

Oct. 16, 1951

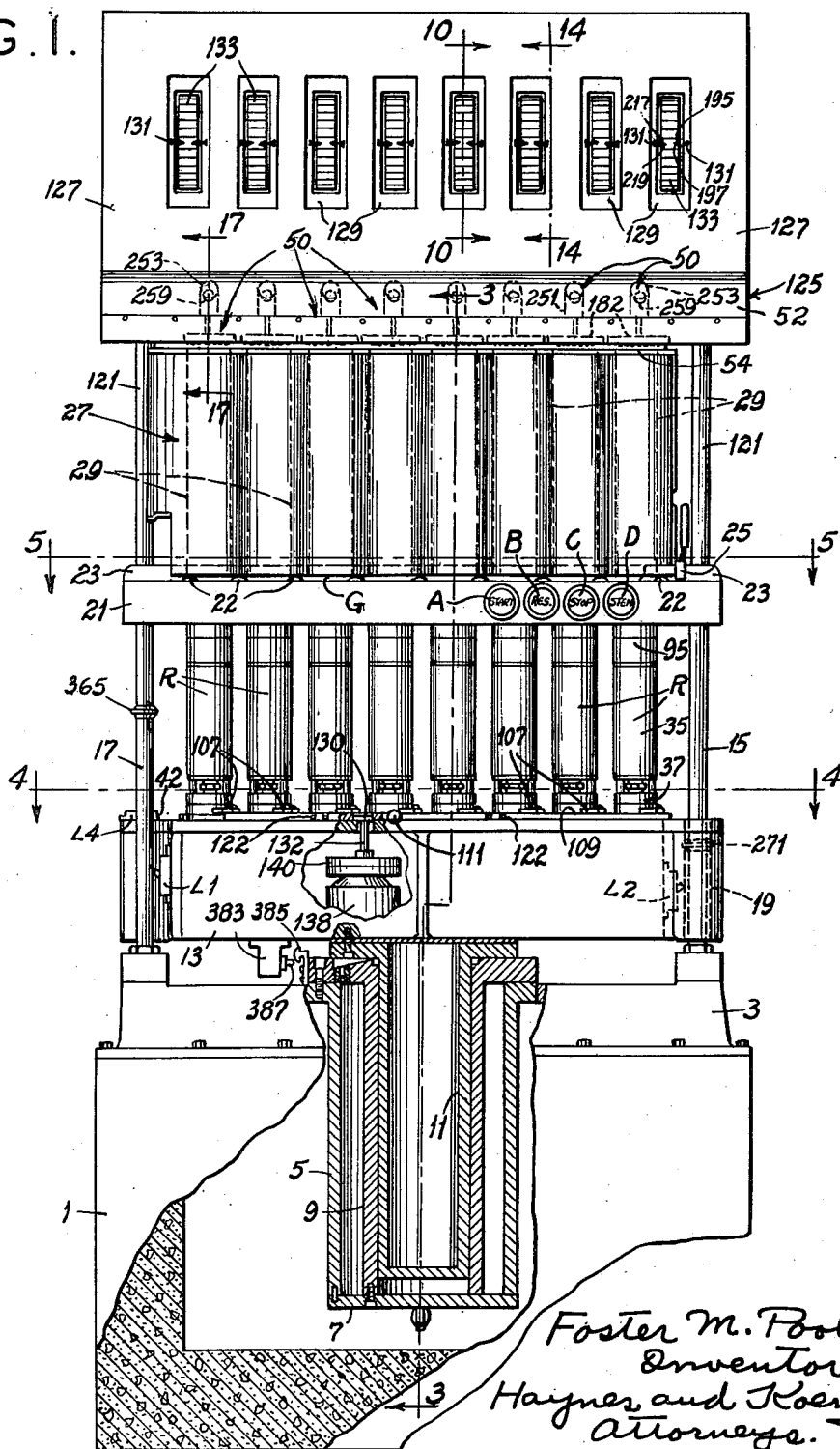
F. M. POOLE
AUTOMATIC RECORDING TUBE CALIPERS FOR
INSIDE MEASUREMENTS WITHIN CYLINDERS

2,571,161

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FIG. 1.



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FIG. 2.

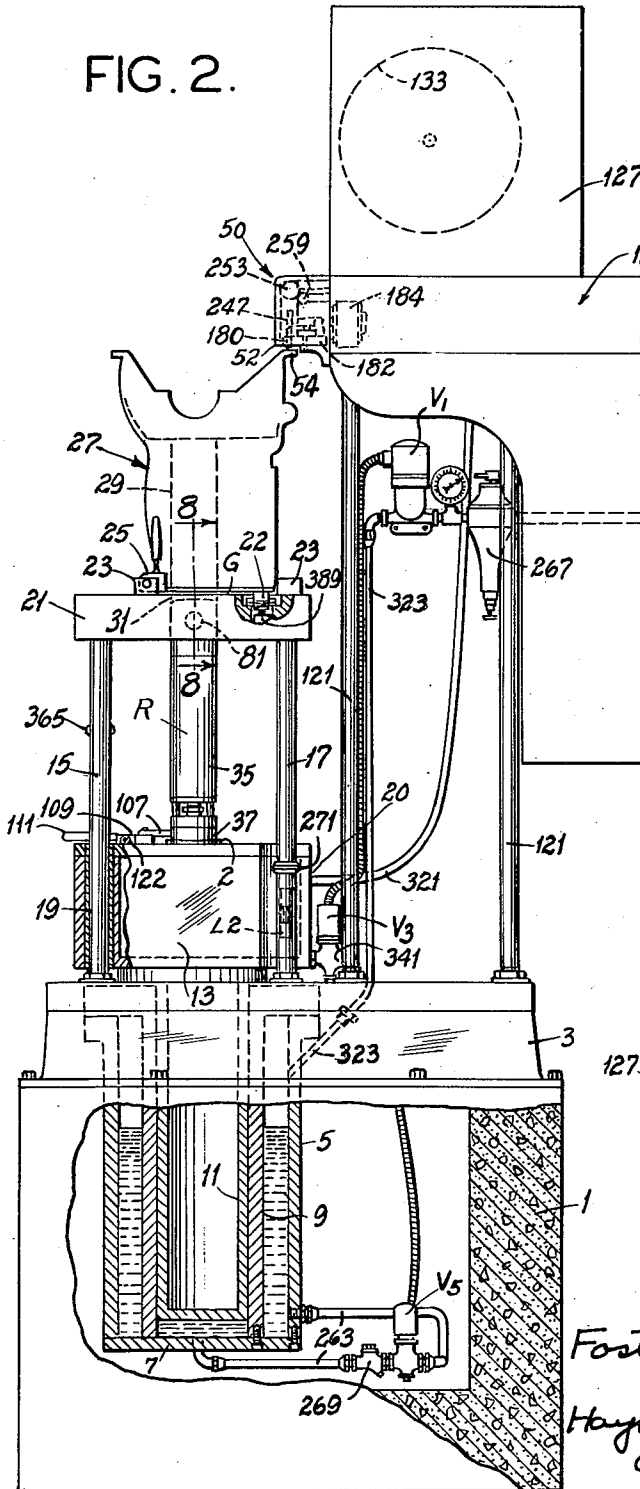


FIG. 23.

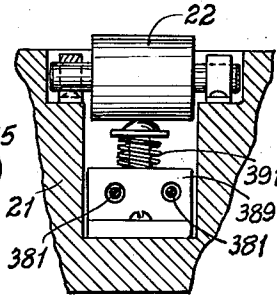
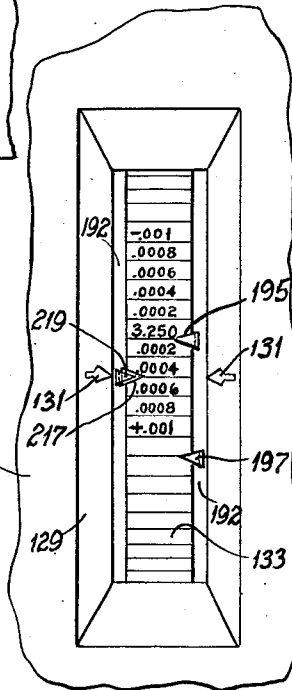


FIG. 13.



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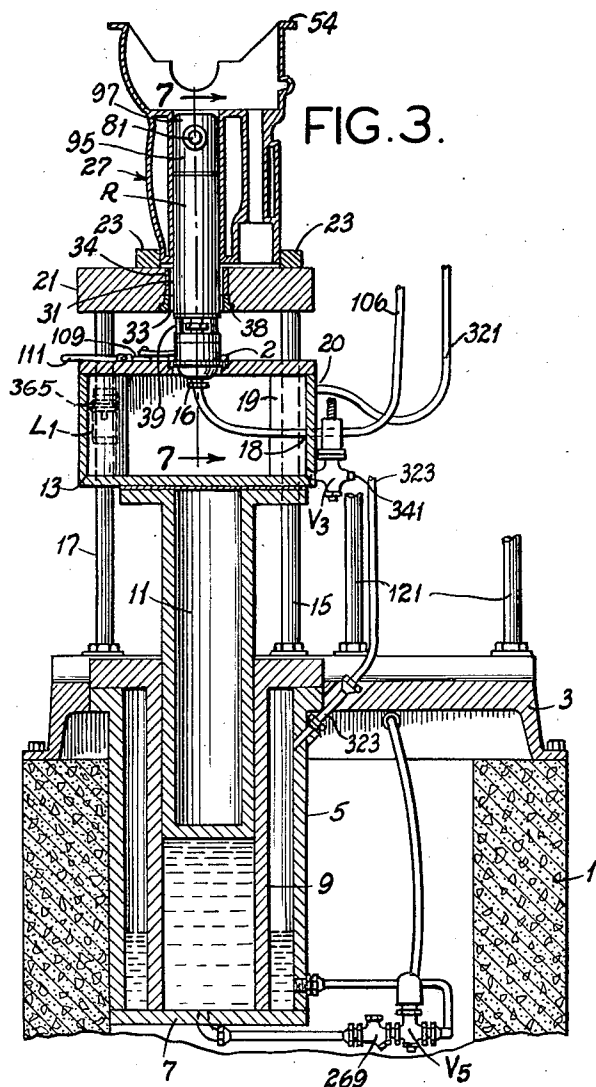


FIG. 3.

FIG. 16.

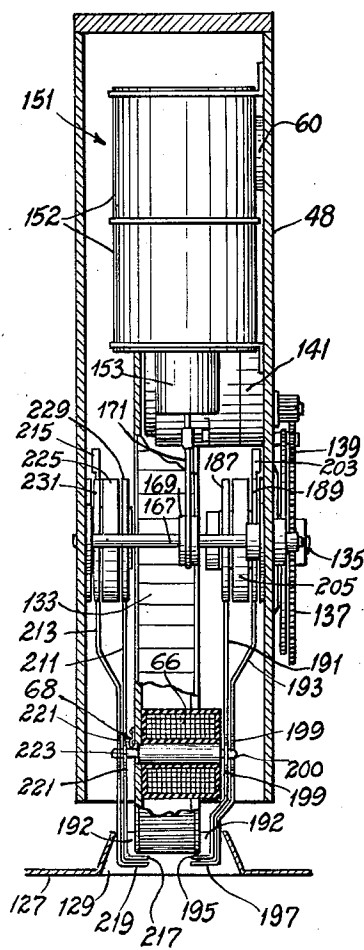
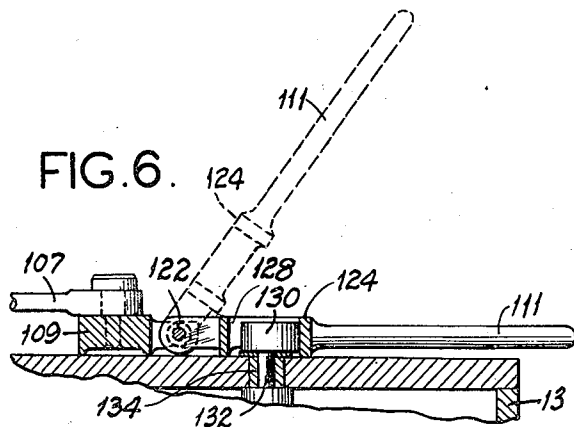


FIG. 6.



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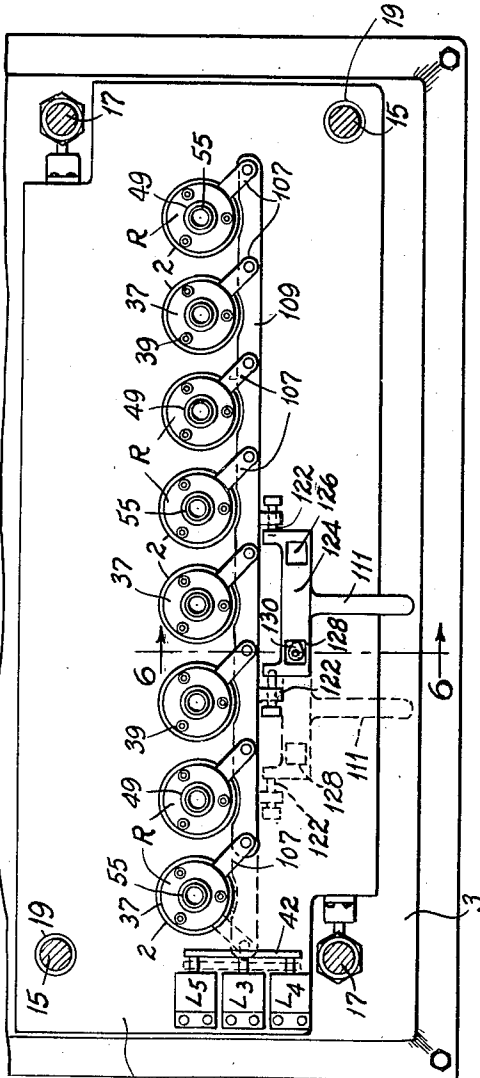


FIG. 4.

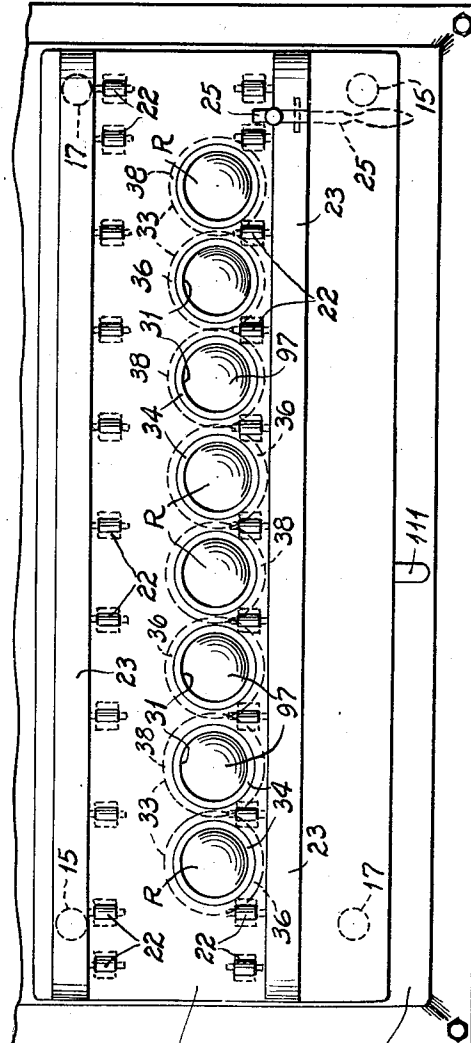


FIG. 5.

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FIG. 7.

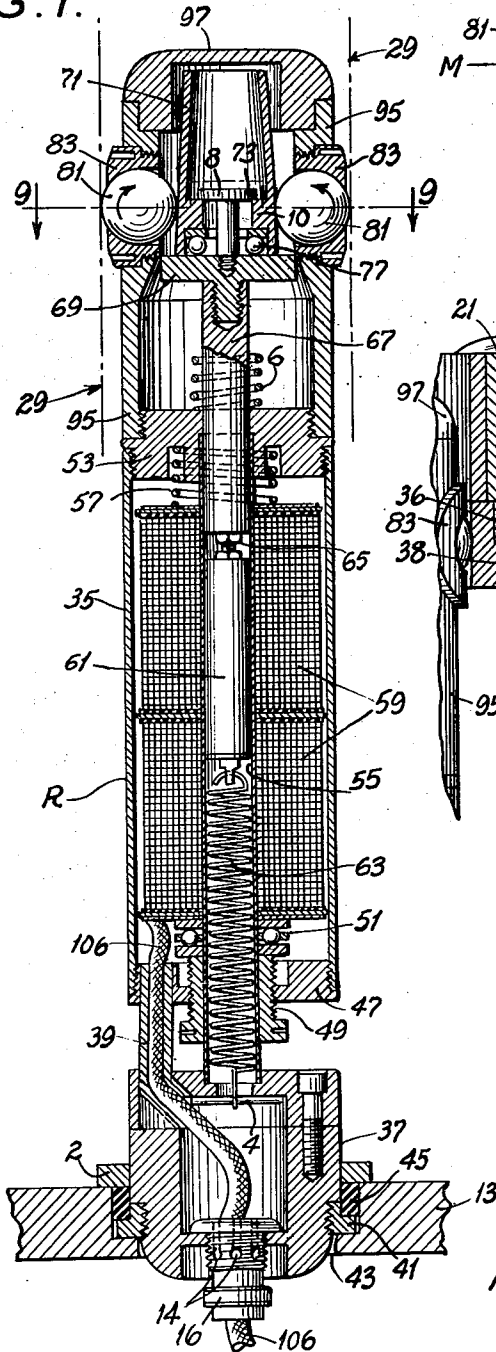


FIG. 9.

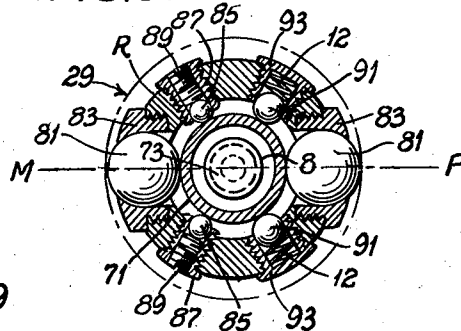
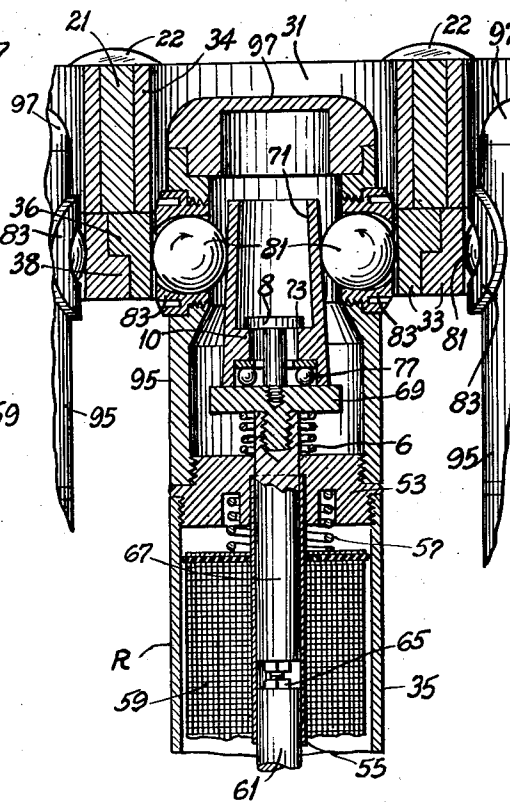


FIG. 8.



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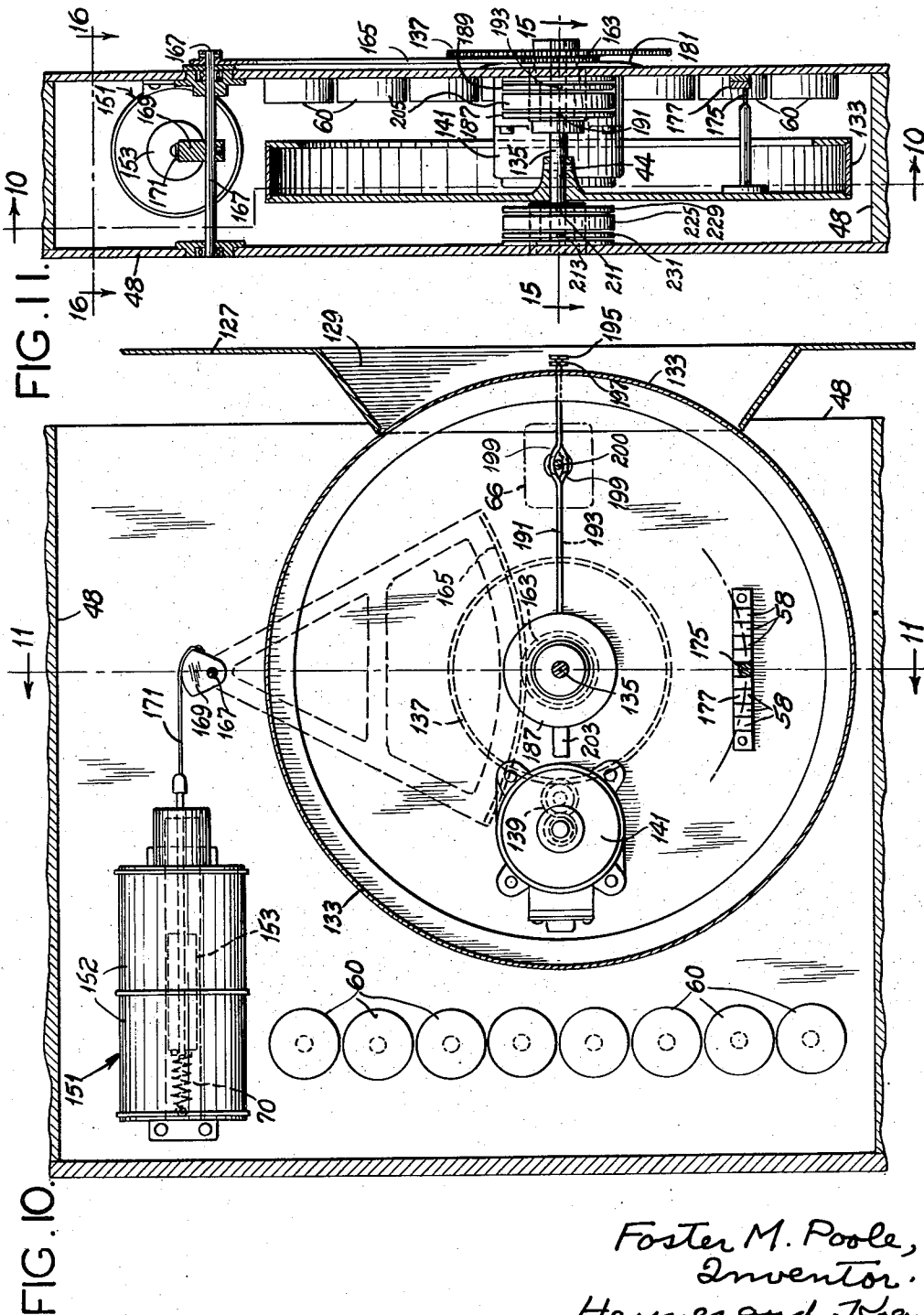
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FIG. 14.

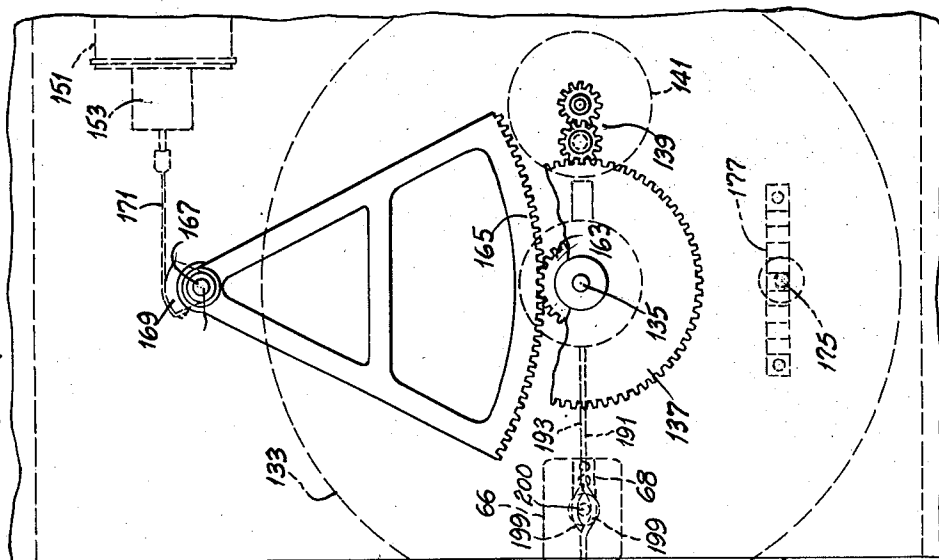


FIG. 12.

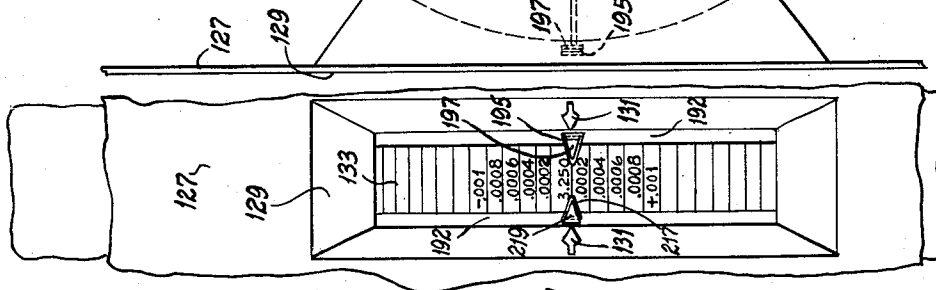
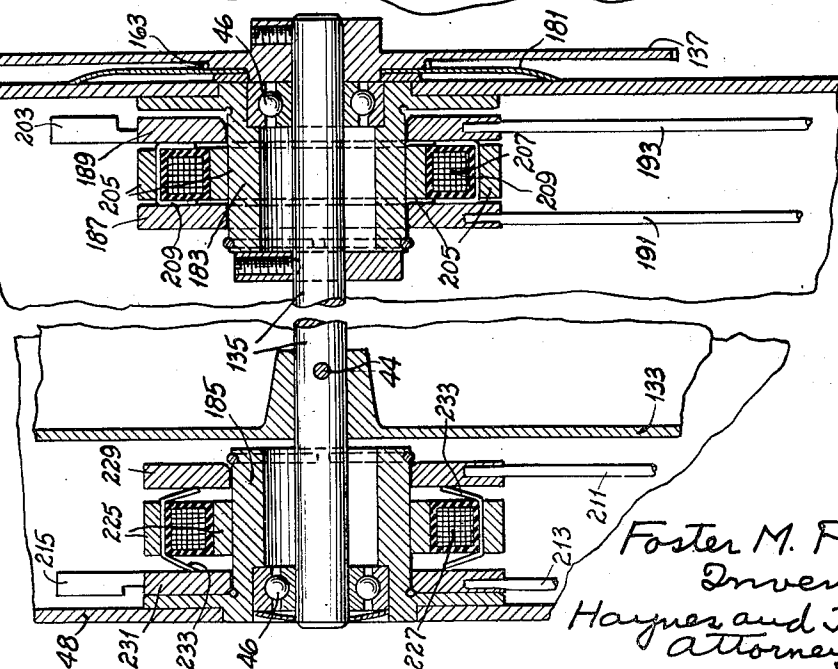


FIG. 15.



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FIG. 19.

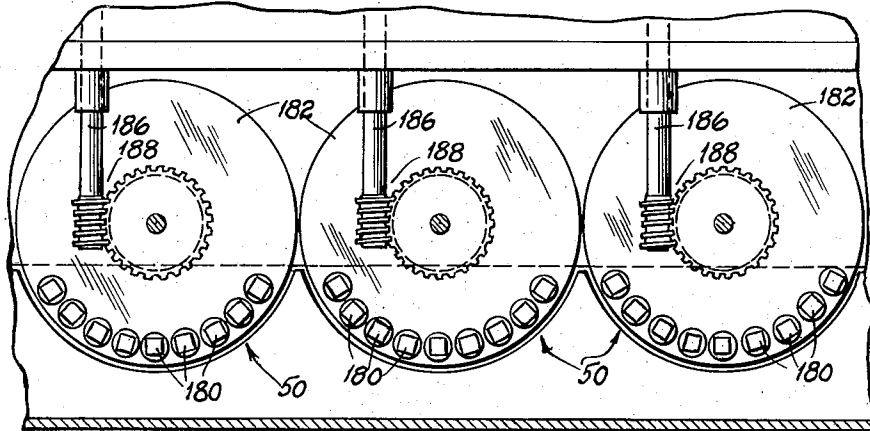


FIG. 17.

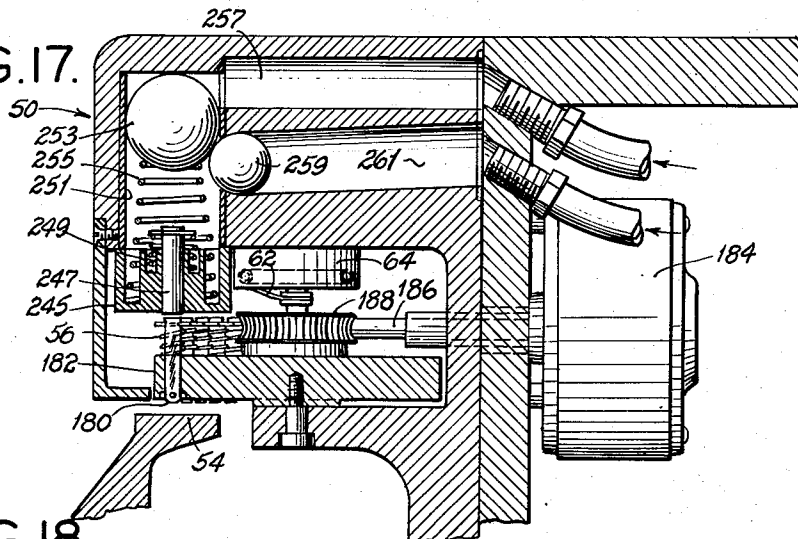
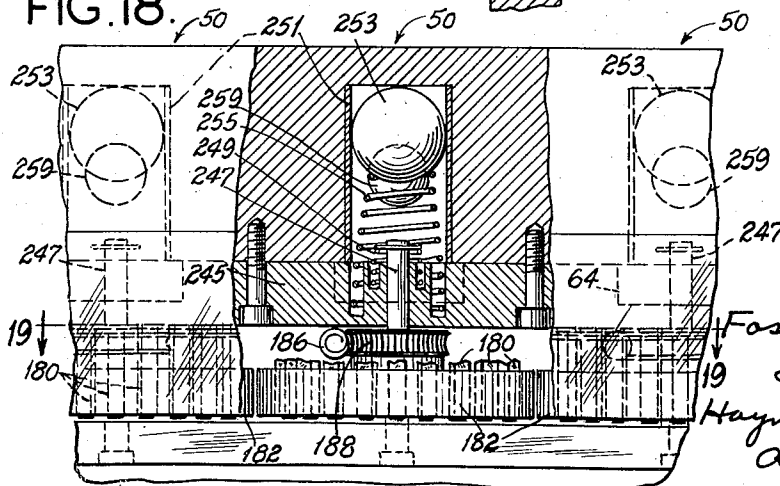


FIG. 18.



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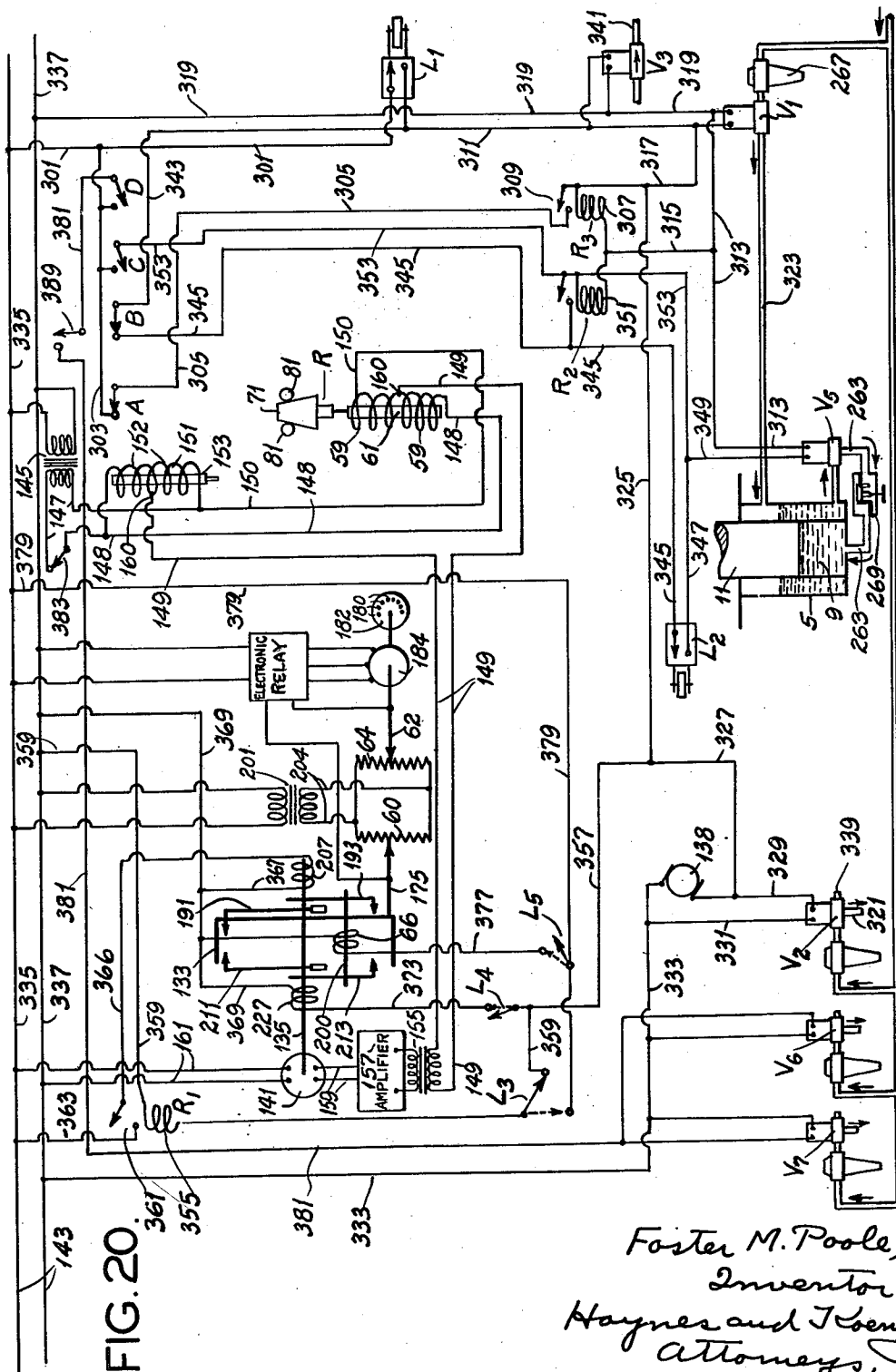
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FIG. 22.

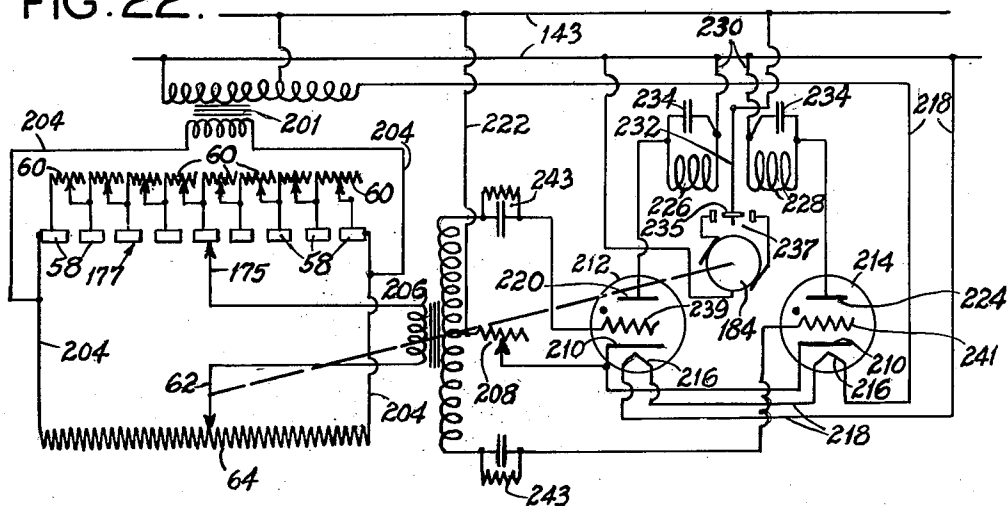
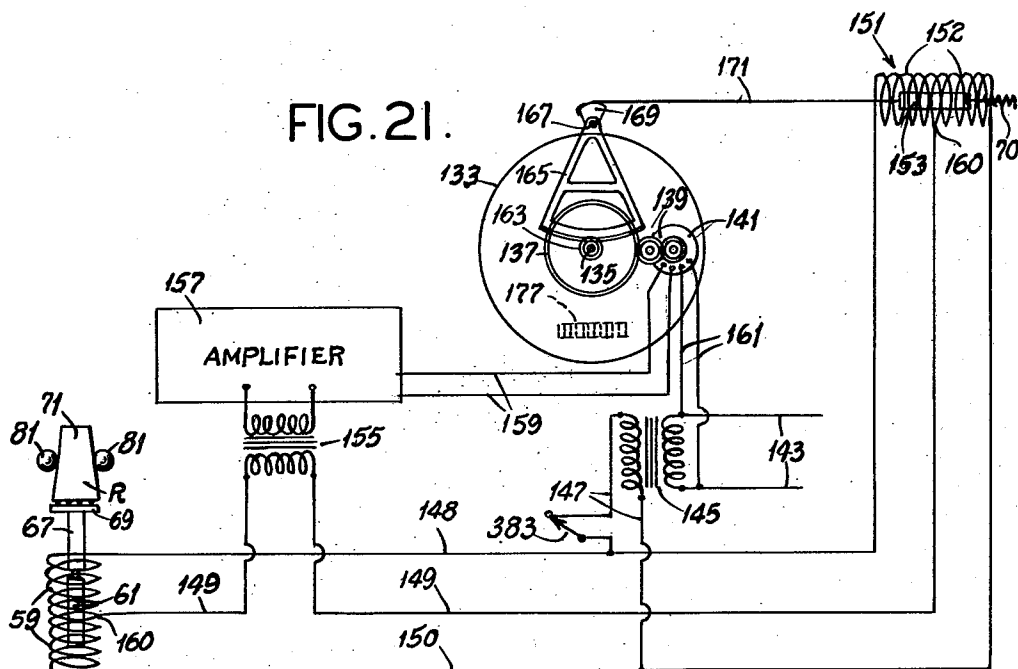


FIG. 21.



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UNITED STATES PATENT OFFICE

2,571,161

AUTOMATIC RECORDING TUBE CALIPERS
FOR INSIDE MEASUREMENTS WITHIN
CYLINDERS

Foster M. Poole, Dallas, Tex.

Application February 23, 1946, Serial No. 649,650

20 Claims. (Cl. 33—178)

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This invention relates to measuring instruments, and with regard to certain more specific features, to automatic recording tube calipers for inside measurements within cylinders.

Among the several objects of the invention may be noted the provision of a measuring instrument in the form of an inspection fixture for conveniently and quickly determining, indicating and registering inside sizes in automotive cylinders and the like; the provision of a measuring instrument of the class described arranged for gang operation whereby an entire group of cylinders in a given engine block or the like may be inspected simultaneously; the provision of apparatus of the class described in which the measurements taken during an operation are visibly continuously indicated and limits of deviation shown; the provision of apparatus of this class in which symbols coordinated with deviations are physically recorded on the engine block or the like being measured; the provision of apparatus of this class which provides diametral measurements at given axial points in the cylinders and also measurements of taper, both of said measurements being obtainable in two perpendicular planes; and the provision of apparatus of the class described which may be simply, conveniently and speedily operated. Other objects will be in part obvious and in part pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, features of construction, and arrangements of parts which will be exemplified in the structures hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, in which one of various possible embodiments of the invention is illustrated,

Fig. 1 is a front elevation of the apparatus, parts being broken away;

Fig. 2 is a right-side elevation of Fig. 1, parts being broken away;

Fig. 3 is a fragmentary section taken on line 3—3 of Fig. 1 but showing an alternative position of parts;

Fig. 4 is a horizontal section taken on line 4—4 of Fig. 1;

Fig. 5 is a horizontal section taken on line 5—5 of Fig. 1;

Fig. 6 is an enlarged detail section taken on line 6—6 of Fig. 4;

Fig. 7 is an enlarged longitudinal section of a transmitter, being taken on line 7—7 of Fig. 3;

Fig. 8 is an enlarged detail section taken on line 8—8 of Fig. 2;

Fig. 9 is a horizontal section taken on line 9—9 of Fig. 7;

Fig. 10 is a detail section taken along lines

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10—10 of Fig. 1 and of Fig. 11 and showing a recorder;

Fig. 11 is a vertical section taken on line 11—11 of Fig. 10;

Fig. 12 is a fragmentary front elevation of a single recorder dial;

Fig. 13 is a view similar to Fig. 12 showing a moved position of certain parts;

Fig. 14 is an enlarged elevation of a recorder, being viewed from line 14—14 of Fig. 1;

Fig. 15 is an enlarged horizontal section taken on line 15—15 of Fig. 11, parts being broken away for condensation of the view;

Fig. 16 is a plan view of a recorder unit, being taken on line 16—16 of Fig. 11, parts being broken away;

Fig. 17 is an enlarged vertical section taken on line 17—17 of Fig. 1;

Fig. 18 is a front elevation of Fig. 17, parts being broken away to show details;

Fig. 19 is a horizontal section taken on line 19—19 of Fig. 18;

Fig. 20 is a simplified circuit diagram;

Fig. 21 is a wiring diagram of one of several recorders;

Fig. 22 is a wiring diagram for one of several stencil motor drives; and,

Fig. 23 is a detail of a roller-operated switch. Similar reference characters indicate corresponding parts throughout the several views of the drawings.

In my United States Patent 2,348,643, dated May 9, 1944, is disclosed in Fig. 1 a measuring transmitter instrument for internal caliper of a cylinder. Several similar transmitters are used in the present invention, operating in parallel in multi-cylinder engine blocks. As may be seen from the patent and below, each transmitter which is indexed R herein consists broadly in a cylindric body adapted to be introduced loosely into the cylinder to be measured. The transmitter cylinder carries radially moving balls which traverse the inside of the cylinder to be measured, the balls being pressed outward by means of a pneumatically biased cone. The cone controls the position of a first armature which is operative in a coil having two sections which are electrically bridged with two sections in a receiver coil in a recording meter. The coil sections in the recording meter control a second armature which in turn controls the meter according to the amount of unbalance introduced into the circuit by motion of the first armature. Thus inequalities in the surface of the cylinder are visually registered by moving the balls through the cylinder to be measured. The present invention employs transmitters of this class in a way such as quickly visually to produce measurements and to register them for a group of cylinders, for example in eight cylinders of

an eight-cylinder engine block. Thus such blocks may be quickly inspected for reliable quantity production.

Referring now more particularly to Figs. 1-3, there is shown at numeral 1 a foundation carrying a fixed bed 3 which supports a vessel 5, the latter forming a liquid sump. This vessel is closed at the bottom by means of the head 7. Within the vessel 5 is a cylinder 9 which is also closed at the bottom by said head 7. This cylinder 9 carries an elevating piston 11 on the upper end of which is carried a hollow air-tight platen 13. Extending upward from the bed 3 are four posts, two diagonal ones of which are numbered 15 and the other two diagonal ones of which are numbered 17. The diagonally opposite posts 15 act as guides through bearings 19 formed at opposite corners of the platen 13. The posts 17 do not pass through bearings in platen 13 but are free from it.

All of the posts 15 and 17 support a stationary fixture 21 in the top surface of which are located supporting roller bearings 22. This fixture 21 carries longitudinal guide means 23 and a manually rotary end stop 25 for predeterminedly positioning on the rollers 22 an engine block 27 to be tested. The stop 25 may at will be rotated counterclockwise (Fig. 2) to pass a block that has been tested (see also the dotted position of 25 in Fig. 5).

The block 27 under consideration has several bored cylinders 29 (eight in the present example) which are to be checked for diameter size, roundness and taper. For this purpose the guides 23 and stop 25 are arranged to position the respective center lines of the cylinders substantially on the respective center lines of openings 31 in the fixture 21 (see Figs. 2, 3, 5 and 8). The spacings of the center lines of the cylinders 29 and those of the openings 31 are about the same, within tolerable limits, so that respective pairs of said openings 29 and 31 are in substantial alignment. The openings 31 are provided near their lower ends with hard steel or similar circular master gage rings 33, the inside diameters of which are of the proper sizes intended for the diameters of the cylinders 29. Above the master gage rings 33 are hardened steel guide sleeves 34 for purposes which will appear. These have inside diameters about equal to those of the respective gage rings 33. Gage rings 33 have oppositely disposed collars 36 and 38 which overlap where tangent as shown in Figs. 5 and 8. As indicated in Fig. 3, which is a section at a right angle to Fig. 8, there is only one gage ring per opening, rings of alternate openings having the alternate collars shown in Fig. 8. Coaxial with the openings 31 are the cylindric transmitters R which are of the general type described in said patent, and more particularly of an improved form such as shown in Figs. 7-9 herein.

Referring to Figs. 7-9, each transmitter R consists in an air-tight cylinder 35 attached to a hollow holder 37 by means of three posts, one of which is hollow as shown at 39 in Fig. 7. Each holder carries a flange 41 which is received in an opening 43 on the top of the hollow platen 13 (see Figs. 1 and 7). Packing is used to make an air-tight connection as shown at 45. Each holder 37 is held upright by means of a holding ring 2 fastened to the top of the platen 13. Each is rotary in the top of the hollow platen 13.

At the lower end of the air-tight cylinder 35 is a head 47 in which is a threaded adjusting member 49. Member 49 backs a thrust bearing 51.

The upper end of the cylinder 35 carries a head 53 from which extends a fixed tube 55, the latter passing through the bearing 51 and member 49 into fixed engagement with the holder 37.

A spring 57 forces an electromagnetic coil consisting of two sections 59 into engagement with the bearing 51. This provides for a zero adjustment of the coil relatively to a slidable magnetic armature 61 in the fixed tube 55. The armature 61 is normally biased by a tension spring 63 in the tube 55. The spring is anchored in the holder 37 by a pin 4. The armature 61, by means of a fastening 65, is coupled to a non-magnetic stem 67, the upper end of which carries a flat disc 69. Below the disc is a bumper spring 6. Beyond the disc is located a hard, accurately tapered cone 71 which is held prisoner to the disc by means of a fastener 73. Fastener 73 has a head 8 under which is held an inner shoulder 10 of the cone. The cone may move laterally on disc 69 but not endwise relatively thereto, although it may move endwise therewith. The cone may also rotate relatively to the disc. A thrust bearing 77 is located between the cone and the disc 69.

Bearing radially against the cone 71 are members of a pair of oppositely located balls 81. These are held prisoner by means of threaded bushings 83. It will be clear that the radial positions of the balls 81 are determined by the axial position of the cone 71. Lateral holding of the cone 71 is determined by small balls 85, which are held in bushings 87 closed by means of threaded plugs 89. Additional balls 91 in bushings 93 are biased toward the cone 71 by springs 12, thus tending to hold the cone with its median plane in the median plane of the balls 81. The stated coplanar relationship is indicated by the dotted line M-P of Fig. 9. This is an important improvement in transmitters of this class. In previous two-point measuring devices of this type, such coplanar relationship was not maintained. In the present case, once the proper adjustment of the plugs 89 has been made for the purpose, the median plane M-P of the cone 71 remains in the diametral plane common to the balls 81, irrespective of the longitudinal or rotary movements of the cone. Stated otherwise, the cone 71 is cradled by the balls 85 in the proper median position and it is resiliently held in its cradled position by means of the resiliently mounted balls 81. It will be noted that the bushings 83, 87 and 93 are located in a head 95 held on member 53. At the end of this extension 95 is a guiding nose 97.

As will be seen later, each transmitter R accomplishes its measurements by a downward movement of the balls 81 through a cylinder 29. Thus the balls 81 will tend to rotate in the direction shown by the arrows in Fig. 8 which is a direction tending to move the cone downward in Fig. 8. This tendency is overcome by the pressure effect of the air in the tube 55 tending to extrude the stem 67 from said tube. This tends to press the disc 69 and to keep the cone 71 snugly against the balls while expanding the latter into contact with the cylinder that is to be measured. Air is brought into the tube 55 from the holder 37. The holder 37 is in communication with compressed air inside of the hollow platen 13. The communication is through openings 14 of a bushing 16. A wire cable 106 enters the bushing from the inside of the platen 13. This cable 106 passes to the coil 59 via the hollow post 39. The cable, with the others serv-

ing the transmitters, passes out of the platen 13 through an airtight joint, as indicated at 18 in Fig. 3. Compressed air is fed to the inside of the platen 13 via connection 20.

From the above it will be seen that the traverse of a set of opposite balls 81 down a cylinder 29 will give diametral readings in a given plane. In order that diametral readings in a plane at 90° may be obtained, the transmitters R have been made rotary in the top of the platen 13, the flanges 41 being rotary under packings 45. In order to rotate the transmitters simultaneously, each holder 37 is provided with a lever 107 which at its outer end is mechanically coupled with a translation coupler bar 109, the latter having a pivoted handle 111. When the handle 111 is thrown sidewise a predetermined distance, it will rotate all transmitters R through 90° (note the dotted lines in Fig. 4).

In either 90° position of every transmitter R it is desirable that it be oscillated through a slight angle as it traverses a cylinder so as to prevent undue localized wear on the respective balls 81. To accomplish this the handle 111 is formed as a T, the head 124 of which swings vertically on the pivots 122 (Figs. 4 and 6). The head 124 of the T carries openings 126 and 128 which are in effect alternate followers for a horizontally rotary cam 130. This cam lies above the upper surface of the platen 13. The cam is mounted on a cam shaft 132 which passes through an opening 134 in said upper surface. This opening is suitably packed to prevent air leakage. The shaft 132 is driven by a motor 138 and a gear reduction box 140. Thus in either of the 90° positions of the transmitters R, they are slightly rocked on vertical axes due to the driving action of the cam 130. The driving action is delivered to the transmitters R through the bar 124, pivots 122, bar 109 and levers 107. As indicated by the dotted lines in Fig. 4, the rocking action is effective in either position of the handle 111. It will be understood that preliminary to moving the handle 111 it is always raised so as to clear the cam 130, but at the end of an adjustment the handle is always again lowered so as to place the cam 130 into a respective one of the openings 126 or 128. The cam is arranged to shift the transmitters R through 4° in an interval of five seconds.

It will also be noted in connection with Fig. 4 that the end of the coupler bar 109 in one position of the transmitters R contacts a bar 42 of a gang of switches. These will be referred to later.

In their lowermost positions the transmitters R are as indicated in Figs. 1 and 2. In such positions the balls 81 are against the hard steel gage rings 33 in the fixture 21 (see Fig. 8). These rings 33 are of such size that the balls 81 take up a position providing a zero reference, as will later appear.

Supported by means of posts 121 on the bed 3 is a platform 125 which carries a case 127 in which are spaced dial openings 129. Openings 129 carry zero index reference marks 131. Behind each opening is an indicating unit of the type shown in Figs. 10-16. There are as many indicating units as cylinders to be tested, eight in the present example. Each unit has exposed behind the respective opening 129 a part of the periphery of a dial drum 133 which carries plus and minus index marks starting at the nominal cylinder size. Each dial drum 133 is rotary with a shaft 135 being pinned at 44. Shaft 135 is car-

ried on bearings 46 located in an individual compartment 48 which is removable from the rear of the case 127. Each dial is driven by a gear 137 attached to shaft 135. Gear 137 is driven through a gear train 139 leading from a two-phase balancing motor 141. The motor 141 is connected into the circuit illustrated in Fig. 21 wherein 143 indicates an A. C. supply line. This supply line 143, through a transformer 145 and leads 147, supplies an impedance bridge circuit including coil sections 59 and 152 and leads 148, 149 and 150. These leads are connected across said coil sections 59 of the transmitter R and across corresponding sections 152 of a coil 151. The armature 61 of the transmitter R is shown in Fig. 21. A corresponding armature 153 is associated with the sections 152 of coil 151. As indicated in Fig. 21, the center tap 160 on each pair of coil sections 59 and 152 supplies an input transformer 155 via line 149. This input transformer 155 feeds an amplifier 157 which through leads 159 feeds one phase of the motor 141. The other phase of the motor is fed from the A. C. line 143 via leads 161.

Connected with the gear 137 on the shaft 135 is a pinion 163 which is meshed with a sector gear 165 swinging on a pivot 167. This sector gear 165 carries an arcuate shoe 169 over which is wrapped and connected a flexible band 171 such as a flexible steel ribbon. This ribbon is connected with the armature 153. The latter is biased by suitable means such as a spring 70.

Thus each motor 141 controls the position of its associated dial 133. When the feeler balls 81 are held in a predetermined position for proper diameter, as in the gage rings 33, the armature 153 may be considered to be in a position to hold its respective dial 133 at zero reference position for nominal diameter opposite the corresponding marker 131. Then, upon introducing the transmitter R into a cylinder deviating from the desired nominal diameter, the feeler balls 81 will change their radial positions, thus affecting movement of the cone 71 so as to reposition the armature 61. This unbalances the impedance bridge circuit so as to energize the input side of the transformer 155. Any small unbalance is amplified in the amplifier 157 and applied to leads 159 to one phase of the motor 141, the other phase of the motor being energized over connection 161. Thus the motor 141 is caused to reposition the armature 153 to establish a new balance of the impedance bridge circuit. A low A. C. voltage arising from any minute unbalancing of the bridge is amplified sufficiently to energize the balancing motor. The phase of this A. C. voltage is dependent upon the direction of the movement of the armature 61 to reestablish balance of the impedance bridge. The proper direction and amount of movement of armature 153 will reestablish balance of the impedance bridge circuit.

The balancing motor 141 is a reversible variable speed induction motor, one winding of which is continuously energized by line voltage and the other energized by the amplified alternating voltage whose phase with respect to the line voltage determines the direction of rotation of the motor. Thus the phase is in effect recognized by the balancing motor 141, hence determining its direction of rotation. It is to be understood that any two-phase motor will remain stationary when one of its phases is deenergized. Therefore whenever there is no energization of the connection 159 the motor 141 will be stationary. The result is that the motor action follows the measuring action of

the balls 81, in one direction for plus deviation from nominal diameter and in the reverse direction for minus deviation from nominal diameter. After each following action and balancing of the impedance bridge circuit, the dial drum 133 takes up a new position proportionately following the deviations from nominal diameter.

A dished spring disc 131 serves to maintain coplanar the thin sector gear 165 and the pinion gear 163.

On opposite sides of the drum 133 are stationary gudgeons 183 and 185 which are respectively fastened to the sides of the compartment 48. Referring to the gudgeon 183, it carries rotary hubs 187 and 189 upon which are, respectively, pointers 191 and 193. The pointers 191 and 193 pass out through the opening 192 and carry radially adjacent fingers 195 and 197, respectively, next to the face of the dial 133. The pointers 191 and 193 are offset as shown at 199 in Fig. 10 to provide an eye for receiving the end of an armature pin 200, when this pin is in the position shown in Fig. 16. The pointer 193 goes under the pin and the pointer 191 over it. Since the hubs 187 and 189 are freely rotary on the gudgeon 183, pointers 191 and 193 will be moved by means of the pin 200 as the latter is moved with the drum 133. In order that the pointer 193 may be biased against the bottom of the pin 200, a weight 203 is provided to the rear of its hub 189. The pointer 191 is biased by its own weight against the top of the pin 200.

The purpose of the pointers 191 and 193 is to obtain maximum and minimum readings, as indicated in Fig. 13. In order to have the pointers 191 and 193 remain in moved positions of the same, a magnetic clutch is provided consisting of a stationary armature 205 on the gudgeon 183. In this clutch is a toric coil 207. U-shaped springs 209 normally bias apart the hubs 187 and 189. These hubs 187 and 189 are magnetic. Hence when the coil 207 is energized, the hubs will be drawn into light frictional engagement with the springs 209. Therefore if and when either pointer 191 or 193 is positioned by the rotary action of the drum 133 and pin 200, the respective pointer will maintain the maximum angular deflection to which it may be pushed in a given operation. Thus the pointers become maximum or minimum reading devices, whereas the dial drum 133 is a continuously reading device. Whenever the coil 207 is deenergized, the hubs 187 and 189 are pushed apart by springs 209 and become released from friction and fall back into their positions against the pin 200. The springs 209 are not absolutely necessary in all designs of the apparatus, since magnetic clutches may be made to open without springs of this type.

On the other side of the drum 133 and on gudgeon 185 are similar pointers 211 and 213, the latter being counterweighted, as indicated at 215. The pointers 211 and 213 carry fingers 217 and 219, respectively. They are also bent to form between them an eye 221 for accommodating the opposite end 223 of the pin 200 when the latter is moved to the left from the position shown in Fig. 16. The portion of the eye formed by the pointer 213 goes beneath the pin and that formed by the pointer 211 goes above the pin when the pin is moved. On the gudgeon 185 is a stationary clutch member 225 having a toric coil 227 magnetically operative upon the magnetic hubs 229 and 231, respectively, of the pointers 211 and 213. Spring clips 233 serve to bias apart the hubs 229

and 231. Energization of the coil 227 will draw together the magnetic hubs so as to provide light frictional clutch engagement to hold the pointers 211 and 213 at maximum deflections. When released, the pointers 211 and 213 will gravitate against the end 223 of the pin 200, provided the pin is in a position to the left of that shown in Fig. 16. As above mentioned in connection with springs 209, the springs 233 may be omitted.

Referring to Fig. 16, it is to be understood that the pin 200 when in the position shown will affect the pointers 191 and 193 for maximum readings by said pointers. When the pin is in its alternative position to the left, its end 223 is inserted into the eye 221 and its other end is withdrawn from the eye between the pointers 191 and 193. A solenoid coil 66 carried on the drum 133 serves to control the position of pin 200, the pin being movable through the center of the coil. Normally the pin 200 is biased to the operative position in connection with pointers 191 and 193, as shown in Fig. 16. This is when coil 66 is deenergized. This is due to return spring 68.

Each drum 133 carries a brush contact 175 which sweeps a commutator 177. The purpose of this is to set up electrical conditions for indexing a punch dial unit 50. There are as many dial units 50 as there are cylinders, namely, eight in the present example. These units are carried upon a shelf 52 extending over a pan rail 54 of the engine block being tested.

In each unit 50 (Figs. 17-19) is a rotary punch dial 182 around the periphery of which are vertically sliding punches 180, each being biased upward into a retracted position by a spring 56 (Fig. 17). Each punch carries on its lower face a suitable mark or symbol to be made on the pan rail 54 of the engine block 27. The symbols on the punches correspond to off dimensions, as indicated on the corresponding dial 133. Considering, for example, the four symbols on each side of the nominal dimension on a dial 133, there are nine corresponding punches 180, one for each of the eight off-dimension symbols and a central one for the nominal dimension symbol. Also, the commutator resistor 177 has a number of insulated segments 58, that is, a central one and four on each side, totaling nine. Between the segments 58 are manually adjustable resistances 60. These control the action of a respective positioning motor 184. This motor through a shaft 186 and a worm gear set 188 controls the rotary position of the respective punch dial 182. Each motor 184 may be of the permanent magnet type. Coupled to each disc 182 is an arm 62 of a rheostat 64.

In order to operate each of the motors 184 so as to turn the corresponding disc 182, each motor 184 and corresponding rheostat 64 are placed in an electronic circuit such as shown in Fig. 22.

Fig. 22 shows schematically one electronic relay circuit whereby an action of a brush 175 on a commutator 177 is accompanied by a follow-up action by a motor 184 to cause in turn a proper setting of a punch-setting disc 182. There are eight of these circuits. Referring to said Fig. 22, which shows one of these circuits, there is shown at numeral 201 a low voltage transformer fed from the A. C. power line 143. This transformer 201 feeds a bridge circuit shown at the left of Fig. 22. This bridge circuit consists of the commutator 177 on one side and the resistance of the rheostat 64 on the other side. The ends of the commutator 177 and rheostat 64 are connected by wires 204 which are fed from the trans-

former 201 as shown. Brush 175 is electrically connected to arm 62 through the primary of a transformer 206. As has already been described, the brush 175 is driven from the dial 133 and the arm 62 is driven from the motor 184. Motor 184 is shown at the right in Fig. 22 and it is to be understood that it controls the position of 62. A dash line has been drawn in Fig. 22 to indicate this fact.

Transformer 206 supplies the input for an amplifier circuit shown at the right which includes a center-tapped secondary of said transformer 206 forming at 208 an adjustable resistance. The latter is connected with the cathodes 210 of electronic tubes 212 and 214. These tubes are of the gas-filled type 70L7-GT. The cathode heaters 216 of these tubes are energized from the line 143 through the transformer 201.

A connection 222 feeds current through the adjustable resistance 208 to the cathodes 210, the circuit then being traceable to the plates 220 and 224, respectively, of the tubes 212 and 214. The plate 220 feeds a relay coil 226 and plate 224 feeds a relay coil 228. Coils 226 and 228 are connected to the other side of the line 143 by wires 230. The coils 226 and 228 control an armature 232 which in turn controls a contact 235 of a reversing switch 237 for the reversible motor 184. Condensers 234 damp the pulsating effects of the pulsating direct current flowing through the coils 226 or 228.

When the contactors 175 and 62 are in the same relative positions in the bridge of their members 177 and 64, respectively, no current will flow to the primary of the transformer 206. Hence there will be no output from the secondary of this transformer. However, according to the setting of the rheostat 208, there will be a certain amount of current flowing through the tubes 212 and 214 through the coils 226 and 228, respectively, thus holding the contact 235 in the mid position. By adjusting the rheostat 208, the current through the coils 226 and 228 may be made just below the required amount for either coil to draw over the armature 232.

Then if the brush 175 is moved to the right or left, current will flow through the primary of the transformer 206 with a certain polarity. The ends of the secondary of the transformer 206 will assume a corresponding polarity, thus making the grid of one tube more positive and the grid of the other tube more negative. The grids of the tubes 212 and 214 are indexed 239 and 241, respectively. Thus one tube is blocked and the other increases its feed with respect to its respective one of the coils 226, 228. This closes the switch 237 in one direction. Thus for an unbalanced condition of the bridge circuit due to movement of the brush 175, the current flowing through one of the tubes 212 or 214 increases while the other decreases.

Moving the brush 175 to the left, for example, will make the brush 175 positive and the arm 62 negative. Moving the brush 175 to the right will make the brush 175 negative and the arm 62 positive. Thus in effect the circuit of Fig. 22 is a polarized relay, the armature 232 closing the contact 235 to the left when brush 175 is moved to the left, and said contact 235 to the right when the brush 175 is moved toward the right. The condenser and resistance combination 243 increases the efficiency of response by properly relating the phase of the input signal applied to the grids 239 and 241.

As soon as the brush 175 is moved in a given

direction, the motor 184 is moved in a direction to cause the arm 62 again to balance the bridge, at which time the contact 235 will reopen to stop the motor. Motor action sets the punch disc 182 in a proportion corresponding to the amount that the brush 175 has moved. This sets the proper punch 180 with the proper index character over the pan rail 54. The respective index characters correspond to those on the dial 133.

To give each properly set punch a blow so that it will register the proper symbol on the pan rail 54, a hammer unit is provided above each punch indexing unit. This hammer unit (Figs. 17 and 18) consists of a vertical bearing 245 for a hammer 247, the latter being normally biased up by a spring 249. The upper end of the hammer 247 is in a cylinder 251 which carries a closely fitting movable ball 253, for example $1\frac{1}{2}$ in. in diameter. This ball is biased upward by a conical spring 255. The ball 253 is periodically subjected to manually controlled air pressure of approximately 30 p. s. i. through a port 257. A second ball 259, for example 1 in. in diameter, protrudes into cylinder 251 from the end of a port 261 and is subjected to manually controlled air pressure of approximately 60 p. s. i. in said port 261. When the 30 p. s. i. pressure is applied in port 257, the total pressure on the ball 253 becomes enough to push it past ball 259. As ball 253 passes the center line of ball 259, the former is quickly accelerated to give a sharp blow to the top of hammer 247. This blow is transmitted to the punch 180, thereby causing the latter to mark the pan rail 54. After air release, the spring 255 returns the ball 253. The control of air pressure in passages 257 and 261 will later be described.

Referring now to Fig. 20, which shows a complete schematic diagram of the apparatus for one set of parts, the remaining elements and operation will now be described. It will be understood that the several additional electrical parts are connected in parallel as required for additional transmitters and recorders but are not shown, for clarity of description.

Each engine block 27 to be tested is placed, with pan rails 54 up, on the rollers 22 and between the guides 23. The block is pushed into position against the stop 25 which is in the position shown in the solid lines in Figs. 1, 2 and 5. In Fig. 5 the engine block is not in position but it is in position in Figs. 1 and 2. The fixture 21 upon which the block is thus mounted may be referred to as an inspection table. The placement of the engine block as described makes it possible upon raising the platen 13 to drive the transmitters R axially into the respective cylinders of the block. This is done by admitting fluid from the sump 5 to the cylinder 9 via pipe 263.

Switch A is a momentary-break switch which is normally closed. It is fed from line 143 over wires 301 and 303. It is for starting the rise of the platen 13 as will appear. This switch A is connected to the load contacts 309 of a holding-in relay R₃ (see wire 305). Relay R₃ is normally open. The coil 307 of this relay, in addition to a connection to a source of initial excitation, is connected in series with its own load contact 309. The source of initial excitation for this relay R₃ is a normally open limit switch L₁ which is carried upon the platen 13 and is operated to close by an upper ring-shaped cam 365. The circuit comprises wire 301 from line wire 335, switch L₁, wires 311, 317, coil 307, wires 315, 313 and 319, back to wire 337 of power circuit 143. The limit switch L₁ is normally open and becomes closed

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at the top of the travel of the platen 13. It reopens on its way down in moving from the cam 355 so that it is again open at the lower end of its travel.

A three-way solenoid valve V₁, when deenergized by deenergization of relay R₃, feeds a regulated air supply to the sump 5 over pipe 323. Therefore, when switch A is opened (even temporarily), relay R₃ opens and will not reclose until limit switch L₁ causes it to do so. As long as the relay R₃ is open, there is no energization of valve V₁. This is because V₁ obtains its current from relay R₃ via line 317.

An air supply regulator is shown at 267. The air connection from pipe 323 is above the fluid in the sump 5, which tends to force fluid out from the sump into the cylinder 9 via pipe 263. When the solenoid valve V₁ is energized, it shuts off this supply of air pressure and vents the air in the sump 5 to atmosphere, as will appear.

A parallel-connected solenoid condensate valve V₃ which is normally open becomes energized to close when relay R₃ is energized, being in parallel with V₁ across lines 311 and 319. This valve V₃ closes a condensate vent 341 from the platen 13, or opens this vent when V₃ is deenergized. A check valve 269 allows free flow in the direction from the sump 5 to the side of the cylinder 9 but restricts reverse flow. The necessary return-flow restriction is made adjustable. A solenoid valve V₅ is normally open, which allows the stated flow.

A three-way solenoid valve V₂ becomes energized when relay R₃ is energized. The circuit for the purpose from side 335 of the line 143 comprises wires 301, 303, closed switch A, wire 305, relay R₃ when closed, wires 317, 325, 327, 329, solenoid valve V₂, wires 331 and 333 to the other side 337 of the line 143.

This valve V₂ feeds a regulated supply of air to the interior of the hollow platen 13 over pipe 321 (see Figs. 2, 3 and 20). This feeds air to all of the transmitters R so as to press their measuring cones 71 and to spread the feeler balls 81 outward. When deenergized, V₂ shuts off this air supply and at 339 vents the air in the transmitters to atmosphere.

The motor 138, which operates the cam 128 as already described, is connected in parallel with the solenoid valve V₂ and is fed from the relay R₃. It functions only during the downward movement of the platen 13, as will appear.

Thus the operator by temporarily opening the switch A deenergizes and opens contacts 309 of relay R₃, which contacts were closed from a previous cycle of operation. This deenergizes the solenoid valve V₁ and causes the feeding of air pressure to the sump 5. This transfers liquid from the sump 5 to the cylinder 9 via pipe 263 and lifts the platen 13. This drives the transmitters R up into the engine cylinders but at this time the transmitters have no air pressure on them and the balls 81 are therefore not pressed into engagement with the cylinders.

When the platen 13 has moved to its top position it stops and then descends, due to the tripping action on cam 355 of the limit switch L₁. The switch L₁ closes at the top of the travel thus energizing R₃ to close contacts 309 and energizing V₁ to shut the latter and vent it, which allows throttled return flow of fluid from cylinder 9 to sump 5. This allows the transmitters to travel down. Relay R₃ has been drawn shut due to feeding current to its coil 307 over the wires above described.

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Switch L₁ is thus at this time the initial source of excitation to energize relay R₃. Solenoid valves V₁ and V₂ shut off the loading air pressures and vent the air in the sump 5 to atmosphere and admit air to the platen 13 and hence to the transmitters R, as explained above. The motor 138, at this time being also energized by the relay R₃, starts to function. The transmitters R now, upon descent, make their measurements of the progressive diameters encountered in the engine cylinders, to indicate such diameters on their respective dials 133, and to show the taper in the cylinders by the spread of the auxiliary right-hand pointers 191 and 193. Left-hand pointers 211 and 213 are not used during this part of the cycle.

The rate at which the platen 13 descends is determined by the adjustable orifice check valve 259. As stated, this orifice check valve allows free flow to the cylinder 9 but restricted flow from it, thus restricting the speed of descent of the platen, but not its ascent. As soon as the platen 13 starts the descent, the switch L₁ leaves the cam 355 and reopens.

Under the above conditions of descent, the feeler balls 81 are pressed out radially against the cylinder walls. V₃ is closed. When these balls reach a predetermined point in the engine cylinders, known as the sizing point, the platen is stopped. This sizing point, for example, may be at a point in a cylinder corresponding to the mid-stroke position of the piston which is later to operate therein. Stoppage is automatically effected at the sizing point by tripping of a limit switch L₂ which is operated by a lower cam 271 (Figs. 1 and 2). This switch L₂ is one of the sources of initial excitation of relay R₂. The circuit connecting L₂ and R₂ is as follows: One side 335 of line 143, wires 301, 303, normally shut switch A, wire 305, relay contacts 309 (when closed), wires 317, 311, 343, normally closed switch B, wire 345, switch L₂, wires 347, 349, coil of valve V₅, wires 313, 319 and back to the other side 337 of the line 143. It will be noted that wire 347 also feeds the coil 351 of the relay R₂ (see wires 347 and 353). This closes relay R₂ and causes valve V₅ to remain closed even though the limit switch L₂ reopens.

Normally-open push button switch C is another source of excitation for relay R₂. When this switch C is closed, current is fed from side 335 of circuit 143 via wires 301, 303 to wire 353, coil 351, wires 315, 313 and 319 and back to wire 337 of line 143. It will be noted that relay R₂, like relay R₃, has a holding-in coil. Relay R₂ and solenoid valve V₅ are normally open. Relay R₂ energizes solenoid valve V₅, thus shutting off the flow of oil from the cylinder 9 to the sump 5. This stops the downward travel of the platen 13 and of the transmitters R with the balls 81 at the sizing point. Thus relay R₂ and the solenoid V₅ cannot be energized on the upward movement of the platen 13 by the tripping of the limit switch L₂, but an operation and holding of push button switch C will at any time stop either upward or downward movement.

It should be understood that the lever 111 was in the position, during downward travel, as shown in solid lines in Fig. 4. This had the effect through this non-cooperative position relative to switches L₃, L₄ and L₅ of energizing the coil 207 and applying clutch friction to the pointers 191 and 193. At this time L₃, which is a single-pole double-throw limit switch, closes one of its contacts which energizes the coil 355

of a time-delay relay R₁, getting its source of power from relay R₃. The wiring is as follows: side 335 of line 143, wires 301, 303, closed switch A, wire 305, closed relay R₃, wires 317, 325, 357, 359, switch L₃, coil 355, wire 359 back to side 337 of line 143. This closes the contacts 361 of relay R₁, which by means of wires 363 from line 335 and wire 366 feed the coil 207, the circuit being closed through wires 367 and 369 to the other side 337 of the line 143. Limit switches L₅ and L₄ are at this time open. Thus any spread assumed by the pointers will be maintained due to friction at the clutch elements 187, 189 (Fig. 15).

After stopping at the sizing point the operator notes the several diameters of the cylinders at this point and also notes the taper in each cylinder, as indicated by the spread of the auxiliary pointers 191 and 193. The latter, remaining spread, indicate the maximum taper. The operator may then accept the engine block. He may stencil his acceptance, showing the actual diameters in respect to cylinders in the engine block or any other desirable symbols for the purpose. This stenciling operation will be described below.

Or, he may at this time repeat the above cycle of operations but taking diameter measurement in a plane at 90° from the plane of the measurements in the above-described cycle. This is accomplished with the handle 111 set at the dotted-line position shown in Fig. 4. When handle 111 is shifted, bar 109 strikes an operator bar 42 for switches L₃, L₄ and L₅ (Fig. 4). Thus in order to obtain a second series of diameter readings in a plane at 90° from the plane of the first cycle described, the handle 111 is shifted from the solid-line position shown in Fig. 4 to the dotted-line position, as stated. Push button switch A is again temporarily depressed and opened. The said lifting sequence of the platen 13 above described is then repeated, except that now the auxiliary pointers 211 and 213 come into play, assuming their respective maximum and minimum positions. This is because the clutch coil 227 and the coil 66 are at this time energized. The switches L₄ and L₅ have closed to their dotted-line positions and L₃ has moved to its dotted-line position (Fig. 20). The circuit then reads as follows: starting with the side 335 of the line 143, wires 301, 303, normally closed switch A, wire 305, contacts 309 of relay R₃ (when closed), wires 317, 325, 357, closed switch L₄, wire 373, coil 227, wire 369 and to the other side 337 of the line 143. A connection 379 from side 335 of the circuit 143 through closed switch L₅ feeds coil 66, which is connected to wire 369 passing to the other side 337 of the line 143. Wire 379 also feeds through switch L₃ (now at the dotted-line position) through the coil 355 of the time-delay relay R₁, thus holding the contacts of this relay closed. The time delay feature of relay R₁ permits shift of handle 111 from one position to the other without having the relay R₁ fall open and thus keeps the pointers 191 and 193 maintained in their last positions.

When coil 66 is deenergized, its armature pin 200 is engageable with all of the pointers 191, 193, 211 and 213. When coil 66 is energized, the armature pin 200 clears the pointers 191 and 193, which are left in their last positions, and remains engageable only with the pointers 211 and 213. It will be noted that the pointers 211 and 213, when handle 111 is in the solid-line position, do not have their magnetic clutches energized. Therefore they float at zero position with the respective dial 133. When the handle 111 is

in its dotted-line position, all of the coils 207, 227 and 66 are energized. Thus pointers 191 and 193 remain in their last positions and are not mechanically influenced by the armature pin 200. Under these conditions the pointers 211 and 213 are mechanically influenced by the armature pin 200 and assume their maximum spread positions due to friction clutching action at 229 and 231, as caused by energization of coil 227 (Figs. 15 and 16).

The operator performs a stenciling operation, to be described, based on the diameter at the sizing point. Before performing a stenciling operation he should recognize the taper characteristics because these alone may be grounds for rejecting a given engine block.

After taper observations, as obtained from the pointers 191, 193, 211 and 213, coupled with observation of the diameter or diameters at the sizing point, the operator depresses the normally open push button switch D, which energizes the several pneumatic hammers 247 (Fig. 17), one for each cylinder. This stencils the accepted mark on the engine block opposite each cylinder corresponding to the cylinder diameter encountered at the sizing point.

The stenciling operation is accomplished through the actuation by switch D of solenoid valves V₆ and V₇. The valves V₆ and V₇ are three-way valves which either pass air or vent it. When the switch D is closed, the requisite circuit is closed from side 335 of line 143 via wires 301, closed switch D, wire 381 (closed safety switch 389, to be described below) to valves V₆ and V₇ in parallel, thence to wire 333 back to the side 337 of the line 143. It will be recalled that each stencil motor is constantly following the action of the respective brush 175, which is driven in proportion to the action of the respective dial 133. This causes constant repositioning of the stencil discs 182, with the result that a proper stencil 180 is always indexed into stenciling position. When valves V₆ and V₇ are opened, air is admitted to the two balls 253 and 259 at the respective pressures of approximately 30 p. s. i. to the ball 253 and 60 p. s. i. to the ball 259. When the pressure above the large ball 253 reaches its full value, the total pressure over the larger area exceeds the total pressure over the smaller ball 259, although the higher unit pressure is applied to the smaller ball 259. Ball 253 then forces back the smaller ball 259 and the former strikes the hammer 247 below it and thus the respective punch 180 is driven against the pan rail 54. When the push button switch D is released (opened), the solenoid valves V₆ and V₇ are deenergized, thus venting the air pressure behind the balls. The ball 253 is instantly returned to its "cocked" position at the top of the cylinder by its return spring 255.

It will be recalled that now the transmitters R have their balls at the sizing point and it is necessary not only to withdraw these from the engine block but it is also desirable to take continued readings for taper. This will necessitate further descent of the platen 13 to its lowermost position. To do this the operator momentarily pushes the normally closed button switch B. This breaks the circuit which was above described in connection with relay R₂ and deenergizes the latter. This in turn deenergizes the coil of valve V₅. Fluid then flows from the cylinder 9 to sump 5 via the throttling check valve 269, and the platen 13 further descends. The pointers 191, 193 and/or 211, 213 continue to be actuated as above de-

scribed, giving readings of any increase in taper, until the end of the cylinder is reached. Finally, the balls 81 of the transmitters R enter the master rings 33. This last action permits the operator to check the zero reference indications for the several transmitters R.

In passing out of the engine cylinders into the table 21, the balls traverse a small gap which in its effect on balls 81 might spoil the taper readings. This is prevented as follows: By mechanically actuating an interruptor switch 383, the power connection is broken to the inductance bridge measuring circuit. This causes any dial 133 to remain in its last position until the circuit is reconnected. The detail for this is shown in Fig. 1, wherein a cam 385 contacts the switch arm 387 of switch 383 and forces the switch open, only at the moment when the balls 81 are traversing the gap which is shown at G. The switch 383 is mounted on the underside of the movable platen 13 while the cam lug is mounted on a stationary part of the bed 3. The switch opening needs only to be momentary.

Since it is conceivable that someone might operate the stencil switch D when no engine block is in position and cause damage to the stencils by unnecessarily hammering them, the following safety feature is provided: A switch 389 is placed in wire 381 in series with the switch D. This switch 389 is placed beneath a loose one of the rollers 22, as shown in Figs. 2 and 23. The roller is normally pushed up from the switch by a spring 391, but when loaded by means of the engine block the switch 389 will be closed. Thus when the engine block is not in position and the switch 389 opened, the stencil hammers cannot be operated. Both the switches 383 and 389 may be of the micro variety in which very little movement of the operating button is required to open or close them.

From the above it will be seen that by means of the push button starting switch A the transmitters R may be driven upward through the cylinders in the block 27. They may be stopped at will by operating the stop switch C. Action may be resumed at will by pressing the resume switch B. After reaching the top of the stroke they descend automatically. Stenciling is made to occur by pressing the switch D. These switches are suitably marked for the given purposes, as indicated in Fig. 1.

It will also be seen that the starting operation causes an initial lift of the transmitters R without a gaging operation, that is, without air pressure tending to expand the balls 81 into gaging contact with the cylinder walls. When the top of the lift is reached, the downward action starts automatically as stated and at this time the gaging balls 81 are automatically pushed into gaging contact with the cylinder walls for measuring action during the downward travel. Downward action is automatically instigated by the action of switch L1. Operation of the handle or lever 111 allows for a second measuring cycle to be brought about at 90° to the first. Furthermore, during a first cycle taper is indicated by spread between the pointers 191 and 193. During this operation the other pointers 211 and 213 follow the dial without spread. Taper during a second measuring cycle (at 90°) is indicated by spread of the pointers 211 and 213 while the formerly spread pointers 191 and 193 remain apart. During either cycle the dial 133 provides a continual visual indication of the diameters encountered. Finally, the diameter at the sizing point is sym-

bolized and recorded on the engine block itself by operation of the stencil switch D.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As many changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. A measuring instrument comprising means for predeterminately positioning a cylinder to be internally measured, a movable member, a measuring transmitter mounted on the movable member and having pressure-operated gage members, means for moving the movable member with the transmitter to move the gage members of the latter into the cylinder without pressure on the gage members, means operative automatically at a predetermined position of the movable member to apply pressure to move said gage members into measuring positions in the cylinder and operative automatically to retract said movable member and the transmitter, means for substantially turning the measuring transmitter relatively to the movable member and the cylinder, means for stopping movement of the movable member and transmitter and for again starting them toward the cylinder in any turned position of the transmitter, and means for vibrating the transmitter through a limited angle in its turning direction regardless of which of its substantially turned positions it is in.

2. A measuring instrument comprising an inspection table, said table having a master-sized opening therein, means for predeterminately positioning a cylindric member to be internally measured substantially coaxially with respect to the opening, a movable platen, a measuring transmitter mounted on the platen and having pressure-operated gage members positioned in said master opening when the platen is in one position, means for moving the platen with the transmitter to move the gage members of the latter from said opening into the cylindric member without pressure on the gage members, and means operative automatically at a predetermined elevation of the platen to apply pressure to move said gage members into measuring positions in the cylinder and automatically to cause retraction of said platen and the transmitter.

3. A measuring instrument comprising an inspection table, said table having master-sized openings therein, means for predeterminately positioning a multi-cylinder member to be internally measured with its cylinders substantially coaxial with the openings, a movable platen, a plurality of measuring transmitters mounted on the platen and respectively having pressure-operated gage members positioned respectively in said master openings when the platen is in one position, means for moving the platen with the transmitters to move the gage members of the latter from said master openings into the respective cylinders without pressure on the gage members, and means operative automatically at a predetermined elevation of the platen to apply pressure to move said gage members into measuring positions in the cylinders and to cause retraction of said platen and the transmitters.

4. A measuring instrument comprising an inspection table, said table having a master-sized

opening therein, means for predeterminately positioning on one side of the table substantially coaxially over the opening a cylindric member to be internally measured, a movable platen on the other side of the table, a measuring transmitter mounted on the platen and having a pressure-operated gage member positioned in said master opening when the platen is in one position, means for moving the platen with the transmitter to move the gage member of the latter from said opening into the cylindric member without pressure on the gage member, means operative automatically at a predetermined advance of the platen toward the table to apply pressure to move said gage member into measuring positions in the cylinder and automatically to cause retraction of said platen and the transmitter, a visual indicator responsive to the action of said gage member adapted continuously to indicate diameters met with in the cylinder by said gage member, and visual means adapted to indicate maximum differences in diameters met by the gage member during a given traverse of the gage member in the cylinder.

5. A measuring instrument comprising an inspection table, said table having a master-sized opening therein, means for predeterminately positioning on one side of the table substantially coaxially over the opening a cylindric member to be internally measured, a movable platen on the other side of the table, a measuring transmitter mounted on the platen and having a pressure-operated gage member positioned in said master opening when the platen is in one position, means for moving the platen with the transmitter to move the gage member of the latter from said opening into the cylindric member without pressure on the gage member, means operative automatically at a predetermined advance of the platen toward the table to apply pressure to move said gage member into measuring positions in the cylinder and automatically to cause retraction of said platen and the transmitter, a visual indicator responsive to the action of said gage member adapted continuously to indicate diameters met with in the cylinder by said gage member, visual means adapted to indicate maximum differences in diameters met by the gage member during a given traverse of the gage member in the cylinder, means for rotating the transmitter on the platen for cylinder measurement in a 90° plane and additional visual means adapted to indicate maximum differences in diameters met with by the gage member in said 90° plane but without cancelling the first-named indication of diameter differences.

6. A measuring instrument comprising an inspection table, said table having a master-sized opening therein, means for predeterminately positioning on one side of the table substantially coaxially over the opening a cylindric member to be internally measured, a movable platen on the other side of the table, a measuring transmitter mounted on the platen and having a pressure-operated gage member positioned in said master opening when the platen is in one position, means for moving the platen with the transmitter to move the gage member of the latter from said opening into the cylindric member without pressure on the gage member, means operative automatically at a predetermined advance of the platen toward the table to apply pressure to move said gage member into measuring positions in the cylinder and automatically

to cause retraction of said platen and the transmitter, a visual indicator responsive to the action of said gage member adapted continuously to indicate diameters met with in the cylinder by said gage member, visual means adapted to indicate maximum differences in diameters met by the gage member during a given traverse of the gage member in the cylinder, a turret, a gang of punches thereon respectively indexed according to said visual indicator, circuit means connecting said visual indicator and the turret adapted to cause movement of the turret proportionally to that of the indicator whereby a proper punch to make a mark corresponding to an indication is at any moment indexed into a predetermined marking position, and means for operating any punch that is in indexed position to mark the cylindric member.

7. A measuring instrument comprising an inspection table, said table having a master-sized opening therein, means for predeterminately positioning on one side of the table substantially coaxially over the opening a cylindric member to be internally measured, a movable platen on the other side of the table, a measuring transmitter mounted on the platen and having a pressure-operated gage member positioned in said master opening when the platen is in one position, means for moving the platen with the transmitter to move the gage member of latter from said opening into the cylindric member without pressure on the gage member, means operative automatically at a predetermined advance of the platen toward the table to apply pressure to move said gage member into measuring positions in the cylinder and automatically to cause retraction of said platen and the transmitter, a visual indicator responsive to the action of said gage member adapted continuously to indicate diameters met with in the cylinder by said gage member, visual means adapted to indicate maximum differences in diameters met by the gage member during a given traverse of the gage member in the cylinder, means for rotating the transmitter on the platen for cylinder measurement in a 90° plane, additional visual means adapted to indicate maximum differences in diameter, met with by the gage member in said 90° plane but without cancelling the first-named indication of diameter differences, a turret, a gang of punches thereon respectively indexed according to said visual indicator, circuit means connecting said visual indicator and the turret adapted to cause movement of the turret proportionally to that of the indicator whereby a proper punch to make a mark corresponding to an indication is at any moment indexed into a predetermined marking position, and means for operating any punch that is in indexed position to mark the cylindric member.

8. A measuring instrument comprising an inspection table, said table having a series of master-sized openings therein, means for predeterminately positioning a multi-cylinder member to be internally measured with its cylinders respectively substantially coaxial over the respective openings, a movable platen, elongate measurement transmitters mounted on the platen and having pressure-operated gage members respectively positioned in said master openings when the platen is in a retracted position, one means for advancing the platen with all of the transmitters simultaneously to move the gage members of the latter from said openings into the cylinders without pressure on the gage mem-

bers, means operative automatically at a predetermined advance of the platen to apply pressure to move all of said gage members into measuring positions in the cylinders and to cause retraction of said platen and the transmitters, individual indicators responsive respectively to the respective actions of said gage members in the cylinders and being each adapted continuously to indicate an individual diameter met with in a cylinder by one of said gage members, and individual visual means adapted to indicate maximum differences in diameters respectively met with by the gage members during a given traverse of the respective gage member in a cylinder.

9. A measuring instrument comprising an inspection table, said table having a series of master-sized openings therein, means for predeterminedly positioning a multi-cylinder member to be internally measured with its cylinders respectively substantially coaxial over the respective openings, a movable platen, elongate measurement transmitters mounted on the platen and having pressure-operated gage members respectively positioned in said master openings when the platen is in a retracted position, one means for advancing the platen with all of the transmitters simultaneously to move the gage members of the latter from said openings into the cylinders without pressure on the gage members, means operative automatically at a predetermined advance of the platen to apply pressure to move all of said gage members into measuring positions in the cylinders and to cause retraction of said platen and the transmitters, individual indicators responsive respectively to the respective actions of said gage members in the cylinders and being each adapted continuously to indicate an individual diameter met with in a cylinder by one of said gage members, individual visual means adapted to indicate maximum differences in diameters respectively met with by the gage members during a given traverse of the respective gage member in a cylinder, and common means for rotating all transmitters on the platen to 90° positions.

10. A measuring instrument comprising an inspection table, said table having a series of master-sized openings therein, means for predeterminedly positioning a multi-cylinder member to be internally measured with its cylinders respectively substantially coaxial over the respective openings, a movable platen, elongate measurement transmitters mounted on the platen and having pressure-operated gage members respectively positioned in said master openings when the platen is in a retracted position, one means for advancing the platen with all of the transmitters simultaneously to move the gage members of the latter from said openings into the cylinders without pressure on the gage members, means operative automatically at a predetermined advance of the platen to apply pressure to move all of said gage members into measuring positions in the cylinders and to cause retraction of said platen and the transmitters, individual indicators responsive respectively to the respective actions of said gage members in the cylinders and being each adapted continuously to indicate an individual diameter met with in a cylinder by one of said gage members, individual visual means adapted to indicate maximum differences in diameters respectively met with by the gage members during a given traverse of the respective gage member in a cylinder, common means for rotating all trans-

mitters on the platen to 90° positions, and means for vibrating said common rotating means less than 90° in either 90° position.

11. A measuring instrument comprising an inspection table, said table having a series of master-sized openings therein, means for predeterminedly positioning a multi-cylinder member to be internally measured with its cylinders respectively substantially coaxial over the respective openings, a movable platen, elongate measurement transmitters mounted on the platen and having pressure-operated gage members respectively positioned in said master openings when the platen is in a retracted position, one means for advancing the platen with all of the transmitters simultaneously to move the gage members of the latter from said openings into the cylinders without pressure on the gage members, means operative automatically at a predetermined advance of the platen to apply pressure to move all of said gage members into measuring positions in the cylinders and to cause retraction of said platen and the transmitters, individual indicators responsive respectively to the respective actions of said gage members in the cylinders and being each adapted continuously to indicate an individual diameter met with in a cylinder by one of said gage members, individual visual means adapted to indicate maximum differences in diameters respectively met with by the gage members during a given traverse of the respective gage member in a cylinder, common means for rotating all transmitters on the platen to 90° positions, and additional individual indicating means adapted to indicate maximum differences in diameters respectively met with by the gage members in another traverse when the transmitters are rotated 90°, without cancelling the indications of the first mentioned indications of maximum differences.

12. A measuring instrument comprising an inspection table, said table having a series of master-sized openings therein, means for predeterminedly positioning a multi-cylinder member to be internally measured with its cylinders respectively substantially coaxial over the respective openings, a movable platen, elongate measurement transmitters mounted on the platen and having pressure-operated gage members respectively positioned in said master openings when the platen is in a retracted position, one means for advancing the platen with all of the transmitters simultaneously to move the gage members of the latter from said openings into the cylinders without pressure on the gage members, means operative automatically at a predetermined advance of the platen to apply pressure to move all of said gage members into measuring positions in the cylinders and to cause retraction of said platen and the transmitters, individual indicators responsive respectively to the respective actions of said gage members in the cylinders and being each adapted continuously to indicate an individual diameter met with in a cylinder by one of said gage members, individual visual means adapted to indicate maximum differences in diameters respectively met with by the gage members during a given traverse of the respective gage member in a cylinder, common means for rotating all transmitters on the platen to 90° positions, additional individual indicating means adapted to indicate maximum differences in diameters respectively met with by the gage members in another traverse when

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the transmitters are rotated 90°, without cancelling the indications of the first mentioned indications of maximum differences, and means for vibrating said common rotating means less than 90° in either 90° position.

13. A measuring instrument comprising an inspection table, said table having a series of master-sized openings therein, means for predeterminedly positioning a multi-cylinder member to be internally measured with its cylinders respectively substantially coaxial over the respective openings, a movable platen, elongate measurement transmitters mounted on the platen and having pressure-operated gage members respectively positioned in said master openings when the platen is in a retracted position, one means for advancing the platen with all of the transmitters simultaneously to move the gage members of the latter from said openings into the cylinders without pressure on the gage members, means operative automatically at a predetermined advance of the platen to apply pressure to move all of said gage members into measuring positions in the cylinders and to cause retraction of said platen and the transmitters, individual indicators responsive respectively to the respective actions of said gage members in the cylinders and being each adapted continuously to indicate an individual diameter met with in a cylinder by one of said gage members, individual visual means adapted to indicate maximum differences in diameters respectively met with by the gage members during a given traverse of the respective gage member in a cylinder, common means for rotating all transmitters on the platen to 90° positions, additional individual indicating means adapted to indicate maximum differences in diameters respectively met with by the gage members in another traverse when the transmitters are rotated 90°, without cancelling the indications of the first mentioned indications of maximum differences, movable punch holders, a gang of punches on each holder indexed according to the visual indicator, plural circuit means connecting said respective visual indicators and the respective holders adapted to move the latter according to indicator movements, whereby a proper punch on each holder to make a mark is at any moment indexed into a predetermined marking position, and common means for operating all punches that are in indexed positions to mark the multi-cylinder member.

14. A measuring instrument comprising means for mounting a cylinder, a transmitter measuring member for the cylinder, a movable support for the measuring member for advancing and retracting it into and from the cylinder, a fluid pressure lift for said support, a solenoid valve for applying fluid pressure to said lift when the valve is open, a relay having load contacts which when open will open said solenoid valve, a holding coil in said relay connected in series with its own load contacts, a limit switch carried on said support constituting when closed a source of initial excitation for said coil, a momentary-break switch connected with the relay whereby the relay may by temporary opening of the switch be opened to energize said valve to effect movement of the support for advancing the measuring member into the cylinder, and means engageable by said limit switch upon predetermined advance of the measuring member into the cylinder for energizing the coil of said relay and hence energizing said valve to stop application of fluid pressure to the lift.

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15. A measuring instrument comprising means for mounting a cylinder, a measuring member for the cylinder, a movable support for the measuring member for advancing and retracting it into and from the cylinder, a fluid pressure lift for said support, a solenoid valve for applying fluid pressure to said lift only when the valve is deenergized, a relay having load contacts which when closed will energize said solenoid valve and when open will deenergize it, a holding coil in said relay connected in series with its own load contacts, a limit switch carried on said support constituting when closed a source of initial excitation for said coil, a momentary-break switch in series with the relay whereby the relay may by temporary opening of the switch be opened to deenergize said valve to effect movement of the support for advancing the measuring member into the cylinder, and means engageable by said limit switch upon predetermined advance of the support and measuring member for energizing the coil of said relay and hence energizing said valve to stop application of fluid pressure to the pressure lift.

16. A measuring instrument comprising means for mounting a cylinder, a measuring member for the cylinder, a movable support for the measuring member for advancing and retracting it into and from the cylinder, a fluid pressure lift for said support including a fluid line having a normally open first solenoid valve, a second solenoid valve controlling application of pressure through said first valve to said lift when the second valve as well as the first valve is open, a relay having load contacts which when open will open said second solenoid valve, a holding coil in said relay connected in series with its own load contacts, a limit switch carried on said support constituting when closed a source of initial excitation for said coil, a momentary-break switch connected with the relay whereby the relay may be opened by temporary opening of the switch to energize said valve to effect movement of the support for advancing the measuring member into the cylinder, means engageable by said limit switch upon predetermined advance of the measuring member into the cylinder for energizing the coil of said relay and hence energizing said second valve to stop application of fluid pressure to the lift, whereupon the lift will descend until the first valve is closed, a second holding-in relay, a second limit switch connected with said second relay and with said first valve, and means for operating the second limit switch and relay upon a predetermined descent of the support to close the first valve to prevent further descent.

17. A measuring instrument comprising means for mounting a cylinder, a transmitter measuring member for the cylinder, a movable support for the measuring member for advancing and retracting it into and from the cylinder, a fluid pressure lift for said support, a solenoid valve for applying fluid pressure to said lift when the valve is open, a relay having load contacts which when open will open said solenoid valve, a holding coil in said relay connected in series with its own load contacts, a limit switch carried on said support constituting when closed a source of initial excitation for said coil, a momentary-break switch connected with the relay whereby the relay may by temporary opening of the switch be opened to energize said valve to effect movement of the support for advancing the measuring member into the cylinder, means engageable by said limit switch upon predetermined advance

of the measuring member into the cylinder for energizing the coil of said relay and hence energizing said valve to stop application of fluid pressure to the lift whereupon it will fall, pressure-operated feeler means in the measuring member, a second solenoid valve controlling pressure on said feeler means, and means responsive to said energization of the relay from the limit switch for energizing the second solenoid valve to open it to apply pressure to said feeler means at the time that the measuring member attains said predetermined advance into the cylinder.

18. A measuring instrument comprising means for mounting a cylinder, a transmitter measuring member for the cylinder, a movable support for the measuring member for advancing and retracting it into and from the cylinder, a fluid pressure lift for said support, a solenoid valve for applying fluid pressure to said lift when the valve is open, a relay having load contacts which when open will open said solenoid valve, a holding coil in said relay connected in series with its own load contacts, a limit switch carried on said support constituting when closed a source of initial excitation for said coil, a momentary-break switch connected with the relay whereby the relay may by temporary opening of the switch be opened to energize said valve to effect movement of the support for advancing the measuring member into the cylinder, means engageable by said limit switch upon predetermined advance of the measuring member into the cylinder for energizing the coil of said relay and hence energizing said valve to stop application of fluid pressure to the lift whereupon it will fall, pressure-operated feeler means in the measuring member, a second solenoid valve controlling pressure on said feeler means, means responsive to said energization of the relay from the limit switch for energizing the second solenoid valve to open it to apply pressure to said feeler means at the time that the measuring member attains said predetermined advance into the cylinder, a diameter indicator, and electrical circuit means connecting the indicator and the feeler means of the transmitter measuring member whereby the indicator continuously indicates diameters.

19. A measuring instrument comprising means for mounting a cylinder, a transmitter measuring member for the cylinder, a movable support for the measuring member for advancing and retracting it into and from the cylinder, a fluid pressure lift for said support, a solenoid valve for applying fluid pressure to said lift when the valve is open, a relay having load contacts which when open will open said solenoid valve, a holding coil in said relay connected in series with its own load contacts, a limit switch carried on said support constituting when closed a source of initial excitation for said coil, and a momentary-break switch connected with the relay whereby the relay may by temporary opening of the switch be opened to energize said valve to effect movement of the support for advancing the measuring member into the cylinder, and means engageable by said limit switch upon predetermined advance of the measuring member into the cylinder for energizing the coil of said relay and hence energizing said valve to stop application of fluid pressure to the lift whereupon it will fall, pressure-operated feeler means in the measuring member, a second solenoid valve controlling pressure on said feeler means, and means responsive to said energization of the relay from the limit switch for energizing the second solenoid valve to

open it to apply pressure to said feeler means at the time that the measuring member attains said predetermined advance into the cylinder, a diameter indicator, electrical circuit means connecting the indicator and the feeler means of the transmitter measuring member whereby the indicator continuously indicates diameters, taper indicating means adapted to receive motion from the diameter indicator to show taper, an electrical control for said taper indicating means to cause it to register taper, and means responsive to said energization of the relay from the limit switch for energizing said control to effect registration by the taper indicating means.

20. In a measuring instrument, a transmitter having rotary movement to two positions, feelers in the transmitter having retracted and working positions, a dial, means connecting the feelers and the dial causing the dial to move proportionately to feeler movements to indicate diameters, a laterally movable armature pin mounted on the dial for bodily movement therewith, a pair of taper-indicating pointers on each side of the dial, each pair normally gravitating against opposite sides on opposite ends of the pin in one position of the latter relatively to the dial, electrically controlled clutches for respectively holding the members of respective pairs of the pointers at any assumed maximum positions as driven by opposite movements of the pin moving bodily with the dial, electric means controlling the lateral position of the pin on the dial to be operatively engaged by either pair of pointers or alternatively by only one pair, and means responsive to different rotary positions of the transmitter for energizing either one or both of said clutches as the case may be, said last-named means in the one position of the transmitter in which one clutch is energized being adapted to operate the control means for the pin to be set to be operatively engaged by both sets of pointers, said control means in the other position of the transmitter in which both clutches are energized being adapted to operate the electric control means for the pin to set it in position to be operatively engaged only by one pair of said pointers while their respective clutch is energized.

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