agent may be provided. It is contemplated in the normal operation of this machine that throughout the cutting operation the tracer shall be deflected a predetermined amount and a signal provided to indicate when the tracer is deflected this predetermined amount, as well as other signals to indicate when this amount is exceeded or diminished so that the operator is enabled, with the assistance of these signals, to maintain the tracer always deflected this predetermined amount and thus be able to produce a work piece which is an exact duplicate of the pattern.

As previously mentioned, prior machines had a tracer which was equal in diameter to the diameter of the cutter for duplicating operations, but in the machine of this invention, since it is necessary to have the tracer deflectible, a correction is necessary and the tracer portion which contacts the pattern should be larger in radius than the cutter by an amount equal to the aforementioned predetermined deflection. The pattern and work piece must still be set up on the machine in the manner previously described.

Due to the conical depressions in opposing ends of members 27 and 34, the intervening ball 32, and the spring 30 which always maintains these parts in contact, it will be evident that when the portion 35 is resting upon the support 36 and the

tracer is deflected that the upper end of the tracer arm will move relative to the axis of the plunger 27 and roll the ball 32 on the conical depressions to cause upward movement of plunger 27. On the other hand, if the tracer 37 is moved axially so as to raise the portion 35 off of the seat 36 the same effect will be produced on plunger 27. The movement of the plunger 27 is utilized as the motivating agent for actuating the signal mechanism.

This mechanism comprises a cross arm 38 mounted on a reduced portion 39 of the upper end of the plunger and held in place by the member 40 threaded on the end of the plunger. A pair of switching members 41 and 42 are pivotally supported in the tracer head, as more particularly shown in Figure 5. The supporting means comprises a fixed conical point 43 engaging one side of the member and an adjustable conical point 44 engaging the other side of the member, whereby an exact fit may be obtained for free movement without lost motion. The member 41 is likewise supported on a fixed conical point 45, and an adjustable conical point 46. Springs 47 and 48 are interposed between a fixed member 49 and the members 42 and 41 for constantly urging the members in an upward direction to close the circuits controlled by each.

The switching member 42 has a flexible lead 50 connected to the contact 51 carried by the member 42, which is adapted to engage a contact 52 carried by, but insulated from, the member 49. The contact 52 has a flexible lead 53 electrically connected thereto. As shown in Figure 4, the lead 53 may be connected to a power main 54 and the lead 50 may be connected to a light 55. In order to complete the circuit, an additional line 56 connects the light to a second power main 57. Thus, when the switching member 42 is raised by the spring 48 the circuit is closed and the light 55 will be turned on.

The switching member 41 is similarly constructed and has a flexible lead 58 connected thereto, leading to light 59 and the other terminal of the light is connected by a line 60 to the power main 57. The member 49 carries a second contact member 61 insulated therefrom and connected by a lead 62 to power main 54. The contact members 52 and 61 are threaded in sleeves to permit vertical adjustment thereof, and lock nuts 63 are provided for securing them in adjusted position.

It will be noted from Figure 2 that the cross bar 38 engages the upper side of the switching members 41 and 42 and when the tracer is held in an undeflected position by the spring 30, the plunger 27 is in its lowermost position, and in this position the cross bar holds the switching members 41 and 42 against the action of springs 47 and 48 in such a position that both of the circuits controlled thereby are open. Furthermore, the contact 61 is so adjusted that it is further away from the switching member 41 than the contact 52 is from the switching member 42, with the result that upon upward movement of the member 27, caused by deflection of the tracer, the switching member 42 will close its circuit before the switching member 41 closes its circuit. The amount of movement that the member 27 has, after permitting the switching member 42 to close its circuit and when it permits the switching member 41 to close its circuit, corresponds to the permissible variation of the tracer in its predetermined deflected position. In other words, when the tracer is out of contact with the

pattern, neither one of the lights is lit, and the tracer may be deflected a small amount and still not close the circuit to either of said lights. When the tracer has been deflected, however, a sufficient amount to permit the switching member 42 to close its circuit, the light 55, which is a white light, is illuminated as a signal to the operator that the tracer is deflected the desired working amount.

Within permissible variations, depending upon the precision limits of accuracy and thereby the setting of the contact member 61, the tracer may be deflected a slight additional amount without changing the signal lights. When this permissible variable has been exceeded, however, the switching member 41 will close its circuit, which will illuminate light 59 which is a red light, and thus signal to the operator that the amount of tracer deflection has been exceeded and that adjustments should be made to reduce the amount of tracer deflection.

In addition to the lights, an indicator 64 is mounted in the tracer head and has a spring pressed plunger 65 adapted to engage the member 40 whereby upward movement of the plunger 27 will cause rotation of the indicator pointer 66 in a clockwise direction. The dial may be suitably graduated micrometrically in thousandths of an inch or less and a zero graduation 67 provided to indicate when the tracer has the predetermined desired amount of deflection, whereby variations from this predetermined amount, either above or below, may be read on the dial.

As an example, the pointer 66 may take up a position five points or rhumbs counterclockwise from the zero point 67 when the tracer is undeflected and as the tracer is deflected by engagement with the pattern, the pointer 66 may move three rhumbs clockwise before the white light is illuminated. The pointer 66 may not only be movable over two rhumbs counterclockwise from the zero point but also two rhumbs clockwise from the zero point, while the white light is illuminated and before the red light is illuminated. If the tracer is deflected an excessive amount beyond this range, then the red light is illuminated, and as a further signal to the operator an audible signal in the form of an electrical buzzer or bell 68 may be connected in series with a light 59, as shown in the diagram of Figure 4, to insure that the operator does not overrun the desired outline. Thus, the pointer may be movable over a certain range, the limits of which represent the plus and minus limits of accuracy within which the pattern is to be reproduced and the white light alone is a signal to the operator that he is staying within those limits and therefore indicates that the deflection of the tracer is coarsely adjusted somewhere between these safe limits and the pointer indicates the exact or fine adjustment of the tracer deflection.

Although the white light is utilized to indicate a certain range of tracer deflection and signals are provided to indicate when each end of the range has been reached, the operator may still work to a greater degree of accuracy by actually following the movement of the pointer.

Since a piloting means has now been provided, which acts independently of the machine controls, or in other words, since the machine controls no longer have to be depended upon to carry the necessary signal to the operator, the manual controls may now be connected to the parts to be

moved through the medium of any desired type of power amplifying or mechanical advantage mechanism. Advantage is taken of this situation to provide such a mechanism which is of such a nature that it will relieve the burden on the operator of providing the cutting force which was necessary in prior machines, as previously described.

A manual control in the form of a hand wheel 69 is provided on the front of the bed 10 and operatively connected for movement of the table 11; and a second hand wheel 70 is supported on the front of the bed 10 and operatively connected for moving the ram 15 toward and from the front of the machine, or in other words, transversely over the table 11. In addition, a pair of hand wheels 71 and 72 are supported on the vertical slide 16 and operatively connected for causing vertical movement of the slide, the two hand wheels being connected to the same mechanism. The purpose of providing two hand wheels is merely for convenience of operating the machine from different stations.

Each of these hand wheels may be connected for operation of its respective slide through the medium of a servo-motor mechanism which may be of any conventional form and the particular form utilized does not constitute a part of this invention. Therefore, it may be the same as that shown in co-pending application, Serial Number 40,060, filed September 11, 1935, of Erwin G. Roehm and Millard Romaine. The essential parts of the various servo-motor mechanisms are illustrated in Figure 6. Briefly, there is shown in that figure a piston and cylinder mechanism, indicated generally by the reference numeral 73, which is operatively connected with the table 11 and is controlled by a servo-valve mechanism indicated generally by the reference numeral 74. The servo-valve is operated by a sprocket wheel 75, which is operatively connected through suitable means to the hand wheel 69 whereby rotation of the hand wheel will shift the servo-valve out of a stop position and a feed back rod 76 will reposition the valve to a stop position.

The ram 15 is moved by a piston and cylinder mechanism, indicated generally by the reference numeral 77, and a servo-valve mechanism, indicated generally by the reference numeral 78, is utilized to control the flow to said cylinder. The servo-valve is operated by a sprocket wheel 79 operatively connected through suitable means to the hand wheel 70 to initiate flow to one end or the other of the cylinder and a feed back rod 80 serves to reposition the valve to a stop position.

The vertical slide 16 is moved by a piston and cylinder mechanism, indicated generally by the reference numeral 81, the piston in this case being stationary and the cylinder being the movable member. The cylinder is connected to a servo-valve mechanism, indicated generally by the reference numeral 82, and the valve is operated by a bevel gear 83 operatively connected to the hand wheels 72 and 71.

Fluid pressure may be supplied to these servo-motor mechanisms from a suitable source of pressure, such as the series of pumps 84, 85, 86 and 87, operated by prime movers 88 and 89.

For profiling operations in which the pattern and work lie, for instance, in a horizontal plane on the table, the vertical slide is moved downward by means of either hand wheel 71 or 72 until the tracer and cutter are in such a position that a relative lateral movement between the cutter and work will effect interengagement thereof and

then the hand wheels 69 and 70 are manipulated in accordance with the signals from the piloting means to maintain the tracer in contact with the pattern and at the desired amount of deflection while the cutter is traversed around the work piece.

In addition to simple profiling operations, as just described, the machine may also be utilized for die-sinking operations, in which case, after the tracer has been engaged with the pattern the hand wheel 72, for instance, and the hand wheel 69 are manipulated in such a fashion that the cutter is moved up and down during traversing movement of the table 11. If it is more convenient and time-saving to traverse the pattern transversely of the table 11, the table may be left stationary and the hand wheel 70 manipulated in conjunction with the hand wheel 71, whereby the plane of the cut will lie crosswise of the table. In some metal removing operations the surface to be produced is a plane surface requiring, for instance, merely the setting of the cutter to depth after which one or more of the slides 11 and 15 are manipulated to effect the cut. If the cut begins at a shoulder on the pattern or ends at a shoulder, the piloting means will automatically signal when the shoulder has been reached and that a new course or direction of movement of the cutter should be effected. The piloting means thus signals to the operator in any case when a change in course, that is, a selection of a new course or direction of movement of the cutter, should be effected.

From the foregoing it will now be seen that manually controlled power amplifying means have been provided for steering the tool along any desired path with respect to the work and that the piloting system indicates, not only when the tool has penetrated the work the desired amount to produce the desired surface, but also clockwise or counterclockwise departures of the tool while traversing from the desired path as predetermined by the pattern.

It is to be understood that the machine in connection with which the invention has been described has been selected for illustrative purposes only, and the invention is not to be considered as confined to the particular machine shown, it having equal application to other metal working machines, including grinding machines wherever it is possible to vary the relation between the tool and work in a direction angularly related to a general traversing direction.

There has thus been provided an improved copying machine of the non-automatic type, which has an improved form of piloting means which is more sensitive and accurate than prior structures and which makes possible the use of other than metal patterns or masters, due to lighter tracer pressure and also the use of power amplifying means between the manual controls and the parts moved, thereby reducing the operator's labors.

I claim:

1. In a profiling machine, the combination with manually operable means for steering a tool along a path predetermined by a pattern in contact with a tracer, of a first signaling means to indicate clockwise departures of the tool from said path, and additional means to signal counterclockwise departures of the tool from said path.

2. In a copying machine the combination with manually operable means for steering a tool along a path predetermined by a pattern in contact with a tracer, of a first visual signaling means to

indicate clockwise departures of the tool from said path, additional visual signaling means to indicate counterclockwise departures of the tool from said path, one of said signaling means also including an audible signal.

3. In a copying machine the combination with manually operable means for steering a tool along a path predetermined by a pattern, of a tracer in contact with said pattern, a first signal light to indicate clockwise departures of the tool from said path, a second signal light to indicate counterclockwise departures of the tool from said path, and means operatively connecting said signal lights for control by said tracer.

4. In a copying machine, the combination with manually operable means for steering a tool along a path predetermined by a pattern, of a first signal light to indicate departures of the tool to one side of said path, a second signal light for indicating departures of said tool to the other side of said path, a tracer in contact with said pattern, electrical circuits connecting said lights for control by said tracer, and an audible signal connected in series in one of said circuits.

5. In a copying machine having a work support and a tool support, the combination with a rotatable cutter journaled in said tool support, of manually operable means for effecting relative movement between the supports in a direction whereby the cutter will penetrate the work, a pattern, a signal light automatically illuminated by the pattern to indicate when the cutter has penetrated the work within the limits predetermined by the pattern, and additional signaling means automatically operable by the pattern to indicate transgressions of said limits.

6. In a profiling machine, the combination with a work supporting slide, of a tool head, a tracer head connected for concurrent movement with the tool head, a manual control operatively connected for effecting a relative feeding movement between the heads and the slide, a tracer arm carried by the tracer head, a second manual control operatively connected for effecting relative movement between the heads and slide in a direction normal to said feeding direction to maintain the tracer arm in contact with a pattern, said tracer arm being deflectible relative to the axis of the tracer head, and means responsive to an over-deflected or underdeflected condition of the tracer to visually indicate either condition to the operator.

7. In a contouring machine in which a cutter is moved over a work piece to duplicate a pattern, the combination of a tracer arm adapted to be swung laterally about a fixed axis when engaging the pattern, a manual control operatively connected for effecting relative movement between the tracer and pattern and in a direction to increase or decrease the amount of tracer deflection, and means responsive to movement of the tracer to indicate positive or negative variations in the amount of deflection thereof.

8. In piloting means for a copying machine, a housing, a tracer supported for universal movement in the housing for deflection by a pattern, electrically operated signaling means carried by the housing for indicating either positive or negative variations of the tracer from a working deflected position, and means operable by the tracer for controlling said signaling means.

9. In a tracer mechanism, the combination of a housing, a tracer arm pivoted for universal movement in said housing, a pair of signal lights carried by said housing, control circuits for the

lights including contacts for closing said circuits, and means carried by the tracer for successively closing said contacts during unidirectional deflection of the tracer.

- 5 10. In a piloting mechanism for a copying machine, the combination of a housing, a deflectible tracer, a pair of signal lights carried by the housing, one to indicate overdeflections of the tracer and the other to indicate a normal working deflected position of the tracer, individual switch  
10 contacts for controlling the electrical circuit to each light, means normally urging the contacts to a circuit closing position, and means operable by the tracer for controlling the closing of said con-  
15 tacts.

11. In a tracer mechanism, a housing, a deflectible tracer, a plunger axially movable by tracer deflection, a plurality of signal lights carried by

the housing to indicate different amounts of tracer deflection, electrical control circuits for the lights, means operable by the plunger for controlling said circuits, an indicator dial, and means operable by the plunger for simultaneously operating said dial while controlling said lights.

12. In a piloting mechanism for a manually controlled copying machine, the combination of a housing, a universally deflectible tracer carried by the housing for engaging a pattern, a plurality of  
10 visual signals carried by the housing for indicating different amounts of tracer deflection, an indicator dial for continuously recording the amount of tracer deflection, an audible signal for indicating overdeflections of the tracer, and means operatively connecting all of said parts for control  
15 by the tracer.

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