June 9, 1959 E. C. BULLARD ET AL 2,890,298

PENDANT SWITCH

Filed Oct. 15, 1953 21 Sheets-Sheet 1

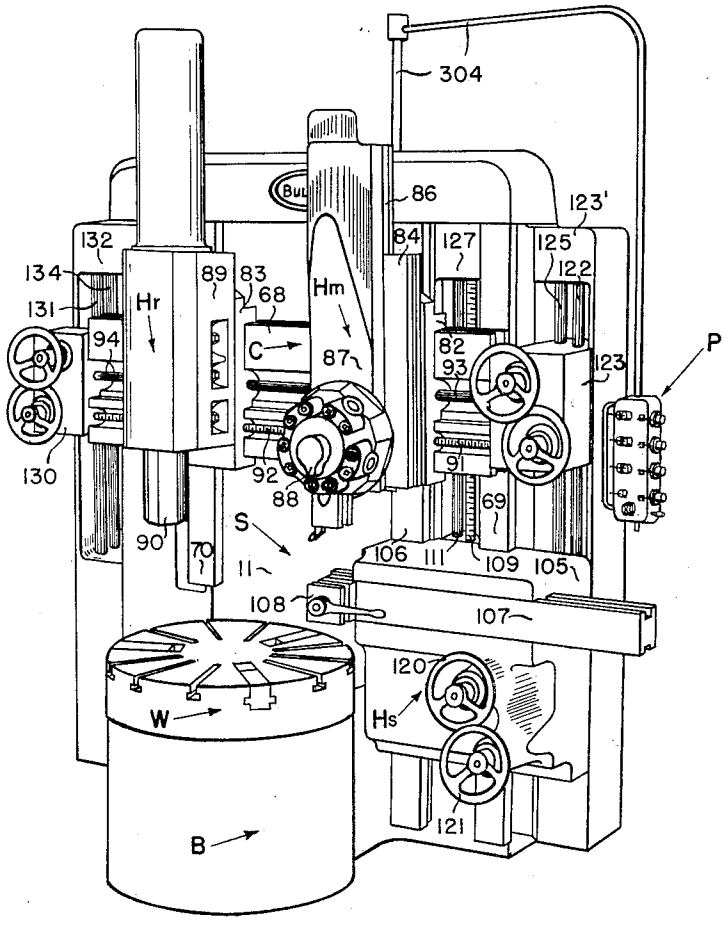


FIG. I

INVENTORS.
EDWARD C. BULLARD
CLAUDE M. GRINAGE

BY

Paul M. Gast

June 9, 1959 E. C. BULLARD ET AL 2,890,298

PENDANT SWITCH

Filed Oct. 15, 1953 21 Sheets-Sheet 2

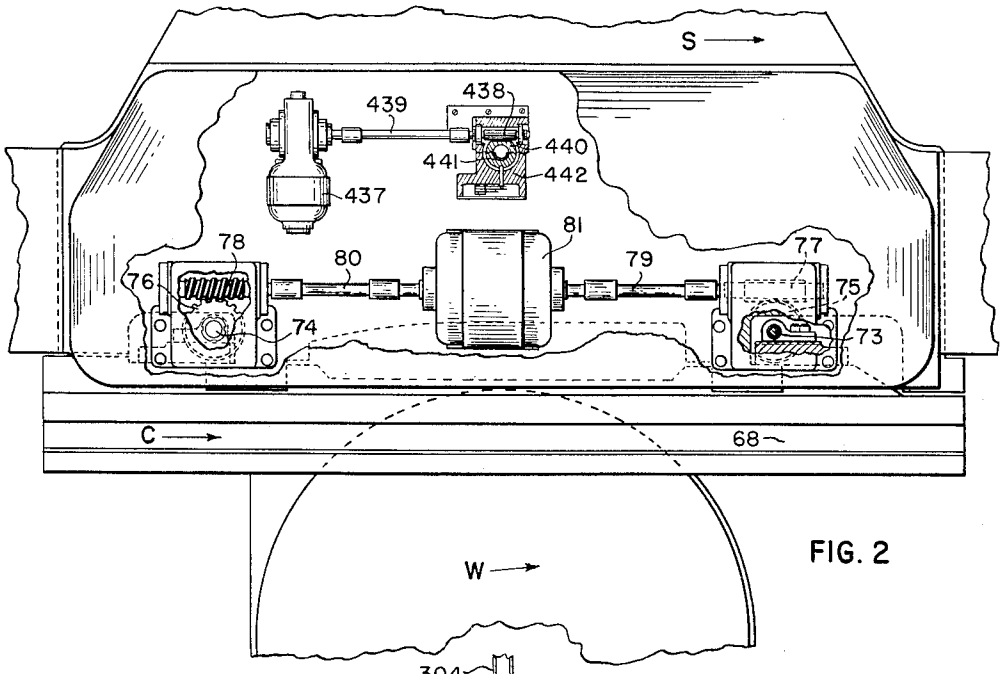


FIG. 2

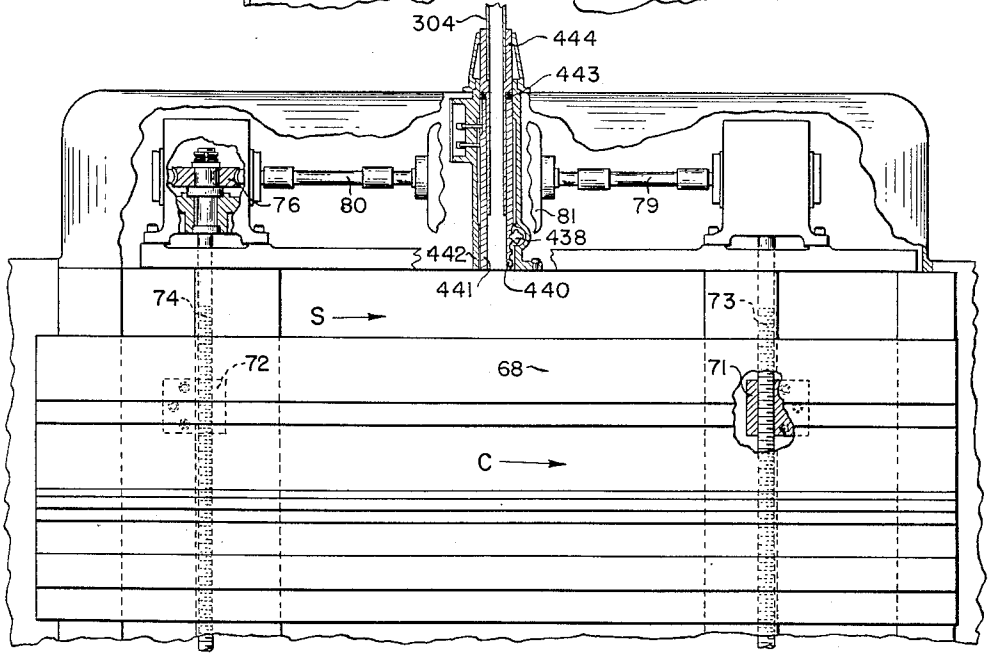


FIG. 3

INVENTORS.
EDWARD C. BULLARD
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June 9, 1959 E. C. BULLARD ET AL 2,890,298

PENDANT SWITCH

Filed Oct. 15, 1953 21 Sheets-Sheet 3

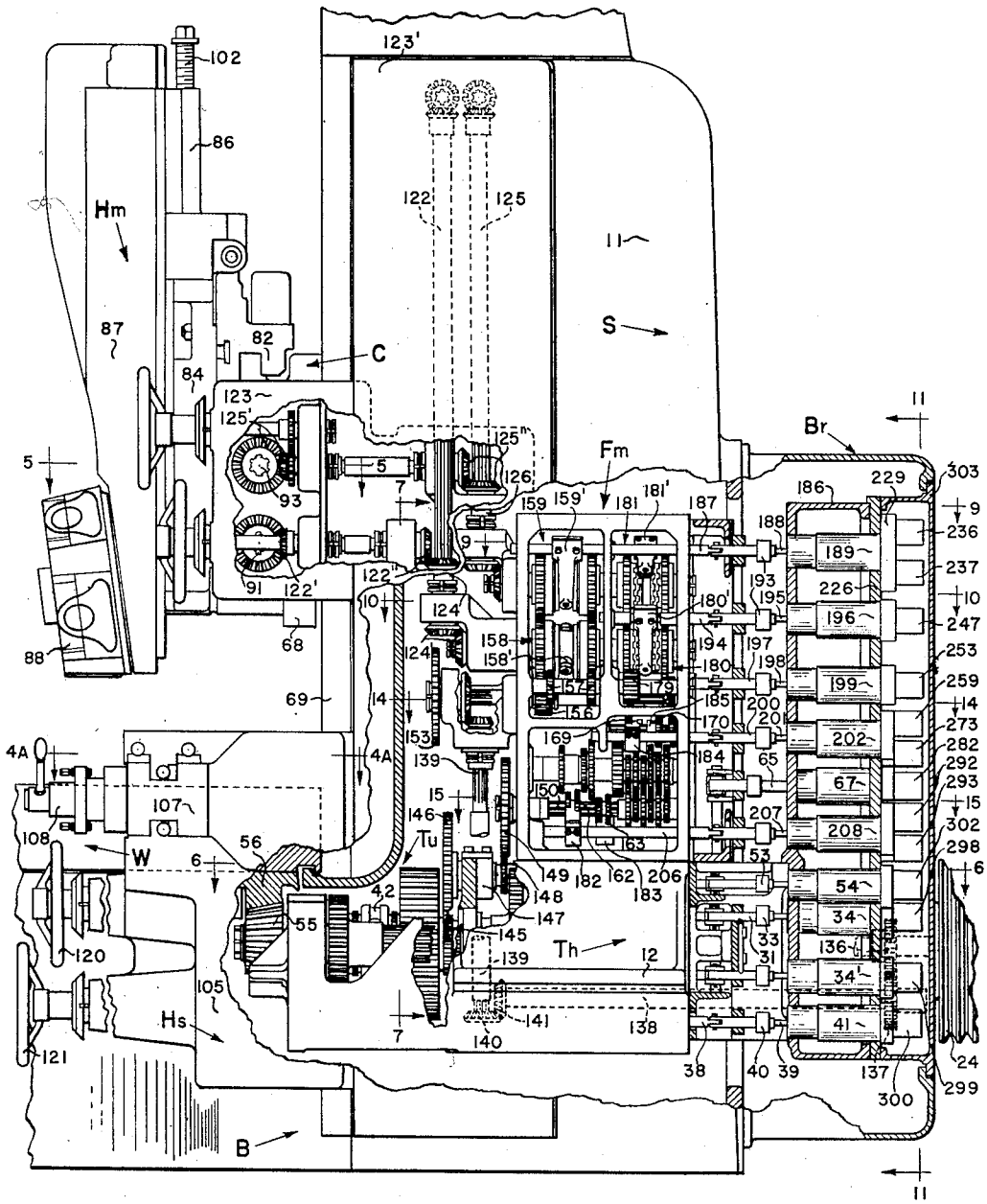


FIG. 4

INVENTORS.
EDWARD C. BULLARD
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Paul M. Fist

June 9, 1959 E. C. BULLARD ET AL 2,890,298

PENDANT SWITCH

Filed Oct. 15, 1953 21 Sheets-Sheet 4

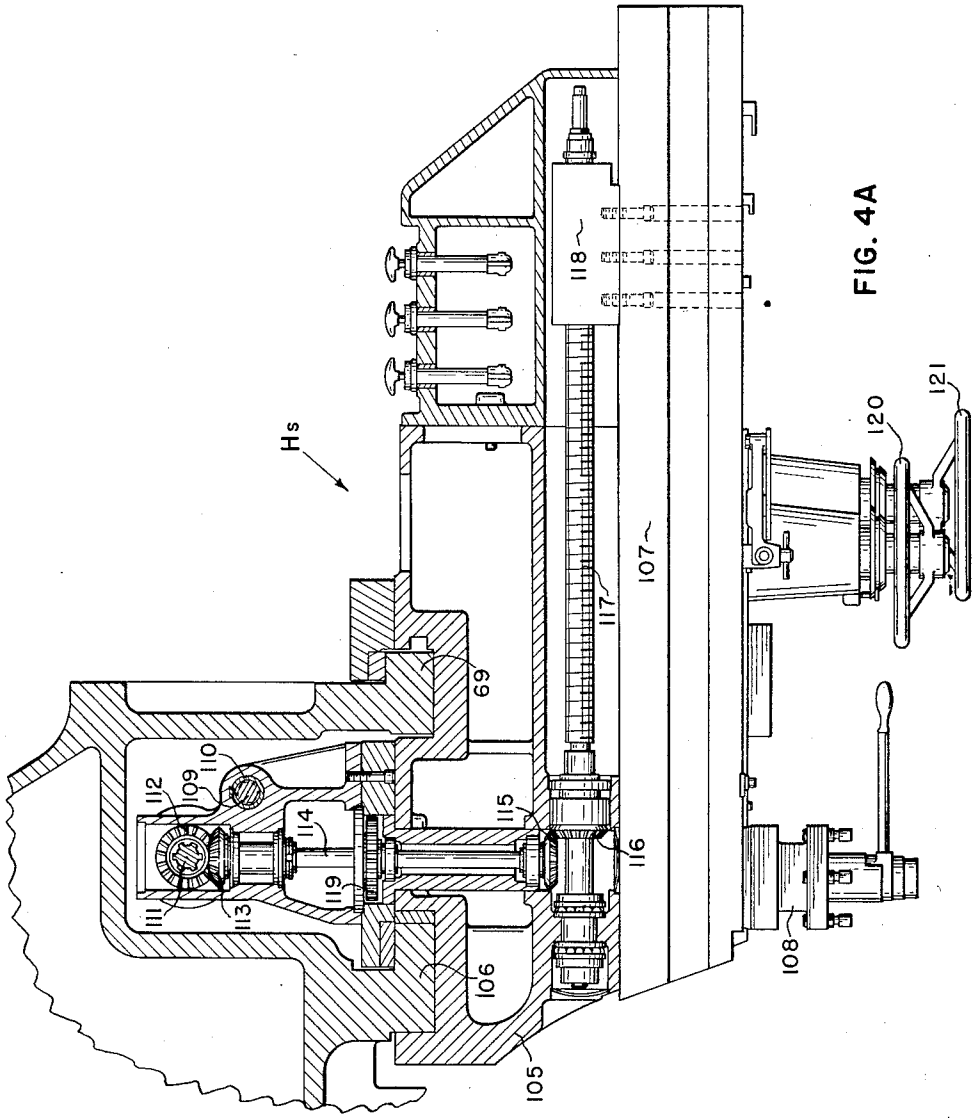


FIG. 4A

INVENTORS.
EDWARD C. BULLARD
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PENDANT SWITCH

Filed Oct. 15, 1953 21 Sheets-Sheet 5

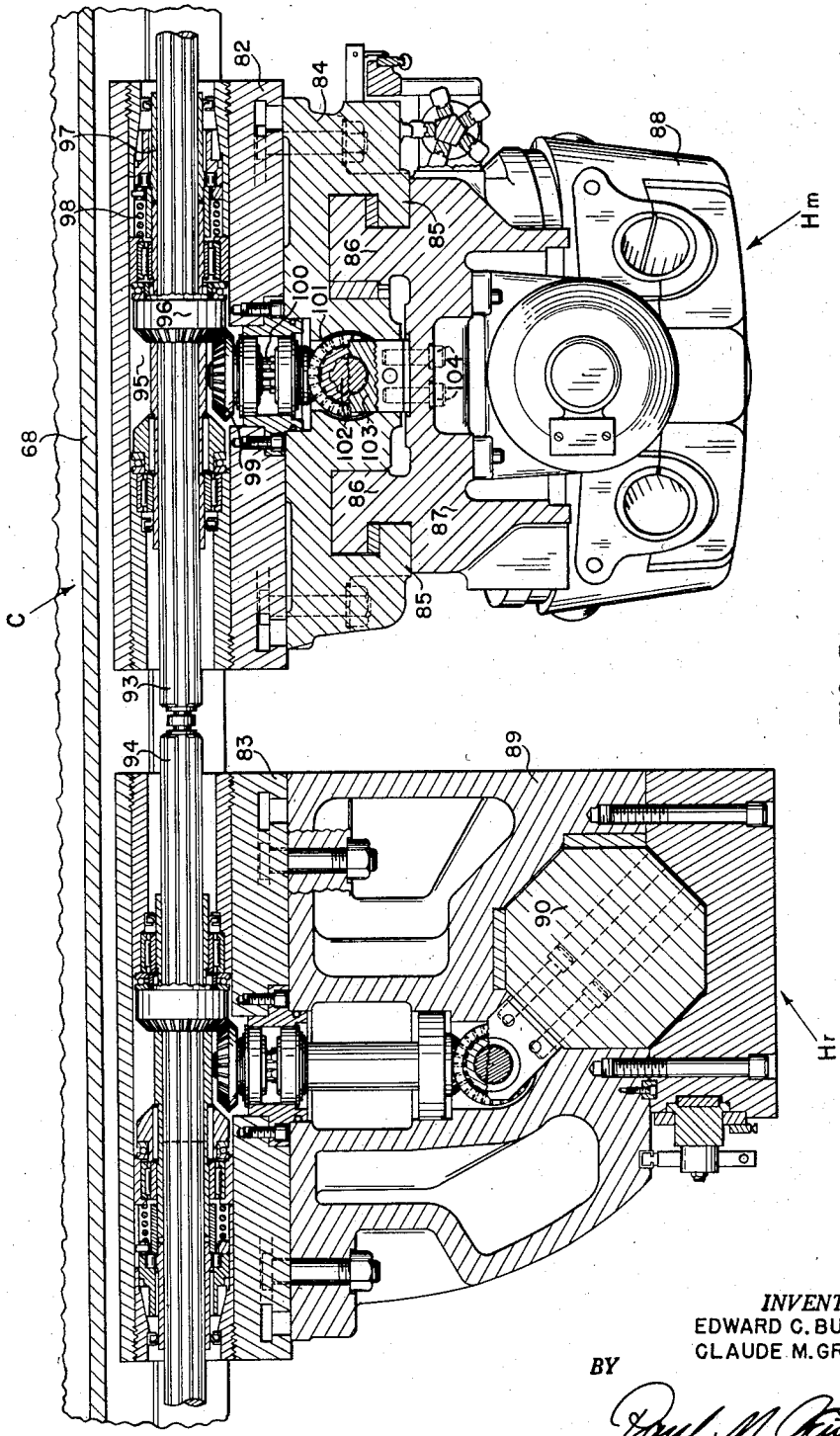


FIG. 5

INVENTORS.
EDWARD C. BULLARD
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Paul M Gist

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PENDANT SWITCH

Filed Oct. 15, 1953 21 Sheets-Sheet 6

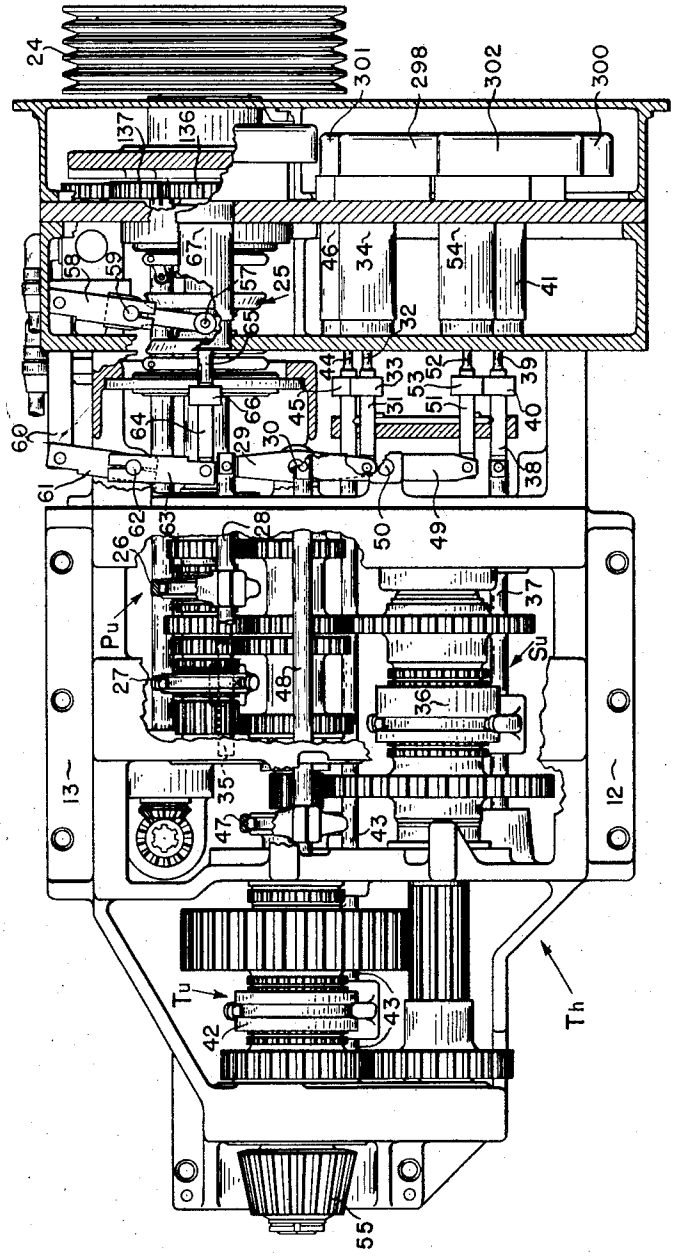


FIG. 6

INVENTORS.
EDWARD C. BULLARD
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Paul M. Fist

June 9, 1959 E. C. BULLARD ET AL 2,890,298

PENDANT SWITCH

Filed Oct. 15, 1953 21 Sheets-Sheet 7

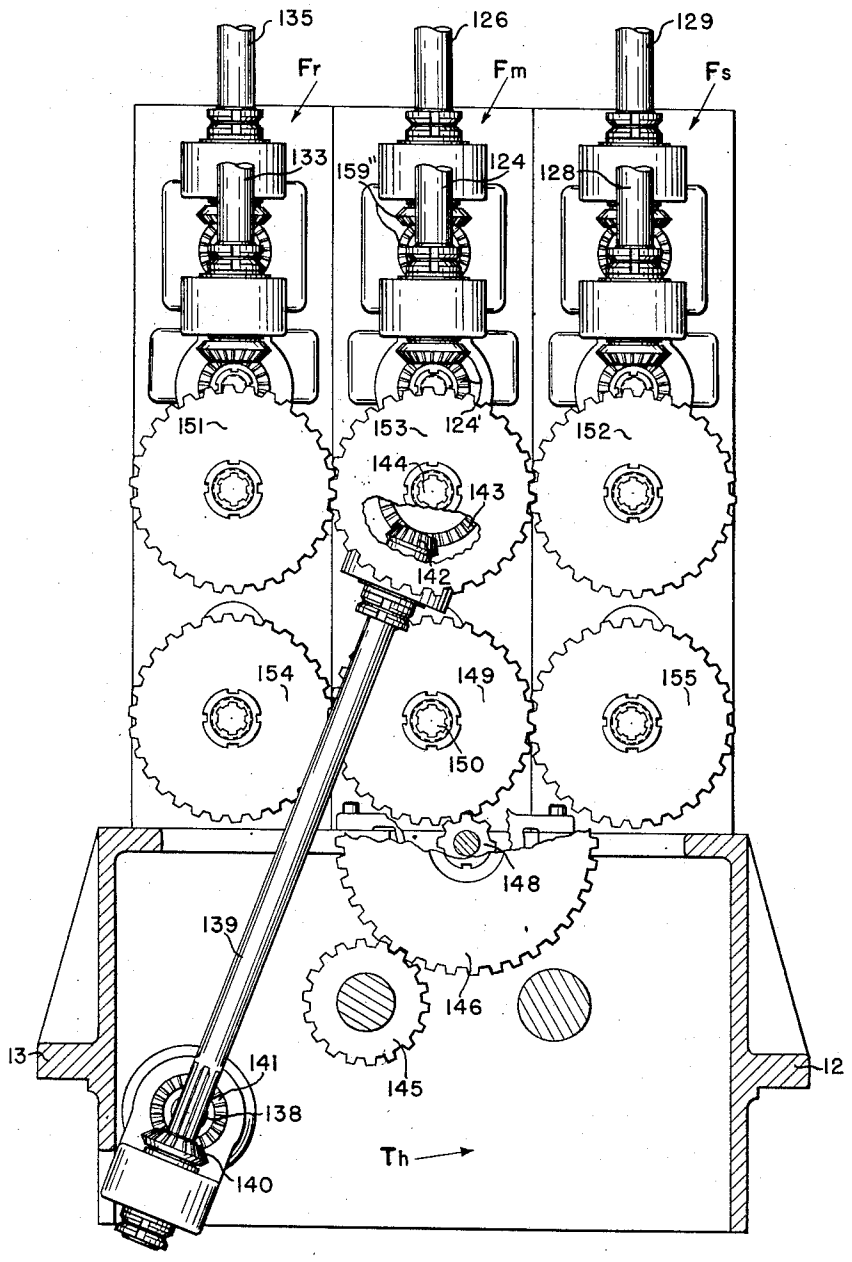


FIG. 7

INVENTORS.
EDWARD C. BULLARD
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June 9, 1959 E. C. BULLARD ET AL 2,890,298

PENDANT SWITCH

Filed Oct. 15, 1953 21 Sheets-Sheet 8

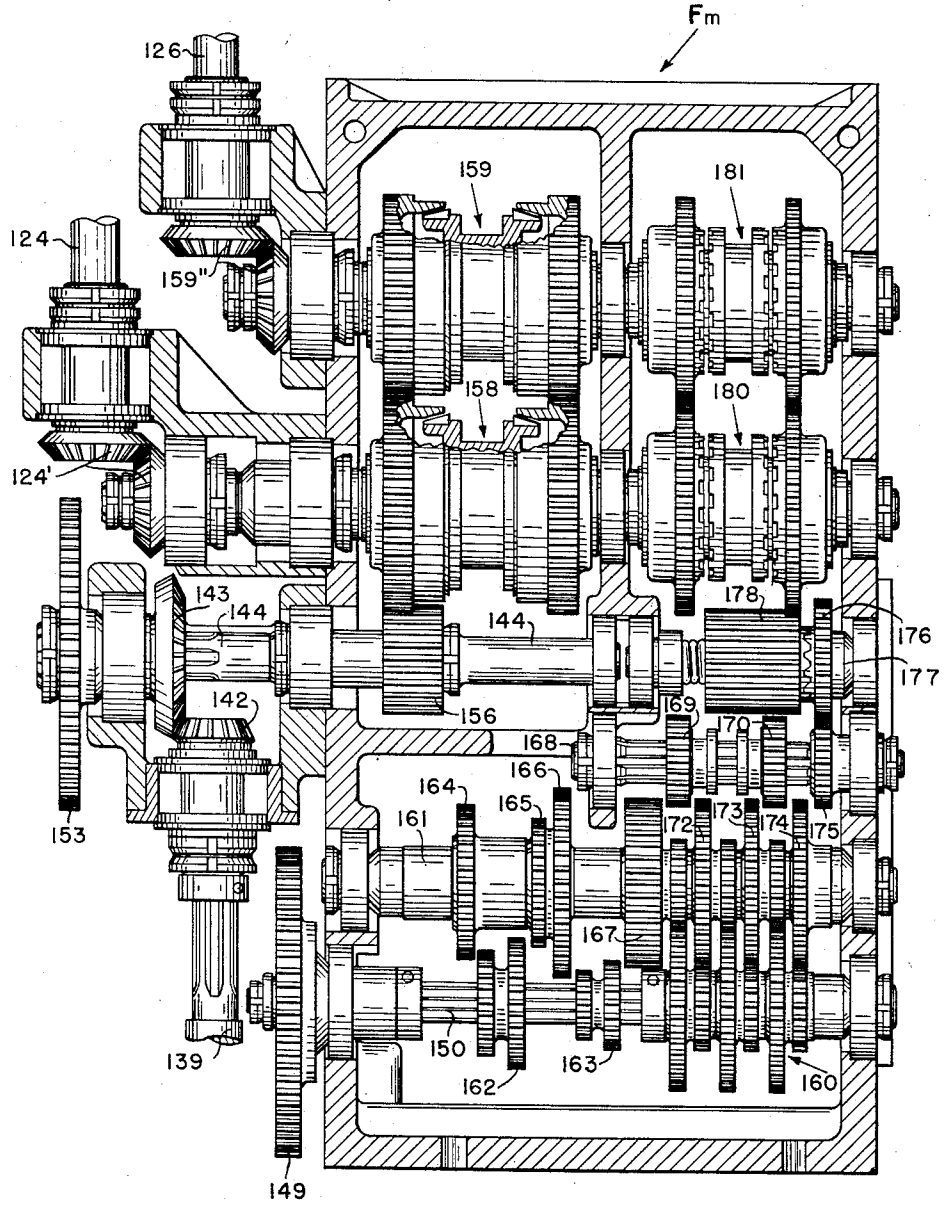


FIG. 8

INVENTORS.
EDWARD C. BULLARD
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Paul M. Gast

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PENDANT SWITCH

Filed Oct. 15, 1953 21 Sheets-Sheet 9

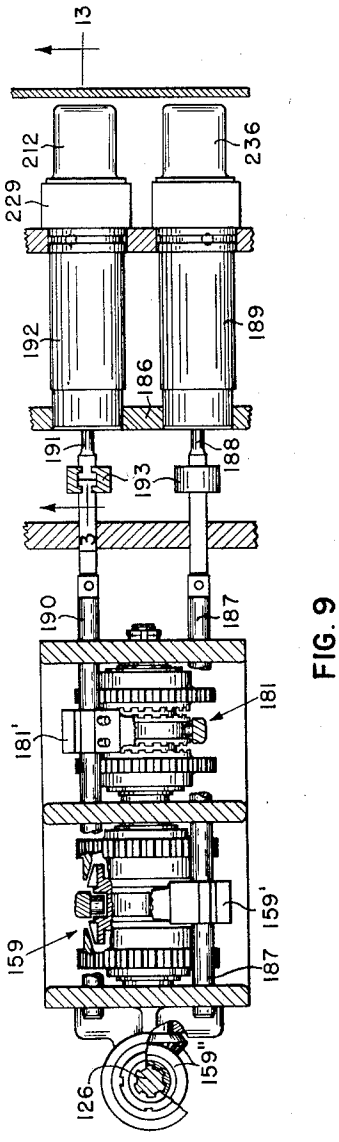


FIG. 9

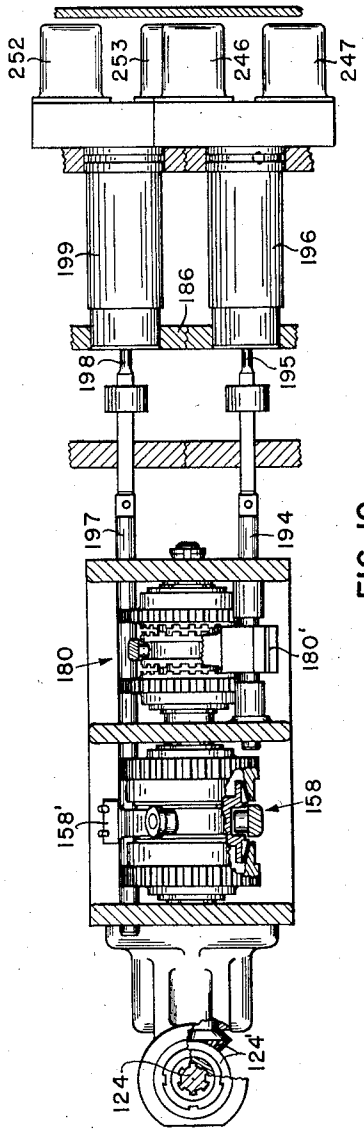


FIG. 10

INVENTORS.
EDWARD C. BULLARD
CLAUDE M. GRINAGE

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Paul M. Gist

June 9, 1959 E. C. BULLARD ET AL 2,890,298

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Filed Oct. 15, 1953 21 Sheets-Sheet 10

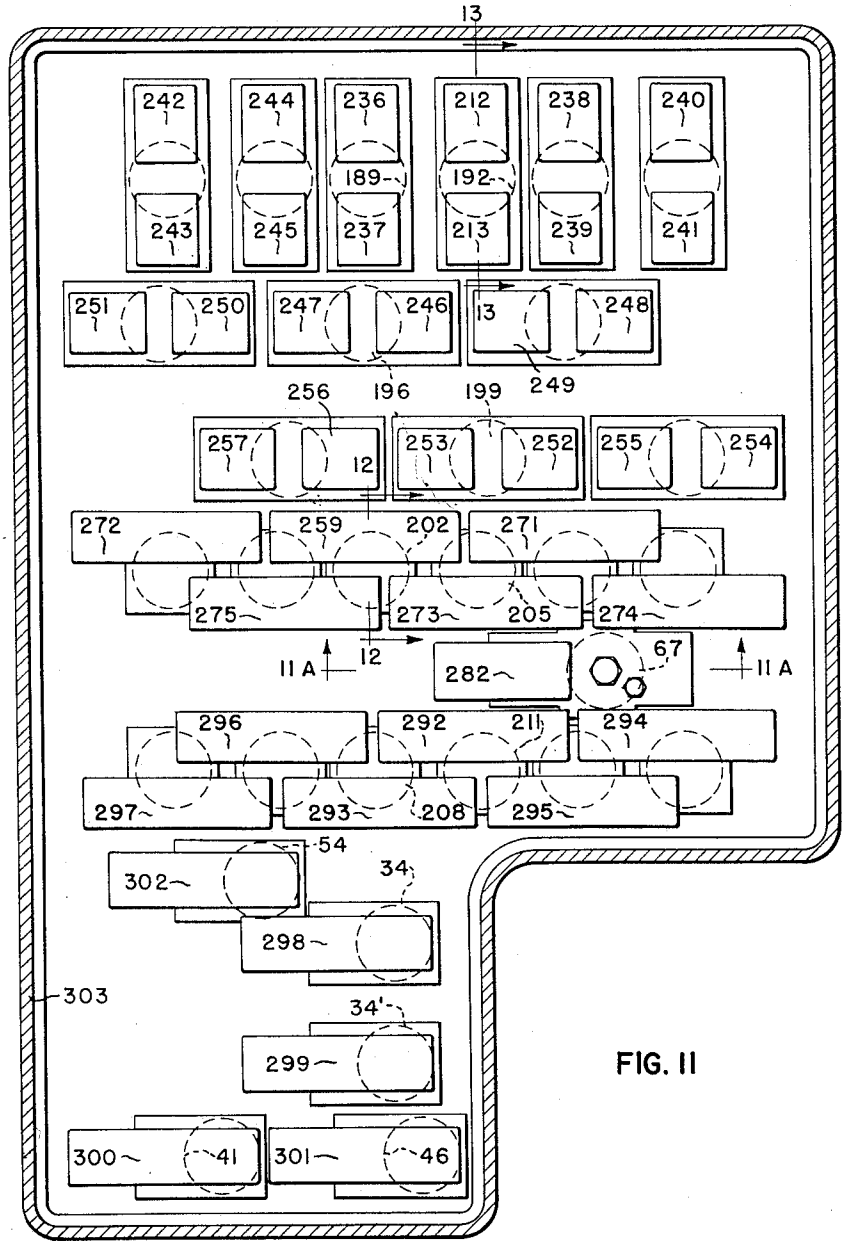


FIG. 11

INVENTORS.
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BY

Paul M. Fest

June 9, 1959 E. C. BULLARD ET AL 2,890,298

PENDANT SWITCH

Filed Oct. 15, 1953 21 Sheets-Sheet 11

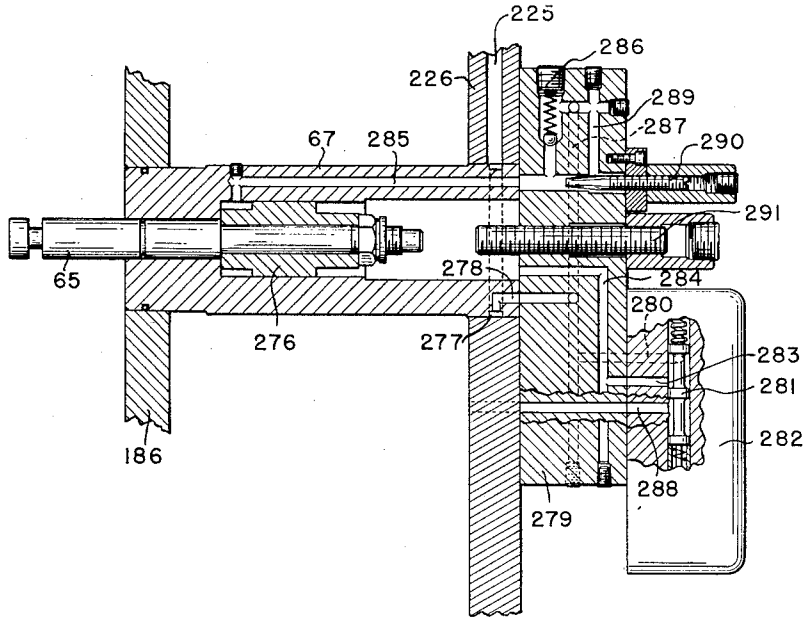


FIG. 11A

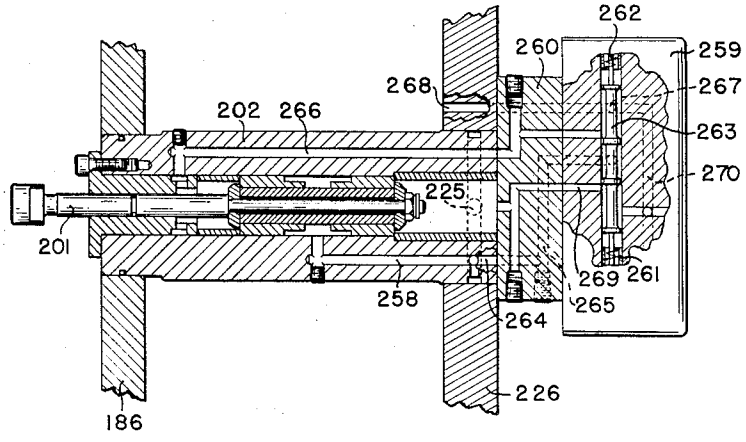


FIG. 12

INVENTORS.
EDWARD C. BULLARD
CLAUDE M. GRINAGE

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Paul M. Fist

June 9, 1959 E. C. BULLARD ET AL 2,890,298

PENDANT SWITCH

Filed Oct. 15, 1953 21 Sheets-Sheet 12

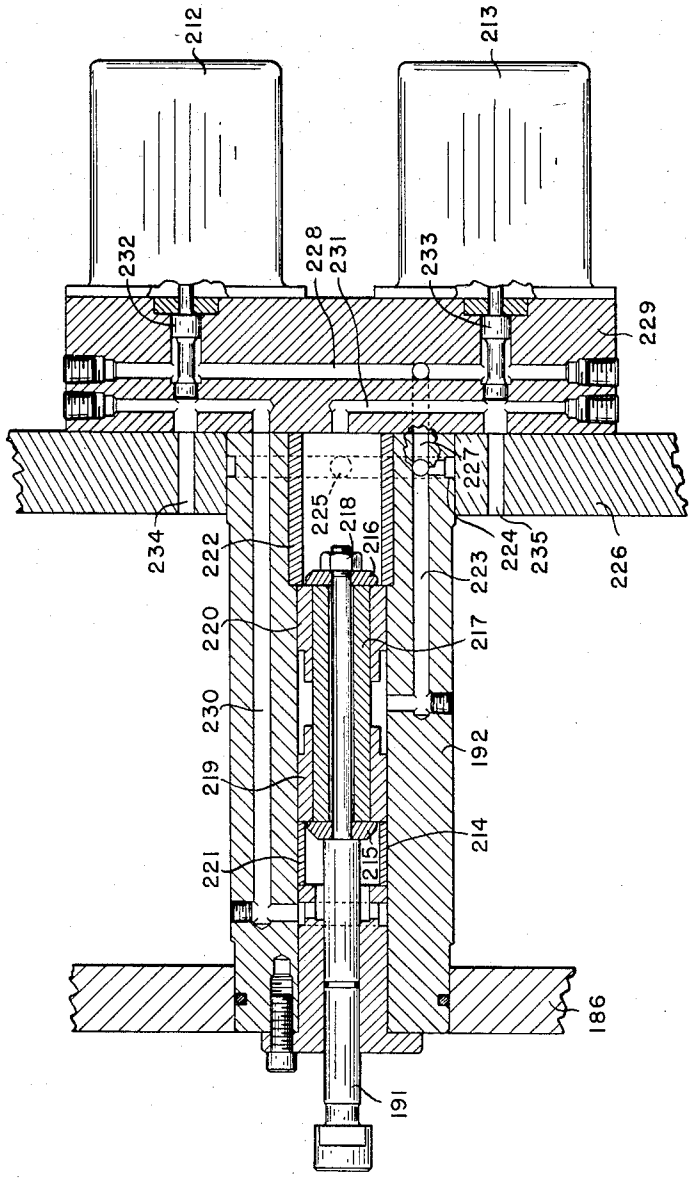


FIG. 13

INVENTORS.
EDWARD C. BULLARD
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Paul M. Gast

June 9, 1959 E. C. BULLARD ET AL 2,890,298

PENDANT SWITCH

Filed Oct. 15, 1953 21 Sheets-Sheet 13

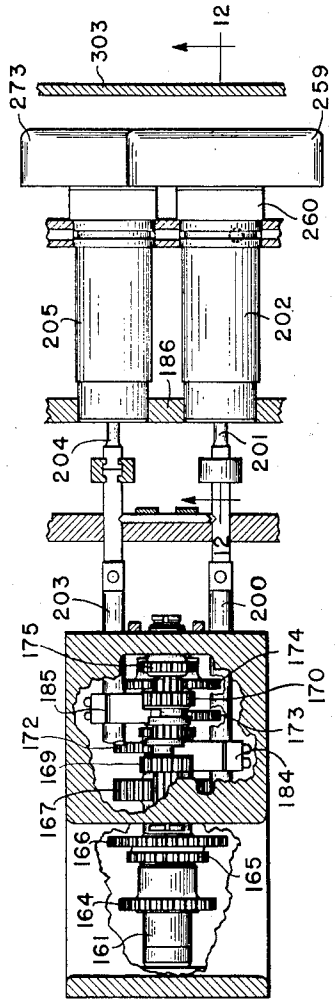


FIG. 14

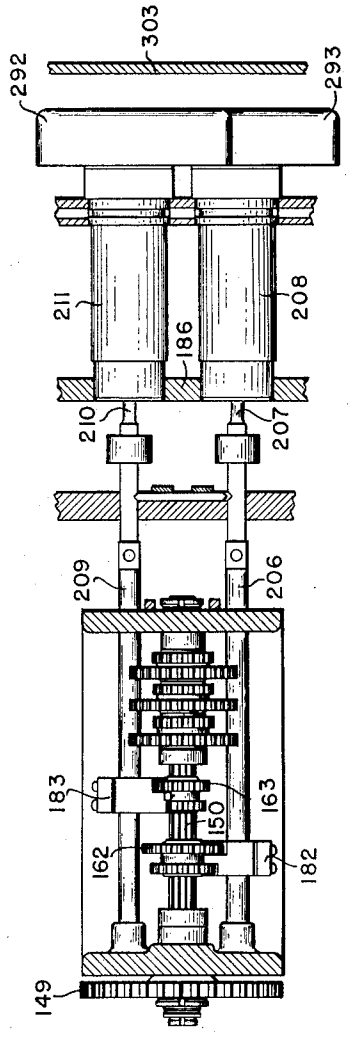


FIG. 15

INVENTORS.
EDWARD C. BULLARD
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Paul M. Fist

June 9, 1959 E. C. BULLARD ET AL 2,890,298

PENDANT SWITCH

Filed Oct. 15, 1953 21 Sheets-Sheet 14

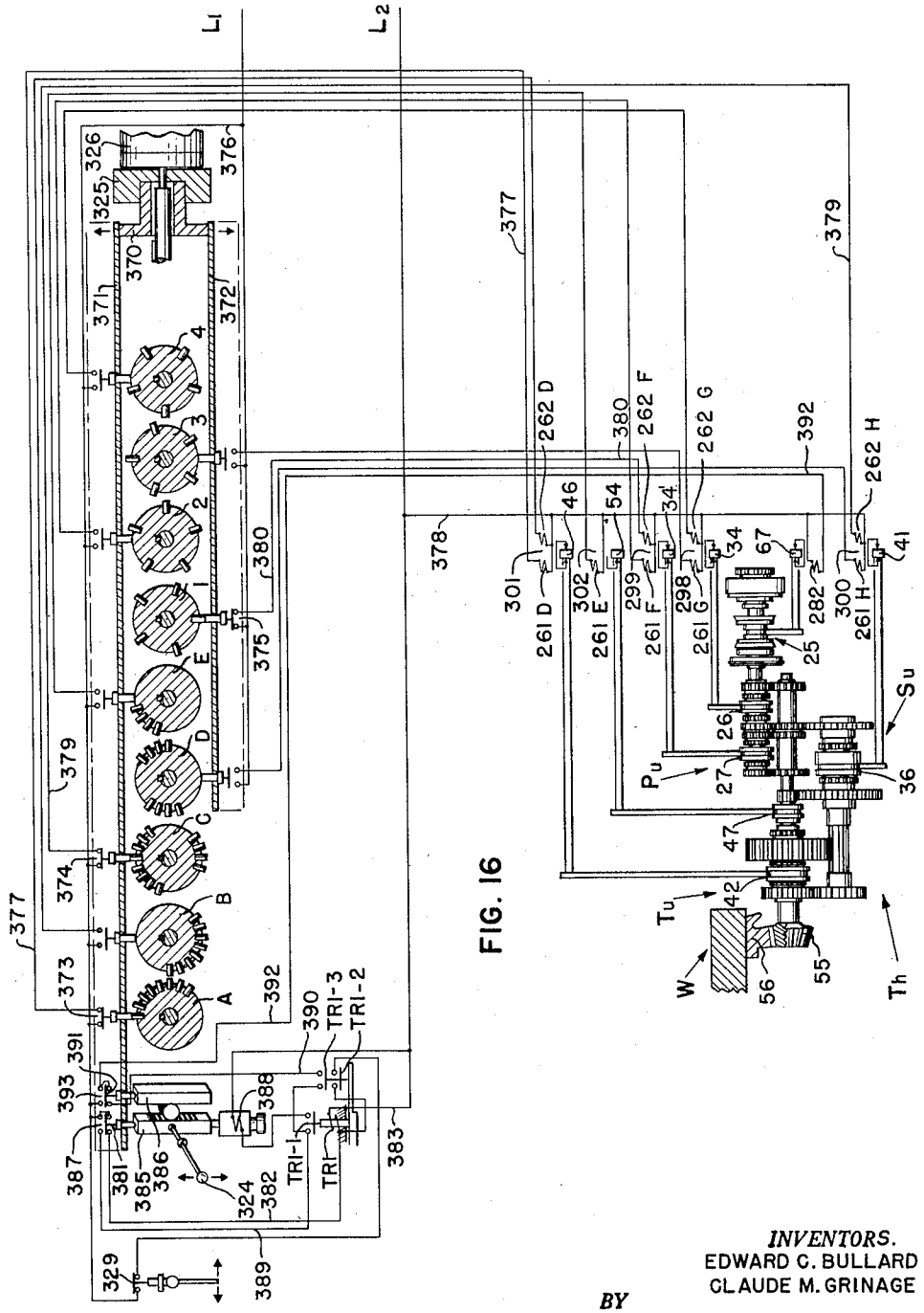


FIG. 16

INVENTORS.
EDWARD C. BULLARD
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Paul M. Geist

June 9, 1959 E. C. BULLARD ET AL 2,890,298

PENDANT SWITCH

Filed Oct. 15, 1953 21 Sheets-Sheet 15

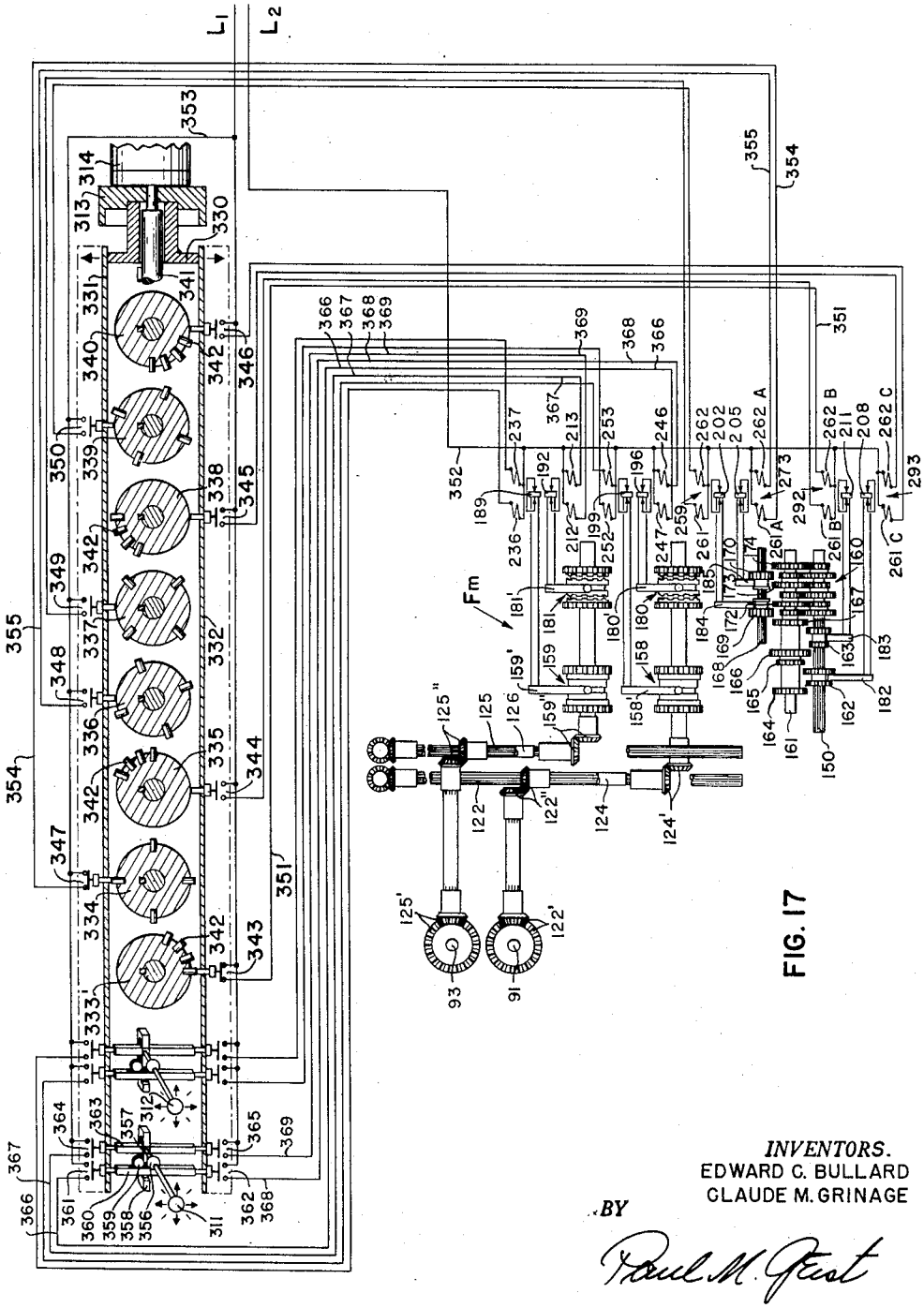


FIG. 17

INVENTORS.
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June 9, 1959 E. C. BULLARD ET AL 2,890,298

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Filed Oct. 15, 1953 21 Sheets-Sheet 16

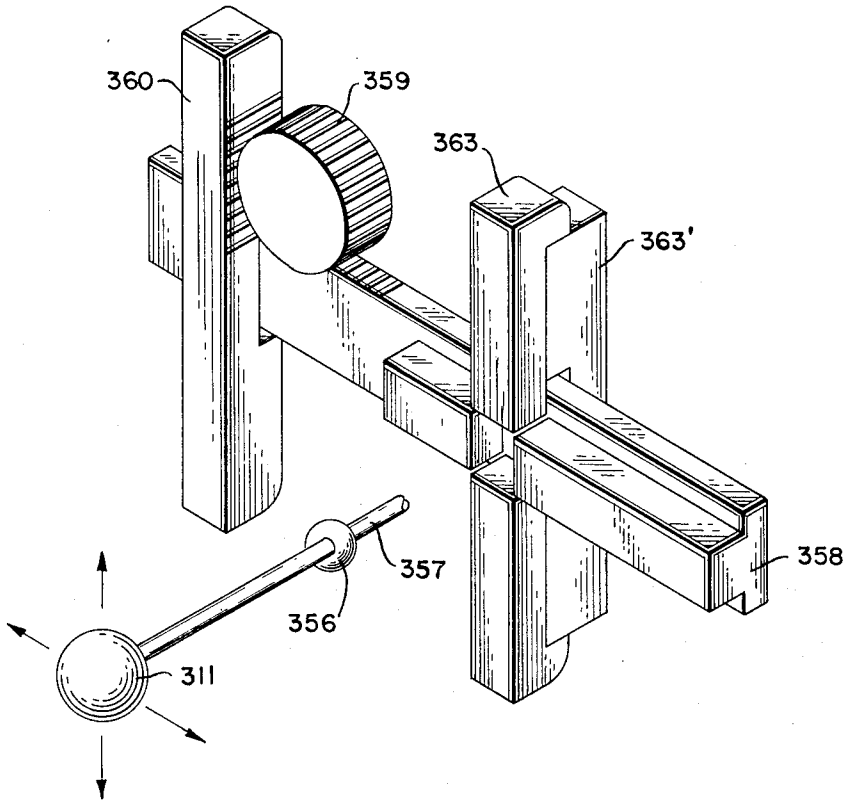


FIG. 17A

INVENTOR.
EDWARD C. BULLARD
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June 9, 1959 E. C. BULLARD ET AL 2,890,298

PENDANT SWITCH

Filed Oct. 15, 1953 21 Sheets-Sheet 17

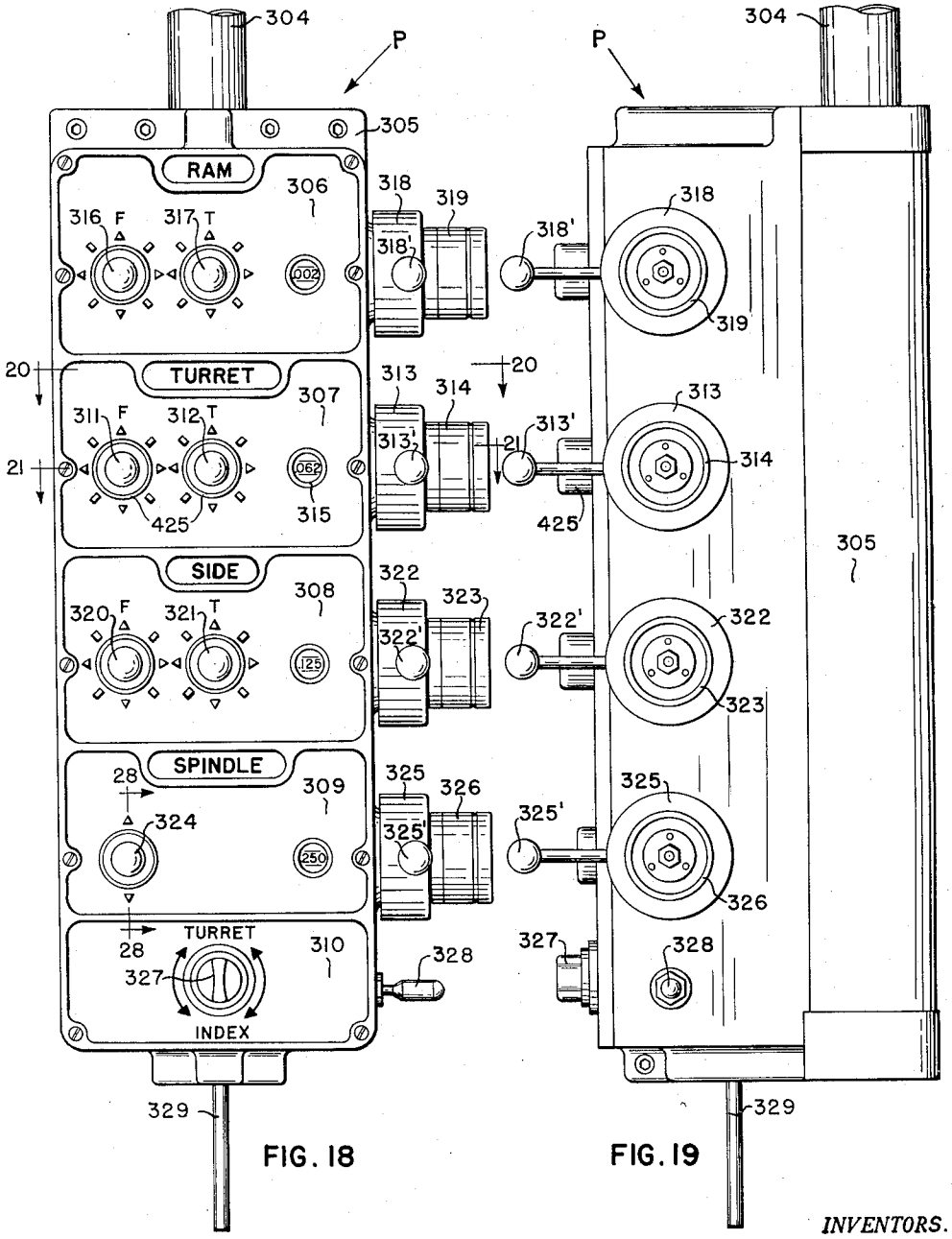


FIG. 18

FIG. 19

INVENTORS.
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CLAUDE M. GRINAGE

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Paul M. Geist

June 9, 1959 E. C. BULLARD ET AL 2,890,298

PENDANT SWITCH

Filed Oct. 15, 1953 21 Sheets-Sheet 18

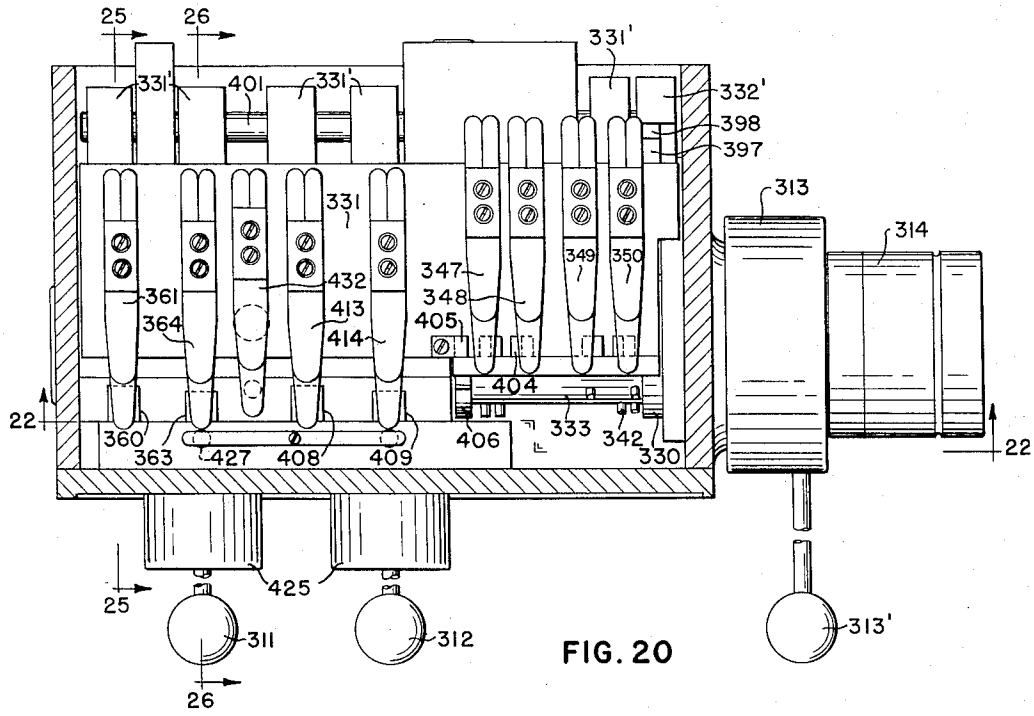


FIG. 20

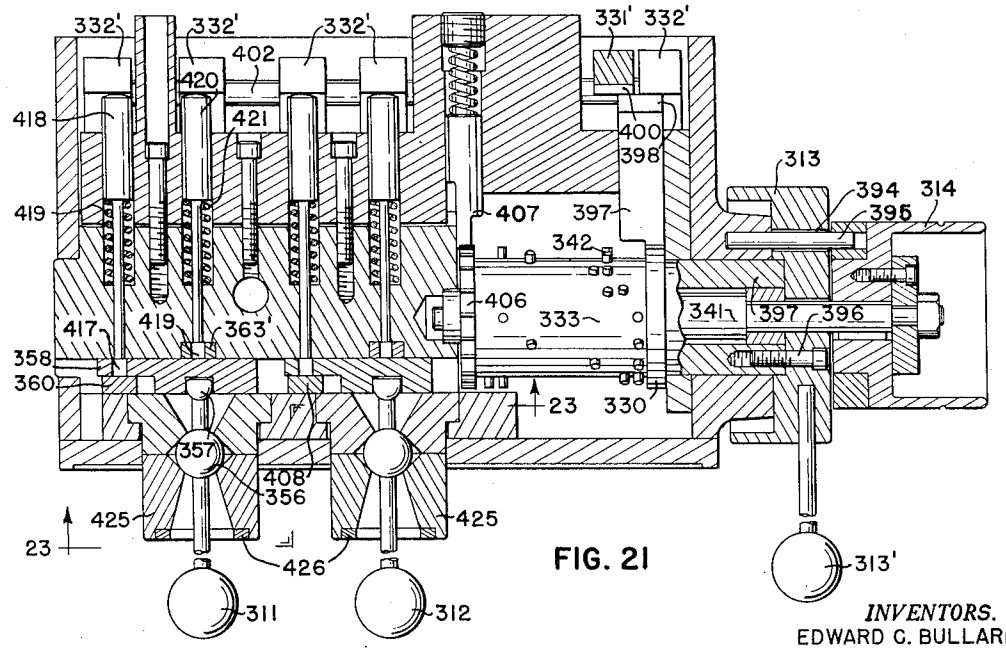


FIG. 21

INVENTORS.
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BY

Paul M Gist

June 9, 1959 E. C. BULLARD ET AL 2,890,298

PENDANT SWITCH

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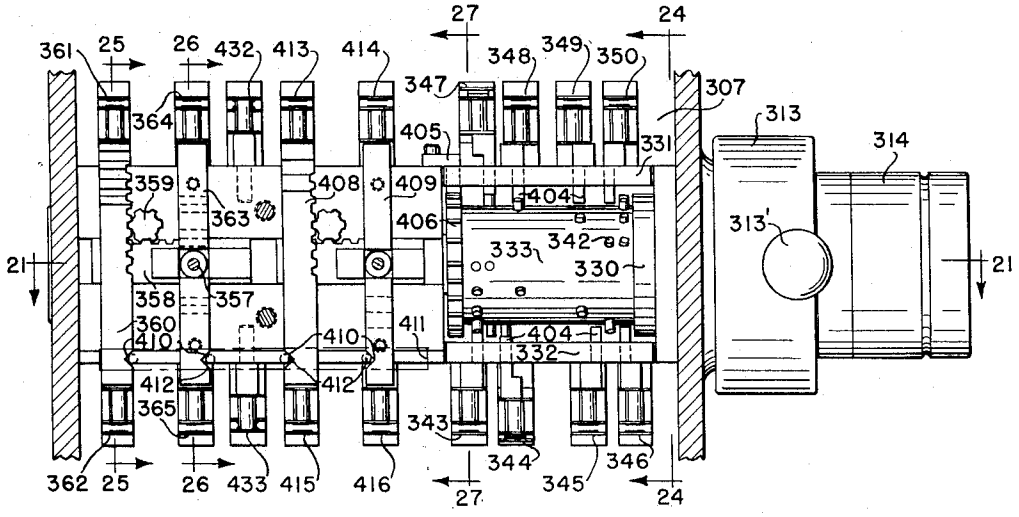


FIG. 22

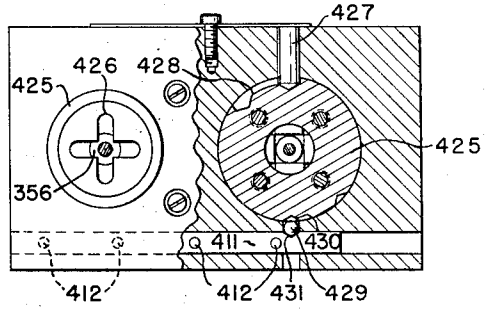


FIG. 23

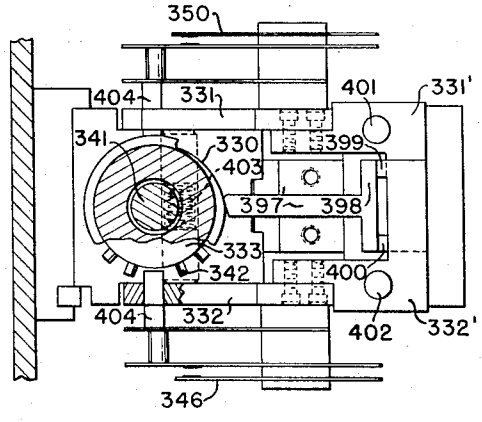


FIG. 24

INVENTORS.
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June 9, 1959 E. C. BULLARD ET AL 2,890,298

PENDANT SWITCH

Filed Oct. 15, 1953 21 Sheets-Sheet 20

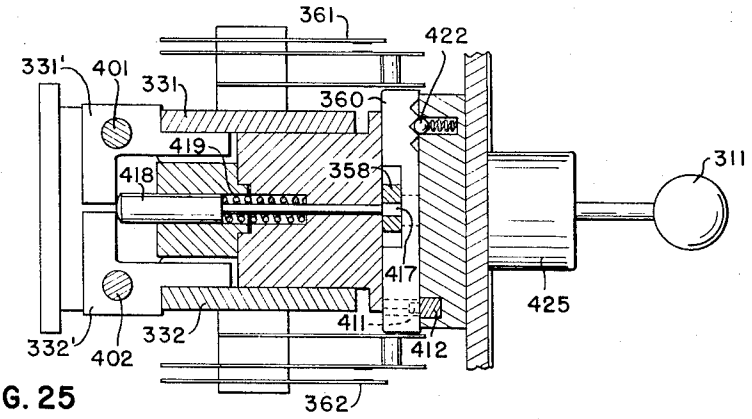


FIG. 25

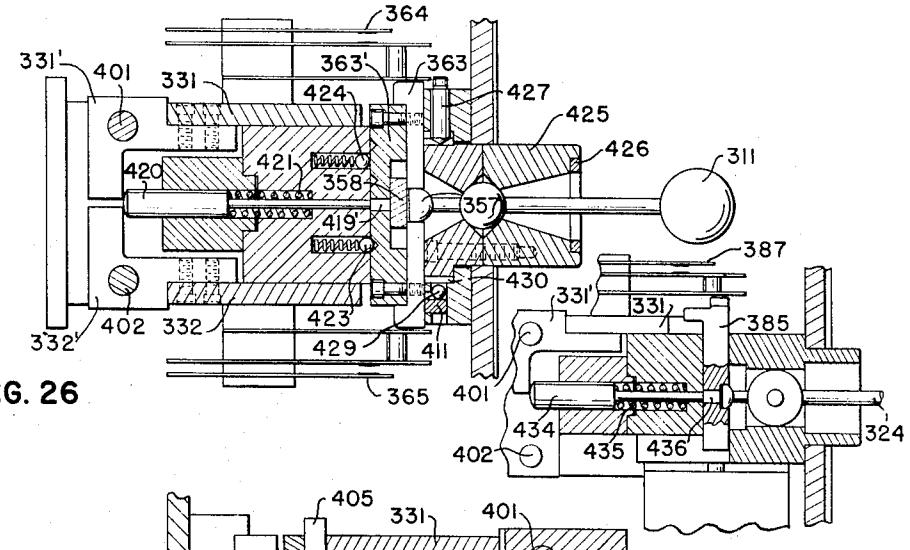


FIG. 26

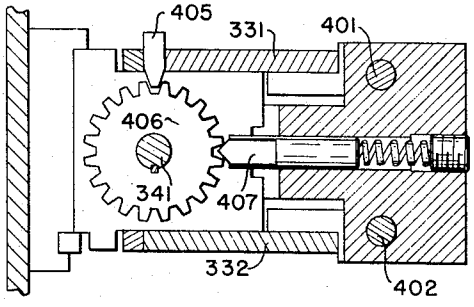


FIG. 28

FIG. 27

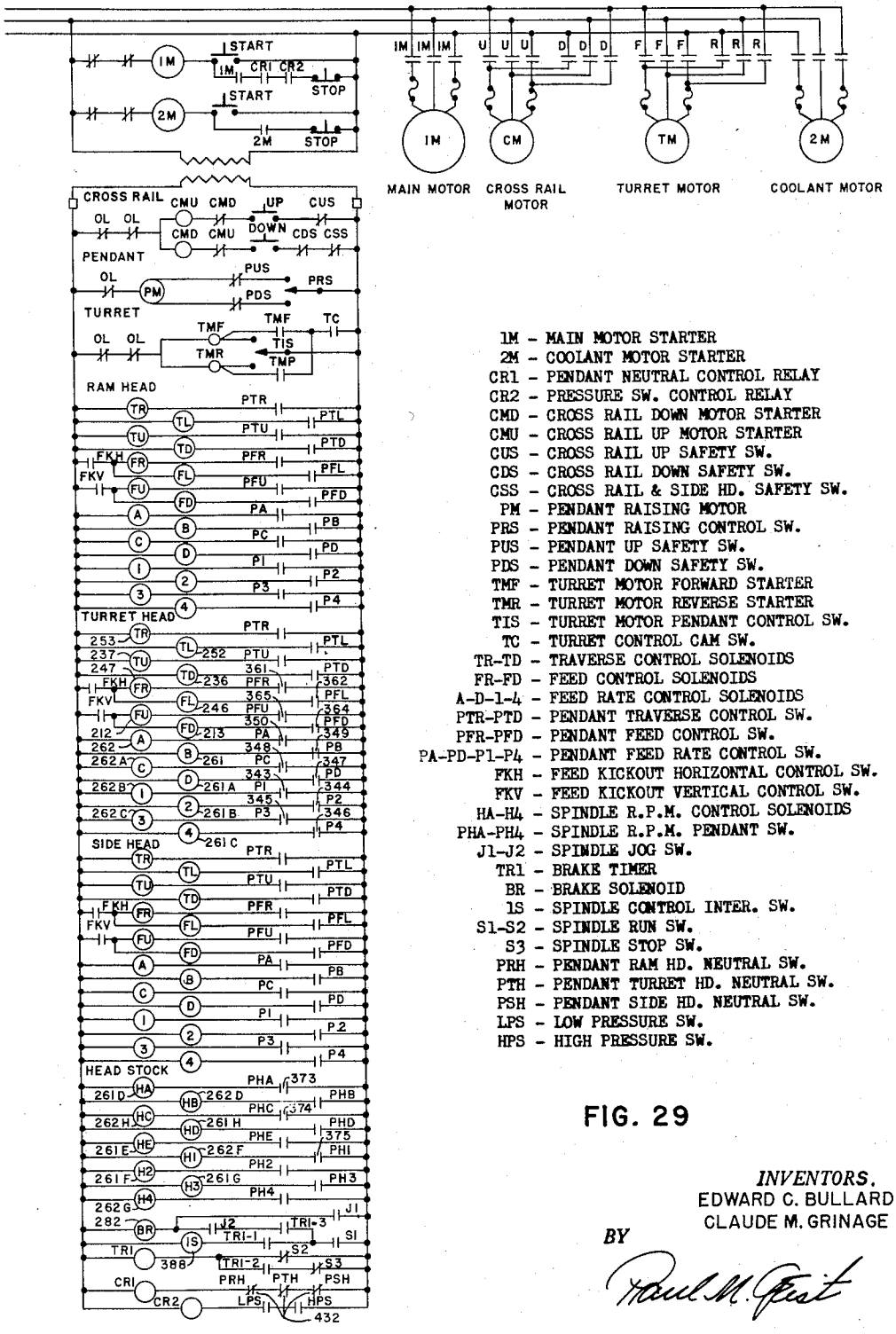
INVENTORS.
EDWARD C. BULLARD
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BY

Paul M. Geist

PENDANT SWITCH

Filed Oct. 15, 1953 21 Sheets-Sheet 21



1M - MAIN MOTOR STARTER
2M - COOLANT MOTOR STARTER
CR1 - PENDANT NEUTRAL CONTROL RELAY
CR2 - PRESSURE SW. CONTROL RELAY
CMD - CROSS RAIL DOWN MOTOR STARTER
CMU - CROSS RAIL UP MOTOR STARTER
CUS - CROSS RAIL UP SAFETY SW.
CDS - CROSS RAIL DOWN SAFETY SW.
CSS - CROSS RAIL & SIDE HD. SAFETY SW.
PM - PENDANT RAISING MOTOR
PRS - PENDANT RAISING CONTROL SW.
PUS - PENDANT UP SAFETY SW.
PDS - PENDANT DOWN SAFETY SW.
TMF - TURRET MOTOR FORWARD STARTER
TMR - TURRET MOTOR REVERSE STARTER
TIS - TURRET MOTOR PENDANT CONTROL SW.
TC - TURRET CONTROL CAM SW.
TR-TD - TRAVERSE CONTROL SOLENOIDS
FR-FD - FEED CONTROL SOLENOIDS
A-D-1-4 - FEED RATE CONTROL SOLENOIDS
PTR-PTD - PENDANT TRAVERSE CONTROL SW.
PFR-PFD - PENDANT FEED CONTROL SW.
PA-PD-P1-P4 - PENDANT FEED RATE CONTROL SW.
FKH - FEED KICKOUT HORIZONTAL CONTROL SW.
FKV - FEED KICKOUT VERTICAL CONTROL SW.
HA-H4 - SPINDLE R.P.M. CONTROL SOLENOIDS
PHA-PH4 - SPINDLE R.P.M. PENDANT SW.
J1-J2 - SPINDLE JOG SW.
TR1 - BRAKE TIMER
BR - BRAKE SOLENOID
1S - SPINDLE CONTROL INTER. SW.
S1-S2 - SPINDLE RUN SW.
S3 - SPINDLE STOP SW.
PRH - PENDANT RAM HD. NEUTRAL SW.
PTH - PENDANT TURRET HD. NEUTRAL SW.
PSH - PENDANT SIDE HD. NEUTRAL SW.
LPS - LOW PRESSURE SW.
HPS - HIGH PRESSURE SW.

FIG. 29

INVENTORS.
EDWARD C. BULLARD
CLAUDE M. GRINAGE
BY
Paul M. Geist

United States Patent Office 2,890,298 Patented June 9, 1959

2,890,298

PENDANT SWITCH

Edward C. Bullard, Southport, and Claude M. Grinage, Stratford, Conn., assignors to The Bullard Company, a corporation of Connecticut

Application October 15, 1953, Serial No. 386,166

25 Claims. (Cl. 200—18)

This invention relates to machine tools and particularly to that type of machine tools in which metal is removed from a workpiece by the action of a tool being moved into engagement therewith while relative movement between the tool and workpiece is effected.

The principal object of this invention is to provide a machine tool requiring a minimum of mental and physical exertion to operate it.

Other objects include the provision of a machine tool having interchangeable unit assemblies so that a maximum number of common unit assemblies and a minimum number of special parts are required to produce a large number of the same type of machine tools having different work capacities; the provision of a machine tool having a plurality of tool-supporting heads in which the feedworks for each tool head is of identical construction and is mounted as an integral part on top of a headstock transmission, all within the base of the machine; the provision of such a machine tool in which the headstock transmission is provided with all shafts having centerlines lying within a single horizontal plane so that the headstock can support a plurality of feedworks transmissions; the provision of such a machine tool in which the actuation of each clutch of the various transmissions is effected by a separate hydraulically-operated piston, all of which are mounted in a removable bracket covering the back end of the combined headstock and feedworks, and in which the pistons are connected to the clutch shift rods by simple easily removable connectors; the provision of such a machine tool in which a removable panel is provided adjacent the removable bracket which supports all of the electrical and hydraulic control means for effecting the various gear shifts in the feedworks and headstock; the provision of such a machine tool in which a single electrical conduit leading from the removable panel contains all of the electrical conductors and extends to a pendant located in convenient access to the operator; the provision of such a machine tool in which all of the controls of the headstock and feedworks are located in a pendant and are operable by finger-tip controls; the provision of such a machine tool including a pendant having all the controls for the machine tool mounted in such a manner that they are directionally operated for movement of the various machine tool heads by finger control, and in which all such controls are effectively interlocked so that no harm can be done to the machine tool; and the provision

of such a machine tool including such a pendant wherein separate dial controls are provided, for selecting spindle speeds and feeds of the tool heads, said controls being arranged in such a manner that they are mechanically interlocked.

The above, other objects and novel features of the invention will become apparent from the following specification and the accompanying drawings, in which:

Figure 1 is a perspective view of a vertical turret lathe to which the principles of this invention have been applied;

Fig. 2 is a partial top plan view of the apparatus shown in Fig. 1, disclosing a detail of the invention;

Fig. 3 is a partial front elevational view with certain parts broken away to illustrate others;

Fig. 4 is an elevational view, partly in section, and with parts broken away to show others, of the machine tool shown in Fig. 1;

Fig. *4a* is a partial plan-sectional view of a portion of the machine tool shown in Fig. 1;

Fig. 5 is a sectional plan view taken substantially along line **5—5** of Fig. 4;

Fig. 6 is a sectional plan view of the headstock transmission taken substantially along line **6—6** of Fig. 4;

Fig. 7 is an end elevational view of the combined headstock and feedworks transmissions taken substantially along line **7—7** of Fig. 4;

Fig. 8 is an enlarged sectional elevational view of one of the feedworks transmissions shown in Fig. 4;

Fig. 9 is a partial sectional plan view taken substantially along line **9—9** of Fig. 4;

Fig. 10 is a partial sectional plan view taken substantially along line **10—10** of Fig. 4;

Fig. 11 is a sectional elevational view taken substantially along line **11—11** of Fig. 4;

Fig. 11*a* is a sectional plan view taken along line **11*a*—11*a*** of Fig. 11, but rotated through 90°;

Fig. 12 is a sectional elevational view taken substantially along line **12—12** of Fig. 11;

Fig. 13 is a sectional elevational view taken substantially along line **13—13** of Fig. 11;

Fig. 14 is a sectional plan view taken substantially along line **14—14** of Fig. 4;

Fig. 15 is a sectional plan view taken substantially along line **15—15** of Fig. 4;

Fig. 16 is a schematic diagram showing the electrical circuit and switches controlling the shifting of the clutches in the headstock transmission;

Fig. 17 is a schematic diagram showing the switches and electrical circuits for controlling the actuation of the clutches in the feedworks transmission;

Fig. 17A is an enlarged view of an operating lever mechanism shown in Fig. 17;

Fig. 18 is a front elevational view of a pendant comprising a portion of the present invention;

Fig. 19 is a side elevational view of the pendant shown in Fig. 18;

Fig. 20 is a sectional plan view taken substantially along line **20—20** of Fig. 18;

Fig. 21 is a sectional plan view taken substantially along line **21—21** of Fig. 18;

Fig. 22 is a sectional elevational view taken substantially along line **22**—**22** of Fig. 20;

Fig. 23 is a sectional elevational view taken substantially along lines **23**—**23** of Fig. 21;

Fig. 24 is a sectional elevational view taken substantially along line **24**—**24** of Fig. 22;

Fig. 25 is a sectional elevational view taken along line **25**—**25** of Fig. 20, but rotated through 90°;

Fig. 26 is a sectional elevational view along line **26**—**26** of Fig. 20, but rotated through 90°;

Fig. 27 is a sectional elevational view taken substantially along line **27**—**27** of Fig. 22;

Fig. 28 is a section taken substantially along line **28**—**28** of Fig. 18; and

Fig. 29 is the main wiring diagram for the machine.

Referring to Fig. 1, the principles of the invention are shown as applied to a vertical boring mill including a base B on which is mounted a rotatable work-supporting table W. A vertically-disposed standard S is integrally connected to the base B and is adapted to support a cross rail C for vertical movement along ways on the front face of the standard S. A main turret head H_m and a ram head H_r are mounted on the cross rail C for horizontal reciprocation therealong. A side head H_s is mounted for vertical movement along additional ways formed on the standard S. Referring to Figs. 4 and 7, a headstock transmission T_h is mounted within the base B and standard S and is drivingly connected to the work-supporting table W. The top surface of the headstock transmission housing is flat, and supports feedworks transmissions F_m, F_r, and F_s, all receiving power from the headstock transmission T_h and adapted to supply through suitable shafting and gears the necessary power to the heads H_m, H_r, and H_s for causing them to move at traverse or selectable feed rates along the ways which support them.

A removable bracket B_r is mounted on the rear of the standard S and includes an inner bracket and panel adapted to support all of the hydro-electrical control elements for actuating the various clutches and gear-shifting elements within the various feedworks F_m, F_r, F_s and the headstock transmission T_h.

Referring to Fig. 1, a pendant P is mounted on the one end of a tube through which pass all of the electrical conductors from the electrical elements within the bracket B_r. The pendant P is conveniently located relatively to the operator's normal position during operation of the machine and it includes dials and switches for controlling every operation of which the machine tool is capable.

Referring to Fig. 1, the base B is of a generally barrel-shaped construction and is adapted to house the spindle bearing construction for the work-supporting table W, as well as the chuck-actuating mechanism therefor, all of which details are not shown in the drawing.

Referring to Figs. 1 and 4, the standard S comprises a vertically-disposed housing **11** that is integrally joined to the barrel B, and extends from the base of the machine to its uppermost point and forms the housing for the various headstock and feedworks transmissions.

Referring to Fig. 7, the headstock transmission T_h is provided with a substantially rectangularly-shaped housing having ears **12** and **13** on opposite sides thereof which are adapted to rest on ways formed on the side walls of the standard S in the interior thereof.

Referring to Fig. 6, the headstock T_h includes a primary unit P_u, a secondary unit S_u, and a tertiary unit T_u of the same general construction as that shown, described and claimed in Patent No. 2,355,624, of E. P. Bullard III et al., to which patent reference is made for specific details of construction.

Power is adapted to be supplied to the headstock transmission T_h through the V-belt pulley **24**; thence it is adapted to pass through a combined clutch and brake mechanism **25**, similar to that shown in the above-referred-to patent; thence into the primary unit P_u. The primary unit includes two positive-action, axially-shiftable clutch elements **26** and **27**. The element **26** is connected to a draw bar **28** that is pinned to an oscillatable lever **29** pivoted on a vertically-disposed shaft **30** that is mounted within the housing of the transmission T_h. The opposite end of the oscillatable lever **29** is connected to a draw bar **31** which in turn is connected to a piston rod **32** by an easily removable connector **33**. Piston rod **32** extends into a cylinder **34** and is connected to a piston that is adapted to be reciprocated within the cylinder **34**, as will be described later.

The clutch element **27** is connected to a draw bar **35** that extends directly beneath the draw bar **28** and is connected to an oscillatable lever identical with lever **29** and located directly beneath the latter and oscillatably mounted on the vertically-disposed shaft **30**. The oscillatable lever connected to the draw bar **35** is likewise connected to a piston adapted to be reciprocated within a cylinder **34'** that lies directly beneath the cylinder **34** and, therefore, is not shown in Fig. 6, but is shown in Fig. 4.

The secondary unit S_u includes a positive-action, axially-shiftable clutch element **36** that is connected to a draw bar **37**. The draw bar **37** is connected to a rod **38** which in turn is attached to a piston rod **39** by an easily removable connector **40**. The piston rod **39** extends into a cylinder **41** and is connected to a piston that is adapted to be reciprocated within the cylinder **41**.

The tertiary unit T_u of the transmission T_h includes a postive-action, axially-shiftable clutch element **42** that is connected to a draw bar **43**, which in turn is connected to a piston rod **44** by an easily removable connector **45**. Piston rod **44** extends into a cylinder **46** and is connected to a piston that is adapted to be reciprocated therein.

The direct drive connection between the tertiary unit T_u and the primary unit P_u includes a positive-action, axially-shiftable clutch element **47** that is connected to a draw bar **48** having its one end attached to an oscillatable lever **49**. The oscillatable lever **49** is pivoted on a vertically-disposed shaft **50** fixed in the frame of the transmission T_h. The opposite end of the oscillatable lever **49** is connected to a draw bar **51** which in turn is attached to a piston rod **52** by an easily removable connector **53**. The piston rod **52** extends into a cylinder **54** and is connected to a piston that is adapted to be reciprocated therein.

The output shaft of the transmission T_h extends leftwardly (Fig. 6) from the tertiary unit T_u and is provided with a beveled pinion **55** that meshes with a bevel ring gear **56** (Fig. 4) attached to the bottom of the work-supporting table W.

The clutch and brake mechanism **25** is adapted to be actuated by the axial shifting of a yoke element **57** (Fig. 6) that is connected to an oscillatable lever **58** pivotally mounted on a vertically-disposed pin **59**. The end of the oscillatable lever **58** opposite that connected to the yoke **57** is attached to a draw bar **60** which latter is connected to one end of an oscillatable link **61** that is fixed to an oscillatable shaft **62** mounted in the frame of the transmission. Another oscillatable link **63** is fixed to the shaft **62** at an elevation different from that of the lever **61** and it is pinned to a draw bar **64**. Draw bar **64** is connected to a piston rod **65** by an easily removable connector **66**. Piston rod **65** extends into a cylinder **67** and is connected to a piston that is adapted to be reciprocated therein.

From the foregoing, it is evident that selective actuation of the pistons within the cylinders **34**, **34'**, **41**, **46**, **54**, and **67** will produce twenty different output speeds of the bevel pinion **55** in the same manner that selective actuation of the positive-action clutches in the above-identified patent produces twenty different speeds of rotation of the output shaft.

One outstanding difference of the headstock transmission T_h of this invention and that shown in the above-

identified patent, is the fact that all power shafts of the present transmission are arranged in a single horizontal plane, so that the frame of the transmission is relatively thin and provides a smooth, horizontally-disposed top surface (Fig. 7) wide enough to support the feedworks transmissions F_r, F_m and F_s.

Referring to Figs. 1 to 5, inclusive, the cross rail C comprises a generally-rectangularly-constructed member 68 extending across the front of the machine. The cross rail 68 is adapted to be reciprocated vertically along machined ways 69 and 70 formed on the front face of the standard S.

Referring to Figs. 2 and 3, threaded nut elements 71 and 72 are rigidly attached to the rear face of the cross rail C and are threaded to vertically-extending screws 73 and 74. The upper extremities of the screws 73 and 74 are provided with worm gears 75 and 76 that mesh with worms 77 and 78 fixed to shafts 79 and 80 that are powered by a double-ended reversible electric motor 81. Accordingly, rotation of the motor 81 in one direction causes the movement of the cross rail C vertically upwardly, and rotation of the motor 81 in the opposite direction causes the vertical movement of the cross rail C downwardly.

The cross rail C is the means for supporting the ram head H_r and the main head H_m for horizontal reciprocable movement. Accordingly, saddle members 82 and 83 (Figs. 4 and 5) are mounted on the cross rail C. The saddle 82 has mounted on its front face a swivel member 84 that is provided with a longitudinally-extending way 85 adapted to cooperate with similar mating ways 86 on a slide 87 to which is attached the rotatable turret 88.

The saddle 83 has mounted on its front face a swivel member 89 within which is mounted an octagonally-shaped ram head 90. Horizontal reciprocation of the saddles 82 and 83, and, consequently, the main head H_m and the ram head H_r, is effected by the rotation of separate, aligned, rotatable screws 91 and 92 (Fig. 1) that thread into nut members (not shown) fixed to the saddles 82 and 83. Vertical reciprocation of the slide 87 and the ram 90 is effected by the rotation of aligned, separate, splined shafts 93 and 94 (Figs. 1 and 5).

Referring to Fig. 5, the saddle 82 is provided with a cored opening 95 within which is mounted a bevel gear 96 having an elongated sleeve portion 97 that is splined to the shaft 93. A one-way clutch mechanism 98 is located between the cored wall of the saddle 82 and the outside diameter of the elongated sleeve on the bevel gear 96 for a purpose to be described later.

The bevel gear 96 meshes with a bevel gear 99 fixed to a stub shaft 100 that is journaled within the saddle 82. The end of the stub shaft 100 opposite that supporting the bevel gear 99 is provided with another bevel gear that meshes with still another bevel gear 101, which latter bevel gear is splined to a vertically-extending screw 102. The screw 102 is threaded to a nut 103 that is bolted to the back of the slide 87 by screws 104. From the foregoing, it is evident that rotation of the splined shaft 93 in one direction will cause the slide 87 to move upwardly and when the splined shaft is rotated in the opposite direction, it will cause the slide 87 to move downwardly. Inasmuch as the slide 87 and the ram head 90 are of substantial mass, the one-way clutch mechnism 98 and a similar one for the ram head 90 cooperate with a braking mechanism that operates to prevent the mass of the corresponding head and slide to overtravel during a downward feed movement of the slide 87 and the ram head 90. The construction and arrangement of the parts of the combined overrunning clutch and brake mechanism are substantially identical with that shown and described in Patent 2,384,809 (Figs. 27 and 27*a*) in the name of E. P. Bullard III et al.

Referring to Figs. 1, 4 and 4*a*, the side head H_s comprises a saddle member 105 adapted vertically to be reciprocated along the way 69 that extends to the base of the machine and an additional way 106. A slide 107 is mounted within the saddle 105 for horizontal reciprocatiion, and a rotatable tool-holding turret 108 is mounted on the one end of the slide 107. Vertical reciprocation of the saddle 105 and, consequently, the slide 107 is effected by the rotation of the screw 109 that extends from the base of the machine upwardly to the top thereof. The screw 109 is threaded into a nut 110 that is integral with the saddle 105. Horizontal reciprocation of the slide 107 is effected by the rotation of a splined shaft 111 that likewise extends from the base of the machine to the top thereof in a parallel relationship to the screw 109. The splined shaft 111 supports a bevel pinion 112 that is mounted within the saddle 105 for rotation, but is held against axial movement relatively to the saddle 105. Accordingly, the bevel pinion 112 vertically reciprocates as an integral part of the saddle 105. The bevel pinion 112 meshes with a bevel pinion 113 that is fixed to a shaft 114 within the saddle 105. Another bevel pinion 115 is fixed to the end of shaft 114 opposite that supporting the bevel pinion 113, and the latter bevel pinion meshes with the bevel pinion 116 fixed to the one end of a screw 117 that is threaded into a nut 118 integral with the slide 107. Accordingly, depending upon the direction of rotation of the splined shaft 111, movement of the slide 107 in a corresponding direction is effected.

A spur gear 119 fixed to the shaft 114 is adapted to mesh with other gearing on shafting at a lower elevation than the screw 117, and a hand wheel 120 (Fig. 1) is connected to said gearing for manually reciprocating the slide 107. A hand wheel 121 is connected through shafting and gearing (not shown) to the screw 109. The rotation of said handwheel 121 causes the saddle 105 to be reciprocated vertically.

The screws 91, 92, and 109, as well as the splined shafts 93, 94, and 111, are adapted to be rotated in either direction at a rapid traverse rate and at sixteen separate feed rates to effect the operation of the heads H_r, H_m, and H_s by three identical feedworks F_r, F_m, and F_s, shown in Fig. 7. Accordingly, screw 91 is connected to vertically-disposed splined shaft 122 (Fig. 1) through two sets of bevel gears 122′ and 122″ contained within the gear box 123 (Fig. 4). The top of splined shaft 122 is connected to the feedworks F_m (Fig. 7) through suitable horizontally-disposed shafting and bevel gearing within housing 123′ (Fig. 1); vertically-disposed shaft 124 in the center of standard S (Figs. 7 and 8); and bevel gears 124′.

The splined shaft 93 (Fig. 1) for effecting vertical reciprocation of the main head H_m is likewise connected to a shaft 125 through two sets of bevel gears 125′ and 125″ contained within gear box 123 (Fig. 4). The top of shaft 125 is connected through suitable horizontal shafting and bevel gearing within housing 123′ to vertically-disposed shaft 126 (Figs. 7 and 8), located in the center of the standard S.

The screw 109 for vertical motion of the said head H_s (Fig. 1) is connected through horizontally-disposed shafting and bevel gears located within the housing 127 and the interior of the standard S, to a vertically-disposed shaft 128 leading to the feedworks F_s (Fig. 7). Likewise, splined shaft 111 for horizontal movement of the side head H_s is connected through horizontally-disposed shafting and bevel gears within the housing 127 and the interior of the standard S, to a vertically-disposed shaft 129 which also leads to the feedworks transmission F_s.

In a similar manner, screw 92 for the ram head H_r is connected through suitable bevel gears and shafting within gear box 130 to a vertically-disposed splined shaft 131 which latter is connected through horizontally-disposed shafting and bevel gears within housing 132 and the interior of the standard S, to the vertically-disposed shaft 133 leading to the feedworks transmission F_r (Fig. 7). Like-

wise, splined shaft **94** for horizontal movement of the ram head H_r is connected through suitable bevel gears and shafting within the gear box **130** to vertically-disposed splined shaft **134** (Fig. 1), which latter is connected through horizontally-disposed shafting and bevel gears within the housing **132** and the interior of the standard S, to vertically-disposed shaft **135** (Fig. 7) leading to the feedworks transmission F_r.

Referring to Figs. 4 and 6, the input shaft of the transmission T_h including the V-belt pulley **24** is provided with a spur gear **136** that meshes with a spur gear 137 fixed to one end of a horizontally-disposed shaft **138**. The shaft **138** is geared to an angularly-disposed shaft **139** through bevel gears **140, 141**. Referring to Fig. 7, the shaft **139** extends angularly upwardly to approximately the center of the feedworks transmission F_m where, through bevel gears **142, 143**, the power from shaft **139** is transferred to a horizontally-disposed shaft **144** (Fig. 8). The rotation of the shaft **144** provides the traverse speed for the feedworks F_m. Referring again to Fig. 4, a spur gear 145 on the output shaft of the headstock transmission T_h intermeshes with a spur gear **146** fixed to a stub shaft journaled within a bearing **147** (Fig. 4). The opposite end of the shaft within bearing **147** that supports gear **146** is provided with a spur gear **148** that meshes with a gear **149** fixed to a shaft **150** for supplying the feed rate speeds to the feedworks transmission F_m, which feed rates, therefore, are at all times maintained proportional to the speed of rotation of the work-supporting table W.

Referring to Figs. 7 and 8, the feedworks transmissions F_r, F_m, and F_s are interchangeable units and the gearing arrangements therein as well as the shiftable clutches thereof are substantially identical with those shown, described and claimed in Patent 2,355,623, in the name of E. P. Bullard III to which patent reference is directed for specific details of construction. One of the important differences, however, between the feedworks transmissions shown in the above-referred-to patent and those of the present invention, includes the relationship of substantially all of the power-transmitting shafts, i.e. lying in a single vertically-disposed plane in the present invention. Such arrangement makes it possible to manufacture identical feedworks transmissions that can be employed for either the main head, the side head or the ram head, all of which, or any number of which may be conveniently mounted as a unitary structure on the top of the housing for the headstock transmission T_h. Inasmuch as these feedworks transmissions are substantially identical, only the feedworks transmission F_m will be specifically described. However, it is evident from a consideration of Fig. 7 that the input power from shaft **139** to the feedworks transmission F_m through shaft **144** is also supplied to the transmissions F_r and F_s through the intermeshing of the spur gears **151** and **152** with a spur gear **153** fixed to and rotatable with the shaft **144**. Likewise, the feed speeds supplied to the feedworks transmission F_m by the gear **149** is also supplied to the feedworks transmissions F_r and F_s through intermeshing spur gears **149**, 154, and **155**.

The rotation of shaft **139**, which is transferred to shaft **144** as previously described, causes the rotation of spur gear **156** and an intermeshing spur gear **157** (Fig. 4), which gears **156** and **157** respectively provide forward and reverse rotation of the intermeshing gears and friction clutch traverse mechanisms **158** and 159, all in the manner described in said above-identified patent. Such rotations are transmitted to shafts **124** and 126 through bevel gear arrangements **124'** and **159''**.

Power from the shaft **150** in the transmission F_m passes through a speed reduction unit **160** (Fig. 8) between shaft **150** and a shaft **161**. Cluster gear **162** on shaft 150 is adapted to be shifted into mesh with cooperating gears **164, 165**; and cluster gear **163** is adapted to be shifted into mesh with gears **166** and **167**. Additionally, a back shaft **168** is provided with a shiftable gear cluster **169** adapted to be shifted into mesh with gears **167** and **172**; and a cluster **170** is adapted to be shifted into mesh with gears **173** and **174**. An output gear **175** of the speed reduction unit **160** is fixed to shaft **168** and is adapted to mesh with a gear **176** on a shaft **177** separate from shaft 144. From the foregoing, it is evident that selective shifting of the gear clusters **162** and **163**, in combination with the shifting of gears **169** and **170**, provides sixteen different rates of rotation of the output gear **175** as well as gear **176**, all in the manner as specifically shown, described and claimed in the above-referred-to Patent 2,355,623, to which patent reference is directed for specific features of detailed construction. Fixed to shaft **177** is a gear **178** that meshes with the gears for one direction of rotation of the shafts **124** and **126**. The gear 178 meshes with a gear **179** (Fig. 4) which latter meshes with the gears providing reverse rotation at feed rate of the shafts **124** and **126**. Positive action clutch engaging means **180** and **181** are provided for effecting forward and reverse rotations of the shafts **124** and **126** at any one of the sixteen rates of feed all in accordance with the description in the above-referred-to patent.

Referring to Fig. 4, the gear cluster **162** is provided with a shifting finger **182**; the gear cluster **163** is provided with a gear shifting finger **183**; the shiftable gear **169** is provided with a shifting finger **184**; the shiftable gear **170** is provided with a gear shifting finger **185**; the mechanism **158** is provided with a clutch shifting member **158'**; the gear and clutch mechanism **159** is provided with a clutch shifting element **159'**; and clutch shifting members **180** and **181** are provided with shifting fingers **180'** and **181'** respectively for actuating the positive action feed clutches of the feedworks transmission. All of these gear and clutch shifting elements are adapted to be reciprocated hydraulically by combined piston, cylinder and valve actuating mechanisms mounted in a unitary supporting member **186** that is adapted to be removably attached to the rear of the standard S within the housing B_r (Fig. 4).

Referring to Figs. 4 and 9, clutch shifting element **159'** is fixed to a draw bar **187** which in turn is connected to a piston rod **188** extending into a cylinder **189** mounted within the bracket **186**. The clutch shifting element **181'** is likewise connected to a rod **190** behind the rod **187** of Fig. 4 (see Fig. 9) that is connected to a piston rod **191** extending into a cylinder **192** within the bracket **186**. The connection between the rods **187, 188,** and **190** and **191** comprises easily removable coupling elements **193** so constructed that no tools are required to remove them.

Referring again to Fig. 4, clutch actuating element **180'** is fixed to a rod **194** that is connected to a piston rod **195** extending into a cylinder **196**. The clutch actuating element **158'** is likewise connected to a rod **197** (Fig. 10) which in turn is connected to a piston rod **198** extending into a cylinder **199**.

The gear shift finger **184** is connected to a draw bar **200** that in turn is connected to a piston rod **201** that extends into a cylinder **202** within the bracket **186**. The clutch-shifting finger **185** is connected to another draw bar **203** behind the draw bar **200** (Fig. 14) and is connected to a piston rod **204** that extends into a cylinder **205**.

Referring to Figs. 4 and 15, the gear-shifting finger **182** is fixed to a draw bar **206**, which in turn is connected to a piston rod **207** that extends into a cylinder **208** within the bracket **186**. The gear shifting finger **183** is fixed to a draw bar **209** directly behind the draw bar **206** (Fig. 15), which former draw bar is connected to a piston rod **210** that extends into a cylinder **211**.

As previously explained, the cylinders **34, 34', 41, 46** and **54** are likewise mounted within the frame **186**. Referring to Figs. 11 and 13, the piston within the cylinder **192** is adapted to be moved to the left or to the right by hydraulic means that is controlled by the action of electric solenoid valves **212** and **213**. Referring to Fig. 13,

the piston rod **191** extends into a bore **214** and supports two discs **215** and **216** in fixed spaced position thereon between which a sleeve **217** is located. The sleeve **217** is held between the discs **215** and **216** by a nut **218**. Also mounted between the discs **215** and **216** are two opposed piston elements **219** and **220** adapted to slide toward and from each other on the outer periphery of the sleeve **217**. Liners **221** and **222** within the bore **214** limit the motion of the piston elements **219** and **220** in one direction. The construction and arrangement of the parts are such that the introduction of hydraulic pressure into the annular space on the left-hand side of the disc **215** forces the piston element **219** and the connecting rod **191** rightwardly as shown in Fig. 13, while the introduction of liquid under pressure into the bore **214** on the right-hand side of the disc **216** forces the piston element **220** and the piston rod **191** leftwardly as shown in Fig. 13. Hydraulic pressure is continuously adapted to be admitted to the annular space between the piston elements **219** and **220** through a passage **223** that is connected to an annular groove **224** within the periphery of the cylinder **192** which latter is in communication with a main supply passage **225** that extends throughout the vertical dimension of a plate **226** (Fig. 4) that closes the rear end of the bracket **186** and assists in supporting the various cylinders previously mentioned. When the chambers of the bore **214** on the left-hand side of the disc **215**, and on the right-hand side of the disc **216** are open to exhaust, the constant pressure supplied to the passage **223** forces the piston elements **219** and **220** away from each other and in abutting relation with the discs **215** and **216**, thereby centralizing the position of the piston rod **191**, hence moving the clutch-shifting finger **181'** to a neutral position.

The duct **223** also includes a branch **227** that communicates with a transverse passage **228** within a valve block or manifold **229** mounted on the closure plate **226**. The passage **228** is adapted to communicate with passages **230** and **231** leading to the chambers of bore **214** on the left-hand side of the disc **215** and the right-hand side of the disc **216**, respectively. Spool valves **232** and **233** are connected to solenoids **212** and **213** and control the flow of liquid from the passage **228** to the ducts **230** and **231**, respectively. Exhaust ports **234** and **235** are likewise provided for selectively exhausting the left- and right-hand chambers of the bore **214**, respectively.

From the foregoing, it is evident that energization of the solenoid **212** will cause the spool valve **232** to move leftwardly (Fig. 13), thereby causing fluid under pressure from duct **228** to pass through the passage **230** to the left-hand side of the bore **214**, and since the chamber of the bore **214** on the right-hand side of the disc **216** is open to exhaust through the passages **231** and **235**, the clutch-shifting finger **181'** moves rightwardly, causing the main head H_m to move upwardly at a feed rate depending upon the feed previously established, as will be described later. Furthermore, energization of the solenoid **213** causes the spool valve **233** to move leftwardly, thereby causing fluid under pressure within the duct **228** to pass through the duct **231** into the right-hand chamber of the bore **214**, and since the left-hand chamber of the bore **214** is open to the exhaust through ducts **230** and **234**, the clutch-shifting finger **181'** (Fig. 9) is moved leftwardly whereupon the main head H_m is moved downwardly at the previously-established feed rate. Upon the de-energization of either of the solenoids **212** or **213**, the corresponding chambers of the bore **214** are exhausted, and the constant pressure within the passage **223** immediately separates the piston elements **219** and **220**, whereupon the clutch-shifting finger **181'** is neutralized.

Referring to Fig. 11, solenoids **236** and **237** are provided for control of the actuation of the piston within the cylinder **189** in the identical manner that the solenoids **212** and **213** control the operation of the piston within the cylinder **192**. Accordingly, energization of the solenoid **236** causes the clutch-shifting finger **159'** (Fig. 9) to be moved rightwardly, thereby causing the main head H_m to move downwardly at a rapid traverse rate. Furthermore, energization of the solenoid **237** causes the clutch finger **159'** to be moved leftwardly, thereby effecting the upward movement of the main head H_m at a relatively rapid traverse rate.

Identical solenoids **238**, **239**, **240** and **241** are provided for identical piston-actuating mechanisms for the ram head H_r, which control its feed and traverse movements through the corresponding feedworks F_r (Fig. 7) in the identical manner that the solenoids **212**, **213**, **236** and **237** control the feed and traverse motion of the main head H_m. Additionally, solenoids **242**, **243**, **244**, and **245** control the movement of the side head H_s through its corresponding feedworks F_s (Fig. 7) in the identical manner that the solenoids **212**, **213**, **236** and **237** control the movement of the main head H_m.

In a similar manner, solenoids **246** and **247** are provided for controlling the flow of liquid to and from the cylinder **196** for actuating the clutch-shifting finger **180'** to cause the main head H_m to be fed inwardly and outwardly. Solenoids **248** and **249** are provided for controlling the inward and outward feeding of the ram head H_r; and, solenoids **250**, **251** are provided for controlling the inward and outward feeding of the side head H_s.

Solenoids **252** and **253** are provided for controlling the flow of liquid to and from the cylinder **199** to cause the actuation of the clutch-shifting finger **158'** thereby to effect the inward and outward traverse movement of the main head H_m.

Solenoids **254** and **255** are provided for controlling the in and out traverse movement of the ram head H_r; and, solenoids **256** and **257** are employed to control the in and out traverse movement of the side head H_s.

Referring to Figs. 4, 11 and 12, the cylinder **202** supports a piston mechanism within it that is connected to the piston rod **201**, which piston mechanism is substantially identical with the piston mechanisms **219** and **220** of Fig. 13. The passage **225** (Fig. 13) extends throughout the vertical length of the plate **226** for supplying liquid under pressure to all of the piston mechanisms as previously described. It communicates with a passage **258** leading to the space within the cylinder **202** between the opposed portions of the piston mechanism for the purpose of moving the piston rod **201** to a neutral position when the spaces within the cylinder **202** on each end of the piston mechanism are exhausted.

A solenoid mechanism **259** is mounted on a manifold **260** which latter is attached to the plate **226**. The solenoid mechanism **259** includes two solenoids **261** and **262** adapted to actuate a spool valve **263** in the following manner. With the solenoids **261** and **262** de-energized, the spool valve **263** is caused to move to the position shown in Fig. 12, by means not shown, and liquid under pressure passes from the supply line **225** through a duct **264** to a passage **265** within the manifold **260**. The liquid under pressure within the line **265** cannot pass the spool valve **263** in the position shown in Fig. 12. The portion of the cylinder **202** on the left-hand side of the piston mechanism is open to the exhaust through the passages **266**, **267**, and the port **268**. Likewise, the right-hand portion of the cylinder **202** is open to the exhaust through the passages **269** and **270**, which latter lead into the duct **267**.

Energization of the solenoid **262** causes the spool valve **263** to move downwardly (Fig. 12) so that the liquid under pressure within the duct **265** is admitted to passage **269**, thence to the portion of the cylinder **202** on the right-hand side of the piston mechanism, causing the latter to move leftwardly, thereby causing the clutch-shifting finger **184** to likewise move leftwardly (Figs. 8, 17 and 14) whereupon gear **169** becomes meshed with the gear **167** within the feedworks F_m. The portion of cylinder **202** on the left-hand side of the piston

mechanism remains open to the exhaust 268 through passages 266 and 267. De-energization of the solenoid 262 causes the spool 263 to return to the position of Fig. 12 as previously explained, and the pressure within the duct 258 to immediately centralize the piston rod 201, thereby disengaging the gear 168 from the gear 167. This neutralizing action is caused by the differential areas of the piston mechanism.

Energization of the solenoid 261 causes the spool valve 263 to move upwardly (Fig. 12) so that the liquid under pressure within the duct 265 passes through the passage 266 to the portion of the cylinder 202 on the left-hand side of the piston mechanism. At the same time, the portion of the cylinder 202 on the right-hand side of the piston mechanism is open to the exhaust port 268 through the ducts 269, 270 and 267. Accordingly, the piston rod 201 and piston mechanism are moved rightwardly (Fig. 12), thereby causing the gear 169 to become meshed with the gear 172 (Figs. 8, 14 and 17). Upon the de-energization of the solenoid 261, spool 263 returns to the position in Fig. 12, and the pressure liquid within the duct 258 immediately neutralizes the piston rod 201 so that the gear 169 is moved out of meshing relationship with the gear 172.

Solenoid mechanisms 271 and 272, identical with the solenoid mechanism 259, are provided for controlling identical gear-shifting fingers for the feedworks F_r and F_s, respectively. Furthermore, identical solenoid mechanisms 273, 274 and 275 are provided for the cylinder 205 (Fig. 14) and the corresponding cylinder for the feedworks F_r and F_s, respectively. Solenoid mechanism 273 controls the shifting of the gear-shifting finger 185 to control the enmeshing of the gear 170 with either gears 173 or 174 within the feedworks F_m (Figs. 8 and 17). The corresponding solenoid mechanisms 274 and 275 control the shifting of the corresponding gears within the feedworks F_r and F_s.

Referring to Figs. 4, 6, 11 and 11*a*, the piston rod 65 extending into the cylinder 67 is provided with a piston 276 adapted to reciprocate therein. Inasmuch as the piston rod 65 is adapted to be moved entirely to the right or entirely to the left, and never to an intermediate neutral position, the piston 276 is a solid member as distinguished from the split piston mechanisms in the other cylinders previously described.

Liquid under pressure is adapted to flow along the main supply duct 225 to a groove 277 surrounding the cylinder 67 which supplies liquid under pressure to a duct 278 leading into a manifold 279. The liquid under pressure from the duct 278 passes through a duct 280 leading to a spool valve 281 that is adapted to be actuated by a solenoid within the solenoid housing 282. When the solenoid within the housing 282 is de-energized, the spool valve 281 is in the position shown in Fig. 11*a*, and liquid under pressure from line 280 is adapted to pass through duct 283 to duct 284, thence to the right-hand side of the piston 276, forcing it leftwardly as shown in Fig. 11*a*. Inasmuch as the area of the piston 276 on its right-hand side is greater than that on the left-hand side, the liquid being exhausted through the duct 285 is at a pressure in excess of that in the line 278. Consequently, the ball check valve 286 is caused to open and this high-pressure liquid in the duct 285 passes into a duct 287 which returns it to the main supply line 225.

Energization of the solenoid within the casing 282 causes the spool valve 281 to move upwardly as shown in Fig. 11*a*, whereupon the right-hand side of the piston 276 is open to the exhaust through lines 284, 283, and a passage 288 within the manifold 279 leading to the atmosphere. When the right-hand side of the piston 276 is open to the exhaust, liquid under pressure from the passage 278 passes through the duct 287 to a duct 289 that communicates with the passage 285 past a needle valve 290. The function of the adjustable needle valve 290 is to effect the engagement of the clutch by the rightward movement of the piston 276 at a relatively slow rate, thereby to avoid shock to the apparatus. An adjusting screw 291 is provided for limiting the rightward movement of the piston 276, thereby to provide an adjusting mechanism for compensating for the wear on the clutch faces during the life of the clutch mechanism.

Referring to Figs. 4, 15, and 11, solenoid mechanisms 292 and 293, identical with solenoid mechanism 259 (Fig. 12) are employed for actuating the gear-shifting elements 183 and 182 (Figs. 4, 8 and 15) to cause intermeshing of gear cluster 162 with gears 164, 165; as well as gear cluster 163 with gears 166 and 167 in the identical manner that the piston mechanism within cylinder 202 actuates the finger 184. Additionally, solenoid mechanisms 294 and 295, identical with solenoid mechanisms 292 and 293, control the shifting of corresponding gear clusters within the feedworks F_r; and, solenoid mechanisms 296 and 297 control corresponding gear clusters within the feedworks F_s.

Referring to Figs. 4, 6 and 11, a solenoid mechanism 298, identical with solenoid mechanism 259 (Fig. 12), controls the shifting of the positive-action clutch 25 of the primary unit P_u of the headstock transmission T_h. An additional solenoid mechanism 299, identical with solenoid mechanism 259 controls the actuation of the piston mechanism within the cylinder 34' to thereby control the shifting of the positive-action clutch 27.

The positive-action axially-shiftable clutch element 36 of the secondary unit S_u of the headstock transmission T_h is adapted to be controlled by the action of the piston mechanism within the cylinder 41 as previously described. A solenoid mechanism 300, also identical with 259 shown in Fig. 12, is provided for controlling the shifting of the secondary clutch 36 in the same manner as the piston mechanism within the cylinder 202 controls the shifting of the clutch finger 184 (Fig. 14). An additional solenoid mechanism 301, identical with solenoid mechanism 259, is also provided for controlling the piston mechanism within the cylinder 46, thereby to control the operation of the clutch shifting element 42 of the tertiary unit of the headstock T_h. Finally, a solenoid mechanism 302 is provided for controlling the actuation of the piston mechanism within the cylinder 54, thereby controlling the action of the clutch element 47 to effect the direct drive connection between the teritary unit and the primary unit of the headstock transmission T_h.

From the foregoing, it is evident that all of the gear and clutch shifting mechanisms, as well as the unitary brake and clutch mechanism, are controlled by forty-two solenoid mechanisms including only three different types. There are twenty-four identical solenoid mechanisms, such as 212, which actuate spool valves identical with spool valve 232 (Fig. 13); and all the remaining solenoid mechanisms, except the brake solenoid mechanism 282, are identical and function in the same manner as solenoid mechanism 259 shown in Fig. 12.

All of the above forty-two solenoid mechanisms are mounted with their corresponding manifolds on the plate 226. This plate 226 can be removed as a unit, thereby facilitating ease in maintenance and repair of any of the piston mechanisms, or replacement of faulty operating solenoids. The removable protective cover plate 303 is fixed to the housing B_r and provides a seal with a sponge rubber gasket between it and the plate 226.

It is further evident from a consideration of the drawings that the entire bracket B_r is independent of the power input sheave 24 and the clutch and brake mechanism, so that adjustment to the clutch and brake can be effected without in any way affecting the contents of the housing B_r.

Furthermore, with the bracket B_r removed, it is a relatively simple matter for an operator to remove the couplings 193 between the various piston rods and the corresponding shifting rods. Accordingly, it is quite

evident that the entire bracket **186**, together with all of the various cylinders used in controlling the operation of the various feedworks and headstocks can be removed as a unit.

The electrical wiring for all of the forty-two solenoids passes through a common duct **304** (Fig. 1) leading to the pendant P.

The pendant P is the central control for all functions of the machine. Referring to Figs. 18 and 19, it comprises an elongated box-like construction **305** made up of three identical compartments **306**, **307** and **308**. Two other compartments **309** and **310** are also included in the housing **305**. Since the compartments **306**, **307** and **308** and the controls therein are identical, and since the specifications specifically describes the feedworks of the main head H_m, only the details of compartment **307** will be described specifically.

Toggle levers **311** and **312** are mounted in the compartment **307** for controlling the direction of movement of the main head H_m either in feed or in traverse. The levers **311** and **312** are entirely directional, i.e., movement of the lever **311** and **312** to any position causes the head H_m to move in the direction represented by the position in space of the levers **311** or **312**. Additionally, the compartment **307** includes a knurled knob **313** that is provided with an operating handle **313'**. The knob **313** is employed in cooperation with a dial knob **314** for pre-setting the rate of feed of the head H_m which feed may appear in the window **315** or be inscribed on the cylindrical portion between knobs **314** and **313**. In a like manner, the compartment **306** includes toggle levers **316** and **317**; a disc **318**; and a knob **319** which elements are adapted to control the movement of the ram head H_r in the same manner that the elements **311**, **312**, **313** and **314** control the movement of the turret head H_m. Likewise, compartment **308** is provided with toggle levers **320** and **321**; a knurled disc **322** and a knob **323**, for controlling the movement and rate of movement of the side head H_s.

The compartment **309** is different from the above three described compartments and includes a single toggle lever **324** for starting the rotation of the work-supporting table W. It also includes a knurled disc **325** and a knob **326** for effecting the selection of the speed of the work-supporting table W.

The compartment **310** is provided with an oscillatable member **327** for controlling the rotation of the turret of the main head H_m. It also includes a switch **328** adapted to effect vertical movement of the pendant for convenience of the operator; and a lever **329** is provided at the bottom of the pendant P, which when moved in any direction effects the stopping of the work-supporting table W.

Referring to Fig. 17, the control mechanism for the feedworks F_m within the compartment **307** is shown schematically to illustrate the manner in which it operates. The knurled disc **313** is fixed to a cam **330** that is adapted to move bars **331** and **332** about pivots (to be more specifically described later) so that the electrical switches mounted thereon are moved out of cooperating position with dogs on a cam **333** which cam is shown schematically as having sections **333'** to **340**, inclusive. The rotatable knob **314** is fixed to a shaft **341** that extends through and is keyed to the cam **333**. Th sections **333'**, **335**, **338** and **340** of cam **333** each include dogs **342** covering a quarter of the peripheries of each said sections which are adapted when effective to close switches **343**, **344**, **345**, and **346**. These dogs **342** are arranged on the cam **333** so that switches **343**, **344**, **345**, and **346** are closed during step by step indexing of cam **333** for succeeding quarter turns of the shaft **341**.

The sections **334**, **336**, **337**, and **339** of cam **333** are identical, each including dogs at four equally-spaced points about each of their peripheries. These dogs are adapted to close switches **347**, **348**, **349**, and **350**. Sections **334**, **336**, **337** and **339** of cam **333** are arranged so that the switches **347**, **348**, **349** and **350** are successively closed four times during the complete revolution of the shaft **341**.

With the apparatus in the condition shown in Fig. 17, switches **343** and **347** are closed while all the remaining switches **344**, **348**, **349**, **345**, **350** and **346** are open. Accordingly, current flows from **L1** through switch **343**, thence through line **351** to solenoid **262B** of the solenoid mechanism **292**, thence to line **L2**, through the conductor **352**. Accordingly, the solenoid **262B** is energized, causing the gear cluster **163** to become meshed with the gear **166**. Additionally, current flows from line **L1** through a conductor **353** to switch **347**, thence through line **354** to solenoid **261A** of the solenoid mechanism **273**, thence to **L2** through the line **352**. Accordingly, solenoid **261A** is energized, causing the gear cluster **170** to become enmeshed with the gear **174**. From the foregoing it is evident that power supplied to shaft **150** through gear **149** (Fig. 8) is transmitted at a reduced rate to the shaft **168** as well as to the gear **175** (Fig. 8), the latter being adapted to transmit such reduced speed to the remaining portion of the feedworks F_m.

Rotation of the disc **313** so that the bars **331** and **332** are pivoted in a manner to move the various switches out of cooperating position relatively to the cam **333** conditions the control apparatus for selecting another gear combination within the feedworks F_m. Assume that the cam **333** is rotated in a clockwise direction as shown in Fig. 17. Rotation of the shaft **341** through $\frac{1}{16}$ of a revolution from the position shown in Fig. 17, and operation of the disc **313** to return the pivotal bars **331** and **332** to their effective positions, causes the switch **343** to close again, the switch **347** to remain open, the switch **348** to close, and all other switches of the control mechanism to remain open. In this instance, current flows from line **L1** to the switch **343**, thence to the solenoid **262B** in the same manner as previously described to again cause the gear cluster **163** to mesh with the gear **166**. Likewise, current flows through line **L1**, conductor **353**, switch **348**, a conductor **355** to solenoid **262A** of the solenoid mechanism **273**, thereby causing the gear **170** to become enmeshed with the gear **173**. Accordingly, the speed at which the shaft **168** is now rotated is at a different rate from that previously described by virtue of the new setting of the knob **314**.

Movement of the knob **314** to 16 different rotative positions produces 16 different rates of rotation of the shaft **168** with the shaft **150** rotating at a speed depending upon the speed of rotation of the gear **148** (Fig. 4) forming part of the headstock transmission T_h. Furthermore, it is evident that any of the 16 speeds may be selected without causing repeated opening and closing of the various switches since the disc **313** must be operated before the knob **314** can be turned (because of an interlock to be described later), and operation of the disc **313** removes the various switches from cooperative position relatively to the cam **333**.

The toggle lever **311** is provided with a pivotal mounting **356** and an end portion **357** extending therebeyond. The end **357** of the toggle lever **311** coacts with a rack member **358** meshing with a pinion **359**, which latter meshes with a rack bar **360**. The rack bar **360** is adapted to close switch **361** when it is moved upwardly and to close switch **362** when it is moved downwardly. Additionally, the end **357** of the toggle lever **311** cooperates with a bar **363** which when it moves upwardly, closes a switch **364** and when it moves downwardly, closes a switch **365**. Furthermore, diagonal movement of the toggle lever **311** toward "10:30 o'clock," as viewed in Fig. 17, causes bars **360** and **363** to simultaneously close switches **365** and **362**; movement of the toggle lever **311** toward "1:30 o'clock" causes the bars **360** and **363** to close switches **361** and **365** simultaneously; move-

ment of the toggle lever 311 toward "4:30 o'clock" causes the levers 360 and 363 to simultaneously close switches **361** and 364; and movement of the toggle lever **311** toward "7:30 o'clock" causes the levers 360 and 363 to simultaneously close switches 364 and 362. The simultaneous closing of the plural switches effects diagonal movement of the turret head H_m in the direction indicated by the movement of the toggle lever 311. Closing of switch **361** causes current to flow from the line L1 through conductor **353**, thence through switch 361, conductor **366** to solenoid **247**, thence through line 352 to L2. Energizing solenoid **247** causes feed clutch 180 to be engaged to effect feeding movement of the head H_m outwardly in accordance with the rate established by the setting of the dogs **342** on the cam **333**. Closing of switch **364** is effected by the movement of the toggle lever **311** toward "6 o'clock," thereby causing current to flow from line L1 through conductor 353, thence through switch **364**, a conductor **367**, thence through solenoid **213**, line **352** to L2. Energization of the solenoid **213** causes the clutch **181** to move leftwardly, thereby effecting downward feed movement of the head H_m at a speed depending upon the pre-set condition of the cam 333.

Closing switch **362** is effected as previously described by the movement of the toggle **311** toward "9 o'clock," thereby causing current to flow from L1 through the switch **362**, thence through a conductor **368** to the solenoid **246**, thence through the line **352** to line L2. Energization of the solenoid **246** causes the member 180' to be moved leftwardly, thereby effecting inward or leftward movement of the head H_m at a feed rate depending upon the pre-set condition of the cam 333.

Closing switch 365 is effected by the movement of the toggle lever **311** toward "12 o'clock," whereupon current flows from line L1 through switch 365, thence through a conductor 369 to solenoid 212, thence through line **352** to line L2. Energization of the solenoid **212** causes movement of the movable portion of the clutch mechanism **181** rightwardly (Fig. 17), thereby causing the main head H_m to move upwardly at a feed rate depending upon the pre-set condition of the cam 333.

Simultaneously closing switches **362** and 365 by the movement of toggle lever **311** toward "10:30 o'clock," causes current to flow from line L1 through switch 362, conductor **368** to solenoid **246**, thence through conductor **352** to line L2, and, at the same time, current to flow from line L1 through switch **365**, thence through conductor **369** to solenoid **212**, thence through line 352 to line L2. Energization of the solenoids 246 and 212 simultaneously causes the shiftable portion of clutch 180 to move leftwardly, thereby causing the main head H_m to move inwardly at a feed rate, and simultaneously, the movement of the shiftable portion of clutch 181 to move rightwardly, thereby effecting upward movement of the main head H_m at a feed rate. Since the feed rates are identical, the main head H_m moves along a 45° path, between "9" and "12 o'clock."

Simultaneous closing of switches **361** and 365, which is effected by the movement of the toggle lever 311 toward "1:30 o'clock," causes the simultaneous energizing of solenoids **212** and **247**, thereby causing the main head H_m to simultaneously feed outwardly or rightwardly (Fig. 1) and, at the same time, feed upwardly at a rate depending upon the pre-set condition of the cam 333. Such simultaneous feeding at a constant feed rate causes the head H_m to move along a 45° path between "12" and "3 o'clock."

Simultaneous closing of switches **361** and 364 is effected by the movement of the toggle lever **311** toward "4:30 o'clock," causing the simultaneous energizing of solenoid **213** and **247**, thereby simultaneously causing the main head H_m to feed downwardly and outwardly at the same rate of speed resulting in the movement of the head H_m along a 45° path between "3" and "6 o'clock."

The simultaneous closing of switches **362** and **364** is effected by the movement of the toggle lever **311** toward "7:30 o'clock," thereby effecting the energization of solenoids **213** and 246, whereupon the main head H_m is fed downwardly and simultaneously fed inwardly at a constant rate of feed determined by the preset condition of the cam **333**. Accordingly, the head H_m moves along a 45° path between "6" and "9 o'clock."

In a like manner, toggle lever **312** is adapted to be moved in any one of eight different radial directions, causing the movement of the head H_m in the direction in which the toggle lever **312** is moved at a rapid traverse rate of speed.

Referring to Fig. 18, the toggle lever **316** can be moved to any one of eight positions, causing the ram head H_r to be moved along a path in the direction in which the toggle lever **316** is moved, and at a rate depending upon the setting of the knob **319**. Additionally, the toggle lever **317** can be moved to eight different positions, thereby causing the ram head H_r to be moved along a path in the direction in which the toggle lever **317** was moved, and at a rapid traverse rate.

Additionally, movement of the toggle levers **320** and **321** likewise controls the movement of the side head H_s in a manner identically as the other two heads were moved by the operation of the toggle levers **311**, **312**, **316** and **317**.

Referring to Fig. 16, the control for the work-supporting table W which control is contained within the compartment **309** (Fig. 18) of the pendant P is shown schematically in combination with a schematic showing of the headstock transmission T_h.

The knurled disc **325** is fixed to a cam **370** which, when turned, causes pivotally-mounted supporting bars **371** and **372** to move the various switches of the control away from the switch-actuating mechanism, i.e. the shaft 325' including the nine portions A, B, C, D, E, **1**, **2**, **3**, and **4**. With the control in the condition as shown in Fig. 16, it is evident that portions A, C, and **1** have closed switches **373**, **374** and **375**. Closing of the switch **373** causes current to flow from line L1 through a conductor **376**, through switch **373**, and thence through a conductor **377** to solenoid **261D**, thence through a conductor **378** to line L2. Energization of the solenoid **261D** causes the clutch **42** to move to the right (Fig. 16), establishing one portion of a gear drive. Closing of switch **374** causes current to flow from line L1 through conductor **376** to switch **374**, thence through line **379** to solenoid **262H**, thence through conductor **378** to line L2. Energization of the solenoid **262H** causes the clutch **36** to move leftwardly, thereby establishing the secondary portion of the gear drive through the transmission T_h. Closing of the switch **375** causes current to flow from line L1 through the switch **375**, thence through a conductor **380**, solenoid **262F**, thence through conductor **378** to line L2. Energization of the solenoid **262F** causes the clutch **27** to move leftwardly, thereby establishing the gear connection in the primary of the transmission T_h so that power flows from the input shaft to the table W through a complete train of gears to produce one of the twenty speeds of rotation of which the table W is capable. The specific details of the transmission T_h as previously referred to are shown and described in detail in Patent No. 2,355,624, and each separate train of gears for each of the twenty speeds is clearly set forth therein.

Operation of the knurled disc **325** to pivotally move the brackets **371** and **372** in a manner to remove all the switches from cooperative position with respect to the portions A, B, C, D, E, 1, 2, 3 and 4 of the control, makes it possible to turn the knob **326** to any one of twenty different positions at which a different gear train is established in the transmission T_h for providing a different rate of rotation of the table W through the action of the solenoids **261** and **262D** to H, inclusive, as represented in the following chart.

Position of handle 326	Effective cam sections	Solenoids energized	Clutch position
1	A	261D	42 right.
	C	262H	36 left.
	1	262F	27 left.
2	A	261D	42 right.
	C	262H	36 left.
	2	261F	27 right.
3	A	261D	42 right.
	C	262H	36 left.
	3	261G	26 right.
4	A	261D	42 right.
	C	262H	36 left.
	4	262G	26 left.
5	A	261D	42 right.
	D	261H	36 right.
	1	262F	27 left.
6	A	261D	42 right.
	D	261H	36 right.
	2	261F	27 right.
7	A	261D	42 right.
	D	261H	36 right.
	3	261G	26 right.
8	A	261D	42 right.
	D	261H	36 right.
	4	262G	26 left.
9	B	262D	42 left.
	C	262H	36 left.
	1	262F	27 left.
10	B	262D	42 left.
	C	262H	36 left.
	2	261F	27 right.
11	B	262D	42 left.
	C	262H	36 left.
	3	261G	26 right.
12	B	262D	42 left.
	C	262H	36 left.
	4	262G	26 left.
13	B	262D	42 left.
	D	261H	36 right.
	1	262F	27 left.
14	B	262D	42 left.
	D	261H	36 right.
	2	261F	27 right.
15	B	262D	42 left.
	D	261H	36 right.
	3	261G	26 right.
16	B	262D	42 left.
	D	261H	36 right.
	4	262G	26 left.
17	C	262H	36 left.
	E	261E	47 right.
	1	262F	27 left.
18	C	262H	36 left.
	E	261E	47 right.
	2	261F	27 right.
19	C	262H	36 left.
	E	261E	47 right.
	3	261G	26 right.
20	C	262H	36 left.
	E	261E	47 right.
	4	262G	26 left.

With the control circuit for the headstock transmission T_h in the condition shown in Fig. 16, current flows from line L1 through conductor **376** to start switch **381**, thence through conductor **382** to TR1 solenoid, thence through conductor **383** to line L2, thereby energizing solenoid TR1 and hence closing normally open switches TR1–1, TR1–2, and TR1–3.

Moving hand toggle lever **324** downwardly moves rack **385** upwardly and rack **386** downwardly. Upward movement of rack **385** opens starting switch **381** and closes starting switch **387**. Opening of switch **381** does not de-energize solenoid TR1 since TR1–2 switch holds the circuit through the stop switch **329**. Closing switch **387** energizes solenoid **388** through switch TR1–1 and causes a pin to engage rack **385** for holding it in its upper position after the toggle **324** is released by the operator. Closing of switch TR1–3 permits current to flow from line L1 through conductor **376**, switch **387**, conductor **389**, switch TR1–3, conductor **390**, switch **391**, conductor **392**, solenoid **282**, conductor **378** to line L2, thereby causing the clutch of the clutch and brake unit **25** to become effective to transmit power to the table W through the gear train established by the pre-set condition of the knob **326**.

Since solenoid **388** causes a pin to lock rack **385** in its upper position, toggle **324** cannot manually be moved to its neutral position. The only way to stop table W from rotating is to open switch **329** which de-energizes solenoid TR1, but this solenoid actuates three switches, namely, TR1–1, TR1–2 and TR1–3. Switch TR1–1 is set to open only after a pre-set time after de-energization of the solenoid TR1, while switches TR1–2 and TR1–3 open instantly upon the de-energization of solenoid TR1. This insures solenoid **388** remaining energized and preventing the manual movement of the toggle **324** to neutral position until after the solenoid **282** has been de-energized by the instant opening of switch TR1–3 and the stopping of table W, at which time solenoid **388** is de-energized and toggle **324** is returned to its neutral position. The reason for this is to prevent shifting of gears in the headstock T_h while the table is running by an interlock which will be more fully explained later.

Movement of toggle lever **324** upwardly moves rack **385** downwardly and rack **386** upwardly, which latter closes switch **393** so that current flows from L1 through conductor **376**, switch **393**, conductor **392**, solenoid **282**, conductor **378** to line L2, thereby energizing solenoid **282** an dengaging the clutch of unit **25** to start table W rotating. Upon the operator releasing toggle **324**, it automatically returns to its neutral position and the table W stops.

The control mechanism within the pendant P is completely interlocked so that no damage can be done to the machine, work or operator. Since each of the assemblies within the compartments **306**, **307** and **308** is identical, only the interlocking structure of the assembly in compartment **307** will be specifically described.

Referring to Figs. 20 and 21, the knurled disc **313** is provided with an arcuate slot **394** that cooperates with a fixed pin **395** for limiting the arcuate motion of disc **313**. A screw **396** connects disc **313** to a sleeve **397** integral with cam **330**. Accordingly, arcuate motion of disc **313** arcuately moves cam **330**, which, as shown in Fig. 24, cooperates with a T-shaped link **397'**. The head **398** of link **397'** is in contact with abutments **399** and **400** integral with L-shaped portions **332'** and **331'**, respectively, of bars **332** and **331**. The portions **331'** and **332'** of bars **331** and **332** are pivotally mounted on pins **401** and **402** in a fixed supporting structure; and, a spring **403** acts on bars **331** and **332** to separate them to cause abutments **399** and **400** to force link **397'** into contact with cam **330**. All of the blocks that support switches **347**, **348**, **349** and **350** are fixed to the bar **331**, while the blocks for switches **343**, **344**, **345** and **346** are fixed to bar **332**. Each switch includes an actuating abutment **404** (Fig. 24) having an end portion adapted to rest on and be forced outwardly by the dogs **342** on the cam **333**. Accordingly, arcuate motion of cam **330** in a clockwise direction (Fig. 24) permits spring **403** to seperate bars **331** and **332** whereupon the switch actuating abutments **404** are pivoted away from dogs **342**, so that cam **333** can be rotated to a desired position by rotating knob **314** without having the switches open and close each time a dog **342** passes the actuators for the switches.

To prevent rotation of knob **314** when a feed selection is effective, a pawl **405** (Fig. 27) is fixed to bar **331** which engages a ratchet **406** fixed to shaft **341** when the bars **331** and **332** are in position to render the switches **343** to **350** effective. However, arcuately moving disc **313** to permit spring **403** to separate bars **331** and **332** removes pawl **405** from ratchet **406** to free shaft **341**. A spring-pressed detent **407** is provided to accurately locate the shaft **341** and cam **333** in each of the twenty positions to which they are to be indexed.

After a desired feed rate has been established, motion of the main head H_m is effected as previously explained by moving the toggle lever **311**. Additionally, traverse motion is effected by moving lever **312**. In order to prevent movement of one of these levers when the other is controlling, and to prevent the operation of knob **313** when one of the levers is effective, the following described interlocking mechanism is provided.

Referring to Fig. 22, each of the bars **360**, **363** for feed control as well as corresponding bars **408** and **409**

for traverse control is provided with identical notches **410** that are in alignment when levers **311** and **312** (Fig. 21) are in their neutral or ineffective positions. A slide bar **411** is provided which supports pins **412**. Pins **412** are so mounted on bar **411** relative to the notches **410** that movement of either bar **408** or **409** causes movement of bar **411** such that the pins **412** seat in the notches **410** of bars **360** and **363**, thereby preventing their movement when lever **312** is out of its neutral position. Likewise, displacement of lever **311** from neutral prevents movement of lever **312** from neutral in a similar manner.

Referring to Figs. 22, 25 and 26, the bars **331** and **332** extend throughout the length of the compartment **307**. A plurality of the L-shaped members **331'** and **332'** are located along pivot rods **401** and **402**, and they provide supporting means for bars **331** and **332**. All the blocks for switches **361**, **364** for feed and those for switches **413** and **414** for traverse are mounted on bar **311**. Additionally, the blocks for switches **362** and **365** for feed and those for switches **415** and **416** for traverse are mounted on bar **332**. Referring to Fig. 25, the rack **358**, the horizontal movement of which vertically moves bar **360**, is provided with a cylindrical hole **417** adapted to be aligned with an interlocking pin **418** urged outwardly by a spring **419**. Additionally, the inner portion **363'** of the composite bar **363** is provided with a cylindrical hole **419'** adapted to be aligned with an interlocking pin **420** that is urged outwardly by a spring **421**. The outer ends of pins **418** and **420** abut against the free ends of cooperating members **331'** and **332'**. Accordingly, since pivotally-outward movement of bars **331** and **332** is caused by arcuate movement of disc **313**, it follows that disc **313** cannot be arcuately moved unless pins **418** and **420** are aligned with holes **417** and **419** at the same time. Such alignment only occurs when lever **311** is in its neutral position. This interlocking relationship provides a dual function in that if disc **313** has been turned to permit a feed selection with knob **314**, the ends of pins **418** and **420** have passed through holes **417** and **419'**, thereby preventing the displacement of lever **311** until the selected feed has been established by returning disc **313** to the position rendering the feed switches effective by their coaction with dogs **342** on cam **333**.

Spring-pressed balls **422**, **423** and **424** are provided to maintain the feed lever **311** in any position to which it is placed until it is manually changed.

To insure the correct displacement of lever **311**, an arcuately movable guide drum **425** (Fig. 23) is provided which includes crossed slots **426**. A detent **427** cooperating with an arcuate slot **428** limits the arcuate motion of drum **425** to 45°. In this 45° position of drum **425**, slots **426** properly guide the lever **311** to effect movement of head H_m along a 45° diagonal. An additional interlock is provided between drum **425** and the slidable bar **411**, which comprises a ball **429** that cooperates with V-notches **430** and **431** on the drum **425** and bar **411**, respectively. This interlock prevents movement of rod **411** until drum **425** is in either of its operative positions, i.e. vertical, horizontal or 45° diagonal.

An identical interlocking mechanism is provided for the traverse toggle lever **312**. The only difference is that a single neutral V-notch is provided for spring-pressed balls **422** and **423** since the lever **312** is desirably automatically returned to neutral when the operator releases it.

Each of the control mechanisms in compartments **306** and **308** includes an identical interlocking mechanism as above described so that all three heads H_m, H_r and H_s are provided with a fool-proof interlocking control system within the pendant P.

There are two additional switches **432** and **433** provided in the control mechanisms for each head within the pendant P (Fig. 22). The switches **432** for each head are wired in series with each other and in series with the main starting switch for the machine. This arrangement prevents starting the machine until all of the knobs **318**, **313** and **322** are in their proper operating positions. The additional switch **433** is an extra switch that can be employed in the event an additional function is desired that has not been described herein.

Referring to Figs. 16, 18 and 28, the interlocking mechanism for the headstock control contained in compartment **309** is essentially identical with that for the feedworks contained in compartment **307**. The only difference resides in the interlock for the single toggle lever **324** which reciprocates the rack bar **385** to close starting switch **387**. Referring specifically to Fig. 28, a member **331'** supporting bar **331** cooperates with a pin **434** that is urged outwardly by a spring **435**. The rack bar **385** includes a hole **436** that is adapted to be aligned with the free end of pin **434** only when toggle lever **324** is in its neutral position.

The switch **327** in the compartment **310** is employed to control the indexing of the turret of the main head H_m, the construction and arrangement of the indexing mechanism and control being substantially the same as that shown and described in Patent 2,384,809, filed September 18, 1945, in the names of E. P. Bullard III et al.

Referring to Figs. 18, 2 and 3, the switch **328** is one which always returns to an open condition as shown in Fig. 18 when released after being held in an upper or lower position. Movement of switch **328** to an upper position energizes a reversible electric motor **437** (Fig. 2) that drives a pinion **438** through a shaft **439**. Pinion **438** meshes with a rack **440** integral with a tubular support **441** that is telescoped within a tubular housing **442** fixed to the standard S of the machine. An anti-friction thrust bearing **443** is located at the top of the tubular support **441**, and supports a tubular member **444** for rotatable movement. The end of conduit **304** (Fig. 1) opposite that connected to the pendant P is fixed within the tubular member **444**.

From the foregoing, it is evident that movement of switch **328** upwardly causes the pendant P to move upwardly so long as said switch is held in its upper position. Immediately upon releasing switch **328**, it returns to its open position, whereupon motor **437** stops as does the pendant P. Movement of switch **328** downwardly causes the pendant P to move downwardly until switch **328** is released, when the pendant P stops. Additionally, the pendant P can be moved in the arc of a circle by virtue of the bearing **443** (Fig. 3) which assists the operator in moving the pendant to any convenient position.

Referring to Fig. 29, it is believed that the legend contained therein will enable those skilled in the art to understand the complete electrical circuit for the machine. Since only the main or turret head H_m and the headstock T_h have been specifically described, the various electrical components thereof are shown in Fig. 29 with both legend identification as well as the numerals employed within the text of the specification. All components for the ram head H_r and the side head H_s as well as various other electrical components of the machine can be clearly identified by the legend accompanying the main wiring diagram of Fig. 29.

Although the various features of the new and improved machine tool have been shown and described in detail to fully disclose one embodiment of the invention, it will be evident that numerous changes may be made in such details, and certain features may be used without others without departing from the principles of the invention.

What is claimed is:

1. A pendant for a machine tool comprising in combination, a housing; a rotatable shaft in said housing; switch-operating dogs fixed to and rotatable with said shaft; a plurality of switches within said housing; means within said housing for supporting said switches; means

for moving said supporting means from a position where said switches cooperate with said dogs, to a position where said switches are unaffected by said dogs; and means between said rotatable shaft and said supporting means for preventing the rotation of said shaft until said supporting means is moved to the position where said switches are unaffected by said dogs.

2. A pendant for a machine comprising in combination, a housing; parallel spaced switch-supporting means within said housing; a pair of switches on each of said supporting means which when energized effect the movement of means forming part of said machine in either direction along paths within intersecting planes; a pivotally-mounted operating finger extending outwardly from said housing; and a linkage between said finger and switches for causing the proper switch of said two pairs to be energized to effect movement of said machine means in the direction in which said pivoted finger is moved.

3. A pendant for a machine comprising in combination, a housing; parallel spaced switch-supporting means within said housing; two pairs of switches on each of said supporting means adapted when energized to cause the movement of means forming part of said machine in either direction along paths within intersecting planes at a rapid traverse rate and at a preselected feed rate; separate pivotally-mounted operating fingers extending outwardly from said housing for said traverse and feed control; and linkage between each finger and its corresponding set of switches for causing the proper switch to be energized to effect movement of said machine means in the direction in which either of said pivoted fingers is moved, and at a traverse or feed rate depending upon the finger selected.

4. A pendant for a machine comprising in combination, a housing; a rotatable shaft in said housing; switch-operating dogs fixed to and rotatable with said shaft; switch-supporting means; a plurality of switches mounted on said switch-supporting means and adapted when selectively energized to cause a member of said machine to move at a preselected feed rate; four additional switches mounted on said switch-supporting means, which when energized effect the movement of said member in either direction along two intersecting paths, at said preselected feed rate; means for rotating said shaft to effect the energization of selected of said plurality of switches; a pivotally-mounted operating finger extending outwardly from said housing; a linkage between said finger and said four additional switches for causing the proper switch of said four additional switches to be energized to effect movement of the tool support in the direction in which said pivoted finger is moved; and means for preventing the movement of said pivotally-mounted operating finger when said shaft rotating means is effective.

5. A pendant for a machine comprising in combination, a housing; a rotatable shaft in said housing; switch-operating dogs fixed to and rotatable with said shaft; switch-supporting means; a plurality of switches mounted on said switch-supporting means and adapted when selectively energized, to cause a member of said machine to move at a pre-determined feed rate; four additional switches mounted on said switch-supporting means, which when energized effect the movement of said member of said machine in either direction along two intersecting paths at a predetermined feed rate; a pivotally-mounted operating finger extending outwardly from said housing; a linkage between said finger and said four additional switches for causing the proper switch of said four to be energized to effect movement of the member of said machine tool in the direction in which said pivoted finger is moved; means for moving said supporting means from a position where said plurality of switches cooperate with said dogs to a position where said plurality of switches are unaffected by said dogs; means between said rotatable shaft and said supporting means for preventing the rotation of said shaft until said supporting means is moved to the position where said switches are unaffected by said dogs; and means for preventing the movement of said pivotally-mounted operating finger when said shaft rotating means is effective.

6. A pendant for a machine comprising in combination, a housing; a rotatable shaft in said housing; switch-operating dogs fixed to and rotatable with said shaft; switch-supporting means; a plurality of switches mounted on said switch-supporting means and adapted when energized selectively to cause a member of said machine to move at a pre-determined feed rate; means for rotating said shaft; two sets of four switches each in addition to said plurality of switches mounted on said switch-supporting means, said last-mentioned sets of four switches each adapted when selectively energized to cause the movement of the member of said machine in either direction along two intersecting paths at a rapid traverse rate, and at the predetermined feed rate; separate pivotally-mounted operating fingers extending outwardly from said housing for said traverse and feed control; linkages between each finger and its corresponding set of four switches for causing the proper switch to be energized to effect movement of said member in the direction in which a selected of said pivoted fingers is moved, and at a traverse or feed rate depending upon the finger selected; and means for preventing the movement of said pivotally-mounted operating fingers when said shaft rotating means is effective.

7. A pendant for a machine comprising in combination, a housing; a rotatable shaft within said housing; means for rotating said shaft; switch-operating dogs fixed to and rotatable with said shaft; a plurality of switches within said housing adapted when selectively energized to cause a member of said machine to move at a pre-determined feed rate; two sets of four switches each in addition to said plurality of switches within said housing, said latter sets of four switches being adapted when energized to cause the movement of the member of said machine in either direction along two intersecting paths at a rapid traverse rate and at a predetermined feed rate; means within said housing for supporting all of said switches; means for moving said supporting means from a position where said plurality of switches cooperate with said dogs, to a position where said plurality of switches are unaffected by said dogs; means between said rotatable shaft and said supporting means for preventing the rotation of said shaft until said supporting means is moved to the position where said switches are unaffected by said dogs; separate pivotally-mounted operating fingers extending outwardly from said housing for said traverse and feed control; linkage between each of said fingers and its corresponding set of four switches for causing the proper switch of said four switches to be energized to effect movement of said tool support in the direction in which a selected of said pivoted fingers is moved, and at a traverse or feed rate depending upon the finger selected; and means for preventing the movement of said pivotally-mounted operating fingers when said shaft rotating means is effective.

8. A pendant for a machine tool including a plurality of tool-supporting heads adapted to be moved along intersecting paths relatively to a work-supporting table, comprising in combination, a housing; a rotatable shaft in said housing for each of said tool-supporting heads; switch-operating dogs fixed to and rotatable with each of said shafts; a plurality of switches within said housing in cooperating relationship with each of said shafts; separate means within said housing for supporting the switches associated with each of said shafts; separate means for moving each of said supporting means from the position where its switches cooperate with the dogs on the corresponding rotatable shaft, to a position where said switches are unaffected by its corresponding dogs; and means between each of said rotatable shafts and

the corresponding switch supporting means for preventing the rotation of each of said shafts until its corresponding switch supporting means is moved to the position where the switches thereon are unaffected by the dogs on the corresponding shaft.

9. A pendant for a machine including a plurality of members, each adapted individually to be moved in either direction along intersecting paths comprising in combination, a housing; a set of four switches within said housing for each of said members; parallel spaced switch-supporting means within said housing for each of said members; a pair of switches on each of said switch-supporting means which switches when energized effect the movement of the corresponding member in either direction along two intersecting paths; a pivotally-mounted operating finger extending outwardly from said housing for each of said sets of four switches; and a linkage between each finger and its associated switches for causing the proper switch of said four to be energized to effect the movement of the corresponding member in the direction, and along the path in accordance with the direction of movement of said finger.

10. A pendant for a machine tool including a plurality of tool-supporting heads adapted to be moved in either direction along a plurality of intersecting paths in co-operating relationship with a rotatable work-supporting table, comprising in combination, a housing; parallel spaced switch-supporting means within said housing for each of said tool-supporting heads; two pairs of switches on each of said switch-supporting means adapted when energized to cause the movement of the corresponding tool-supporting head in either direction along two intersecting paths at a rapid traverse rate and at a preselected feed rate; separate pivotally-mounted operating fingers extending outwardly from said housing for said traverse and feed control for each of said tool-supporting heads; and a linkage between each finger and its corresponding pairs of switches for each of said tool-supporting heads for causing the proper switch to be energized to effect movement of the corresponding tool-supporting head in the direction, and along the path in accordance with the direction of movement of a selected pivoted finger, and at a traverse or feed rate depending upon the finger selected.

11. A pendant for a machine comprising in combination, a housing; a rotatable shaft in said housing; switch-operating dogs fixed to and rotatable with said shaft; means for rotating said shaft; a plurality of switches within said housing, adapted when selectively energized to cause a member of said machine to be rotated at a pre-determined speed; other rotatable shafts within said housing; switch-operating dogs fixed to and rotatable with each of said other shafts; separate switch-supporting means for each of said shafts; a plurality of switches for each of said other shafts mounted on the corresponding switch-supported means, adapted when selectively energized to establish a pre-determined feed rate for a corresponding other member of said machine; four additional switches for each of said other shafts mounted on the corresponding switch-supporting means, which when energized effect the movement of the corresponding other member in either direction along intersecting paths; means for rotating each of said other shafts to effect the energization of selected of said plurality of switches for each of said other members; pivotally-mounted operating fingers extending outwardly from said housing for each of said other members; a linkage between each of said fingers and its corresponding set of four additional switches for the corresponding other member for causing the proper switch to be energized to effect movement of the corresponding other member in the direction in which the corresponding finger is moved; and means for preventing the movement of any of said pivotally-mounted operating fingers when the means for rotating their corresponding rotatable shaft is effective.

12. A pendant for a machine including, housing; two sets of four switches each within said housing, adapted when energized to cause the movement of means forming part of said machine in either direction along its respective path of motion at a rapid traverse rate and at a predetermined feed rate; separate pivotally-mounted operating fingers extending outwardly from said housing for said traverse and feed control; a linkage between each finger and its corresponding set of four switches for causing the proper switch to be energized to effect movement of said member in the direction in which either of said pivoted levers is moved, and at a traverse or feed rate depending upon the finger selected; and means between said linkages to prevent the movement of either of said fingers when the other finger is out of a neutral position.

13. A pendant for a machine tool having a tool support and a feedworks transmission therefor, comprising in combination, a housing; a rotatable shaft in said housing; switch-operating dogs fixed to and rotatable with said shaft; a plurality of switches within said housing adapted when selectively energized to cause said feedworks to operate at a preselected feed rate; four additional switches within said housing which, when energized, effect the movement of said tool support in either direction along two intersecting paths at said preselected feed rate of said feedworks; means for rotating said shaft to effect the energization of selected of said plurality of switches; pivotally-mounted operating finger means extending outwardly from said housing; linkage between said finger means and said four additional switches for causing the proper switch to be energized to effect movement of the tool support in the direction in which said pivoted finger means is moved; and means rendered effective by the movement of said finger means for preventing the rotation of said shaft until said pivoted finger means is in a neutral position.

14. A pendant for a machine tool having a tool support and a feedworks transmission therefor, comprising in combination, a housing; a rotatable shaft in said housing; switch-operating dogs fixed to and rotatable with said shaft; a plurality of switches within said housing, adapted when selectively energized to cause said feedworks to operate at a preselected feed rate; four additional switches within said housing which, when energized, effect the movement of said tool support in either direction along two intersecting paths at said preselected feed rate of said feedworks; means for rotating said shaft to effect the energization of selected of said plurality of switches; interlocking means adapted to prevent the rotation of said shaft; pivotally-mounted operating finger means extending outwardly from said housing; linkage between said finger means and said four additional switches for causing the proper switch to be energized to effect movement of the tool support in the direction in which said pivoted finger means is moved; and separate interlocking means adapted to cooperate with said first mentioned interlocking means for preventing the operation of said finger means when said first-mentioned interlocking means is in position to permit rotation of said shaft.

15. A pendant for a machine tool having a feedworks transmission, a tool support and a work support, comprising in combination, a housing; a rotatable shaft in said housing; switch-operating dogs fixed to and rotatable with said shaft; a plurality of switches within said housing, adapted when selectively energized to cause a pre-determined feed rate to be established within the feedworks transmission of said machine tool; four additional switches within said housing which, when energized, effect the movement of the tool support of said machine tool in either direction along two intersecting paths at the feed rate established in said feedworks; means within said housing for supporting all of said switches; a pivotally-mounted operating finger extending outwardly from said

housing; a linkage between said finger and said four additional switches for causing the proper switch of said four to be energized to effect movement of the tool support of said machine tool in the direction in which said pivoted finger is moved; means for moving said supporting means from a position where said plurality of switches cooperate with said dogs to a position where said plurality of switches are unaffected by said dogs; means between said rotatable shaft and said supporting means for preventing the rotation of said shaft until said supporting means is moved to the position where said switches are unaffected by said dogs; and means between said supporting means and said linkage for preventing the movement of said switch-supporting means until said finger is in a neutral position.

16. A pendant for a machine comprising in combination, a housing; a rotatable shaft in said housing; means for rotating said shaft; switch-operating dogs fixed to and rotatable with said shaft; switch-supporting means; a plurality of switches mounted on said switch-supporting means and adapted when energized selectively to cause a member of said machine to move at a pre-determined feed rate; two sets of four switches each in addition to the plurality of switches mounted on said switch-supporting means, said last-mentioned sets of four switches each adapted, when selectively energized, to cause the movement of said member in either direction along two intersecting paths at a rapid traverse rate, and at the pre-determined feed rate; separate pivotally-mounted operating fingers extending outwardly from said housing for said traverse and said feed control; linkages between each finger and its corresponding set of four switches for causing the proper switch to be energized to effect movement of said member in the direction in which a selected of said pivoted fingers is moved, and at a traverse or feed rate depending upon the finger selected; separate means for each of said fingers adapted to prevent one being moved from a neutral position when the other is not in a neutral position; and means for preventing the movement of any of said fingers from a neutral position when said shaft rotating means is effective.

17. A pendant for a machine tool having a feedworks transmission, a tool support and a work support, comprising in combination, a housing; a rotatable shaft within said housing; switch-operating dogs fixed to and rotatable with said shaft; a plurality of switches within said housing adapted when selectively energized to cause a predetermined feed rate to be established within the feedworks of said machine tool; two sets of four switches each in addition to said plurality of switches within said housing, said sets of four switches being adapted when energized to cause the movement of the tool support of the machine tool in either direction along two intersecting paths at a rapid traverse rate and at the predetermined feed rate established in said feedworks; means within said housing for supporting all of said switches; means for moving said supporting means from a position where said plurality of switches cooperate with said dogs, to a position where said plurality of switches are unaffected by said dogs; separate pivotally-mounted operating fingers extending outwardly from said housing for said traverse and feed control; linkages between each of said fingers and its corresponding set of four switches for causing the proper switch to be energized to effect movement of said tool support in the direction in which a selected of said pivoted fingers is moved, and at a traverse or feed rate depending upon the finger selected; means on said switch-supporting means for preventing the rotation of said shaft until said supporting means has been moved to a position where the switches thereon are unaffected by the dogs on said shaft; and means between said movable switch-supporting means and each of said linkages for preventing the movement of said supporting means unless both said pivotally-mounted fingers are in a neutral position, and for preventing the movement of either of said fingers from a neutral position when said supporting means is in a position where the switches thereon are unaffected by the dogs of said rotatable shaft.

18. A pendant for a machine tool having a feedworks transmission, a tool support and a work support, comprising in combination, a housing; a rotatable shaft within said housing; switch-operating dogs fixed to and rotatable with said shaft; a plurality of switches within said housing adapted when selectively energized to cause a pre-determined feed rate to be established within the feedworks of said machine tool; two sets of four switches each in addition to said plurality of switches within said housing, said sets of four switches being adapted when energized to cause the movement of the tool support of the machine tool in either direction along two intersecting paths at a rapid traverse rate and at the pre-determined feed rate established in said feedworks; means within said housing for supporting all of said switches; means for moving said supporting means from a position where said plurality of switches cooperate with said dogs, to a position where said plurality of switches are unaffected by said dogs; separate pivotally-mounted operating fingers extending outwardly from said housing for said traverse and feed control; linkages between each of said fingers and its corresponding set of four switches for causing the proper switch to be energized to effect movement of said tool support in the direction in which a selected of said pivoted fingers is moved, and at a traverse or feed rate depending upon the finger selected; means on said switch-supporting means for preventing the rotation of said shaft until said supporting means has been moved to a position where the switches thereon are unaffected by the dogs on said shaft; means between said movable supporting means and each of said linkages for preventing the movement of said supporting means unless both said pivotally-mounted fingers are in a neutral position, and for preventing the movement of either of said fingers from a neutral position when said supporting means is in a position where the switches thereon are unaffected by the dogs of said rotatable shaft; and interlocking means between said linkages for preventing the movement of either of said pivoted fingers when the other is out of its neutral position.

19. A control for a machine including a member adapted to be moved in either direction along two intersecting paths at substantially right angles to each other comprising in combination, a housing; two sets of four switches each within said housing, the selective energization of one switch in each set of which effects the movement of said member in one direction along one of said paths at a feed or traverse rate, and the simultaneous energization of selected pairs of said switches within each set effects the movement of said member along paths at 45° to said intersecting paths; a pivotally-mounted finger extending outwardly from said housing for each set of switches; guides for directing the movement of said fingers in directions parallel to said intersecting paths; means for turning said guides through a 45° angle whereby they direct the movement of said fingers along paths at 45° to that of the two intersecting paths of motion of said movable member; a linkage between each of said fingers and its corresponding switches for causing the proper switch or pair of proper switches to be energized to effect movement of said member in the direction in which said fingers are moved, and at a traverse or feed rate depending upon which finger is selected; and means cooperating with said linkages to prevent the operation of either finger when the other is effective.

20. A control for a machine including a member adapted to be moved in either direction along two intersecting paths at substantially right angles to each other comprising in combination, a housing; a set of four switches within said housing, the selective energization of one of which effects the movement of said member in

one direction along one of said paths, and the simultaneous energization of selected pairs of which effect movement of said member along paths at 45° to said intersecting paths; a pivotally-mounted finger extending outwardly from said housing; a guide for directing the movement of said finger in directions parallel to said intersecting paths; means for turning said guide through a 45° angle whereby it directs the movement of said finger along paths at 45° to that of said interesting paths; a linkage between said finger and switches for causing the proper switch or pair of switches to be energized to effect movement of said member in the direction in which said finger is moved; and an interlock between said guide and finger adapted to prevent turning of said guide until said finger is in a neutral position.

21. A control for a machine including a member adapted to be moved in either direction along two intersecting paths at substantially right angles to each other by a feedworks transmission including means to move the member at a relatively rapid traverse rate or at a selected feed rate comprising in combination, a housing; two sets of four switches each within said housing, the energization of any one of which in each set effects the movement of said member at a rapid traverse rate or at a feed rate in one direction along one of said paths, and the simultaneous energization of selected pairs of which in each set effects movement of said member along paths at 45° to said intersecting paths at traverse or feed rate; pivotally-mounted fingers extending outwardly from said housing, one for controlling said traverse rate, and one for controlling said feed rate; guides for directing the movement of said fingers in directions parallel to said intersecting paths; means for turning said guides though a 45° angle whereby they direct the movement of said fingers along paths at 45° to that of said intersecting paths; and a linkage between each finger and its corresponding set of four switches for causing the proper switch or pair of switches to be energized to effect movement of said member in the direction in which selected of said pivoted fingers is moved, and at a traverse or feed rate depending upon the finger selected.

22. A pendant for a machine tool of the type including a rotatable work-supporting table, and a tool-supporting member adapted to be moved vertically toward and from said work-supporting table as well as horizontally inwardly toward, and outwardly from the center of said work-supporting table, comprising in combination, a housing; four switches within said housing arranged at the four extremities of an H-shaped design, the switch at the upper left extremity of said design being adapted when energized to cause said tool-supporting member to move outwardly from the center of said work-supporting table, the switch at the lower left extremity of said design adapted when energized to cause said tool support to move inwardly toward the center of said rotatable work-supporting member, the switch at the upper right extremity of said design being adapted when energized to cause said tool support to move downwardly toward the work-supporting table, and the switch at the lower right extremity of said design adapted when energized to cause said tool support to move upwardly from said work-supporting table; a pivoted lever extending outwardly from said housing; a reciprocable link connected to said lever and extending between the right-hand extremities of said H-shaped design; a reciprocable rack extending between the parallel legs of said H-shaped design and adapted to be engaged by said pivoted lever; an additional rack extending between the left-hand extremities of said design; and a pinion between said last-mentioned racks, the construction and arrangement of the parts being such that pivotal movement of the finger in an upward direction causes the right-hand link to move downwardly, thereby closing the switch at the lower right extremity of said H-shaped design, pivotal movement of the finger downwardly causes said right-hand link to move upwardly to close the switch at the upper right extremity of said H-shaped design, movement of said pivoted lever leftwardly causes said racks and pinion to effect closing of the switch at the lower left extremity of said design, and rightward movement of said pivotal finger causes said racks and pinion to effect closing of the switch at the upper left extremity of said design.

23. A pendant for a machine tool of the type including a rotatable work-supporting table, and a tool-supporting member adapted to be moved toward and from said work-supporting table as well as along an intersecting path inwardly toward and outwardly from the center of said work-supporting table, comprising in combination, a housing; two sets of four switches each within said housing, each set arranged at the four extremities of an H-shaped design, the switches at the upper left extremities of said designs being adapted when energized to cause said tool-supporting member to move outwardly from the center of said work-supporting table at a feed and traverse rate respectively, the switches at the lower left extremities of said designs adapted when energized to cause said tool support to move inwardly toward the center of said rotatable work-supporting member at a feed and traverse rate respectively, the switches at the upper right extremities of said designs being adapted when energized to cause said tool support to move toward the work-supporting table, at a feed and traverse rate respectively, and the switches at the lower right extremities of said designs adapted when energized to cause said tool support to move from said work-supporting table at a feed and traverse rate respectively; pivoted levers, one for each of said sets of four switches, extending outwardly from said housing; a reciprocable link connected to each of said levers and extending between the right-hand extremities of the corresponding H-shaped designs; a reciprocable rack extending between the parallel legs of each of said H-shaped designs and each adapted to be engaged by one of said pivoted levers; and additional rack extending between the left-hand extremities of each of said designs; and a pinion between each of said last-mentioned groups of racks, the construction and arrangement of the parts being such that pivotal movement of either of the fingers in an upward direction causes the right-hand link of each design to move downwardly, thereby closing the switches at the lower right extremities of said H-shaped designs, pivotal movement of either of the fingers downwardly causes said right-hand links to move upwardly to close the switches at the upper right extremities of said H-shaped designs, movement of said pivoted levers leftwardly causes said racks and pinions to effect closing of the switches at the lower left extremities of said designs, and rightward movement of said pivotal fingers causes said racks and pinions to effect closing of the switches at the upper left extremities of said designs.

24. A control for a machine tool including, a housing; two sets of four switches each within said housing, adapted when energized to cause movement of means forming part of said machine tool in either direction along two intersecting paths at a rapid traverse rate and at a pretermined feed rate; separate pivotally-mounted operating fingers extending outwardly from said housing for said traverse and feed control; linkage between each finger and its corresponding set of four switches for causing the proper switch to be energized to effect movement of said member in a direction in which either of said pivoted levers is moved, and at a traverse or feed rate depending upon the finger selected; notches associated with said linkages adapted to be aligned when all of said fingers are in a neutral position; and a slidable bar having means adapted to cooperate with said notches to prevent the movement of either of said fingers when the other finger is out of a neutral position.

25. A pendant for a machine comprising in combination, a housing; a rotatable shaft in said housing; switch-

operating dogs fixed to, and rotatable with said shaft; a plurality of switches within said housing adapted to be operated by said dogs; means for neutralizing said switches so that upon rotation of said shaft, said switches are not energized; and means adapted to cooperate with said neutralizing means and said shaft to prevent the rotation of said shaft until said neutralizing means is effective to neutralize said switches.

References Cited in the file of this patent

UNITED STATES PATENTS

1,794,193	McKerlie	Feb. 24, 1931
2,009,536	Warg	July 30, 1935
2,143,255	Abe	Jan. 10, 1939
2,150,838	McClure	Mar. 14, 1939
2,202,766	Trosch	May 28, 1940
2,355,625	Bullard	Aug. 15, 1944
2,391,881	Clay	Jan. 1, 1946
2,397,978	Paulus et al.	Apr. 9, 1946
2,526,487	Kurzweil	Oct. 17, 1950
2,575,792	Bullard	Nov. 20, 1951
2,612,071	Kurzweil	Sept. 30, 1952
2,670,633	Schoepe	Mar. 2, 1954
2,694,755	Schuman	Nov. 16, 1954
2,701,477	Schoepe	Feb. 8, 1955