April 10, 1962 B. KRALOWETZ 3,028,775

FORGING MACHINE

Filed March 30, 1959 7 Sheets-Sheet 1

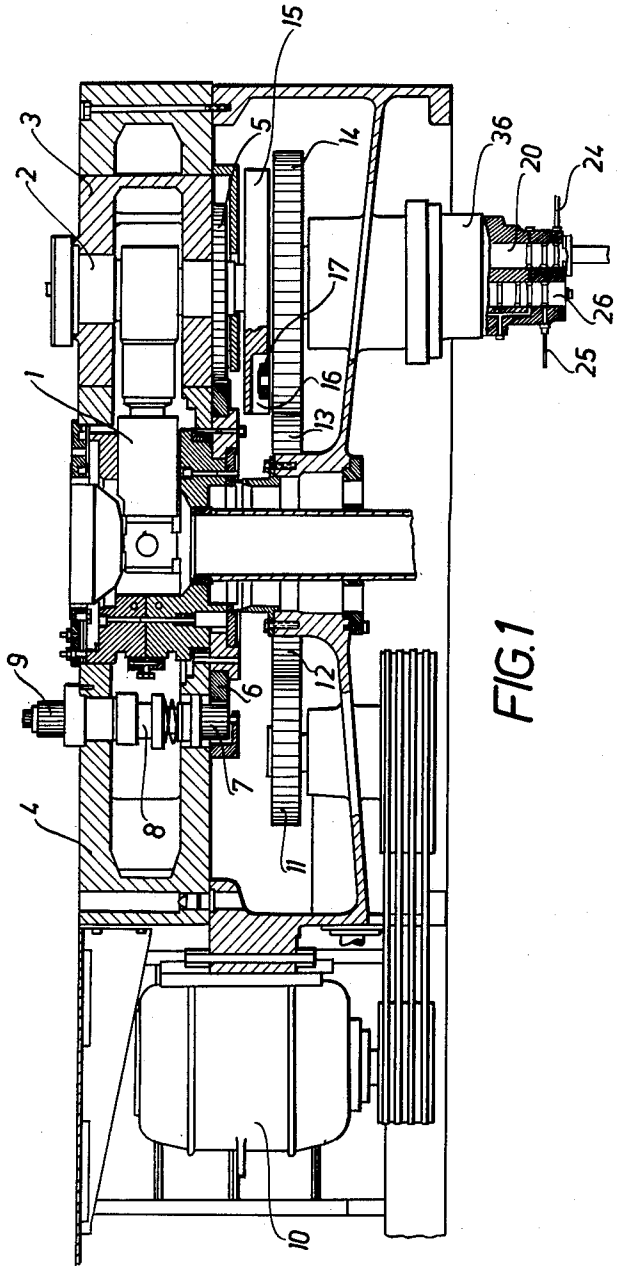


FIG. 1

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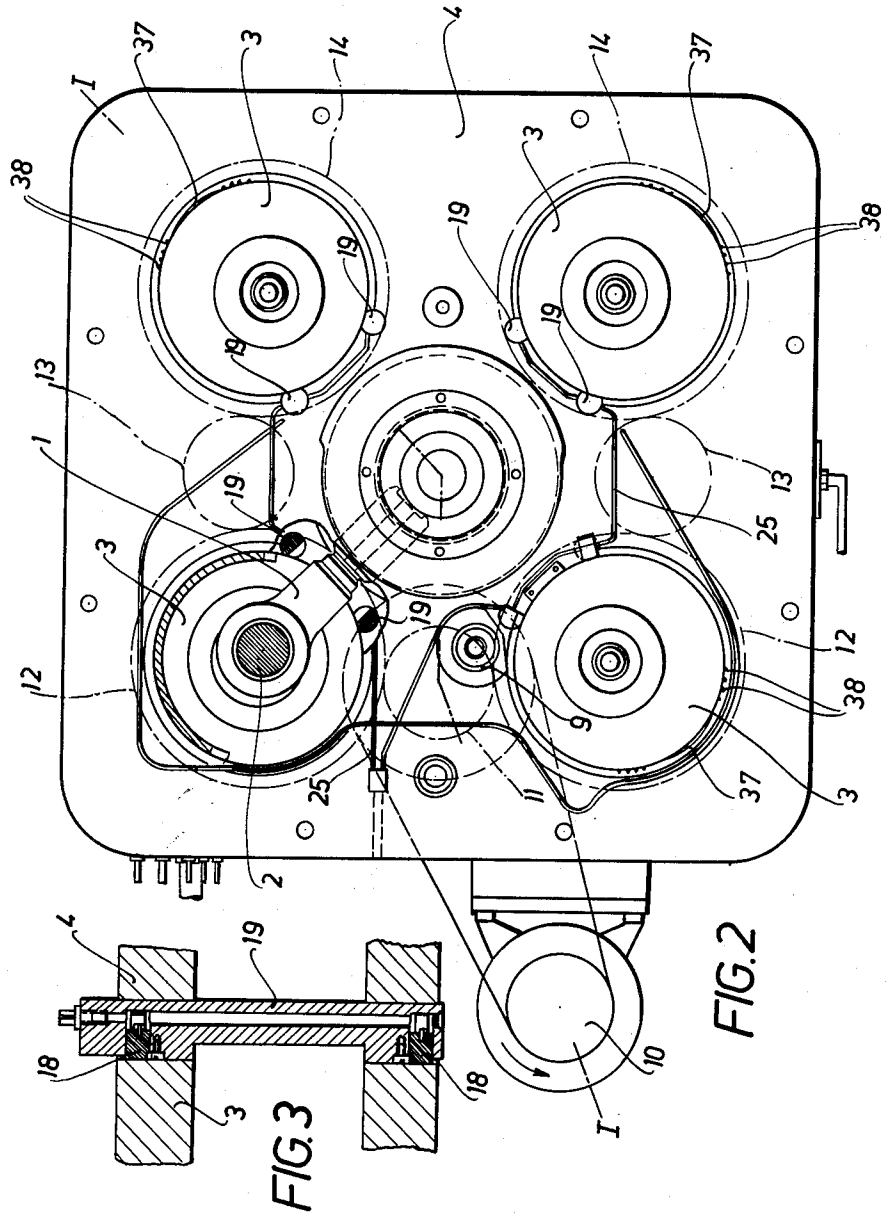


FIG. 2

FIG. 3

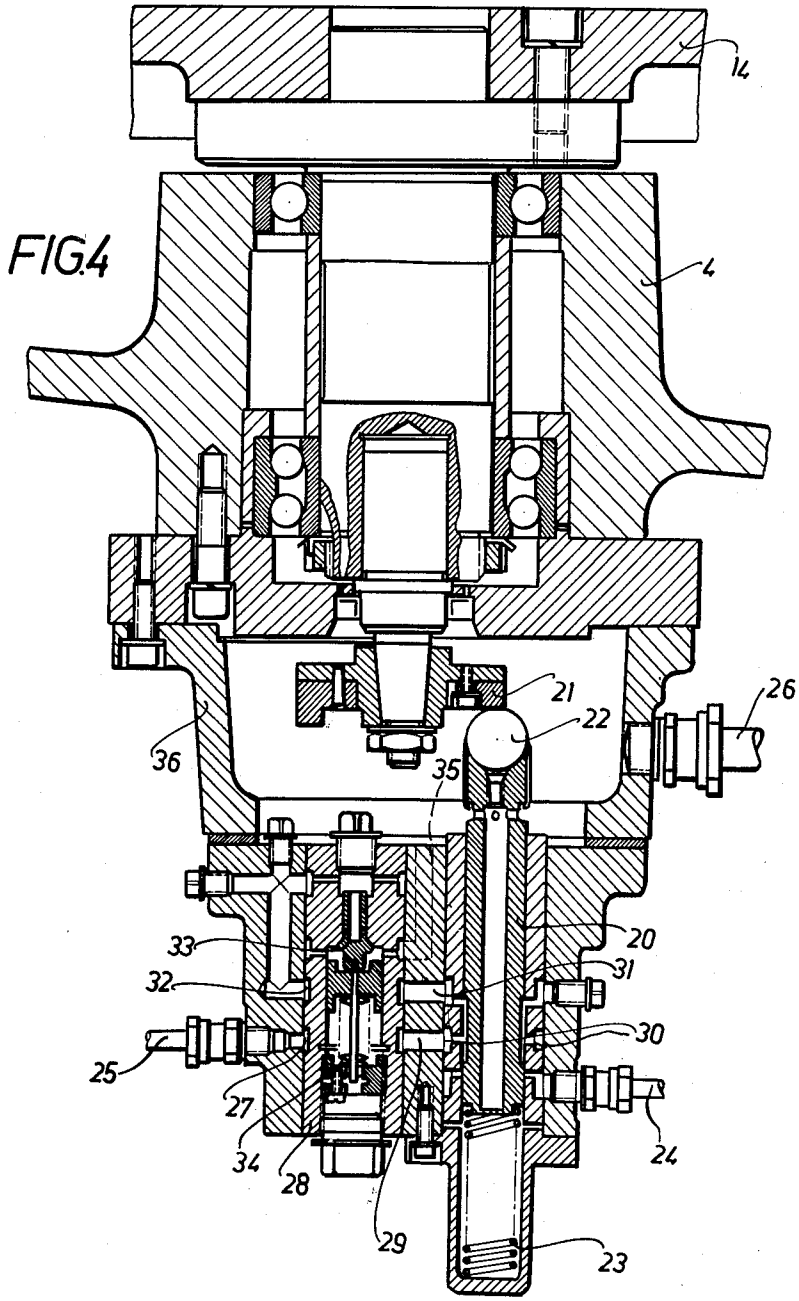
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FORGING MACHINE

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FIG.4



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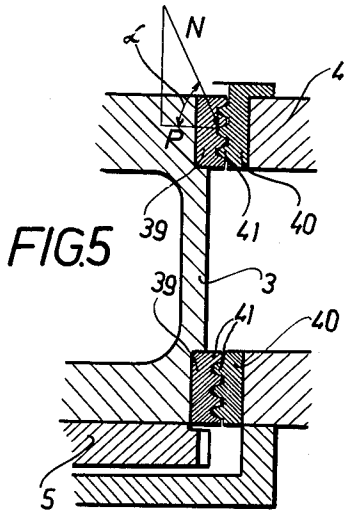


FIG.5

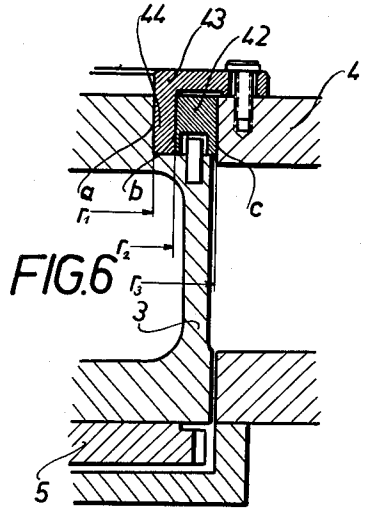


FIG.6

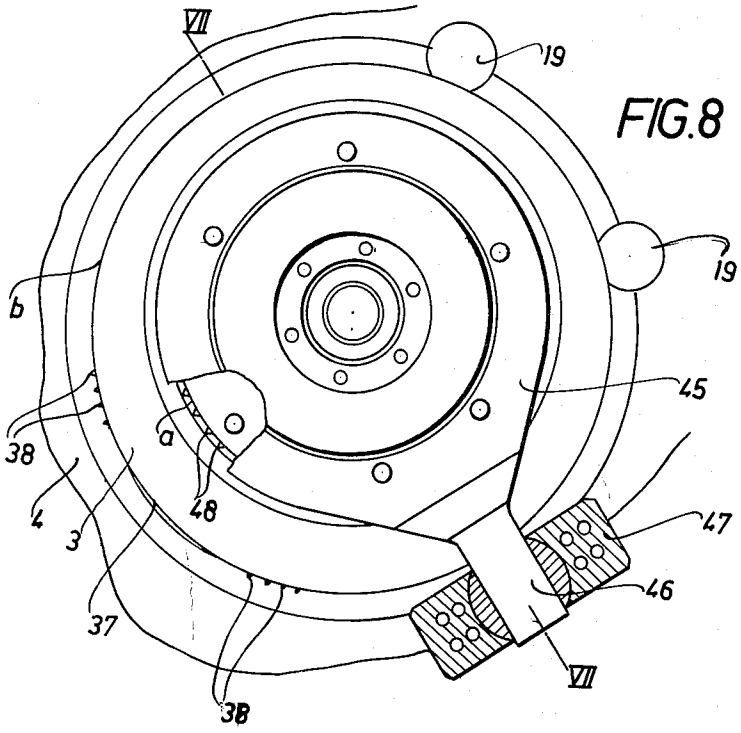


FIG.8

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FORGING MACHINE

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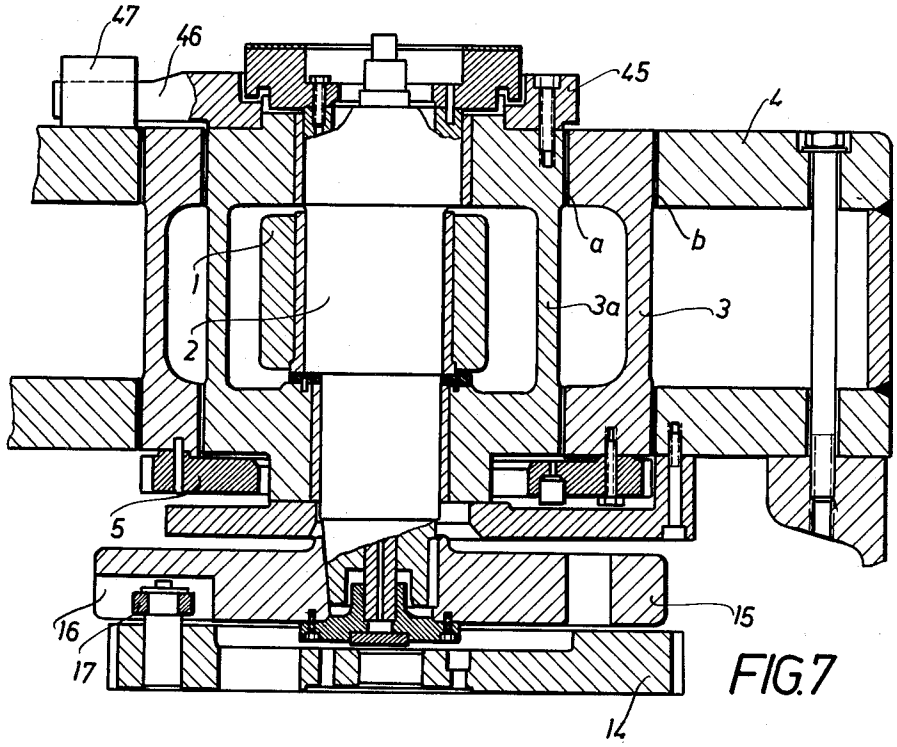
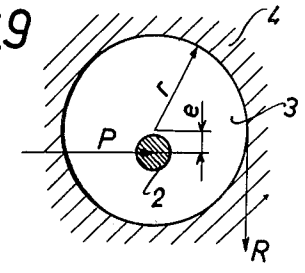


FIG.7

FIG.9



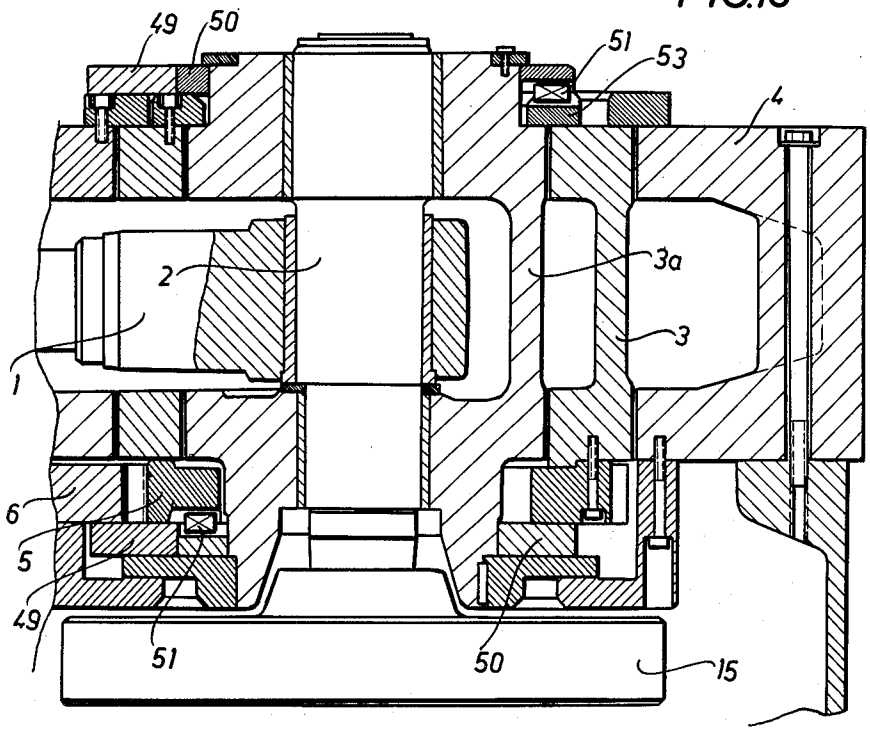
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FIG.10



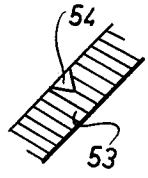


FIG.13

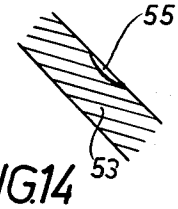


FIG.14

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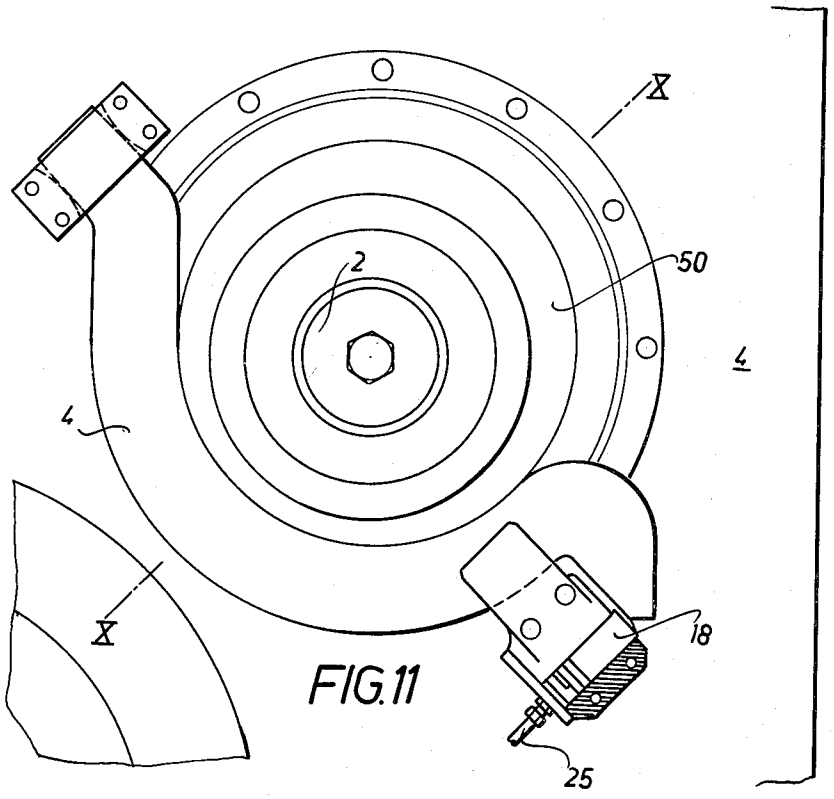


FIG.11

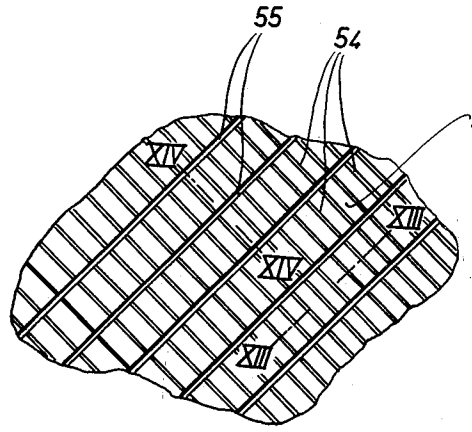


FIG.12

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United States Patent Office 3,028,775 Patented Apr. 10, 1962

3,028,775

FORGING MACHINE

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Filed Mar. 30, 1959, Ser. No. 802,803
Claims priority, application Austria Apr. 4, 1958
9 Claims. (Cl. 78—21)

This invention relates to a forging machine of that known type, in which the hammers are reciprocating connecting rods driven by eccentric shafts eccentrically mounted in cylindrical housings mounted for rotary adjustment in the forging box. Whereas the eccentric shafts effect the reciprocating high-speed working movement of the hammers, the rotary adjustment of the housings of these eccentric shafts serves for varying the stroke position of the hammers, i.e. for setting the depth of penetration of the hammer tools to obtain the desired cross-sectional size of the workpiece. Since the eccentric shafts are eccentrically mounted in their adjustable housings, the reaction forces set up in the hammers due to the deformation of the workpiece produce torques and tend to rotate the housings for the eccentric shafts. These forces are relatively strong and, therefore, their transmission to the control system of the adjustable housings must be avoided. This requires measures whereby the occurring torques are opposed.

It is an object of the invention to provide a forging machine which provides for a large range of adjustment of the hammers whereas the adjustable housings for the eccentric shafts driving the hammers are comparatively small in diameter.

The forging machine according to the invention has clamping pistons which act radially on the adjustable housings and are preferably arranged on the side of the housings through which the connecting rods extend. The pistons are suitably hydraulically operated to force the adjustable housings against opposite bearing surfaces during the hammer blow in order to increase the friction between the adjustable housings and the forging box. Thus, the adjustable housings are virtually clamped fast in their bearings during the hammer blow. This causes any lubricating oil which may be disposed between the bearing surfaces to be squeezed out, whereby the torque which is due to the bearing friction and opposes the reaction torque during the hammer blow is increased.

The above and various preferred features of the invention are illustrated by way of example in the accompanying drawings, wherein

FIGS. 1 and 2 are a sectional view taken on line I—I of FIG. 2, and a top plan view, respectively, showing the forging box with the hammers without the means for gripping and moving the workpiece,

FIG. 3 is an enlarged sectional view taken on line III—III of FIG. 2,

FIG. 4 an enlarged view similar to FIG. 1 and showing the control slide valve with the camwheel,

FIGS. 5 and 6 are views similar to FIG. 1 showing modifications of the mounting of the adjusting housings for the eccentric shafts.

FIGS. 7 and 8 are a sectional view taken on line VII—VII of FIG. 8 and a top plan view, respectively, showing another form of the mounting of the housings,

FIG. 9 is a diagram of the forces occurring adjacent to the bearings,

FIGS. 10 and 11 are in a sectional view taken on line X—X of FIG. 11 and a top plan view, respectively, and show another possibility of mounting the housings.

FIG. 12 is an elevation showing a housing band and

FIGS. 13 and 14, respectively, are enlarged sectional views taken on lines XIII—XIII and XIV—XIV of FIG. 12.

The hammers of the forging machine consists of connecting rods 1, which are reciprocated at high speed by eccentric shafts 2. The driving eccentric shafts 2 are eccentrically mounted in cylindrical housings 3, which are mounted for rotary adjustment in the forging box 4. A rotation of the adjustable housings 3 in the forging box 4 results in a change of the distance of the axes of the eccentric shafts 2 from the workpiece axis (which coincides with the vertical centre line of the machine) and in a variation of the stroke position of the connecting rods 1 and of the depth of penetration of the hammers into the workpiece.

According to FIG. 1 each adjustable housing 3 has connected thereto a spur gear 5, which is in mesh with a central spur gear 6. The spur gear 6 is in mesh with a pinion 7, the drive shaft 8 of which carries at the top an additional pinion 9. The pinion 9 may be in mesh, e.g., with a rack, not shown, which is reciprocable by means of a hydraulic piston. A displacement of the piston or rack causes a rotation of the pinions 9 and 7, as well as of the central spur gear 6 and, by means of the spur gears 5, also of the adjustable housings 3, for varying the stroke positions of the connecting rods and the depth of penetration of the hammer tools. The rotation of the pinion 9 could also be effected by other means, of course. For driving the eccentric shafts 2 of the connecting rods 1 a common drive motor 10 is provided, which drives a gear 11 by means of a V-belt. The gear 11 meshes with gears 12 in the range of the immediately adjacent eccentric shafts and drives by means of respective idler wheels 13 the gears 14 adjacent to the two other eccentric shafts. Owing to the eccentric arrangement of the eccentric shafts 2 in the adjustable housings 3 and the adjustability of these housings the gears 12, 14 are not rigidly coupled to the eccentric shafts but each eccentric shaft 2 carries a flywheel 15, the radial groove 16 of which is engaged by a sliding block 17 on the gear 12 or 14, respectively. This coupling between the gears 12, 14 and the flywheels 15 enables a relative displacement of the axes of the eccentric shafts relative to the axes of the drive gears (FIGS. 1 and 7).

The adjustable housings 3 are acted upon by clamping pistons 18 (FIG. 3), which extend radially of the housings and are mounted in inserts 19 disposed on both sides of each connecting rod 1. The admission of pressure oil or the like to these clamping pistons causes the latter to force the housings 3 against the respective opposite bearing surfaces. The supply of pressure fluid to the clamping pistons pulsates in the working rhythm of the hammers or connecting rods 1. For this purpose a control slide valve 20 is provided, which is reciprocable by a camwheel 21, against which the valve is urged by a spring 23, with a ball 22 interposed. Being non-rotatably connected to the shaft of one of the gears 14, the camwheel 21 revolves in unison with the eccentric shafts 2.

In the position of the control slide valve 20 shown in FIG. 4 the high-pressure conduit 24 is closed whereas a low pressure prevails in the conduit 25 leading to the inserts 19 and the clamping pistons 18 and a connection to the oil drain 26 is established for the surplus oil. The oil in the conduit 25 can flow through the annular groove 27 of part 28, the bore 29, the groove 30 of the slide valve, the bore 31, the annular groove 32 and further bores to a valve 33, which is loaded by a spring 34 under variable initial stress. A depression of valve 33 will cause the oil to flow through the bore 35 into the housing 36, which surrounds the camwheel 21. This oil will serve as lubricating oil for the revolving and displaceable members and can finally flow off through the conduit 26. By the rotation of the camwheel 21 the slide valve 20 is depressed so that the oil under high pressure can advance

from the conduit 24 through the groove 30 of the slide valve, the bore 29 and the annular groove 27 into the conduit 25 whereby pressure is admitted to the clamping pistons 18 whereas the bores 31 and all other passages are shut off by the control slide valve 20.

As is apparent from FIGS. 2 and 8 each of the bearing surfaces of the forging box 4 has on the side opposite to the connecting rod a recess 37 so that the adjustable housings 3 clear the bearing surfaces in this zone. Oil stripping and draining grooves 38 are provided in the bearing surfaces adjacent to this recess.

FIG. 9 is a diagram representing the forces which occur adjacent to the adjustable housings 3. P is the reaction force which is effective in the hammers during the deformation of the workpiecse. Due to the eccentric arrangement of the eccentric shafts 2 this reaction force P exercises a torque on the bearing bushing 3. For an eccentricity e, the torque equals $P \times e$ if the additional torque due to the sliding bearing friction of the eccentric shaft 2 in the housing 3 is neglected. To provide for a self-locking action, the torque $P \times e$ must be balanced by a torque $R \times r$, R being the force of static friction between the housing 3 and the forging box 4 and r being the radius of housing 3. The friction force R is known to be equal to the normal pressure times the coefficient μ of static friction. If it is assumed that the normal pressure is approximately equal to the reaction force P, the following relation results:

$$P \times e = P \times r\mu$$

or

$$\mu = \frac{e}{r}$$

This means that a self-locking action of the adjustable housings 3 in the forging box 4 can be reliably expected only if the actually effective coefficient of friction between the housings 3 and the forging box 4 exceeds the value calculated by means of the above equation. As the coefficient of friction itself can hardly be influenced to an appreciable extent it was previously necessary to provide the ratio of bushing radius to eccentricity as determined by the coefficient of friction. This meant that very large diameter housings were required to enable an adjustment of the stroke position of the hammers through a wide range.

It is shown in FIGS. 5 to 8 how a self-locking action can be obtained with much smaller diameter housings 3.

According to FIG. 5, rings 39 are nonrotatably connected to the adjustable housings 3 and corresponding rings 40 are affixed in the machine box 4. These rings 39, 40 have interengaging wedge-shaped annular ribs 41. It is understood that the reaction force P acts only in a plane normal to the axis of the respective housing. Where α is the angle between the normal force and the reaction force, the normal force N resulting from this reaction force P has the magnitude

$$\frac{P}{\cos \alpha}$$

so that the equation

$$P \times e = \frac{P \times r}{\cos \alpha} \mu$$

or

$$\mu = \frac{e}{r} \times \cos \alpha$$

must now be fulfilled, which indicates the desired improvement in the conditions for the self-locking action of the adjustable housings 3.

As is shown in FIG. 6, each adjustable housing 3 is indirectly rather than directly mounted in the forging box 4. This is effected by means of a ring 42, which is non-rotatably connected to the housing 3 but displaceable in a radial direction or in a plane normal to the axis. Another ring 43 is connected in the same manner to the forging box 4 and has a cylindrical portion 44 extending between the housing 3 and the first ring 42. Thus, three sliding surfaces a, b and c are effective during a rotation of the housing 3. If the respective radii are r_1, r_2 and r_3 the subsequent modified form of the controlling equation results:

$$P \times e = Pr_1 + Pr_2 + Pr_3$$

or

$$P \times e = P(r_1 + r_2 + r_3)$$

This means that the friction torque has been approximately trebled.

The adjustable housings may consist of two sleeves 3, 3a, which are eccentrically mounted one in the other and the inner one 3a of which forms the bearing for the eccentric shaft 2 and is locked against rotation (FIGS. 7 and 8). To lock this inner sleeve 3a against rotation a ring 45 having a radial extension 46 is affixed to the top of the inner sleeve 3a. This extension is pivotally and displaceably held in a fixed guide 47 provided in the forging box 4. In this case there are two cylindrical friction surfaces a and b. The torque due to the reaction force P is thus opposed by a friction torque which is composed of the friction torque between the inner sleeve 3a and the outer sleeve 3 and the friction torque between the outer sleeve 3 and the forging box 4. If r_1 and r_2 are the radii of the inner and outer sleeves, respectively, the formula

$$P \times e = P(r_1 + r_2)$$

results, which shows that the total friction torque has been almost doubled. The inside surface of the outer sleeve 3 is again provided with oil stripping and draining grooves 48.

In the construction shown in FIGS. 10 and 11 the clamping pistons 18 do not directly act on the adjustable housings consisting of two sleeves 3, 3a but two stirrups 49 are provided at the top and bottom, respectively. One end of the stirrups 49, which embrace the adjustable housing on the connecting rod-side over an angle of more than 90°, is affixed to the forging box 4 for limited pivotal movement, whereas the clamping piston 18 applies pulsating pressure to the other end. Eccentric rings 50 are arranged between the stirrups 49 and the inner housing sleeve 3a and rotate with the outer housing sleeve 3 because they are coupled by a key 51, inserted in a radial groove, to a ring 52 screwed to the outer housing or at the bottom to the gear 5. As a result, the stirrups 49 apply pressure through the eccentric rings 50 to the inner housing sleeve 3a. Owing to the eccentric shape of the ring the adjusting movement of the sleeve 3a relative to the stirrups 49 is compensated and the latter need not change their position.

The adjustable housing 3 or the sleeves 3, 3a or the rings 42 and 43, 44 may have sheet metal bands. A part of such a band 53 is shown in FIGS. 12–14. This band has two sets of grooves consisting of closely spaced (about 2 mm.), narrow grooves 54 at an angle of 45° and oppositely inclined wider grooves 55 having a wider spacing (about 6 mm.). The grooves promote a quick running down of the film of lubricating film to increase the friction.

I claim:

1. A forging machine which comprises, in combination, a forging box; a plurality of cylindrical housings mounted for rotary adjustment in said forging box; an eccentric shaft eccentrically mounted in each of said housing; a plurality of connecting rods, said rods each constituting a hammer arranged to be driven by a respective one of said shafts to perform hammer blows in a predetermined direction, each of said housings having a clamping piston associated therewith, said clamping pistons being mounted in said forging box and movable in the direction of the blows of the associated hammer; means energizing said pistons during each of said hammer blows to force the associated housing against said forging box, whereby the

friction between said housing and said forging box is increased, and releasing said pistons intermediate said blows; and friction surface means interposed between each of said housings and said forging box, said friction surface means providing an area of frictional engagement between said housing and said box larger than the radial projection of said area on the forging box.

2. A forging machine as set forth in claim 1 wherein said friction surface means includes a wedge shaped annular rib on each of said housings and a plurality of ribs on said forging box, the ribs on said housings interengaging the ribs on said forging box.

3. A forging machine as set forth in claim 1, wherein said friction surface means includes a plurality of first rings respectively secured on each of said plurality of housings against rotation about the axis of the respective housing, and movable thereon in a plane substantially perpendicular to said axis; and rotatable with said housing relative to said forging box; and a plurality of second rings each secured on said forging box against rotation relative to the axis of an associated one of said housings and movable on said box in a plane substantially perpendicular to the latter axis, each of said second rings having a cylindrical portion interposed between a respective one of said first rings and the respective housing, whereby an enlarged friction area between said housing and said forging box is provided.

4. A forging machine as set forth in claim 1, wherein said friction surface means includes an outer sleeve member carried by each of said housings, and an inner sleeve member eccentrically mounted in each outer sleeve member and secured on said forging box against rotation relative to the axis of the associated housing, said inner sleeve member constituting bearing means for said eccentric shaft.

5. A forging machine as set forth in claim 4, further comprising a guide member fixedly mounted on said forging box; and a radial extension on one of said inner sleeve members, said guide member movably and pivotably engaging said extension.

6. A forging machine as set forth in claim 4, further comprising a plurality of stirrup means each embracing a respective one of said inner sleeve members over an angle of at least 90°, said stirrup means being radially spaced from the axis of the associated housing in said predetermined direction; and an eccentric ring member secured against rotation on each of said outer sleeve members and interposed between respective ones of said inner sleeve members and said stirrup means.

7. A forging machine as set forth in claim 4, further comprising a plurality of bearing faces on said forging box, said friction surface means including a member in frictional engagement with and rotatable relative to said bearing faces, each of said bearing faces being associated with one of said clamping pistons and having a portion diametrically opposite said piston and formed with a recess free of said member of said friction surface means.

8. A forging machine as set forth in claim 7, wherein said portion is formed with oil draining grooves adjacent said recess.

9. A forging machine as set forth in claim 1, wherein said forging box and one of said housings have mutually engaging bearing surfaces, at least one of said bearing surfaces being constituted by a band having a first set of relatively closely spaced and relatively narrow elongated grooves inclined obliquely to a vertical direction, and a second set of relatively widely spaced and relatively wide grooves angularly intersecting said first set.

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