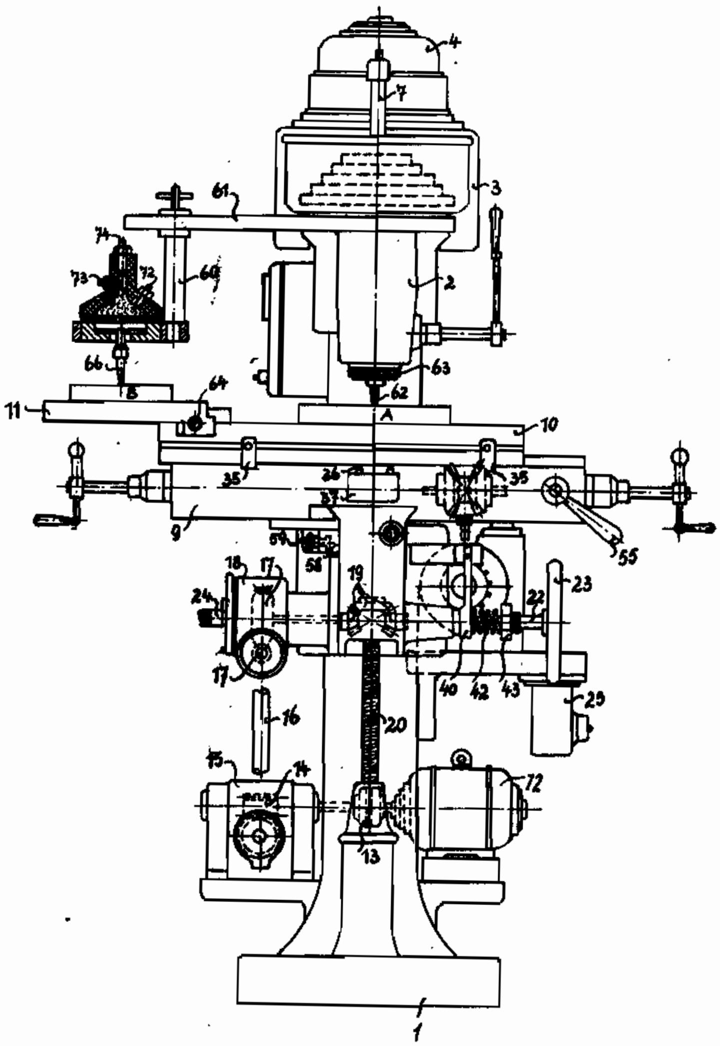
PUBLISHED
MAY 4, 1943.
BY A. P. C.

E. F. MÜLLER
ELECTRIC FEELER CONTROLS FOR MACHINE TOOLS
Filed Aug. 3, 1938

Serial No. 222,743
8 Sheets-Sheet 1

Fig. 1



Inventor
Eduard Felix Müller
by Knight Bros
Attorneys

PUBLISHED MAY 4, 1943. BY A. P. C.

E. F. MÜLLER

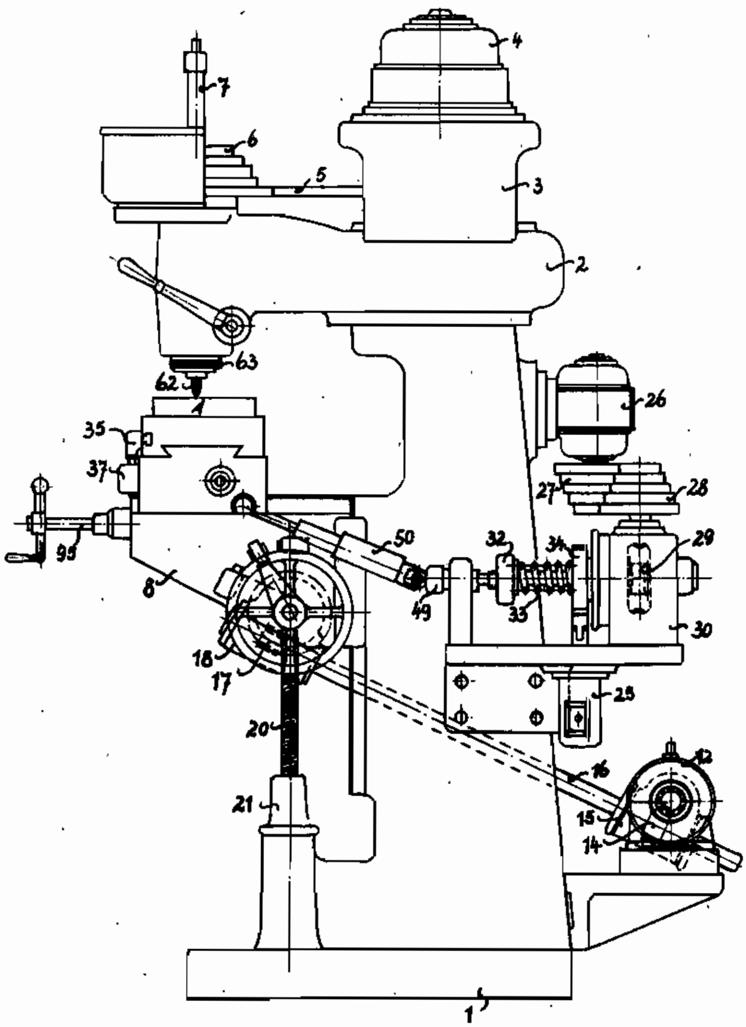
ELECTRIC FEELER CONTROLS FOR MACHINE TOOLS

Filed Aug. 3, 1938

Serial No. 222,743

8 Sheets-Sheet 2

Fig. 2

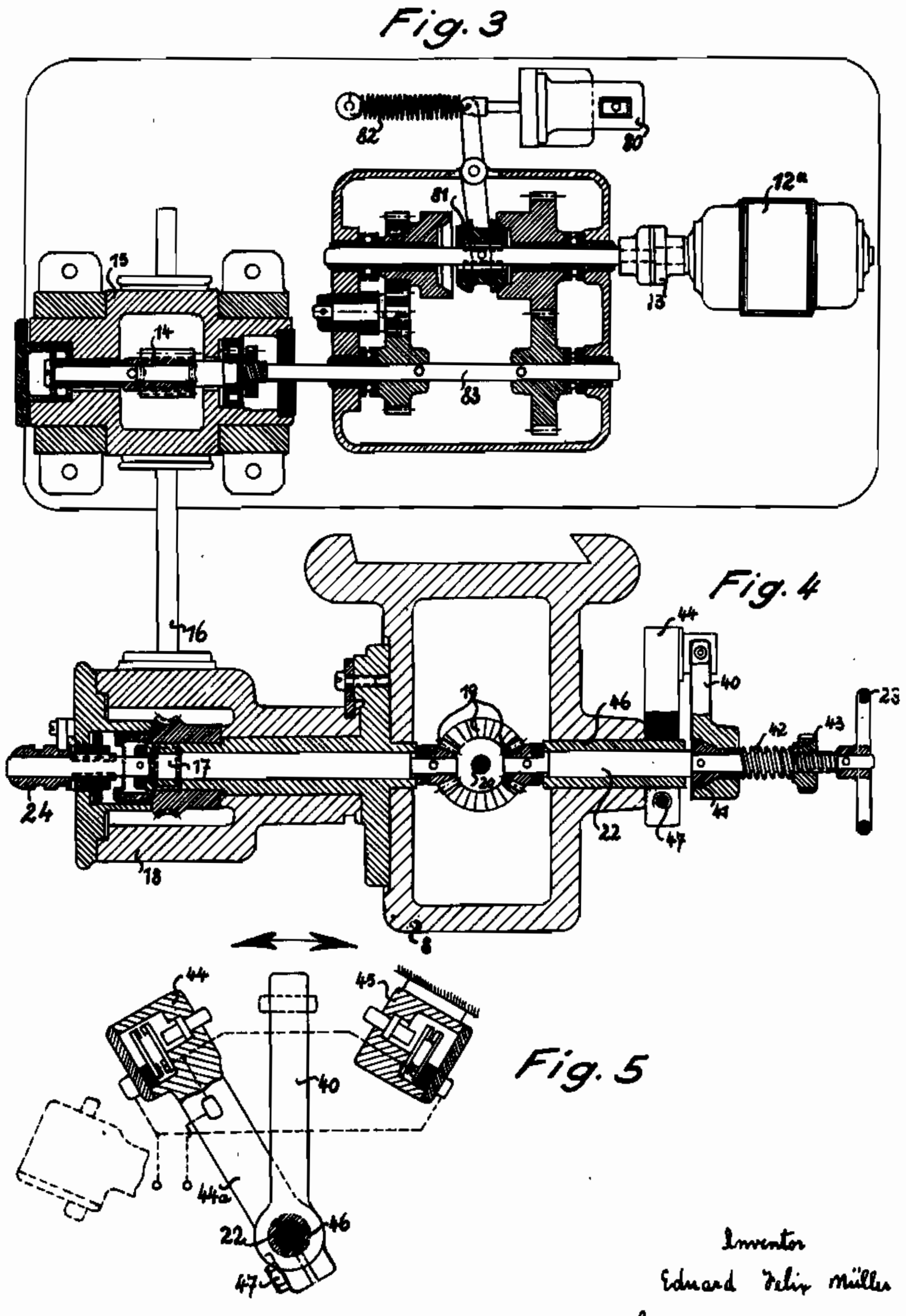


Inventor
Eduard Felix Müller
by Knight Bros
Attorneys

PUBLISHED E. F. MÜLLER Serial No.

MAY 4, 1943. ELECTRIC FEELER CONTROLS FOR MACHINE TOOLS 222,743

BY A. P. C. Filed Aug. 3, 1938 8 Sheets-Sheet 3



Inventor
Eduard Felix Müller
by Knight Bros
Attorneys

PUBLISHED

MAY 4, 1943.

BY A. P. C.

E. F. MÜLLER

ELECTRIC FEELER CONTROLS FOR MACHINE TOOLS

Filed Aug. 3, 1938

Serial No. 222,743

8 Sheets-Sheet 4

Fig. 6

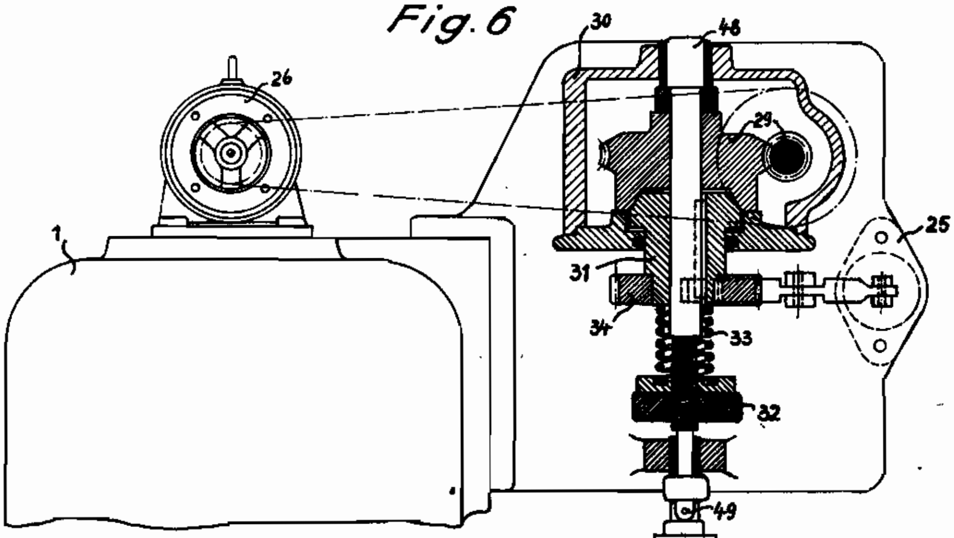


Fig. 7

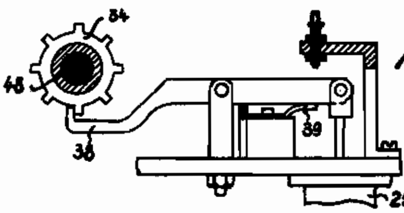
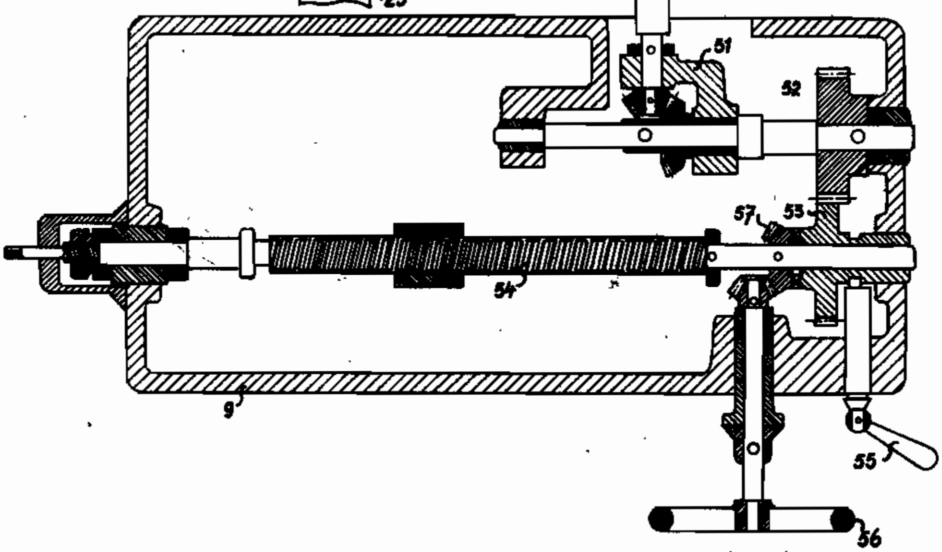


Fig. 8



Inventor
Eduard Felix Müller
by Knight Bros
Attorneys

PUBLISHED MAY 4, 1943. BY A. P. C.

E. F. MÜLLER

ELECTRIC FEELER CONTROLS FOR MACHINE TOOLS

Filed Aug. 3, 1938

Serial No. 222,743

8 Sheets-Sheet 5

Fig. 9

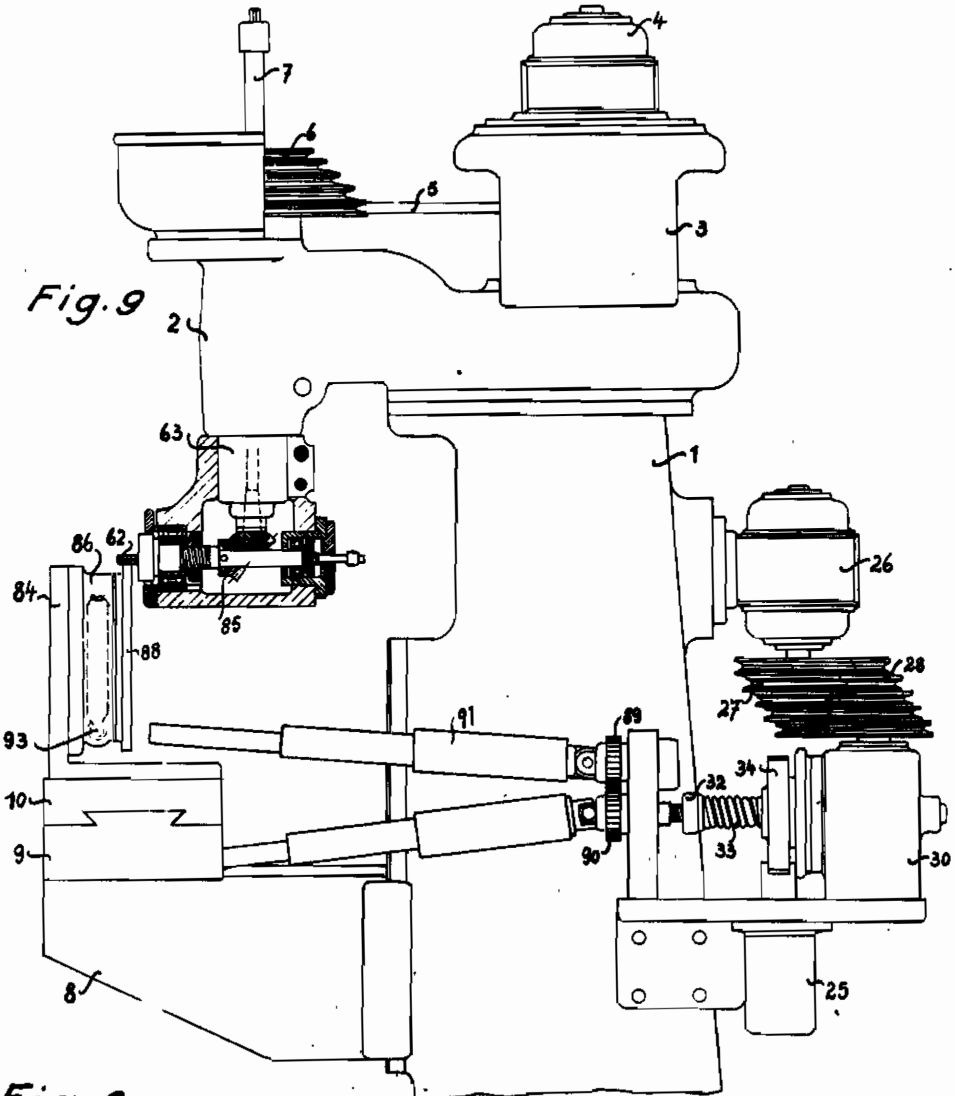
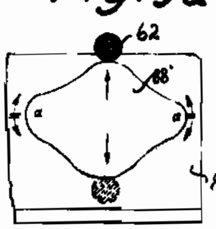


Fig. 9a



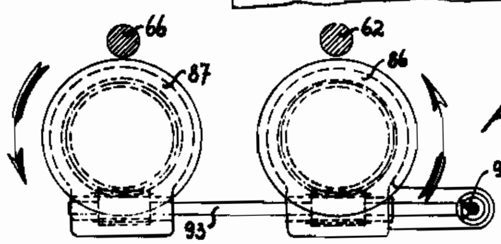


Fig. 10

Inventor
Eduard Felix Müller
by Knight Bros
Attorneys

PUBLISHED
MAY 4, 1943.
BY A. P. C.

E. F. MÜLLER

ELECTRIC FEELER CONTROLS FOR MACHINE TOOLS

Filed Aug. 3, 1938

Serial No.
222,743

8 Sheets–Sheet 6

Fig. 14

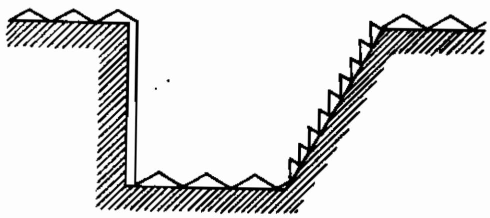


Fig. 11

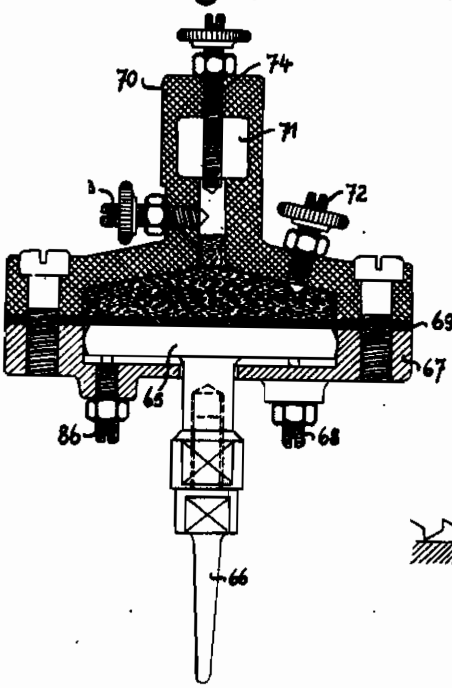
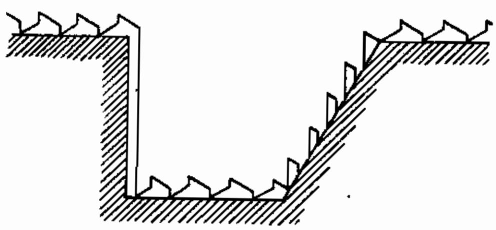
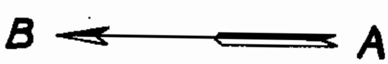


Fig. 15





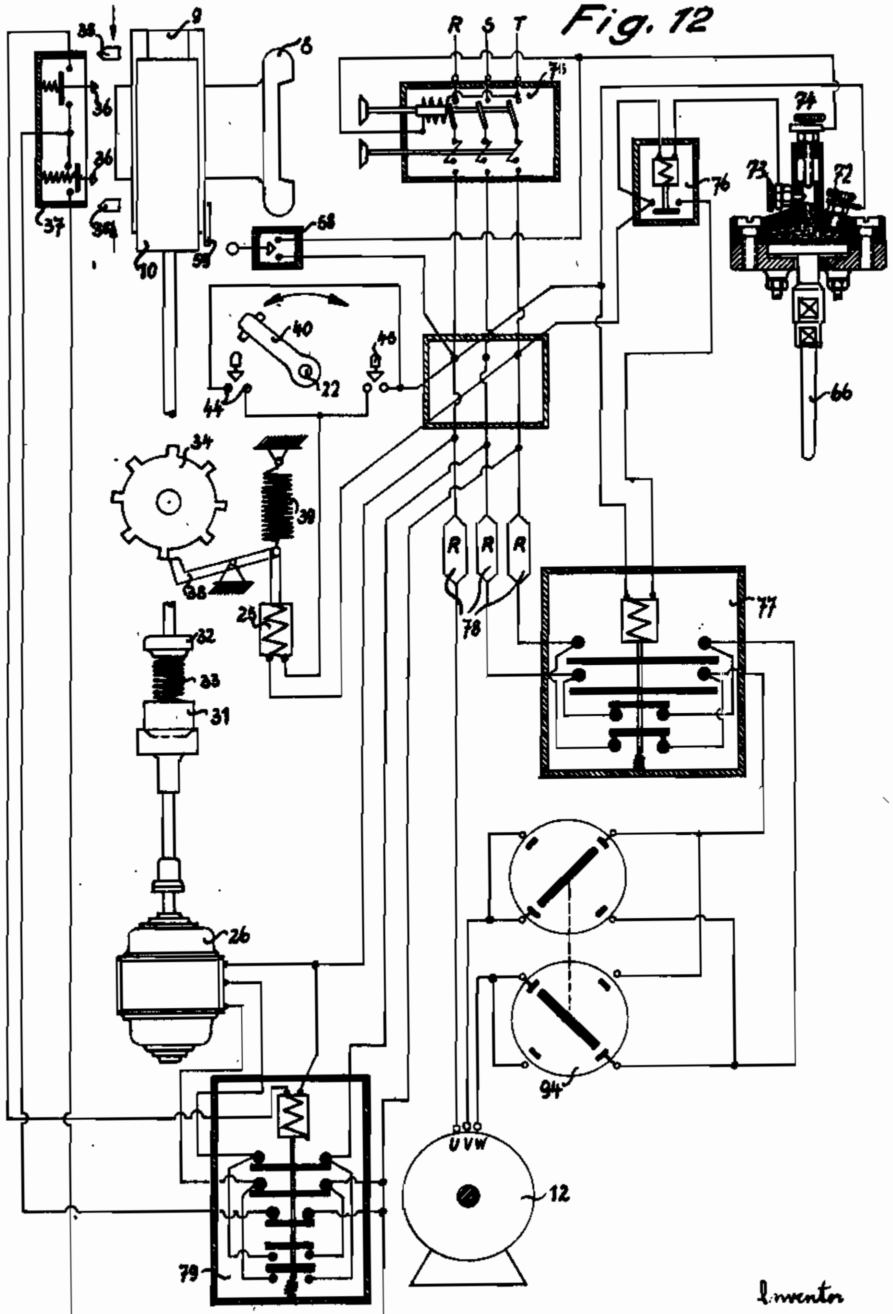
Inventor
Edward Felix Müller
by Knight Bros
Attorneys

PUBLISHED MAY 4, 1943. BY A. P. C.

E. F. MÜLLER
ELECTRIC FEELER CONTROLS FOR MACHINE TOOLS
Filed Aug. 3, 1938

Serial No. 222,743
8 Sheets-Sheet 7

Fig. 12



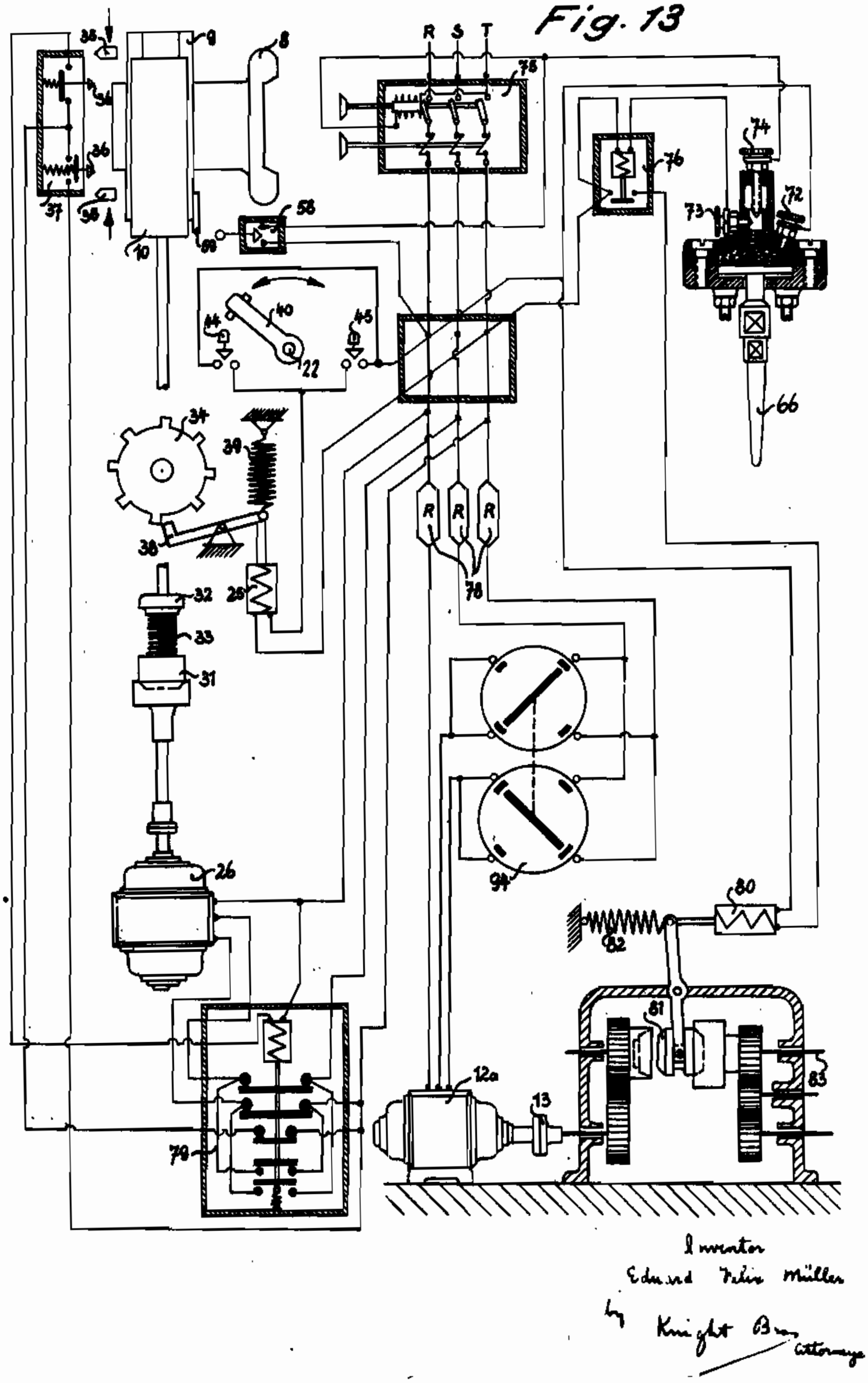
Inventor
Eduard Felix Müller
by Knight Bros
Attorneys

PUBLISHED
MAY 4, 1943.
BY A. P. C.

E. F. MÜLLER
ELECTRIC FEELER CONTROLS FOR MACHINE TOOLS
Filed Aug. 3, 1938

Serial No.
222,743
8 Sheets-Sheet 8

Fig. 13



Published May 4, 1943

Serial No. 222,743

ALIEN PROPERTY CUSTODIAN

ELECTRIC FEELER CONTROLS FOR MACHINE TOOLS

Eduard Felix Müller, Leipzig, Germany; vested in the Alien Property Custodian

Application filed August 3, 1938

This invention concerns improvements in or relating to electric feeler controls for machine tools. The tool is moved in dependence upon the movements effected by a feeler which passes over a pattern, so that an exact duplicate of the pattern is obtained.

If the feeler control is mounted subsequently upon an existing milling machine, the milling cutter is fixed in the usual way in the milling machine spindle and the guide sleeve is firmly clamped in the milling spindle head, so that the cutter assumes a fixed position, thus not being movable in the direction of the spindle axis. The feeler device is connected rigidly to the head-piece and thus also to the milling cutter, by means of a connecting arm.

The feed of the feeler occurs in the direction of the spindle axis. This control is effected by means of spindles, bevel wheels, worm and worm wheels. The guide feed is retained in the normal manner, but a friction coupling and a locking brake are provided which, influenced by an oscillating switch, come into operation at a given moment and lock the longitudinal feed. Both movements, control in height and longitudinal feed, are separately derived each from an electric motor.

In the machining process, there are two feeds, namely, the feeler feed and the pilot or guide feed. The feeler feed is effected in a direction to and from the object to be machined, whilst the guide feed moves longitudinally with respect to the object. The guide feed therefore moves at right angles to the feeler feed.

With larger types of machines, the feeler feed movement is preferably located in the milling cutter spindle carriages.

According to the invention, there is provided an electric feeler control for maehine tools, in which there is a two-position feeler for controlling the feeler feed and an indirect control of a guide feed in dependence upon the control movement effected by the feeler, the guide feed movement being controlled in dependence upon the extent of the path traversed by the feeler.

Many closely adjacent points are felt off and this closeness is adjustable by an oscillating switch and is dependent upon the choice of the speed of feed.

The movements of the feeler are as follows:

(1) towards the pattern,

(2) after contact with the pattern, away therefrom,

(3) after leaving the pattern, again towards it.

By means of this feeler which represents a double position switch, the control current circuits are so influenced that a spot-shaped and exact feeling off is possible. The feeler responds to movement in all directions.

Conditions for the machine which is to be provided with this control are: a reversal which permits placing the table in reciprocating movement and which permits an adjustment of the stroke of the table, furthermore a subsidiary movement which occurs by a definite amount with respect to the transverse movement after each stroke of the table.

The contour milling is effected by two round tables which are fixed to an angle iron at right angles to the table and are mounted on the working table and are driven in the same way be a sliding shaft which is in connection with the locking brake and friction coupling. An angle gearing for clamping on to the milling cutter spindle guide sleeve permits the milling cutter to function in the horizontal position and so to permit the contour milling.

The arrangement according to the present invention is particularly suitable for machining dies for drop presses and for the plastics industry or the like, and for the contour milling of cam discs corresponding to sheet metal templates.

The feeler is conveyed line by line over the surface of the pattern, or respectively the tool over the work. At the end of each cut, a lateral forward movement or feed occurs equal to the width of a cut. The cutting movement takes place in the vertleal direction and the stepwise feed forward in the horizontal direction.

In order that the present invention may be clearly understood an example of the general design, construction and manner of operation will be deseribed with reference to the accompanying drawings, in which:

Fig. 1 is a front elevation of a maehine tool;

Fig. 2 is a side view of the machine shown in Fig. 1;

Fig. 3 is a sectional plan view showing the control with reversing gear and the transmission of the control movement to the lifting shaft;

Fig. 4 is a sectional plan view showing the introduction of the control movement by the lifting shaft up to the bracket spindle and the oscillating switch arrangement;

Fig. 5 shows the oscillation switch;

Fig. 6 is a sectional view of the drive and locking of the longitudinal feed;

Fig. 7 shows the locking brake with brake magnet;

Fig. 8 is a view in section of the driving mechanism parts for the movement of the table;

Fig. 9 shows the device for contour milling from sheet metal templates;

Fig. 9*a* is a sketch of the contour milling without the round table;

Fig. 10 shows the drive of the round table;

Fig. 11 is a sectional drawing of the feeler;

Fig. 12 shows the circuit diagram for three-phase current operation with a reversing motor;

Fig. 13 is the circuit diagram for three-phase current operation with reversing gear;

Fig. 14 shows the rough machined article; and

Fig. 15 shows the article during the finishing process.

The machine itself is a normal milling machine (Figs. 1 and 2) and consists, inter alia, of a pedestal **1** and a headpiece **2**. On the headpiece **2** is mounted a motor carrier **3** which supports a milling motor **4**. This milling motor **4** drives a milling spindle **7** by means of V-belts **5** and a stepped pulley **6**. The machine is also provided with an angle bracket **8**, a cross slide **9**, a working table **10**, on which the work A is clamped, and a pattern table **11** which supports the pattern B.

Movement of the angle bracket **8** is electrically controlled in a vertical direction. When the working table **10** effects an upward and downward movement, a contact **73** shown in Fig. 11 is opened and closed, this contact controlling the vertical movement and also the longitudinal feed. By reason of this operating principle a feeler **66**, described in more detail below, associated with the contact **73** moves to and fro relatively to the pattern so that the current circuit of the contact **73** is closed when the feeler touches the pattern B and is opened again during the return movement and so on. By means of this opening and closing of the current circuit, there is controlled through an auxiliary relay **70** (Figs. 12 and 13) a reversing relay **77** which influences a reversing motor **12** (Figs. 1, 2 and 12) in such a manner that clockwise or anticlockwise rotation thereof is suddenly initiated.

In order to protect the motor **12** from excessive heating, a protective resistance **78** (Figs. 12 and 13) is provided in each phase. The reversing movement is transmitted from the motor **12** through a coupling **13** (Fig. 1) onto a lower worm gear **14**, which is supported in a lower oscillating housing **15** (Figs. 1, 2 and 3). A rising shaft **16** transmits the movement into an upper worm gear **17** (Figs. 1, 2 and 4) which is located in an upper oscillating housing **18**. By means of two bevel wheels **19**, the movement is then transmitted to a bracket spindle **20** which engages with a bracket spindle nut **21**. In this manner, the upward and downward movement of the angle bracket **8** is attained.

In order that the angle bracket **8** may also be moved manually, a bevel wheel shaft **22** (Fig. 4) is provided with a handwheel **23**. In the upper oscillating housing **18** a coupling **24** is mounted which permits the automatic vertical movement to be cut out and allows the bracket **8** to be shifted manually.

In parallel to the current circuit which influences the reversing motor **12**, an oscillating switch **40—44** (Figs. 4 and 5) is actuated which controls the current circuit of a locking magnet **25** (Figs. 6 and 7) which is required for locking the longitudinal feed. The drive for the longitudinal feed is effected from a motor **26** (Figs. 2 and 6) which is coupled through a multiple groove V-belt pulley **27** to a stepped pulley **28** which drives a worm gear **29** located in a worm bearing housing **30**. The movement is transmitted to a clutch coupling **31** (Fig. 6), which by means of a nut **32** and a spring **33** can be adjusted to a particular torque. A ratchet wheel **34** having straight rectangular teeth is keyed to the clutch core **31**, so that locking can occur in both directions of rotation since the reversal of the working table **10** is effected by the motor **26**.

The reversal is effected electrically. Stop cams **35** (Figs. 1, 2 and 12) which are fixed on the working table **10** press against push knobs **36** of a push button switch **37** which is screwed onto the cross slide **9**. In this way a reversing relay **79** (Figs. 12 and 13) is influenced and the motor **26** is correspondingly reversed in polarity and thus changes its direction of rotation.

A locking lever **38** (Figs. 7, 12 and 13) in the form of a double-armed lever is set in operation after the locking, by a magnet **25**. If the magnet **25** is de-energized, the locking lever **38** is drawn back by a spring **39** and the longitudinal feed again comes into operation. The oscillating switch **40—43** is driven from the bracket spindle **20** by means of the bevel wheels **18** and shaft **22**. As long as the feeler touches a level surface, the oscillating switch lever **40** which is carried along by a driver cone **41** (Figs. 4 and 5), the spring **42** and nut **43**, oscillates only between two contacts **44** and **45** without touching them. Even, however, in machining a level surface, the contact systems **44** and **45** can be touched, and this in the finishing and for increasing the accuracy. During the backward and forward oscillation, a locking of the longitudinal feed does not occur so that the working table **10** is moved backward and forward on the cross slide **9**.

If the feeler pin **66** comes to a depression of such dimensions that the previous depression movement of the table, which occurs only with a level surface, is exceeded, then the oscillating switch lever **40** strikes against the contact **44** or **45**, closes the current circuit of the locking magnet **25**, so that the lock **34** and **30** comes into operation and stops the longitudinal feed until the feeler pin **80** again abuts underneath.

The table **10** immediately commences the return movement downward and the oscillating switch lever **40** then interrupts the contact **44** or **45** which has just been closed and the locking magnet **25** is de-energized. The return spring **39** (Figs. 7, 12 and 13) unlocks the longitudinal feed and the working table **10** again resumes its movement.

The contact **45** (Figs. 4 and 5) of the oscillating switch **40—43** is firmly fixed on the angle bracket **8**. The other contact **44** is connected to a lever **44*a*** which is supported on a conical bush **46** and can there be moved and firmly clamped by a clamping screw **47**. The reason for this movement will be explained below.

The automatic longitudinal movement is transmitted from a clutch coupling shaft **48** (Figs. 6 and 8) onto a sliding shaft **50** through a ball joint **49** and from the shaft **58** through a bevel gear **51** and two spur-wheels **52** and **63** onto the table spindle **54**. If the working table **10** is to be adjusted in the longitudinal direction manually, it is necessary for the automatic longitudinal feed to be disengaged. This is effected by means of a coupling lever **55** which takes the spur-wheel 53 and the bevel wheel 57 out of engagement. The table can then be moved manually through a handwheel 56.

On the bracket 8 there is a terminal switch 58 (Figs. 1, 12 and 13) which is actuated by a cam stop 59 adjustably clamped on the cross slide 9. This terminal switch 58 serves to attain a limited stroke in the transverse direction and to stop the working table 10 in any desired adjusted width of cut. As can be seen from the circuit diagrams of Figs. 12 and 13, this terminal switch 58 is directly behind the automatic switch 75 in the current circuit so that the terminal switch 58 is in a position to stop the whole machine.

The feeler is constructed as a double position switch and is connected through a rotatable rod 60 and a connecting arm 61 to the headpiece 2 and thus also to the milling cutter 62. The feeler is adjustable in level with respect to the milling cutter 62 by the milling cutter spindle guide sleeve 63 being movable by means of a toothed wheel. Furthermore, the feeler can oscillate about the rod 60 and can be moved along the connecting arm 61. An additional fine adjustment of the feeler pin 68 with respect to the milling cutter 62 is possible by the pattern table 11 being finely adjustable by means of a spindle 64 (Fig. 1) with respect to the cross slide 9.

The feeler consists of a disc 65 (Fig. 11) having a central stud carrying the interchangeable feeler pin 66, which is screwed thereto. Externally, the disc 65 is ground slightly spherical so that the feeler can easily move over corners. It must, however, fit exactly into the ring 67. On the flat side, the disc 65 rests on three set screws 69. The fastening of the feeler is effected through the ring 67. On the ring 67 and over the disc 65 is placed an elastic plate 69 which is clamped circumferentially by the upper part 70 (of insulating material). The upper part 70 is provided with a bore 71 which broadens out downwardly into a flat extension. The square of the ratio of the diameters (for instance 6 millimetres diameter of the bore at the top and 60 millimetres diameter of the bore at the bottom gives the square of the ratio as $10^2=100$) then gives almost frictionless transmission.

In the hollow space of the upper part 10, there is located the operating liquid, namely mercury, up to the mark given on Fig. 11. This arrangement works in a similar manner to the known hydraulic ram, which converts a small foree into a large force. For with the feeler described, a small movement of the feeler is converted into a large travel of the displaced mercury, so that it can be regarded as a hydraulic travel amplifier. The exact adjustment level is effected by screws 68 which are also adjusted to compensate for large temperature differences.

If a slight pressure is applied to the feeler pin 66 vertically from below, or laterally, then the displacement causes the mercury to rise in the bore 71. By means of the screw 72, current is conveyed into the mercury. With the position of the feeler as shown, the auxiliary relay 76 (Figs. 12 and 13) and the reversing relay 77, are cut out. The pattern B approaches the feeler pin 66 and as soon as contact is made the mercury rises and contacts with the screw 73. The auxiliary relay 76 and the reversing relay 77 are energized and the motor 12 suddenly changes its direction of rotation. The working table 10 moves away from the milling cutter 62 and the pattern table 11 away from the feeler pin 66, and the mercury again falls below the tip of the screw 73. The auxiliary relay 76 and also the reversing relay 77 are again de-energized. The polarity of the motor 12 is thereby reversed and the table 10 again runs upwards towards the feeler pin 66, the cycle of operations being repeated. The screws 72 and 73 are provided with hard metal tips. On the failure of any intermediate apparatus, on starting the feeler pin 66, the mercury will rise until the screw 74 makes contact. In this way the quick break release of the protecting switch 75 is set in operation and the entire current supply is cut off. Furthermore, the safety switch is provided with a bimetal release, so that the machine is also stopped on the occurrence of other faults caused for instance by racing of the milling spindle on the normal current being exceeded. The equalization of pressure in the feeler is effected by a bore which is broadened out at the top.

Instead of providing the reversing motor 12, the reversing gear can be operated by a three-phase motor 12a (Fig. 3). The current circuit which in the embodiment with reversing motor controlled the reversing relay 77, now controls an electromagnet 80 which attracts a reversing coupling 81.

As soon as the current circuit is interrupted, the magnet 80 is de-energized and the spring 82 predominates and reverses the direction of rotation which the shaft 83 transmits to the lower worm gear 14 and onto the bracket 8.

The contour milling (Figs. 9 and 10) is rendered possible by the milling tool 62 being brought into the horizontal position by a bevel wheel drive 85. On the working table 10 there is clamped an angle iron 84 which is provided with two similarly driven round tables 86 and 87. One round table 86 carries the work, for instance, the cam disc 88 to be milled, and the sheet metal template is laid flat upon the other round table 67. A feeler suitable for the horizontal position operates on the sheet metal template. The electric vertical movement is maintained in the table movement. The automatic longitudinal movement with the clutch coupling 31—33 and locking device 25, 34 and 38, functions through two toothed wheels 89 and 90 on a second sliding shaft 91 which drives through two bevel wheels 92 onto the worm shaft 93 of the round tables 86 and 87.

With larger types of machines, the electric control is located in the transverse movement of the cross slide 9, and it thus acts on the transverse spindle 95 (Fig. 2), which moves the cross slide, that is, in the horizontal direction. The round tables 86 and 87 are then arranged horizontally on the working table 10 and are also driven by the automatic longitudinal movement with locks 25, 34 and 38 and clutch coupling 31—33.

A reversing switch 94 is inserted in the current circuit in order that such parts as are actually to be machined on the round table in the contour milling process, can also be copied on the longitudinal table. The work 88 is clamped on the angle iron 84 (Fig. 9a). Parallel thereto is fixed the sheet metal template and first of all the upper circumference of the work 88 is felt off to the two points a, so that the electric vertical movement of the working table occurs from below upwards.

The reversing switch 94 is then reversed and the lower part of the work 88 is felt off again to the two points a, so that the electrical vertical movement now, however, occurs from above downwards. By means of this arrangement, it is not necessary to provide two round tables but all similar articles can be copied in this way.

Finally, the diagrams shown in Figs. 14 and 15 will be explained.

During rough machining (Fig. 14) considerable importance is placed on a great amount of work and small accuracy. This can, in the first place, be attained by the selection of a high speed of feed, and secondly by the adjustment of the oscillating switch **40**—**43**, in such a manner that the two contacts **44** and **45** are placed widely apart so that the longitudinal feed is not interrupted with the usual vertical control, and the oscillating switch lever **40** only swings backward and forward without touching the contacts **44** and **45**, so that it is immaterial whether the points to be felt off are brought quite close together, since the locking of the table feed commences even before the electric vertical control has terminated. It is thus seen that the accuracy is not dependent upon the contact path and the play of the driving mechanism parts, but only upon the closeness of the points to be felt off. This closeness can be regulated to any desired small value, the accuracy thus being extremely great.

In the two Figs. 14 and 15 the points to be felt off are shown wide apart for clarity in order that the method of working of this described arrangement can be understood. It is assumed that the working table **10** moves from A to B, that is, in the direction of the arrow.

EDUARD FELIX MÜLLER.