Nov. 19, 1957 W. K. SCHMID 2,813,461

FEELER CONTROLS

Filed Dec. 14, 1953 9 Sheets-Sheet 1

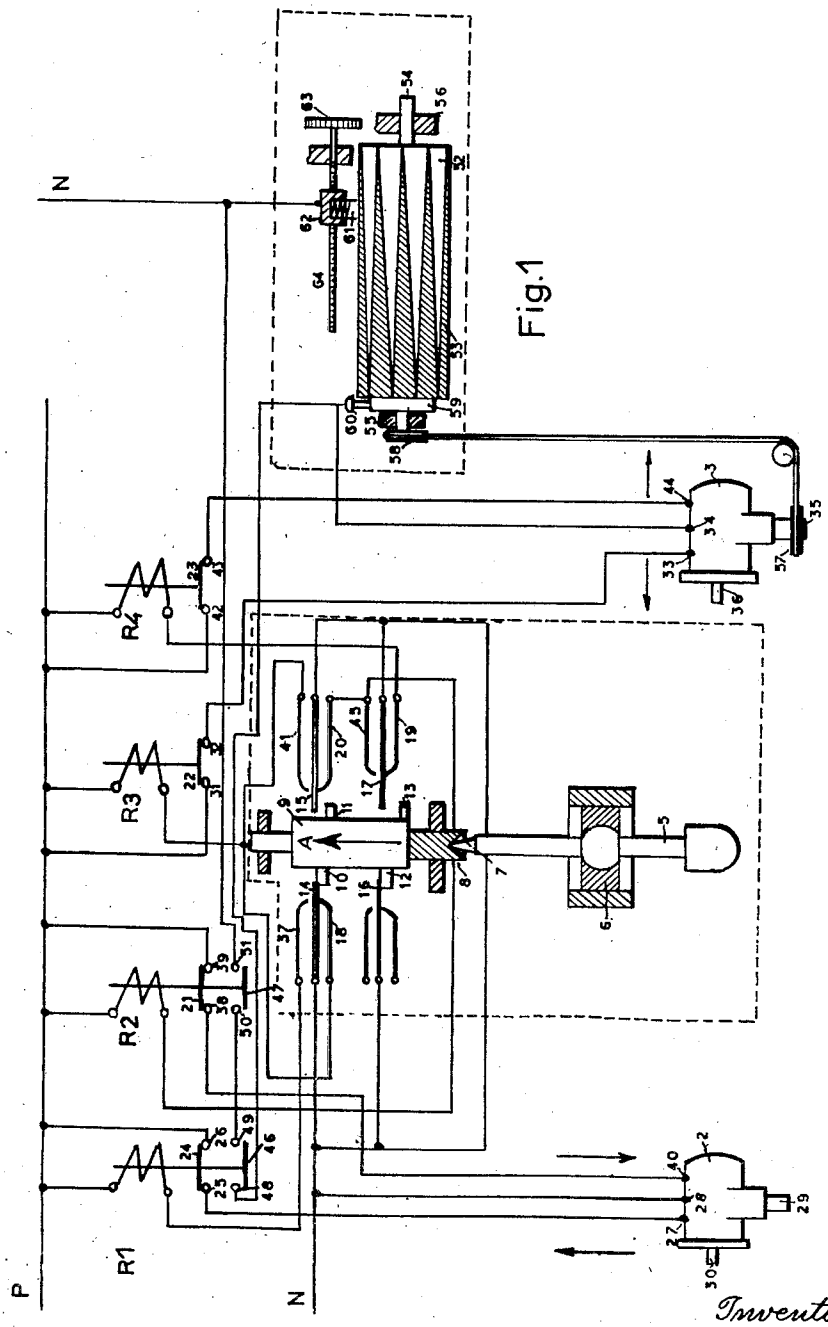


Fig.1

Inventor
Wolfgang Karl Schmid
By Eric D. Raukel
Agent

Nov. 19, 1957 W. K. SCHMID 2,813,461
FEELER CONTROLS
Filed Dec. 14, 1953 9 Sheets-Sheet 2

Fig.2

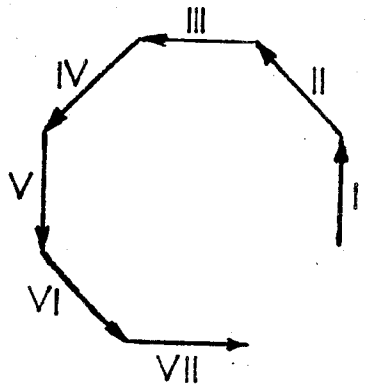


Fig.3

	R1	R2	R3	R4	
I	out	on	on	on	↑
II	out	on	out	on	↖
III	on	on	out	on	←
IV	on	out	out	on	↙
V	on	out	on	on	↓
VI	on	out	on	out	↘
VII	on	on	on	out	→

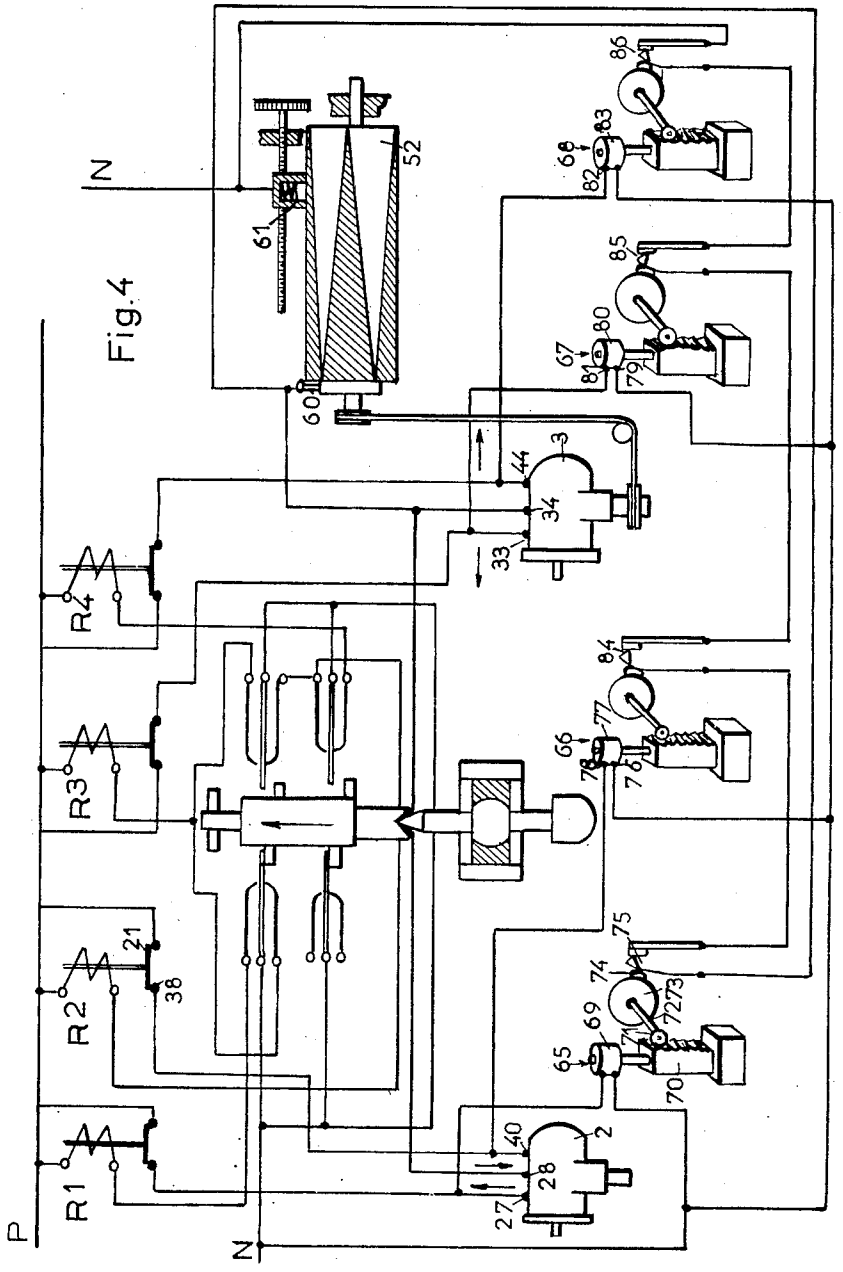
Inventor
Wolfgang Karl Schmid
By Eric D. Rauhut
Agent

Nov. 19, 1957 W. K. SCHMID 2,813,461

FEELER CONTROLS

Filed Dec. 14, 1953 9 Sheets-Sheet 3

Fig. 4



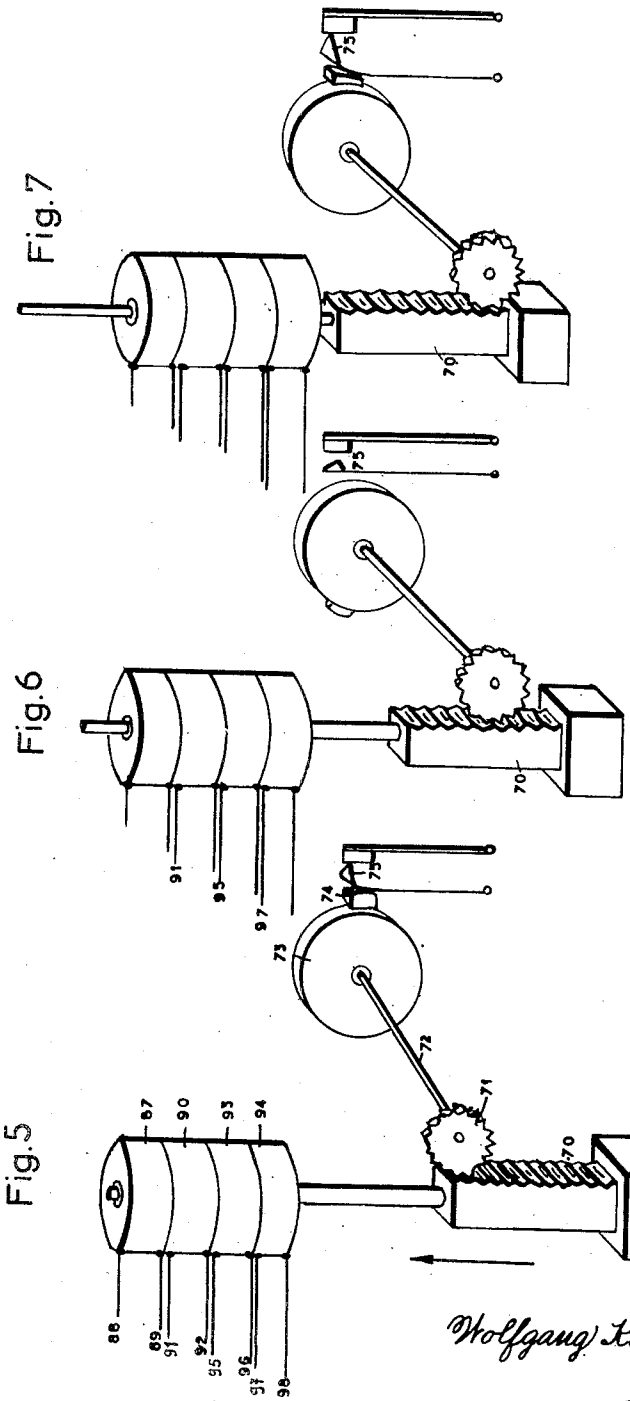
Inventor
Wolfgang Karl Schmid

By Eric D. Haukel
Agent

Nov. 19, 1957 W. K. SCHMID 2,813,461

FEELER CONTROLS

Filed Dec. 14, 1953 9 Sheets-Sheet 4



Inventor
Wolfgang Karl Schmid

By Eric D. Mackel
Agent

Nov. 19, 1957 W. K. SCHMID 2,813,461

FEELER CONTROLS

Filed Dec. 14, 1953 9 Sheets-Sheet 5

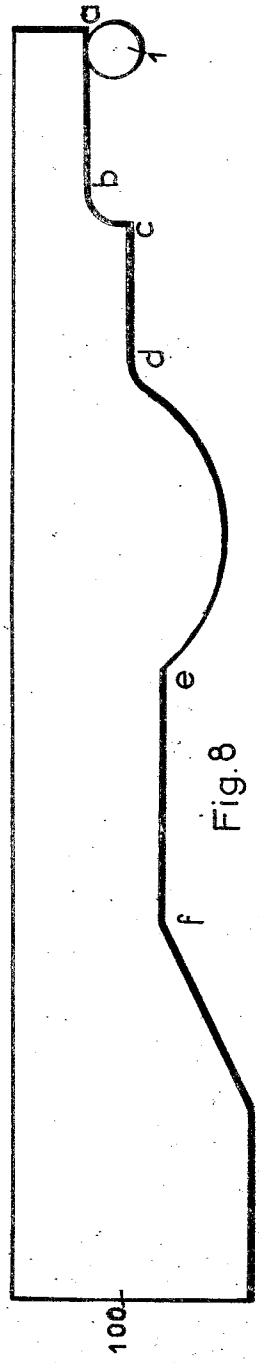


Fig. 8

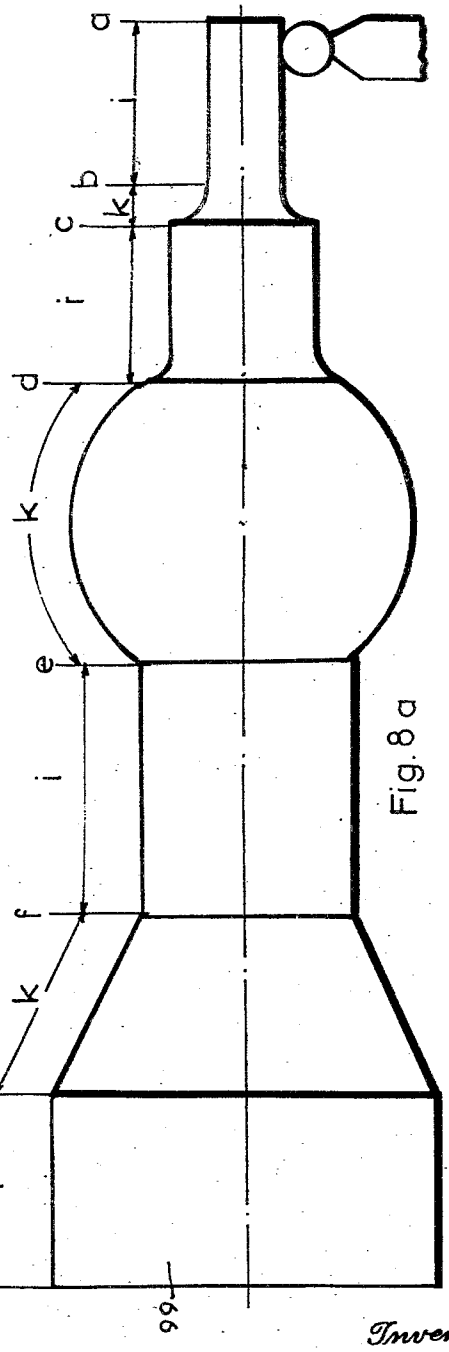


Fig. 8a

Inventor
Wolfgang Karl Schmid
By Eric D. Manuel
Agent

Nov. 19, 1957 W. K. SCHMID 2,813,461

FEELER CONTROLS

Filed Dec. 14, 1953 9 Sheets-Sheet 6

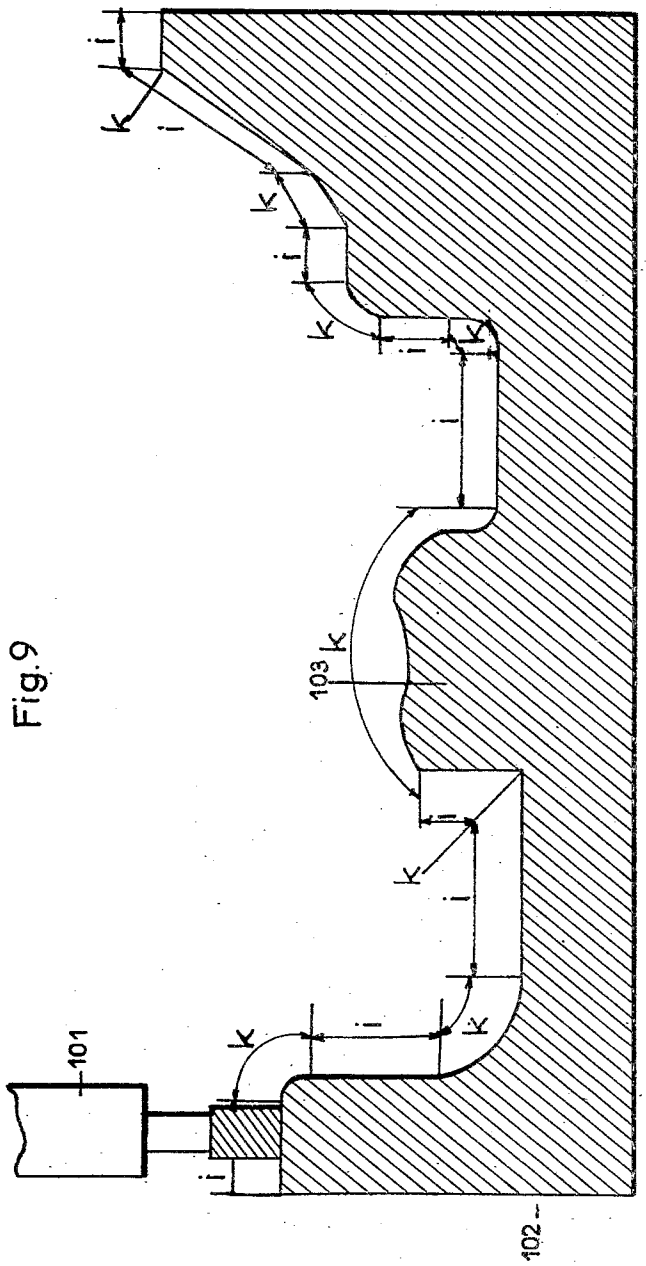


Fig. 9

Inventor
Wolfgang Karl Schmid

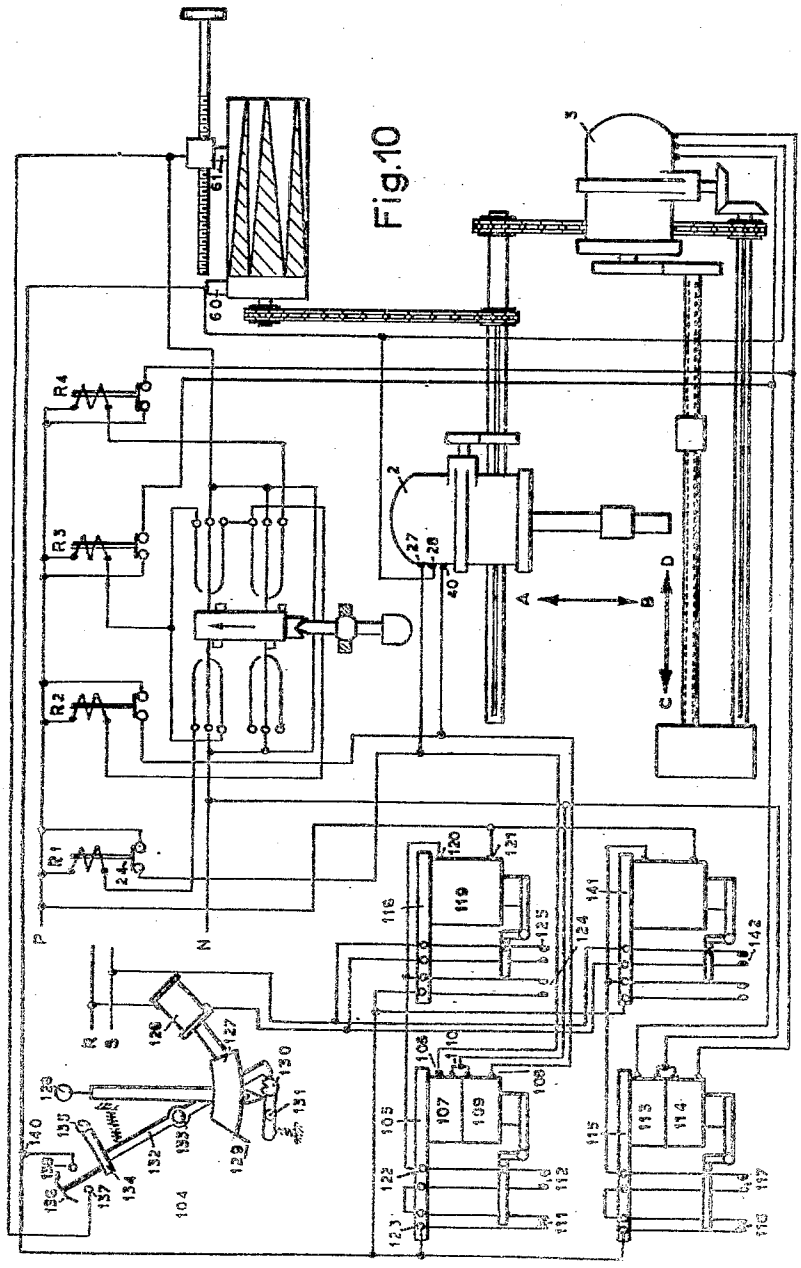
By Emil D. Mankel
Agent

Nov. 19, 1957 W. K. SCHMID 2,813,461

FEELER CONTROLS

Filed Dec. 14, 1953 9 Sheets-Sheet 7

Fig.10



Inventor
Wolfgang Karl Schmid
By Eric D. Fincke
Agent

Nov. 19, 1957 W. K. SCHMID 2,813,461

FEELER CONTROLS

Filed Dec. 14, 1953 9 Sheets-Sheet 8

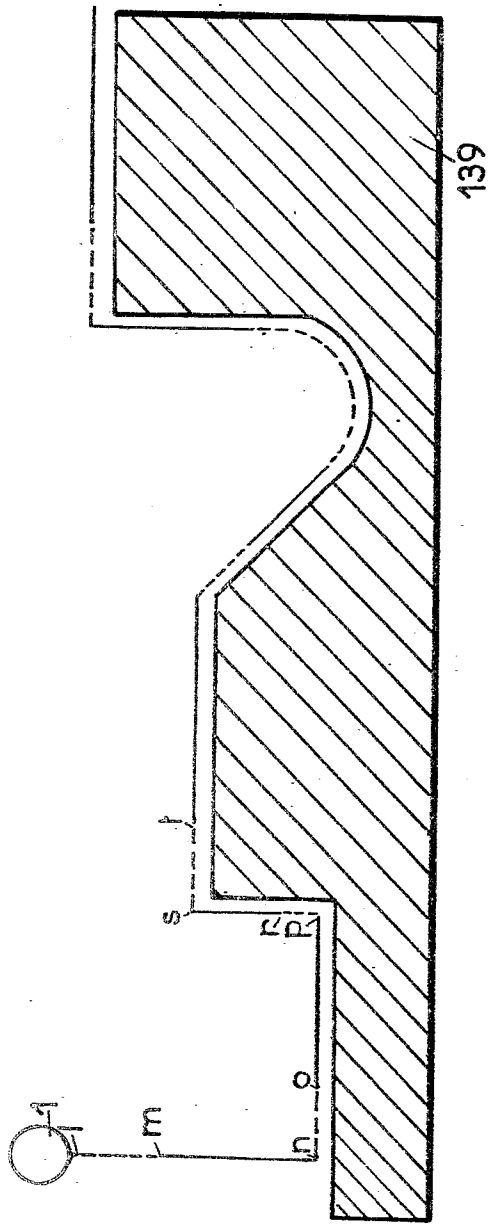


Fig. 10 g.

Inventor
Wolfgang Karl Schmid

By Eric D. Muskel
Agent

Nov. 19, 1957 W. K. SCHMID 2,813,461

FEELER CONTROLS

Filed Dec. 14, 1953 9 Sheets-Sheet 9

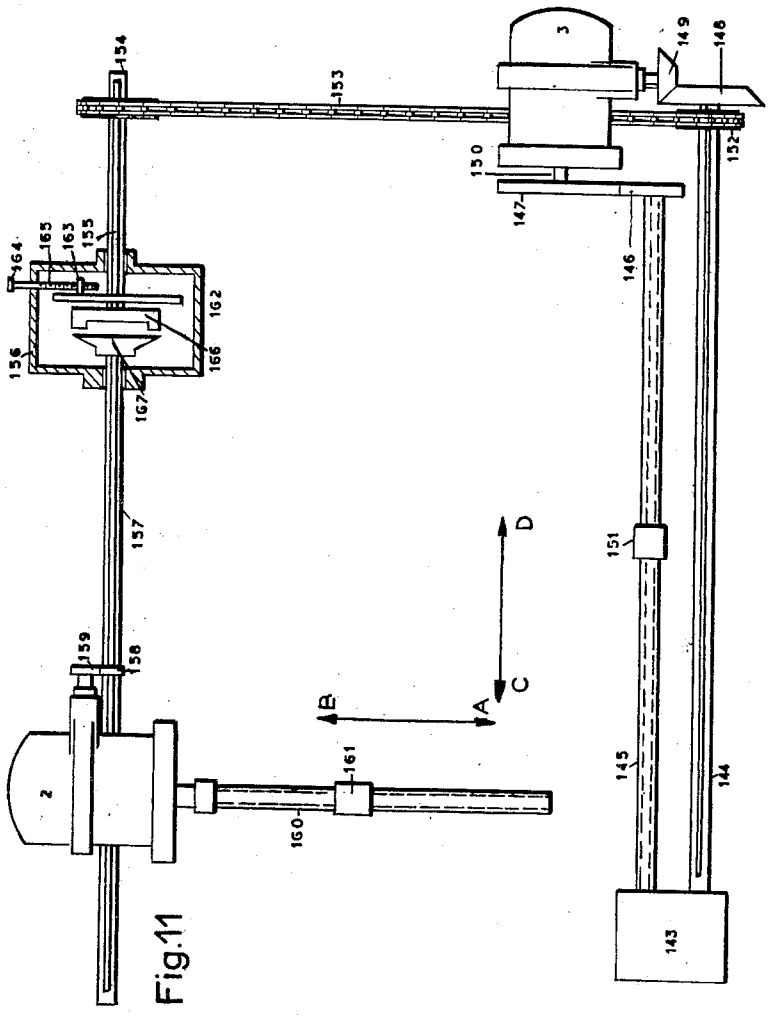


Fig.11

Inventor
Wolfgang Karl Schmid

By Eric D. Kleinkel
Agent

United States Patent Office 2,813,461 Patented Nov. 19, 1957

2,813,461

FEELER CONTROLS

Wolfgang Karl Schmid, Gagny, France

Application December 14, 1953, Serial No. 398,156

5 Claims. (Cl. 90—13.5)

The present invention relates to tracer or feeler controls, and more particularly, to tracer controls having a velocity of the movement of the tracer or feeler which is controlled automatically by the feeler in dependency on the shape of a contour.

The accuracy of the operation of such tracer controls is highly dependent on the chosen velocity of movement of the tracer due to the inertia of the electric switching members and the braking and starting periods of the masses to be moved. The modern cemented carbide tools allow high cutting speeds and rapid feeding movements which cannot be fully used with the tracer controls hitherto applied. It is quite possible to obtain high velocities of the tracer along contours proceeding in the direction of the movements of the support; however, as soon as irregularly shaped contours are involved, the velocity of the tracer has to be diminished, because, otherwise, too large inaccuracies are involved.

The present invention teaches with what means an automatic change of the velocity of the movement of the tracer can be obtained in dependency on the contour to be scanned. The tracer scans thereby all rectilinear contours at a high velocity and diminishes automatically the speed of the tracing movement whenever changes of the direction of the course of the contour occur. Thus, by this device, the working periods are considerably shortened, which is important particularly if larger work pieces, having long cylindrical sections, are to be turned which have irregular forms only at predetermined locations. Also, in the milling of larger dies frequently plane surfaces occur which would admit a considerably faster machining, whereas at the recesses having contours the machine has to work considerably slower, due to the required accuracy. Since such work pieces frequently require many working hours, a considerable saving of time is obtainable by the invention to be described hereinafter.

In the drawings, the present invention is illustrated by way of example. Thus,

Figure 1 is a diagram schematically showing the working principle of an electric tracer control in which, in all movements proceeding at right angles to the axis of the tracer, the velocity of movement of the tracer is automatically increased by the tracer via relays;

Figure 2 shows diagrammatically the seven different directions of movement controlled by the tracer;

Figure 3 is a table indicating the switching operations of the four relays at the seven commanding positions of the tracer;

Figure 4 shows schematically the working principle of the tracer control with electric time relay and an automatic increase of the velocity of the tracing movement at all rectilinear contours in longitudinal and transverse directions, as well as in the resultant direction of movement;

Figures 5 to 7 show perspective views of a special time relay having four windings, in three different positions, respectively;

Figures 8 and 8*a* show a work piece to be turned on a

lathe controlled by means of a tracer, together with the template, and the feed velocities assigned to the various portions, said velocities being automatically adjusted;

Figure 9 shows the corresponding feed movements when milling a die;

Figure 10 shows diagrammatically an electrical tracer control with a time relay designed as a pendulum, and four auxiliary relays;

Figure 10*a* explains how a template is scanned by the tracer; and

Figure 11 shows schematically an additional device for adjusting the direction of the resulting movement.

Referring to the drawings, and first to Figure 1, the novel tracer control system comprises a tracer **1**, a magnetic reversing clutch **2** for the transverse movement, a further magnetic reversing clutch **3** for the longitudinal movement, relays R1, R2, R3, and R4, and a control device **4**. The scanning spindle **5** of the tracer is supported by the ball socket **6** so as to be movable in all directions. If the tracer **1** is attached to a support of a lathe, so that it participates in the displacements of the turning tool, and if behind the lathe a template is arranged having a contour to be scanned by the scanning spindle of the tracer, the tracer controls the working cycle of the machine in a manner known per se in the art. The tracer is equipped with a plurality of contacts which actuate the relays R1 to R4 and control the magnetic reversing clutches **2** and **3**. To this end, a sliding pin **7** is mounted on the upper end of the scanning spindle **5**, said pin engaging a cone **8** attached to an insulated block **9** on the sides of which projections **10**, **11**, **12** and **13** are provided. When the block **9**, which slides in a guiding device (not shown), moves in the direction A, due to deflection of the scanning spindle, contact leaves **14**, **15**, **16** and **17** are bent one after the other by the projections **10**, **11**, **12** and **13**, respectively. In the position shown in Figure 1 of the drawings, in which the scanning spindle is vertical, the tracer is free, that is, it does not engage a template. This position corresponds to the first control position of the tracer in which the relays R2, R3 and R4 are energized or switched on as indicated in Figures 2 and 3. In this position, the contact leaf **14** engages contact **18** so that the winding of relay R3 is energized; the contact leaf **17** engages contact **19** so that the winding of relay R4 is energized and the contact leaf **15** engages contact **20** so that the winding of relay R2 is energized. Hence, the energized relays R2, R3 and R4 are holding their rest contacts **21**, **22**, **23**, respectively, in open position. Only the relay R1 remains de-energized, so that its rest contact **24** is closed. By means of the rest contact **24**, the contacts **25** and **26** are bridged, whereby the magnetic reversing clutch **2** is switched on via a line connecting contact **25** to terminal **27** of the clutch **2**. Terminal **28** of the magnetic reversing clutch **2** is connected with one N of the leads fed from a direct current network, while the contact **26** of the relay R1 is connected to the other P of the leads of the same direct current network. The magnetic clutch **2**, which is driven via a shaft **29** by a motor (not shown) at a constant number of revolutions, rotates a driving shaft **30** in such a manner, that the support to which the tracer is attached moves forward in transverse direction, as indicated in Figures 2 and 3. Thus, the tracer is moved toward the template, and its tracer spindle is deflected when the same engages the template. When this occurs, the tracer is brought into the control position II, i. e., the block **9** is lifted or slightly displaced in the direction A. As a result of this, the contact leaf **14** is moved away from the contact **18** by the projection **10**. Thus, the winding of the relay R3 is de-energized, so that the relay will no longer attract its armature. The relay R3 now closes its rest contact **22** which bridges the contacts **31** and **32** and

connects terminal 33 of the magnetic reversing clutch 3 to the positive lead P of the direct current network. Since terminal 34 of the clutch 3 is connected to the negative lead N of the network through the control device 4, the magnetic reversing clutch 3 is energized and moves the tracer in the longintudinal direction toward the left. A shaft 35 of the clutch 3 is driven by a motor (not shown) at a constant number of revolutions, while a driving shaft 36 of this clutch is coupled with the driving spindle of the longitudinal support. As soon as the clutch is energized, the longitudinal support is moved together with the tracer toward the left.

As indicated in Figures 2 and 3, both magnetic clutches are now running and the tracer, when in control position II, moves in the resultant direction obliquely toward the left. If the scanning spindle of the tracer is still more deflected, so that it arrives at control position III, the contact leaf 14 is brought into engagement with the contact 37 by means of the projection 10. Thus, the winding of relay R1 is energized. The relay R1 attracts its armature and opens its rest contact 24, thus de-energizing the magnetic clutch 2. As indicated in Figures 2 and 3, only a longitudinal movement towards the left takes now place. If the tracer spindle is deflected to a still greater extent, the control position IV is obtained, i. e., the contact leaf 15 is lifted by the projection 11 and thereby becomes disengaged from the contact 20. As a result of this, the relay R2 will be de-energized and closes its rest contact 21. This rest contact 21 bridges the terminals 38 and 39, whereby a terminal 40 of the magnetic reversing clutch 2 will be connected to the positive lead P of the direct current network. The driving shaft 30 of this clutch will now rotate in reverse direction and the tracer moves obliquely backward in the resultant direction, as indicated in Figures 2 and 3. If the tracer spindle is deflected to a still greater extent, it arrives at the control position V, i. e., the relay R3, as shown in Figures 2 and 3, is again energized. This is accomplished by deflecting the contact leaf 15 by means of the projection 11 so far, that the same engages a contact 41. The relay R3 now energized opens its rest contact 22, thus removing the bridge from the contacts 31 and 32, so that the magnetic reversing clutch 3 is switched off. Now, only the reversing clutch 2 is running, so that the tracer moves away from the template in transverse direction.

The relay R4 is finally de-energized at the control position VI, as indicated in Figures 2 and 3. This is accomplished by lifting the contact leaf 17 by means of the projection 13 and disengaging the same from the contact 19. The relay R4 closes its rest contact 23 and thus bridges the contacts 42 and 43, so that the terminal 44 of the magnetic reversing clutch 3 is now connected to the positive lead P of the network. Now, the two magnetic reversing clutches 2 and 3 are running, so that the tracer moves in the resultant direction obliquely backwards, as shown in Figures 2 and 3. In the control position VII, the relay R2 is energized, as indicated in Figures 2 and 3, because the projection 13 lifts the contact leaf 17 to such an extent, that it engages the contact 45. The relay R2 is now energized and opens its rest contact 21. As a result of this, the bridging of the contacts 38 and 39 is removed and the magnetic clutch 2 is de-energized. Now, only the magnetic clutch 3 is running and moved the tracer in longitudinal direction towards the right.

As shown in Figure 1, the relays R1 and R2 are provided with make contacts 46 and 47, respectively. If the relay R1 is energized, the make contact 46 bridges the contacts 48 and 49, while the make contact 47 bridges the contacts 50 and 51. Contact 51 is connected to the lead N of the network. The contacts 49 and 50 of the two relays R1 and R2 are electrically connected to each other. These two make contacts control the device 4. This control device 4 comprises a cylindrical insulating body 52, to which conductive or metallic segments 53, tapering towards the right, are attached. A shaft 54 of the cylinder 52 is supported for rotation by bearings 55 and 56. The driving means which rotates the driving shaft 35 of the clutch 3 drives the cylinder 52 by means of suitable pulleys 57, 58, interconnected by a transmission belt or chain. At the left end of the cylinder 52, there is arranged a slip ring 59 of brass or copper, which is conductively connected with all of the segments 53. A stationary carbon brush 60 is riding on the slip ring 59. A second carbon brush 61 is arranged in a holder 62 which can be longitudinally adjusted by means of a hand wheel 63 and a spindle 64. The brush 61 is connected to the lead N of the network. The brush 60 is electrically connected to the terminal 34 of the clutch 4. As shown in Figure 1, the make contacts 46 and 47 of the two relays R1 and R2, when closed, are connected in series and the brushes 60 and 61 are then bridged by these make contacts. If the two brushes 60 and 61 are not bridged, the magnetic reversing clutch 3 receives current impulses in time intervals determined by the control cylinder 52. The more the brush 61 is displaced towards the left, the longer are these individual switching intervals, so that the number of revolutions of the driving shaft of the clutch 3 increases, as disclosed in my U. S. patent application S. N. 326,395, filed December 17, 1952. By means of the hand wheel 63, the number of revolutions of the clutch 3 can be adjusted to a normally admissible speed for scanning irregular contours. If longer straight contours are on the template, i. e., if longer cylindrical shaft pieces are to be turned, the tracer is brought to the control position III and remains there, whereby the two relays R1 and R2 are simultaneously energized, as indicated in Figures 2 and 3. By the contacts 46 and 47 of these relays, the brushes 61 and 60 of the control device 4 are bridged, as described in the foregoing, so that the longitudinal movement is now carried out at an increased feeding speed. Therefore, all cylindrical work pieces are rapidly machined on a machine controlled by the system according to the present invention.

It is frequently desirable to work at an higher feeding speed also in transverse direction if, for instance, larger transverse faces, permitting faster working, occur on the work pieces. Therefore, the control system has to be so universal that a quicker feeding movement is always imparted when the tracer remains for a longer time in a certain control position.

Figure 4 of the drawings shows means by which such improvement of the present invention can be accomplished. As shown in this figure, the same tracer, together with the four relays R1 to R4, can be used. The operations of the tracer and of the relays correspond to those in Figure 1. By means of the cylinder 52, the two electromagnetic reversing clutches 2 and 3 are controlled. Four time relays 65, 66, 67 and 68 are provided in this automatic control system. The winding 69 of the time relay 65 is connected to the lead N of the direct current network and to the terminal 27 of the electromagnetic reversing clutch 2. When the relay R1 is de-energized, due to the closing of the rest contacts of this relay, the winding 69 of the time relay 65 is energized simultaneously with the magnetic clutch 2. The time relay 69 attracts its armature 70 and rotates by means of a rack on one side of this armature 70 a pinion 71 fastened to a shaft 72, to which a cam disc 73 is secured carrying a cam 74. In the lower position of the armature 70, shown in Figure 4 of the drawing, contact pair 75 is closed, i. e., when the winding 69 is de-energized and thereby the armature 70 has dropped due to its own weight. The time relay 65 is equipped with a braking or delay means, so that about 3–5 seconds are required before the armature 70 is completely attracted. Terminal 76 of the winding 77 of the time relay 66 is also connected to the lead N. Terminal 78 of the winding 77 is connected to contact 38 of the rest contact bridge 21 of the relay R2. When the relay R2 is de-energized and closes its rest contact bridge 21, the winding 77 is energized. At the same time, as described above, the

terminal 40 of the magnetic reversing clutch 2 is connected to the network. According to the direction in which the magnetic reversing clutch 2 is switched on, either the time relay 65 or the time relay 66 is energized. The terminal 79 of the winding 80 of the time relay 67 is also connected to the lead N. The terminal 81 of the winding 80 of this time relay 67 is connected to the terminal 33 of the magnetic reversing clutch 3, while terminal 82 of the winding 83 of the time relay 68 is connected with the terminal 44 of the magnetic reversing clutch 3.

When, by means of the relays R1 to R4, the magnetic reversing clutches 2 and 3 are switched on and off in a certain working rhythm, the four time relays are energized and de-energized in the same working rhythm. All of the contacts of the four time relays, i. e., the contact pairs 75, 84, 85 and 86 are connected in series and bridge the contact brushes 60 and 61 of the control device 4 if the magnetic clutches are constantly switched on and off for a certain time. However, as soon as a change in the course of the contour of the template to be traced occurs, switching impulses are caused by the tracer. If, for instance, the tracer has to scan a contour which is downwardly inclined to a great extent, the control positions I, II change and, thus, switching impulses are continuously imparted to the clutch 3. The time relay 67 also receives current impulses, so that the contact pair 85 is opened to interrupt the bridging of the two brushes 60 and 61. The center terminals 28 and 34 of the clutches 2 and 3, respectively, are connected to the brush 60 of the cylinder 52. The brush 61 is connected to the lead N. When the contact pairs 75, 84, 85 and 86 are closed, the two clutches 2 and 3 rotate at the full number of revolutions. However, as soon as one of these contact pairs is opened, the clutches are energized via the cylinder 52 by current impulses, so that they will run correspondingly slower.

Figures 5 to 7 show a modified time relay having four windings in three different operative positions, respectively. By this single time relay, the four time relays 65, 66, 67 and 68, shown in Fig. 4, can be replaced. The first winding 87 of the time relay in Figures 5 to 7 has two terminals 88 and 89, which are connected to the reversing clutch 2, shown in Fig. 4. To this end, the terminal 88 has to be connected to the terminal 27, while the terminal 89 is connected to the lead N, see Fig. 4. Likewise, the second winding 90 has two terminals 91 and 92, of which terminal 91 is connected to the terminal 40 of the reversing clutch 2, while the terminal 92 is connected to the lead N, see Figure 4. The two other windings 93 and 94 are connected in an analogous manner to the magnetic reversing clutch 3, i. e., the terminal 95 to the terminal 33 and the terminal 97 to the terminal 44 of the magnetic reversing clutch 3. The terminals 96 and 98 are connected to the lead N.

Figure 5 shows the relay in de-energized condition, all of its windings being disconnected from the network. The armature 70 is at its lowermost position and, thus the contact pair 75 is closed by the cam 74.

Figure 6 shows the armature 70 in its center position in which the contact pair 75 is opened, as the cam 74 does not engage any of the contacts of this contact pair.

Figure 7 shows the time relay with completely attracted armature 70 and closed contact pair 75. By this time relay, the bridging of the brushes 60 and 61 of the cylinder 52 is controlled in the same manner as by the time relays 65 to 68, described in more detail in the foregoing with reference to Figure 4.

Referring now to Figures 8*a* and 8, a work piece 99 to be turned on a tracer controlled lathe and a template 100 to be traced at the various automatically adjusted feeding speeds, are shown. The distance *a*—*b* of the contour of the template is scanned by the tracer 1 at a high feeding speed. Beginning at the point *b*, switching steps occur and the bridging of the two brushes 60 and 61 (Figure 4) of the control cylinder 52 is suspended by the time relay, so that the tracer scans the distance *b*—*c* at a lower feeding speed. The distance *c*—*d* is traced at a high feeding speed, since it is cylindrical, while the tracer 1 moves along the distance *d*—*e* at a reduced feeding speed. The distance *f*—*g* is traced at a lower speed, and the distance *g*—*h* at a higher speed. The contours at which the turning tool is displaced at a high feeding speed are denoted by the letter *i*, and the contours at which the turning tool is moving at a reduced feeding speed is denoted by the letter *k*.

Figure 9 illustrates a similar control operation for duplicating milling of a die 102. The contours 103, on which the milling tool 101 works at a high or reduced feeding speed, are denoted by the letters *i* and *k*, respectively, as in Figure 8*a*.

Figure 10 shows an electrical tracer control with a time relay 104 designed as a pendulum, and four auxiliary relays 105, 115, 118 and 141. The auxiliary relay 105 is actuated together with the magnetic reversing clutch 2. In order to accomplish this, the terminal 27 of the reversing clutch 2 is connected to the terminal 106 of the winding 107 of the relay 105. The terminal 40 of the reversing clutch 2 is electrically connected to the terminal 108 of the winding 109 of the relay 105. The two other ends of the windings 107, 109, are connected to the terminal 110 of the relay 105, terminal 110 being connected to the lead N. The relay 105 is provided with rest contacts 111 and make contacts 112. The windings 113 and 114 of the second auxiliary relay 115 are electrically connected to the magnetic reversing clutch 3 in an analogous manner. The relay 105 attracts always when the magnetic reversing clutch 2 is energized to operate either in the right or in the left hand direction. The relay 115 is switched on in an analogous manner when the magnetic reversing clutch 3 is energized for right or left hand rotation. The rest contacts 111 and the make contacts 112 of the relay 105 are connected in series and are mechanically so designed that, upon energization of the relay 105, first the make contacts 112 are closed and, thereafter, the rest contacts 111 are opened. Also, during switching off, the contacts 111 are closed first and thereafter the contacts 112 are opened. As a result of this, the relay 105, at the switching on or switching off of the magnetic reversing clutch 2, always transmits a short switching impulse by means of the contacts 111 and 112. The rest and make contacts 116 and 117 of the relay 115 are designed in the same manner. The relay 118 is controlled by the relay 105. The winding 119 of the relay 118 is provided with two terminals 120 and 121. The terminal 121 is connected with the lead P. The terminal 120 is also connected to the terminal 122 of the relay 105. The terminal 123 of the relay 105 is connected to the brush 60 which is fed by the lead N via the segments 53 and the brush 61. As soon as the relay 105 attracts its armature, the winding 119 of the relay 118 is connected to the network. By means of holding contact 124, this relay 118 remains energized and, by means of its make contacts 125, switches on a winding 126 of the time relay 104 provided with a pendulum 127 which is suspended at 128 by means of a leaf spring. The pendulum 127 is attracted by the energizing winding 126 until a pawl 130 rotatably mounted at 131 is moved downwards by a projection 129 of this pendulum, whereby the lower part of a lever 132, operatively associated with the pawl 130, is swung to the left. The lever 132 is rotatably supported on the pivot 133. A lever 134, rotatably mounted on a pivot 135, engages the upper end of the lever 132, so that this lever 134 is held turned upwardly to hold a contact bridge 136 separated from contacts 137 and 138. The control cylinder 52 is bridged via the contacts 137 and 138 when the lever 134 disengages from the end of the lever 132 so as to cause the contact bridge 136 associated with the lever 134 to interconnect the terminals 137 and 138.

The terminal 137 is connected to the lead N while the terminal 138 is connected to the brush 60 of the control cylinder 52.

The operation of this device will be described with reference to the steps explained in Figure 10*a* showing a template 139 to be scanned by the tracer 1. As soon as the machine is switched on, the relays R2, R3 and R4, Figure 3, are connected to the network. As shown in Figure 10, the magnetic reversing clutch 2 is switched on by the rest contact 24 of the relay R1 and the tracer 1 moves toward the template 139 in the direction B from the point 1 to the point *m*. The terminals 106 and 110 of the winding 107 of the auxiliary relay 105 are also connected to the network. The auxiliary relay 105 closes its make contacts 112 and opens subsequently its rest contacts 111 so that, for a short interval, a current impulse is applied to the winding 119 of the relay 118 in the circuit from the lead N via contact 137, closed contacts 137, 136, 138, terminal 140, terminal 123, rest contacts 111, closed make contacts 112, terminal 122 of relay 105, terminal 120 of winding 119 of relay 118, terminal 121 of winding 119 of relay 118 to lead P. The relay 118 is energized and held in this condition by means of its own holding contacts 124. Via the make contacts 125, the winding 126 of the time relay 104 is energized so that the pendulum 127 is attracted and the contact bridge 136 opened. As a result of this, the brushes 60 and 61 of the control cylinder 52 are no longer bridged, so that the magnetic reversing clutch 2 will run at a reduced number of revolutions. The pendulum of the time relay will oscillate for a few seconds before it comes to rest and the contact bridge 136 is closed. Starting at the point *m*, the tracer 1 moves at a high speed towards the template 139, shown in Figure 10*a*. In other words, the tracer 1 runs first slowly, for the distance indicated by dotted line *l*—*m*, and quickly from *m* to point *n*. When contact bridge 136 opens, the holding contacts 124 of the relay 118 are opened, so that the relay 118 is de-energized. At the point *n*, the tracer 1 engages the contour of the template 139 so that the tracer spindle is deflected and the magnetic reversing clutch 3 is switched on, whereby the auxiliary relay 115 is energized. The auxiliary relay 141 is switched on by means of the contacts 116 and 117 of relay 115. The auxiliary relay 141 is maintained energized by its own holding contacts and switches on the winding 126 of the time relay 104 via the contact pair 142. The pendulum 127 of the time relay 104 is attracted towards the right and, as a result of this, the contact bridge 136 is moved to open position. Now, the tracer 1 continues to move in transverse direction towards the template and is deflected to such extent that it is brought to control position III, whereby the magnetic clutch 2 is switched off. Since the pendulum 132 of the time relay 104 is still oscillating, the contact bridge 136 remains in open position. The tracer 1 is now moving at low feeding velocity in horizontal direction from the point *n* to the point *o*, as shown in Figure 10*a*. No change in the control takes place, because the contour of the template 139 is rectilinear. The pendulum 132 of the time relay 104 comes to rest after an interval and causes the contact bridge 136 to close, so that the machine will operate at a high feeding velocity. Thus, the tracer 1 scans the contour quickly from *o* to *p*. At the corner *p*, the magnetic reversing clutch 2 is switched on to rotate in reverse direction under the action of the tracer 1. The terminal 108 of the winding 109 of the relay 105 is now connected to the network via the terminal 40. By means of the contacts 111 and 112, the relay 118 is re-energized and held in this condition. The winding 126 of the time relay 104 is energized by a voltage impulse via the closed make contacts 112, which lasts until the time relay 104 opens the contact bridge 136, so that the holding action of the relay 118 is interrupted. The tracer 1 now moves from the point *p* to the point *r* at a low speed, i. e. until the pendulum 132 of the time relay 104 arrives at its rest position. At this instant, the contact bridge 136 is closed and the tracer moves at a high speed from *r* to *s*. As indicated in Figure 10*a*, the tracer 1 scans at a high velocity also slanting contours. The device described can be modified in various ways, i. e., the described circuit diagrams indicate only the fundamental principle of the invention.

Figure 11 shows a further improvement of the new control system permitting adjustment of the feed in transverse direction. In this embodiment, the new tracer-controlled driving means are applied to a lathe. A shaft 144 and a spindle 145 of the lathe are journalled at one side in a gear box 143. The shaft 144 is driven via the gear box at a number of revolutions which can be adjusted according to the requirements. To the right end of the shaft 144, there is attached a bevel gear 148 which is engaged by a smaller bevel gear 149 driving the magnetic reversing clutch 3 for the longitudinal movement. The driven shaft 150 of the clutch 3 is attached to a gear 147 driving a gear 146 mounted on the right end of the threaded spindle 145 on which a spindle nut 151 is provided. According to the energization of the reversing clutch 3 caused by the tracer for right or left running, the nut 151 will be displaced in the direction C or D, respectively. Furthermore, a sprocket wheel 152 is mounted on the shaft 144 which drives another sprocket wheel 154 by means of a chain 153. This sprocket wheel 154 is mounted on an auxiliary shaft 155 arranged in the rear of the lathe. A second auxiliary shaft 157 is driven by this shaft 155 via a control gear mechanism 156, a gear 158 being provided on the shaft 157 and driving a gear 159 secured to the driving shaft of the magnetic reversing clutch 2. This clutch 2 is arranged at the rear end of the transverse support. The shaft 157 and the gear 158 are constructed in such a manner that the latter can be displaced on this shaft as required by the movements of the transverse support. A spindle 160 for the transverse support is driven via clutch 2. According to the operation of this clutch 2, for right or left run, a spindle nut 161 moves in the direction A or the direction B, respectively. Generally, the transmission ratios of the transverse and longitudinal gears are chosen in such a manner that the velocities of the advance of the longitudinal and transverse supports or of the two spindle nuts 151 and 161 are exactly equal. If cones, having an angle of 45°, are to be turned on the lathe, they can be machined without steps. In this case, the longitudinal and the transverse clutches are continually switched on so that the control device is bridged and the lathe turning the cone operates at a high feeding velocity. In case of cones having a larger or smaller angle, the well known steps would occur. In the latter case, one of the movements is continually switched on or off, so that, by means of the time relay, the bridging of the control drive is interrupted, whereby the machine operates at a slower feed. By means of the control gear 156, the speed of the transverse travel can be changed, i. e., it can be adapted to the desired cone. For this purpose, a plate 162 is attached to the shaft 155 inside the gear box 156, said plate 162 carrying specially designed segments of the general shape and function of the segments 53 in Figure 1. A brush 163, riding on said plate 162, can be adjusted with respect to this plate by means of a hand wheel 164 via a spindle 165. An energizing coil 166 receives current impulses via the segments of the plate 162 and the brush 163 so that a disc 167 is attracted at a certain operating rhythm and is then released. The electric connections of and between the various electric control elements, clutches, etc. have been omitted in Figure 11, as they are principally the same as those in Figure 1.

By means of the hand wheel 164, the number of revolutions of the shaft 157 can be adjusted as disclosed in my U. S. patent application S. N. 326,395, filed December 17, 1952. This hand wheel 164 can be provided with a

graduation, so that the desired conicity of the work piece can be readily adjusted. For example, the number of revolutions of the reversing clutch **2** can be decreased by means of this hand wheel **164**, so that the resulting movement corresponds to an angle of 30°. If the work piece to be turned has cones having an angle of 30°, the latter can be machined on the new machine without steps at a high feed velocity.

In the foregoing, only a few embodiments of the invention have been disclosed. However, the invention can be applied to other machine tools and may be modified in various ways. For instance, the brush **163** in the control gear **156** can be replaced by two or more brushes. This is preferable in case of mass production, where a work piece with several conical parts has to be machined. In such a case, stops can be provided on the machine by which the circuit is automatically closed by the one or the other of such brushes. At the first cone, the machine operates in an inclined direction having an angle different from that of the second cone occurring on the same work piece. In case of large dies, the adjustability of the direction of the slanting movement has great advantages. The better the slanting movement is adapted to the contour of the work piece, the fewer switching actions are caused by the tracer and the better is the appearance of the surface of the finished work piece.

I claim:

1. A tracer-controlled copying machine tool, comprising a support, a tracer mounted for relative movement on said support and being adapted to trace the contour of an object, a tool also mounted on said support and being adapted to machine an object, a first drive means for driving said support in one direction, a second drive means for driving said support in another direction having an angle to said first direction, each of said drive means including an electromagnetic clutch, electric contact means associated with said tracer, circuit means connectable to a source of electric energy and including said contact means and said clutches so as to control the latter in accordance with the positions of said contact means which, in turn, are controlled by said tracer, control means including a periodic current interrupting device and being associated with said circuit means and operable by said contact means for selectively switching at least one of said electromagnet clutches to be operated by continuous current by-passing said interrupting device to obtain a rapid feed velocity of said tracer and said tool along straight portions of said contour and by current impulses via said interrupting device to obtain a reduced feed velocity of said tracer and said tool along inclined portions of said contour.

2. A tracer controlled copying machine tool according to claim 1, wherein at least one time delay means is provided in said circuit means to delay the actuation of said electromagnetic clutch when switching operations in said circuit means take place.

3. A tracer-controlled copying machine tool according to claim 1, wherein said periodic current interrupting device is provided with means to adjust the length of the current interruptions.

4. A tracer-controlled copying machine tool, according to claim 1, wherein said control means and said current interrupting device are arranged in the circuit means to act on said two electromagnetic clutches.

5. A tracer-controlled copying machine tool according to claim 1, wherein separate control means and current interrupting devices are provided for each of said electromagnetic clutches.

References Cited in the file of this patent

UNITED STATES PATENTS

2,116,593	Bouvier et al.	May 10, 1938
2,351,649	Wintermute et al.	June 20, 1944
2,362,318	Staples	Nov. 7, 1944
2,523,918	Petschauer	Sept. 26, 1950

FOREIGN PATENTS

459,685	Great Britain	Jan. 13, 1937