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JUNE 15, 1943.

BY A. P. C.

E. FOUQUET

MACHINES FOR MANUFACTURING ROTATION OR REVOLUTION BODIES

Filed Nov. 24, 1941

Serial No. 420,312

10 Sheets-Sheet 1

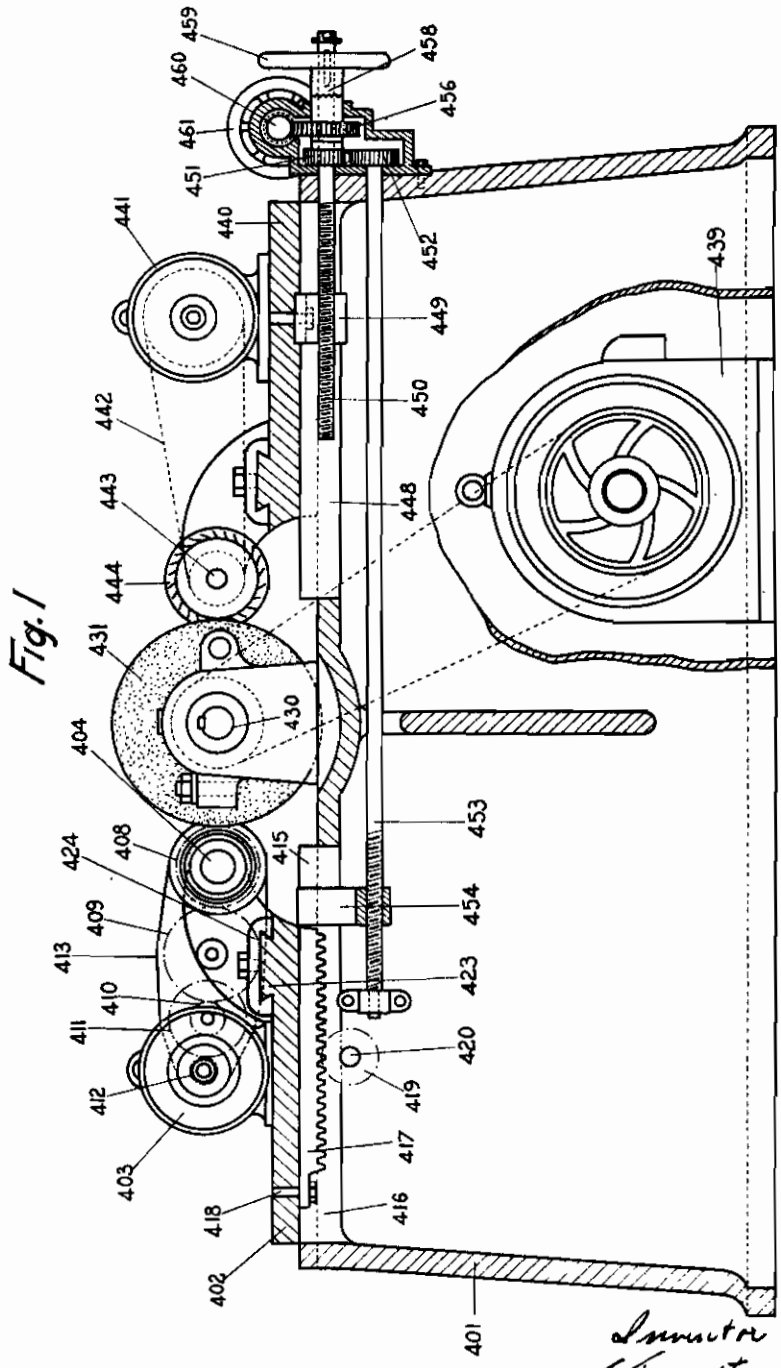

Fig. 1

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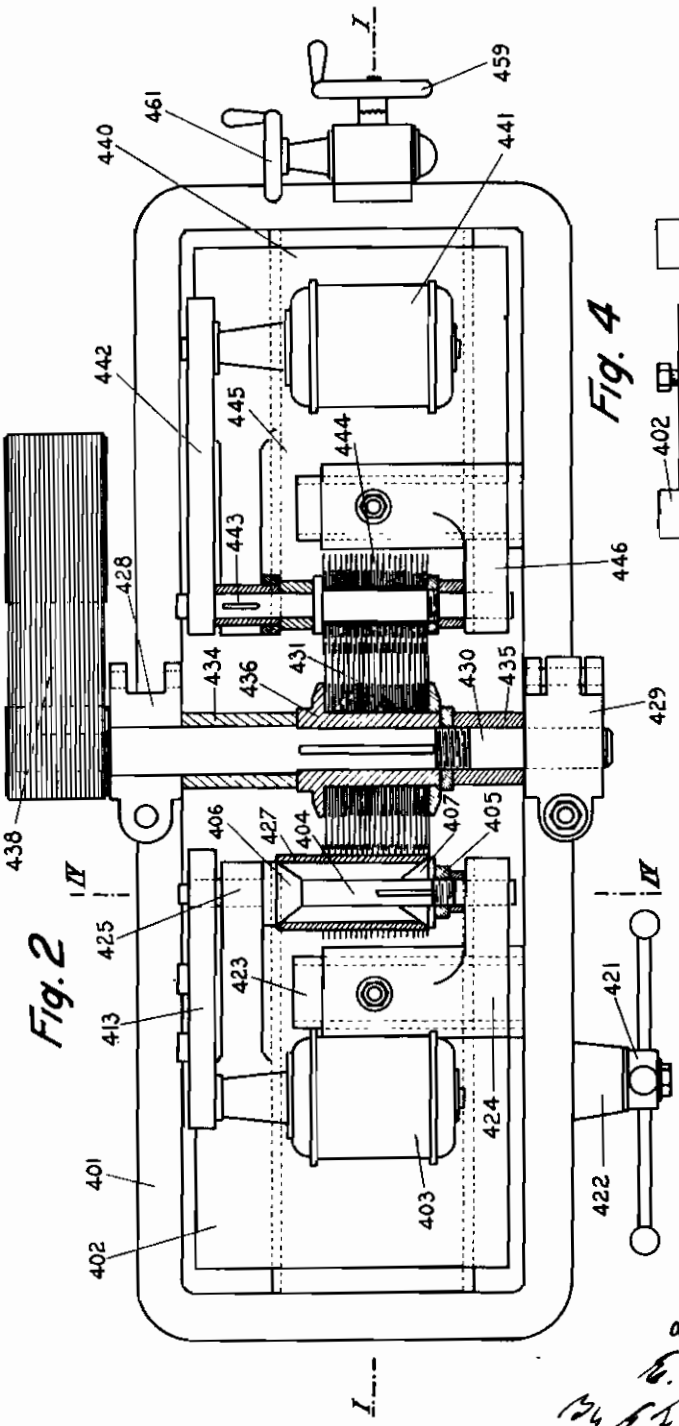

Fig. 2

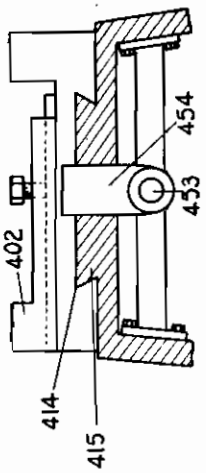

Fig. 4

Fig. 3

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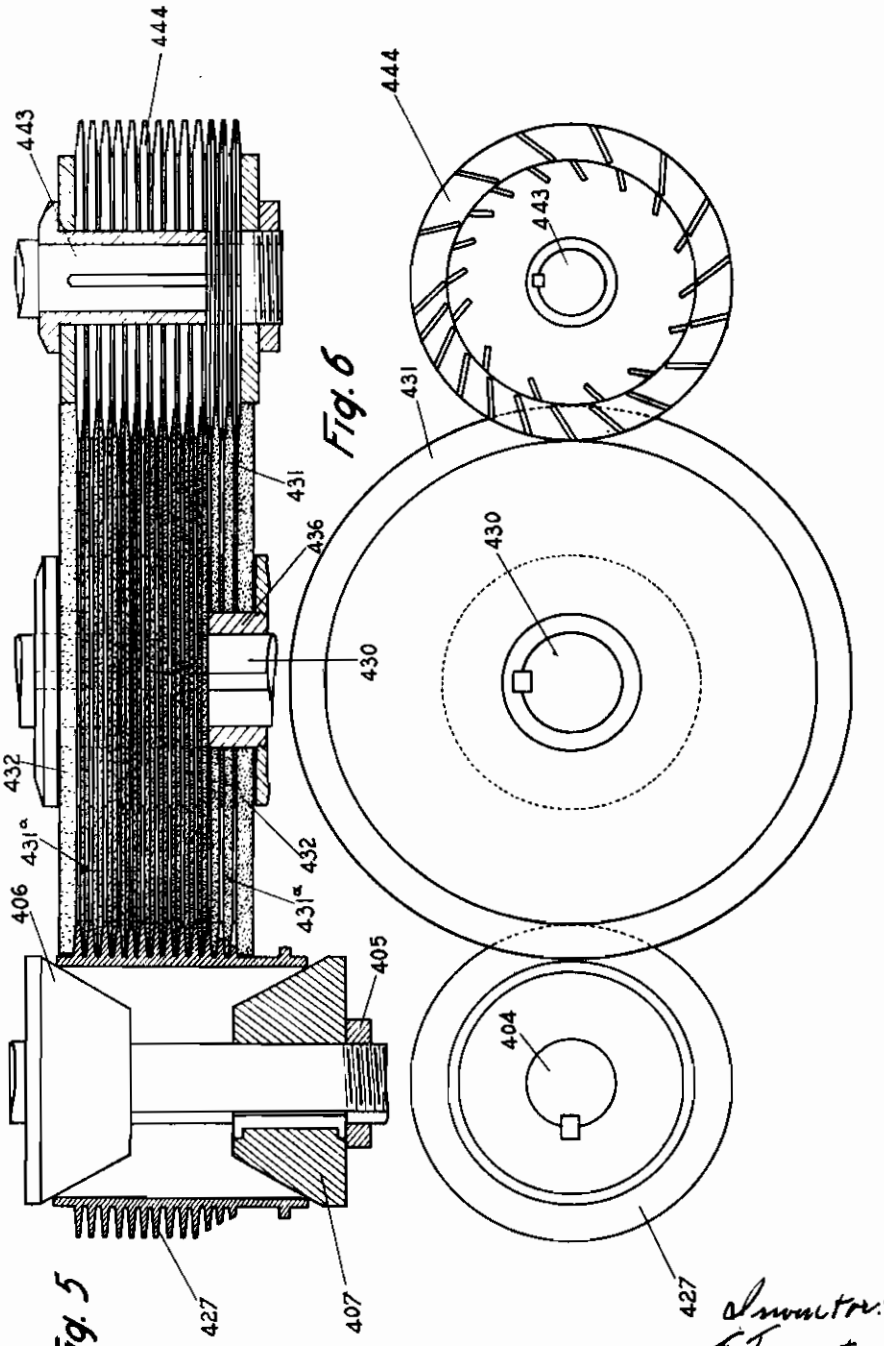

Fig. 5

Fig. 6

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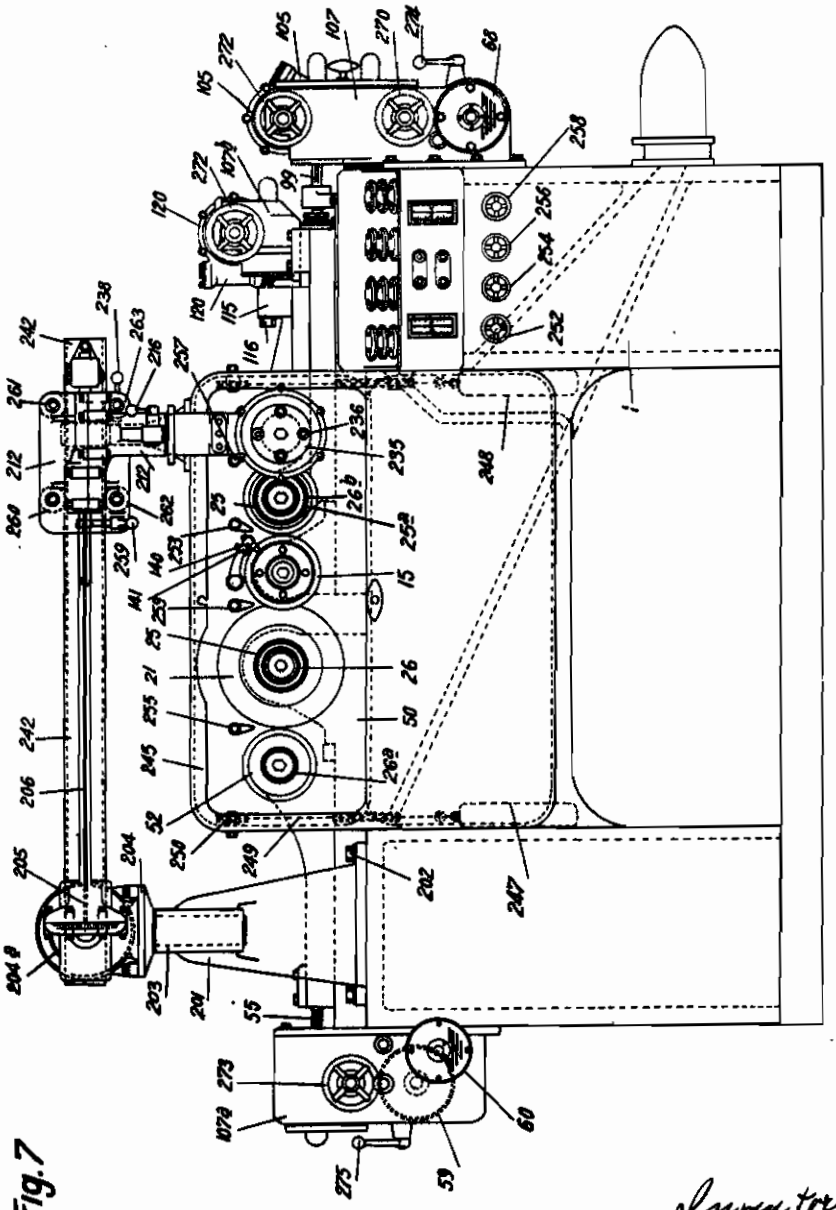

Fig. 7

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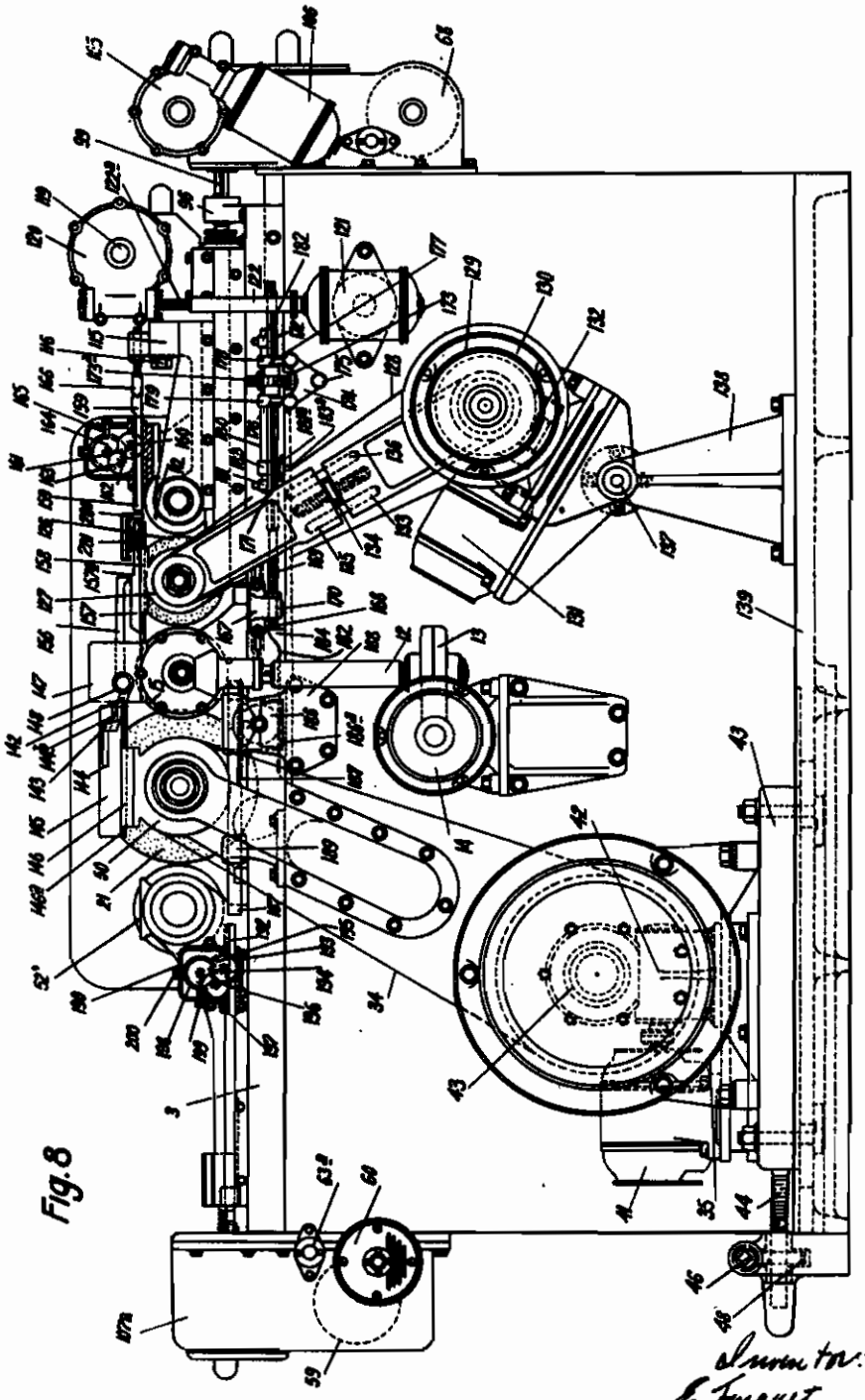

Fig. 8

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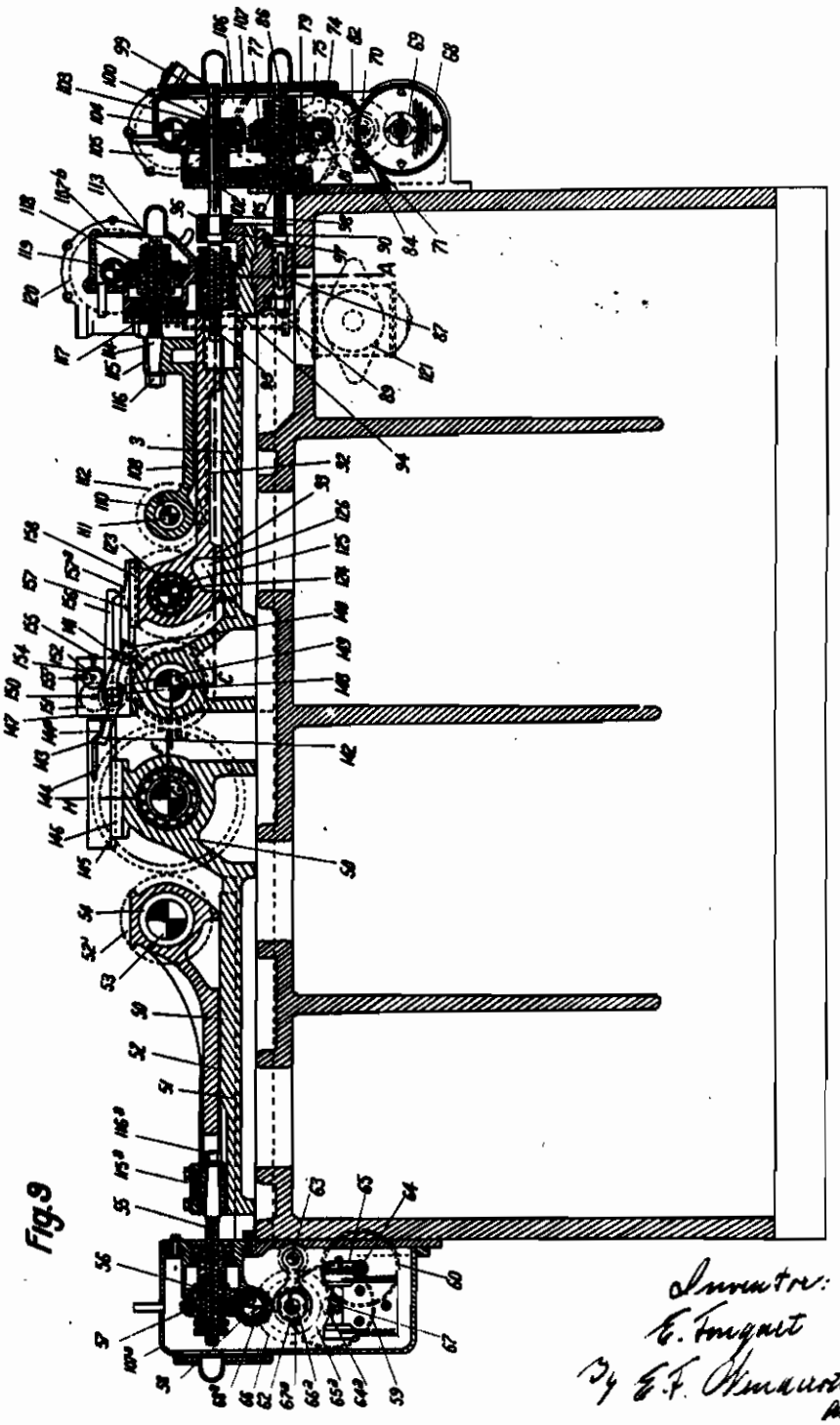

Fig.9

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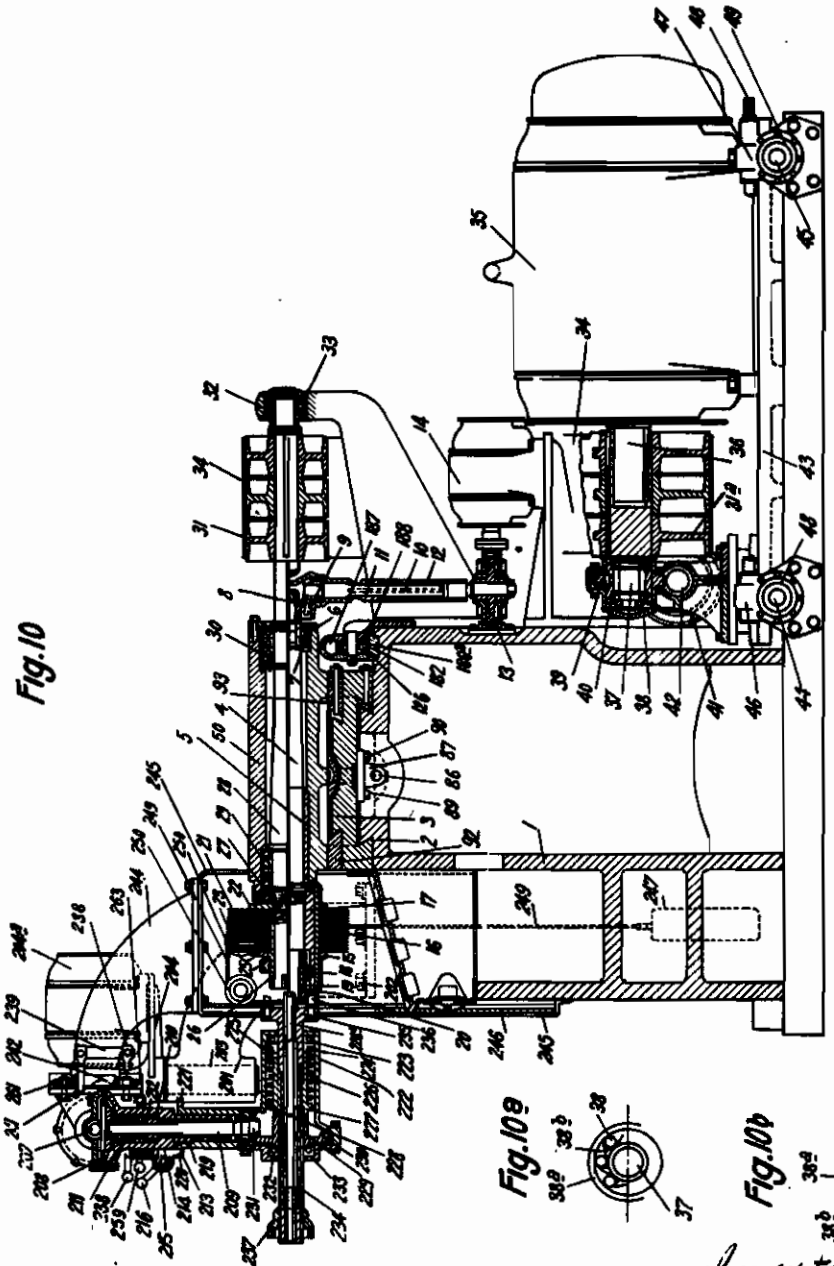

Fig.10

Fig.10a

Fig.10b

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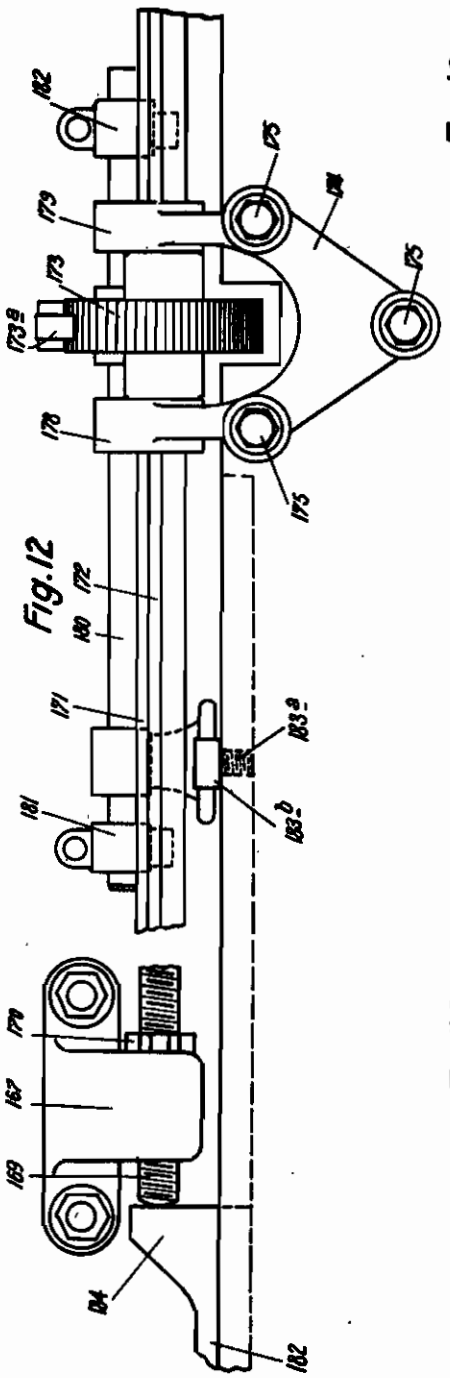

Fig. 12

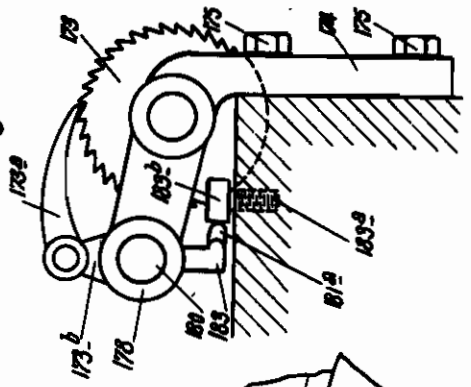

Fig. 13

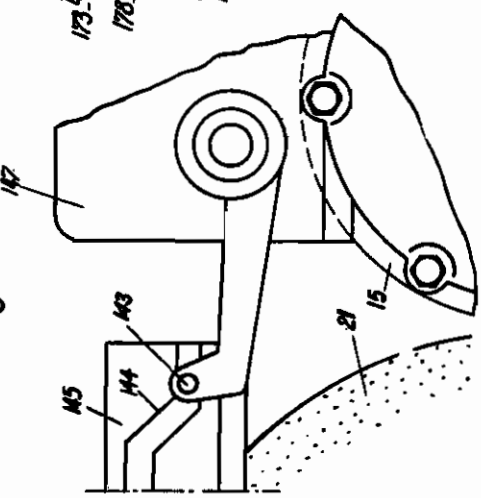

Fig. 11

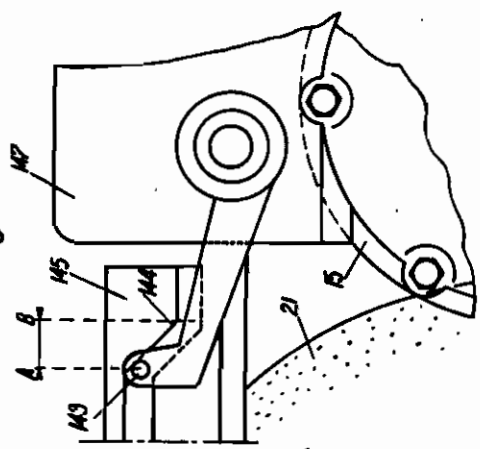

Fig. 11a

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Fig. 14

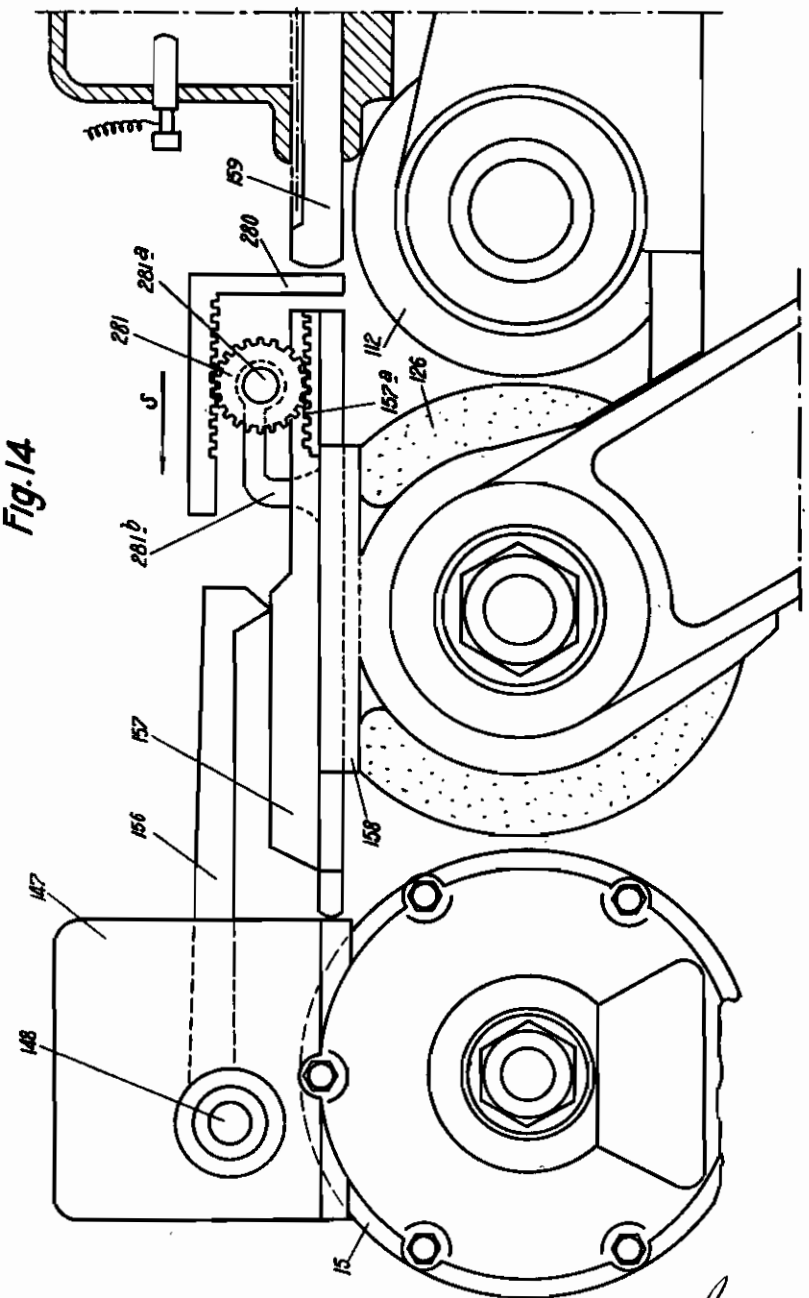

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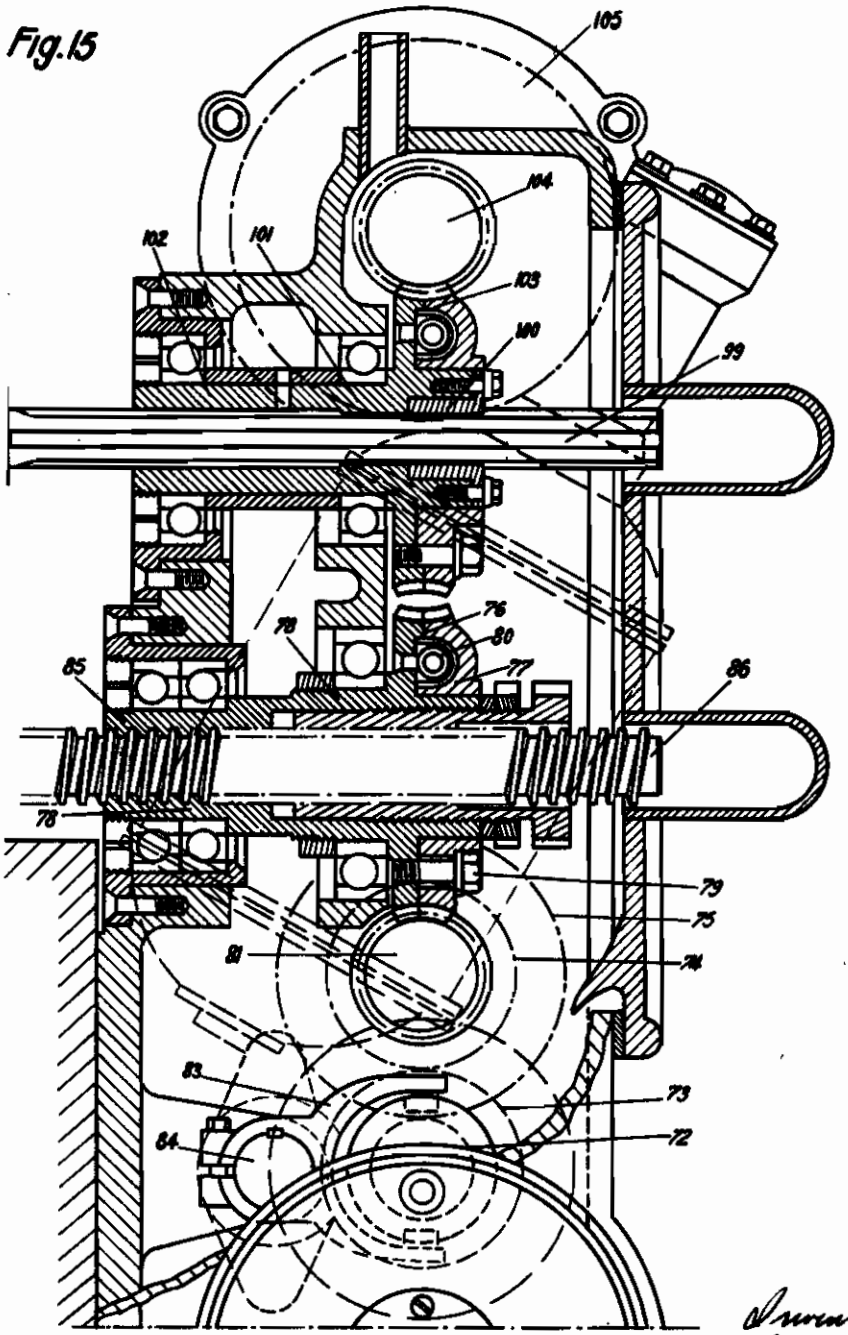
Fig. 15



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ALIEN PROPERTY CUSTODIAN

MACHINES FOR MANUFACTURING ROTATION OR REVOLUTION BODIES

Eugène Fouquet, Clermont-Ferrand, France; vested in the Alien Property Custodian

Application filed November 24, 1941

The object of the present invention is to provide a method and a machine for machining rotation of revolution bodies, and particularly for manufacturing the ribs of air-cooled aviation engine cylinders.

At present, the machining of the ribs of air-cooled engine cylinders is effected by simple or multiple lathe tools. This method, however, is long and costly. Furthermore, large difficulties are encountered during the machining, due, on one hand, to the comparatively short distance between adjacent ribs, and, on the other, to the reduced thickness of the cylinder walls. Besides, the steels used for making the cylinders are specially treated for increasing their hardness, so that the cutting tools will frequently break and, even if the greatest precautions be taken for the machining operation, the later will always be lengthy and delicate. It will further be noted that it is impossible to make the distance between adjacent ribs as small as desirable since it is impossible to reduce the width of the tools below a given value without further increasing the risk of breaking the tools.

The present invention has the object of remedying these drawbacks. It provides a very rapid and precise machining while the distance between adjacent ribs may be made smaller as has been possible up to the present.

The method according to the invention consists in effecting the machining of the ribs by means of multiple grinders consisting in elementary grinders spaced from one another by a number of spacing members and arranged on the same axis.

The method is further characterised by a continuous or non-continuous grinding of the grinders themselves, effected on the machine carrying the grinders.

To this effect, the machine according to the present invention comprises a multiple grinder at least, accompanied by a corresponding device adapted to grind the grinder itself and hereafter called the grinding device, the axis of which is parallel to the grinder axis, the grinder and grinding device being movable on the machine frame so that they may be moved towards or away from one another.

In a practically advantageous embodiment, the machine comprises two multiple grinders or grinder sets, called the primary and secondary, acting on either side of the cylinder on which the ribs are to be formed, simultaneously or in succession, and associated each with suitable grinding or forming members. The primary and secondary grinders have in principle different diameters and one may use as secondary grinders the primary grinders after they have been partially worn out.

The movement of the grinders, both the main grinders and those of the grinding members, towards or away from one another, the variations in the speed of rotation of the main grinders and of those of the grinding device in accordance with the sequence of operations to be performed may be obtained in principle automatically by means of electromagnetic relays actuated by checking members supervising the execution of the job.

The machine is preferably designed in such a manner that said checking members will come to action only when the job they supervise is near its completion.

The machine may further comprise a servo blocking device, movable perpendicularly to the cylinder and grinder axes and comprising the required parts for clamping and freeing the parts maintaining in place the cylinder, the grinders and the grinding devices.

Several other characteristics of the machine will appear from the following specification relating to two embodiments chosen by way of example and represented on the joined drawings, in which:

Figures 1 to 6 refer to a first embodiment, which is particularly simple and non-automatic.

Figure 1 is an elevation with section along the line I—I of Figure 2 and with the support partially torn away.

Figure 2 is a plan view corresponding to the preceding figure, with a section along the line II—II of Figure 1.

Figure 3 is a detail showing in elevation a movable head stock.

Figure 4 is a section along the line IV—IV of Figure 2.

Figure 5 is a partial plan view with a section at an enlarged scale, showing more particularly the mounting of the cylinder to be machined, the multiple grinder and the mounting of the grinding device.

Figure 6 is an elevation corresponding to Figure 5.

Figures 7 to 15 refer to a second machine operating automatically.

Figure 7 is a general elevation, in front view.

Figure 8 is a rear view without the protecting cover.

Figure 9 is a longitudinal section showing the

casings for the mechanisms driving the various carriages.

Figure 10 is a transverse section through the points A—B—C—D—E—F—G and H of Figure 9, showing the cylinder carrying and primary grinders carrying spindles in section.

Figures 10*a* and 10*b* concern details of a free-wheel bearing of one of the driving motors.

Figures 11 and 11*a* are diagrammatic elevations for explaining the operations of the cams associated with the control members.

Figure 12 shows at a larger scale a detail of a part of Figure 8, certain parts being left away for permitting a better understanding.

Figure 13 is a sectional elevation perpendicular to Figure 12.

Figure 14 shows in detail, at a larger scale, a part of Figure 8, and

Figure 15 shows, also at a larger scale, a detail of the right hand side of Figure 9.

In Figures 1 to 6, the machine comprises a main frame **401** on which a carriage **402** is movable longitudinally. On this carriage is mounted a motor **403** which may drive the shaft **404** or cylinder carrying shaft. The rotation is obtained by means of a gear **408** keyed to the shaft **404** (Figure 1), a gear **409**, a gear **410** and a gear **411** keyed to the same shaft, and of a pinion **412** keyed to the shaft of motor **403**. The whole mechanism is protected by a casing **413**.

On the shaft **404** is centered the cylinder **427** to be machined, the centering being effected (Figures 2 and 5) by cones **405**, **407** locked by a nut **405** screwed on a thread of shaft **404**.

The shaft **404** is supported on one hand by a fixed head stock **425** fixed to the carriage **402**, and on the other hand by a movable head stock **424** (Figures 1, 2, 3), the lower part of which is provided with a dovetail groove and movably mounted on a correspondingly formed rib **423** arranged transversely on the carriage **402**. This movable head stock **424** may thus be moved towards the outside for allowing the cylinder **427** constituting the job to be inserted on the shaft **404**. A screw **426** is provided for blocking the movable head stock **424** in the required position.

The longitudinal movements of the carriage **402** are obtained by means of a rack **417** blocked to the carriage by the screw **418** (Figure 1) and meshing with the pinion **416** keyed to shaft **420** which is mounted in the bearing **422** integral with the frame **401**. The shaft **420** is actuated by means of the hand-wheel **421**. The frame (Figure 4) carries a projecting rib **415** of dovetail form, on which is movable a carriage **402** fitted with a corresponding groove **414**.

On the frame **401** of the machine and towards the middle of the latter are marginally arranged bearings **428**, **429** for a shaft **430** carrying the multiple grinder indicated as a whole by **431**. The bearing lids **428**, **429** are hinged to the corresponding parts for facilitating a dismounting of shaft **430** and displacement of the grinder **431**. The grinder **431** consists in a series of grinding elements **431***a* separated by spacing members **432**, the diameter of which is such that they do not hinder the grinding of the grinder itself op to the extreme limit. A spacing bushing is provided in **434** on the shaft **430**, and the grinders **431***a* and spacing members **432** are engaged alternately on a hub **436** keyed to the shaft **430**, a threaded ring **435** screwed on a thread of shaft **430** maintaining the whole arrangement in position. The rotation of shaft **436** is obtained by means of a single or multiple belt **438** driven by a motor **439** fixed to the base plate of the machine.

The frame **401** further comprises a second carriage, or grinding carriage **440**, to which is fixed a motor **441** driving over a belt **442** a shaft **443** carrying the grinder **444** of the grinding device. This grinder consists in a pile of steel discs adapted for grinding the multiple grinder **431**. The shaft **443**, together with shaft **404**, is carried on one hand in a fixed head stock **445** integral with the carriage **440**, and on the other hand in a head stock **446** which is movable in a transverse direction with respect to the movement of the carriage **440** on the frame **401**.

The guide of carriage **440** comprises a longitudinal groove **448** in which is movable a nut **449** integral with the carriage **440** and engaging the thread of a shaft **450** carrying a pinion **451** meshing with another pinion **452** keyed to a threaded shaft **453** parallel to shaft **450**. The shaft **453** carries a thread engaging a nut **454** movable only longitudinally in the groove **416** in which is also movable the rack **417** of carriage **402**. The nut **454** forms a stop for the carriage **402** as will be indicated further below. On the outer end of shaft **450** is mounted freely a worm wheel **456** which may be coupled to the shaft **450** by a bushing **458** angularly coupled with the shaft **450** with which it may be moved along. The bushing **458** is provided with a control hand-wheel **459**. The worm wheel **456** meshes with a screw **460** moved by hand through the means of hand-wheel **461**.

The operation of this machine is as follows:

After fixing the cylinder **427** to be machined on the shaft **404**, the various motors are started up and, by acting upon the hand-wheel **421**, the carriage **402** is progressively moved towards the multiple grinder **431**. This movement is limited by the nut **454** forming a stop. After machining a cylinder **427**, the latter is taken off the machine and replaced by another. Before effecting a new grinding, the grinder **431** itself is ground. For this, the hand-wheel **461** is actuated in order to approach the carriage **440** to the grinder, the grinding wheel **444** then effecting the desired grinding. It will be noted that the displacement of carriage **440** has set up a movement of the stop **454** by the same amount but in the opposite direction. Under these circumstances, it is possible to effect a perfectly precise grinding of the cylinders since the grinding will be ended each time the carriage **402** strikes against the stop **454**.

The uncoupling of the worm wheel **456** by means of the bushing **458** permits to move the grinding wheel **444** back by acting upon the hand-wheel **458**.

One will now describe the automatic machine shown on Figures 7 to 15.

This machine comprises essentially, on the frame **1**, the following parts suitably cooperating for machining a cylinder **15**:

A set of primary grinders **21**, or primary multiple grinder,

A set of secondary grinders **126**, or secondary multiple grinder,

A wheel **52'** for grinding or shaping the primary multiple grinder, and

A wheel **112** for grinding or shaping the secondary multiple grinder.

For describing the various devices ensuring the required cooperations, one will first examine the various carriages (cylinder, primary grinder, secondary grinder and grinding wheel carrying carriages) and the parts they carry, and thereafter the control parts, the devices used for accounting,

when moving the grinding wheels, for the wear of the grinders, and lastly the servo blocking device.

Cylinder-carrying carriage

This carriage 3 (Figures 9 and 10) moves longitudinally in a dovetail groove 2 provided in the main frame 1 (Figure 10). The carriage is provided with a bore in which is arranged the spindle 4 rotating on one hand in the bearing 5 and on the other hand in the bearings 6 and 7.

This spindle 4 receives the cylinder 15 to be machined and maintained in place by a split socket 16 engaging a conical support 17 and actuated by a nut 18. The latter receives its longitudinal movement from a screw 19 integral with an apertured plate 20.

The rotation of spindle 4 is obtained by means of the bevel wheel 8 meshing with pinion 9 which is keyed to shaft 10 provided with longitudinal grooves and coupled by means of keys 11, in rotation with the sliding socket 12 which receives its motion from the helical wheel 13 driven by the motor 14 driving a guide-screw not visible on the drawing. It is clear that owing to this slidable drive, the vertical distance between the spindle 4 and the shaft of motor 14 may be varied at will.

The longitudinal displacements of the cylinder carrying carriage 3 are obtained, with two different speeds, in the following manner (Figure 9):

On the shaft of an electric motor 68 is keyed a pinion 69 meshing with a gear 70 on the shaft of which are arranged a pinion 72 and a gear 73 (Figure 13). The pinion 72 meshes with a larger gear 75. The gear 73 meshes with a gear 74 of same size. The gears 74 and 75 are both keyed to the tangent screw 61 (Figure 15) meshing with the two-piece pinion 76 provided with a slack absorbing device of a known type, such as that shown by way of example and comprising two toothed half rings 77 and 76, the half ring 76 forming a nut 85 on shaft 86, and the half ring 77 being pivoted on 78 and permitting to take up the slack by means of the bolt 78 and coil spring 80 which may move the two toothed half rings 77 and 78 by an amount equal to the slack existing in the thread of the tangent screw 81.

It is clear that the transmission from motor 68 to pinion 76 may be effected at two different speeds according as to whether it is performed over the wheels 72 and 75 (low speed), or over the equal wheels 73 and 74 (high speed). The speed is determined in a known manner by a sliding dog clutch 82 coupling either wheel 72 or wheel 73 with the corresponding shaft, the movements of the dog clutch being obtained by means of a fork 83 fixed on the shaft 84 and actuated in a known manner by an arrangement of electromagnets which has not been shown for simplicity.

The endless screw 86 is coupled by a cone with a support 87 fixed to the carriage 3 by screws 89 and 90.

Primary grinder carrying carriage

Like the cylinder carrying carriage, this carriage 50 moves in the dovetail groove 2 of the main frame (figure 10). The bore of this carriage receives the spindle 28 revolving in the ball bearings 29 and held axially by thrust bearings 30. The spindle 28 carries a thread 27 on which is screwed the hub 22. This hub 22 is fitted with a primary multiple grinder 21 arranged between a fixed flange of the hub 22 and a movable flange 23, the individual or elementary grinders being clamped by means of a washer and the toothed nut 25, this nut also carries slots 28 for blocking the whole on the thread 27.

The other end of spindle 28, carried by a support 32 through the means of a ball bearing 33, carries a pulley 31 on which passes a belt 34 which is also passed over the pulley 31*a*.

The drive of spindle 28 is effected either at a high speed or at a low speed by the motors 35 and 41 (figures 8 and 10). The shaft 36 of motor 35 (figure 10) is coupled in rotation, by means of a key, with pulley 31*a*. The shaft 36 carries an extension 37 rotating in the free-wheel rollers 38 shown in detail in figures 10*a* and 10*b*. The outer rolling path 36*a* is coupled in rotation with the socket 40 to which is keyed the ring 39 driven by the endless screw 42 driven in turn by the motor 41. Normally the extension 37 driven by the shaft 35 rotates in the bearings 38, but when, owing to the starting up of motor 41 and to the slowing down of motor 35, the ring 38 tends to rotate faster than the extension 37, the rollers 38*b* are locked in their casing thus causing the extension 37, shaft 36 and pulley 31*a* to be driven by the motor 41 which is the low speed motor.

In order to permit a tightening of the belts 34, the motors 35 and 41 (figures 8 and 10) are fixed to a general support 43 which may be moved by the screws 44, 45 driven together by the endless screws 46 and 47 acting upon the nut forming pinions 48 and 49.

Secondary grinder carrying carriage

This carriage 92 (figure 9) carrying the secondary multiple grinder 126 mounted on the spindle 125 rotating, owing to the bearings 124, in the bore 123, is movable longitudinally on the cylinder carrying carriage 3 by means of a slide 93 at the end of which is fixed the slack absorbing nut 94. The nut 94 may receive a longitudinal movement from a serew 95 rotating without longitudinal movement in the bearings 97 and 98 held in a supporting bearing 96 which is fixed in a suitable manner to the carriage 3. The axis of the screw 95 is extended by a grooved shaft 98 (figure 15) which may be driven in rotation by pins 100 and 101 with slack absorbing devices by partial rotation. These pins are integral with the hub 102 of the pinion-nut 103 formed by two pieces like the pinion-nut 76 and similar to the latter. This pinion is in mesh with the screw 104 driven by a screw gear 105 of a known type driven itself by a motor 106 fixed to the main casing 107 (see figures 8 and 9).

The rotation of the grinders 126 carried by the secondary grinder carrying carriage 92 is obtained as follows: (figure 8):

On the spindle carrying the multiple grinder 126 is fixed a pulley 127 connected by a belt 128 to a driving pulley 129 which may be driven at two different speeds, as described for motors 35 and 41, either by motor 130 (high speed) or by motor 131 driving the screw gear 132 (low speed). The connection of the motor group 130 and 131 with the secondary grinder carrying carriage 92 is effected by an extendable connecting rod 133 formed of two parts, one integral with the motor flange 130 and the other with the carriage 92. Guiding studs 135, 136, prevent both parts of the extendable connecting rod to play transversely with respect to one another, and a screw with opposed threads 134 permits a more or less thor-

ough tightening of the belt 128. This extendable connecting rod 133 urges the motor group 130, 131 into the one or other direction according to the relative motion of the cylinder carrying carriage 3 and the secondary grinder carrying carriage 92. The motor group 130, 131 is, indeed, pivoted to the shaft 137 resting on one hand in a bore of the frame 1 and on the other hand on a overhung table 138 fixed to the support 139.

Grinding carriages

There are two such carriages: the grinding carriage 52 for the primary grinders and the grinding carriage 108 for the secondary grinders.

The grinding carriage 52 for the primary grinders moves longitudinally with respect to the primary grinding carriage 50 by means of a slide 51 provided in this carriage. The grinding carriage carries the grinder 52' keyed to the shaft 53 housed in its bore 54. The movements of the primary grinding carriage 52 with respect to the primary grinder carrying carriage 50 are obtained as follows:

The carriage 50 in integral with a support 115*a* in the conical bore of which is blocked by the nut 116*a* the cone forming the end of a screw 55 engaging with a slack absorbing two-piece nut 56, 57 forming a pinion with helicoidal teeth, similar to pinion 76 already described. The nut-pinion 56—57 is driven by a tangent screw 58 which may be rotated either by a high speed motor 59 or by a low speed motor 60, corresponding to two different speeds for the motion of the grinding carriage 52 with respect to the primary grinder carrying carriage 50.

For the high speed, the pinion 62*a* keyed to the shaft of motor 59 drives the gear 65*a* mounted on shaft 66*a* which rotates in turn the wheel 67*a* keyed to the same shaft 66*a* and driving at the same speed the wheel 68*a* keyed to the shaft of the tangent screw 68.

For the low speed, the screw 64 keyed to the shaft of motor 60 drives tangentially the wheel 65 on the shaft of which is keyed the wheel 67 driving in turn the wheel 66 mounted on the shaft 66*a*, whence the motion is transmitted as before, over 67*a*, to the wheel 68*a* and to the tangent screw 58. For passing from one speed to another it is therefore necessary that the coupling of shaft 66*a* be transferred from one of the wheels 65*a* (high speed) and 66 (low speed) to the other. This is obtained in a known manner by means of a slide gear actuated by a fork movable on the axis 63 and actuated by two (not shown) electro-magnets arranged one in front, the other at the rear and supplied with current at the required moments.

The secondary grinding carriage 108 carrying the grinder 112 fixed to shaft 111 arranged in the bore 110, is movable longitudinally, by means of a suitable slide, on the secondary grinder carrying carriage 92.

The motion of carriage 108 with respect to carriage 92 is obtained as follows:

The carriage 109 carries a support 115 provided with a conical bore in which is inserted a cone 114 blocked by the nut 116. The cone 114 forms the end of a screw 113 engaging a nut-pinion 117, 118 similar to the nut-pinion 76. This nut-pinion is driven in rotation by the screw 119 driven in turn by a worm gear 120 and a rocking motor 121 pivoted to the machine frame (see Figure 8). This motor drives the group, whatever its position, by means of a grooved slide 122, 122*a*.

Checking members

The supervision of the machining operations is effected by means of feelers actuated only when the various operations to be checked by them are about to be ended. Two such feelers will be described here by way of example, although they may be provided in any desired number.

The two feelers are indicated respectively by 140 and 141 (see Figures 7, 8 and 9). They are both keyed on a common shaft 148 mounted in a casing 147 fixed to the cylinder carrying carriage 3. On the shaft 148 is also keyed the gear 149 meshing with pinion 150 integral with wheel 151 driving pinion 152 on the shaft of which is keyed a rotating disc of insulating material carrying a conducting segment 154 which closes or opens a circuit, according to its position with respect to the contact blades corresponding to the terminals 155, 155'.

On the primary grinder carrying carriage 58 is fixed a guide 146 in which is slidable a cam 145 carrying a groove 144 engaged by a stud 143 of a protection lever 142 integral with the feeler 140. The cam 145 may come to strike against the casing 147.

The feeler 141 is integral with the protecting lever 156 resting on a cam 157 slidable in the guide 158 fixed on the secondary grinder carrying carriage 92. The cam 157 may also come to strike, by one of its ends, against the casing 147. The other end of the cam 157 may act as a stop for a feeler 158 through the means of an intermediate part 280, the mounting of which will be explained later.

The feeler 159 is provided with a rack meshing with a pinion 160 integral with the gear 161 driving the pinion 162 integral with the gear 163 driving, through the means of a pinion, the insulating disc 164 provided with a conducting segment 185 cooperating with the contact blades connected to two terminals of a circuit, these two terminals occupying different positions with respect to the segment 165 according to the position of the rack feeler 159. The movement of the latter, at the other end of the cam 157, is limited by the adjustable stop 166.

Devices for taking into account, in the motion of the grinder carrying carriages, the wear of the grinders

It is clear that the movements of the grinder carrying carriages with respect to the corresponding multiple grinders must be so much greater as the wear of the grinders increases. This is obtained by limiting the movements of the grinder carrying carriages by means of adjustable stops and displacing said stops automatically in terms of the wear of the grinders.

In the case of the primary grinder carrying carriage 52, the amplitude of its displacement is determined by the movement of the cylinder carrying carriage, since it is the cylinder carrying carriage and not the primary grinder carriage that moves during the work.

An adjustable support 167 is fixed by screws 168 on the cylinder carrying carriage 3. This support (see particularly Figure 12) comprises a slack absorbing nut 170 in which is screwed the feeler 169 carrying a not threaded extension 171 in which is formed a longitudinal groove 172 adapted to receive a (not visible) key of a ratchet 173 provided with a pawl 173*a*. It will be seen that the ratchet 173 is coupled in rotation with the feeler 169 and permits a longitudinal motion

of the latter. The ratchet 173 is arranged between the arms of a bracket 174 fixed to the machine frame by screws 175. This bracket also carries two parallel bores 170, 179 in which is movable the shaft 180 pivoted on the other hand in the supports 181, 182 fixed to the carriage 3. To shaft 180 are keyed the support 173b of pawl 173a and lever 183 carrying an inclined place 181a on which a roller 183b may roll, the threaded shaft 183a of which engages a dovetail slide of frame 1, in which moves a slide 182 carrying on the other hand a stop 183 cooperating with the feeler 188. The slide 182 further carries a rack 186a (Figure 8) meshing with a gear 186 without slack, driving the rack 187 fitted with a stop and sliding in the supports 188, 188 fixed to the machine frame 1.

The primary grinder carrying carriage 52 further carries a casing 190 called the amplifying casing, traversed by a feeler 192. This feeler is provided with a rack 193 meshing with pinion 194 belonging to the wheel 195 which is in mesh with pinion 196 driving, over another gearing, the insulating disc 197 to which is fixed the conducting segment 198 cooperating with the contacts of terminals 199 and 200.

The operation of the whole device is easily understood:

As the wear of the grinder increases, the cylinder carrying carriage 3 must come, for its work closer and closer to the shaft of the primary grinder 21. The shaft 180, carried along by carriage 3, accordingly moves over a larger distance with respect to the frame, the incline 191a advances with respect to the roller 183b and comes to roll over it. The lever 183 is thus rocked and rocks in turn the shaft 180 and the support 173b of the roller. The roller 173a causes the wheel 173, and with it the shaft 171, to rotate. The threaded feeler 169 is thus moved with respect to the support 167 and consequently with respect to the carriage 3. This move is transmitted, in the opposite direction, through slide 182, from wheel 186 to the stop 187. Thus, it is seen that the length of path of feeler 192, determining the length of the displacement of the carriage, has been increased.

Concerning the motion of the secondary grinder 112, its adjustment is obtained as follows (Figure 14):

The intermediate part 280 is integral with a rack meshing with a gear 281 mounted on a shaft 281a held by an extension 281b belonging to the guide 158 of the secondary grinder carrying carriage. The wheel 101 is in mesh with a rack 157a of the slide-cam 157.

As the wear of the secondary grinder 126 increases, its carriage will come, during operation, closer and closer to cylinder 15. Under these circumstances, the casing 147 will repel the cam 157, which, through rack 157a and wheel 281, moves the intermediate part 280 in the direction of arrow 5. The effect is the same as if the cam 157 had been shortened, with a corresponding increase in the stroke of feeler 159.

Servo blocking device

This device serves the purpose of clamping the cylinder and grinders in position on the various carriages and comprises a support 201 fixed to frame 1 by bolts 202 (Figure 7 to 10). The support carries a socket in which is engaged the cantilever pivot 203 carrying the plate 204 on which is mounted the motor 204a. The casing of this motor is integral with a bevel gear casing 205 for transmitting the motor drive to the horizontal shaft 206. The latter carries a pinion 207 (Figure 10) meshing with a bevel wheel 208, in the hub of which is slidable a grooved shaft 209 driven in rotation by the bevel wheel 208 by means of keys 210 integral with the hub. The hub itself is rotatable in the bearing 211 of casing 212 (Figures 7 and 10). The casing itself forms a slide on the cantilever bar 242.

The casing 212 carries an outer thread on which is engaged the inner thread of a nut-casing 219 fitted with a lateral extension 222 in which is mounted the screwing and unscrewing shaft described below. The pitch of the thread carried by the nut-casing is such that one half revolution of this casing causes the screwing and unscrewing shaft to rise or sink by an amount corresponding to the vertival distance between the axis of the cylinder spindle and the axis of the primary grinder carrying carriage spindle. It has been found indeed that this slight displacement of said axes with respect to one another is favourable for certain jobs.

The nut casing 219 may occupy two positions diametrically opposed with respect to casing 212. To this effect, an outer flange of the nut-casing carries two conical apertures 220, 221 into which may penetrate a locking bar 213 movable in a perforation of casing 212. This locking bar carries a rack 214 meshing with a gear 215 actuated by a control lever 216. A not shown spring urges the lock into downward direction. It is clear, that by acting upon lever 218, the lock 213 may be pulled clear from aperture 220, after which the casing 219 will be moved over half a circle with respect to casing 212 and the lock 213 permitted to return into the aperture 221.

The cylinder carrying extension 222 has an outer diameter which is slightly smaller than the inner diameter of cylinder 15, in order to permit an easy application of the latter on the former. The extension contains a bearing 223 on which rests a ring 224 provided with a shoulder, carrying the ball thrust bearing 225 and receiving the push of spring 226, this spring resting on the other hand on a collar 227 of a slotted driving bushing 229 which is brought to mesh, by spring 228, with the hub 229 of a gear ring 230 meshing with the conical pinion 231 keyed to the end of shaft 209. The wheel 230 rests on the thrust bearing 232 held by the ring 233.

The hub 229 is engaged by a hollow shaft 234 grooved on the outside. The grooves of this shaft cooperate with corresponding inner grooves of the hub so that the shaft 234 is driven in rotation while being freely slidable longitudinally and may be pulled or pushed at will by the operator.

At one end, the hollow shaft 234 carries a plate 236 provided with pins 236 which may engage in apertures 20 of bushing 19 mentioned above. At the other end, the shaft carries a ring forming a key 237 for slackening the threaded hubs of the primary and secondary grinders, and also of the grinding wheels. The hollow shaft 234 further contains a hexagonal key 228a driven in rotation by the shaft.

In Figure 10 it may be seen how the operator may pass form the tightening of slackening position for the cylinder, to the position for tightening or slackening the grinder. For this, he will exert a pull on shaft 234 in order to disengage the pins 236 from the apertures 20. He will then act upon the lever 16 for disengaging the

lock 213 from the bore 220, after which he will rock the whole arrangement in order to bring the ring 237 into the position occupied by the disc 235 and vice-versa. It is then merely necessary to push the ring 237 in a manner that its slots engage the slots 26. Once this coupling effected, the hexagonal key 228a is pushed to engage a corresponding housing provided at the end of the grinder carriage spindle. The operator will then start the motor 204a which, through the transmission described above, will drive the hollow shaft 234 in the unscrewing direction. As soon as the grinder 21 is slackened, the operator takes off the ring 237 and inserts in its place the primary grinder 21.

On the rectangular cantilever 242 is longitudinally movable, as indicated, the slide constituted by casing 212 (Figure 7). To this effect, the slide comprises rollers 260, 261 and 262, 263 which may roll in longitudinal V-shaped grooves formed on the bar 242 (see Figure 10). A (not shown) brake, actuated by lever 258, permits to stop the slide in any desired position of the length of bar 242.

The bar 242 is normally maintained in operating position by a support 244 (Figure 10) fixed to a protecting cover plate 245. One may also rock this bar about the pivot 203 in order to bring it outside of the operating field. For this, it is only necessary to act upon the lever 236 locking the bar, integral with the shaft 239 pivoted in the support 244 and receiving the bolt 241 which maintains the bar 242 in a housing provided in the support 244.

The protecting cover 245 is screwed to the frame 1 and comprises a sliding door 246 balanced by a counterweight 247, 248 hung to the cables 249 passing over pulleys 250.

Inside the protecting cover are arranged (Figure 7) cooling coils 253, 255, 257, 259 connected by hose to a source of liquid and controlled by valves 252, 254, 256, 258.

For permitting the operator a constant control of the various parts of the machine, the frame has been provided with a desk fitted with all the switches and other control gear necessary for following the operation of the machine.

For effecting the various adjustments necessary in operation, a number of hand-wheels 270, 271, 272, 273 have been provided, keyed to the required shafts, acting through the levers 274 and 275 (Figure 7) onto the dog clutches and thus permitting an actuation by hand of all the parts of the machine.

Operation of the machine

The operation of the machine will be described, by way of example, in the particular case where it is used for machining ribs, with successive operation of the primary and secondary grinders, and where the feelers 140 and 141 serve respectively for checking the work at the bottom of the grooves and on the outside of the ribs.

Supposing the cylinder 15 and the multiple grinder 21 occupy the positions shown in Figure 4, the operator first of all rocks the cantilever 242 out of the machine field, after having set it free by acting upon the locking lever 238. He then closes the flap 245 and thereafter performs the necessary adjustments.

For well understanding this adjustment, one should refer to Figures 11 and 11a. On Figure 11, the parts have been shown in the position to which they are brought for adjustment, i. e. in which the grinder 21 is tangent to the cylinder 15. The pin 143 of the protecting lever 142 lies in the lower straight part of the groove 144 of cam 145 slidable in the supporting carriage 50 of the primary grinder carrier.

The operator then chooses a gauge having for instance 0.5 mm less than the depth of the ribs to be obtained, and places this gauge between the casing 147 and cam 146. He then moves the cam 145 towards the easing 147 until casing and cam are both in contact with the gauge. The work is then started. Towards the end of the work, the parts occupy the positions of Figure 11a. The pin 143 has attained the upper horizontal part of groove 144. As long as the pin 143 remained in the slanting part of the groove, the protection lever 142 maintained the feeler 140 at a certain distance from the job to be checked, thus being protected during the greater part of the work of the primary grinders. When the work of the primary grinders is about to be ended, i. e. when the depth of the grooves between ribs is equal to the distance AB, the pin 143 is no longer retained and the feeler 140 comes into contact with the place of work of the grinders.

After having adjusted the mutual positions of the sliding cam 145 and casing 147, the machine is started up. The sector 154 touches the blades 155' and thus establishes the circuits in such a manner that the primary multiple grinder rotates at high speed and that the cylinder carrying carriage advances at low speed.

When the amount of machining performed is such that the feeler 140 will attain the required position, the insulating disc 153 will have moved by such an amount that the conducting segment leaves the blades of terminals 155' and comes in contact with the blades of terminals 155, with the following results:

1. The current in motor 68 is reversed, while under the action of the suitable electromagnet the sliding gear 82 is simultaneously brought into the position corresponding to high speed. The carriage 3 consequently moves back, rapidly clearing the primary multiple grinder.

2. The motor 106 is supplied with current in the direction corresponding to an advance of the secondary grinder carrying carriage 92 over the carriage 3, so that the secondary multiple grinder comes to action on the cylinder. The secondary grinders will for instance round off the apex of the ribs. This operation is checked by the feeler 141 of the protecting lever 156, the duty of which is, similar to that of the protecting lever 142, to free the feeler, so that it may come into contact with the rib apex, only when the ribs are about to be ended.

3. Current has been sent through the motor 59 and the suitable electromagnet has brought the dog clutches in position corresponding to high speed, so that the grinder carrying carriage 52 has moved on the carriage 50 to high speed position. This move goes on until the feeler 192 (Figure 2) comes into contact with the stop 187. At this moment, the segment 198 of the insulating disc 197 set in rotation by the rack 192 comes into contact with the blade of the suitable terminal for actuating the required electromagnet and bringing the dog clutch into the low speed position, while the low-speed motor 60 is supplied with current. Under these conditions, the grinder 52' grinds the primary grinders 21.

4. The latter rotate slowly. Indeed, owing to the movement of the conducting segment 154, the current has been cut off in motor 35 and set up in motor 41. As soon as the speed of motor 35 has

fallen below that of motor 41, the free wheeling device 38 is set in action, with the effect that the pulleys 31a are now driven by motor 41, and these pulleys drive, over the intermediate parts described, the grinders 21 at low speed.

With such a machine, it is possible to obtain conical ribs in one or more operations.

One side of the ribs will for instance be cut by the primary grinders with the required rounding off at the bottom of the groove. The other side will be cut together with the corresponding rounding off at the bottom of the groove, by the secondary grinders. The grinders will then be changed and replaced by such in form of a cone cut at the slope required for the rib. It will thus be possible to obtain the conical ribs.

For permitting the forming of conical ribs with a single set of grinders, a certain advantage is obtained if the cylinder axis 15 is displaced with respect to the grinder axis 21 as shown on the drawings, in order to prevent any clogging. The resulting deformation of the ribs may be compensated on the grinder grinding the grinder itself, causing it to give the grinder a correspondingly altered shape.

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