Aug. 1, 1961 H. ROBRA ET AL 2,994,303

HYDRAULIC PRESSES WITH VALVES OPERATED BY SERVO-MOTORS

Filed April 16, 1958

5 Sheets-Sheet 1

FIG. 2

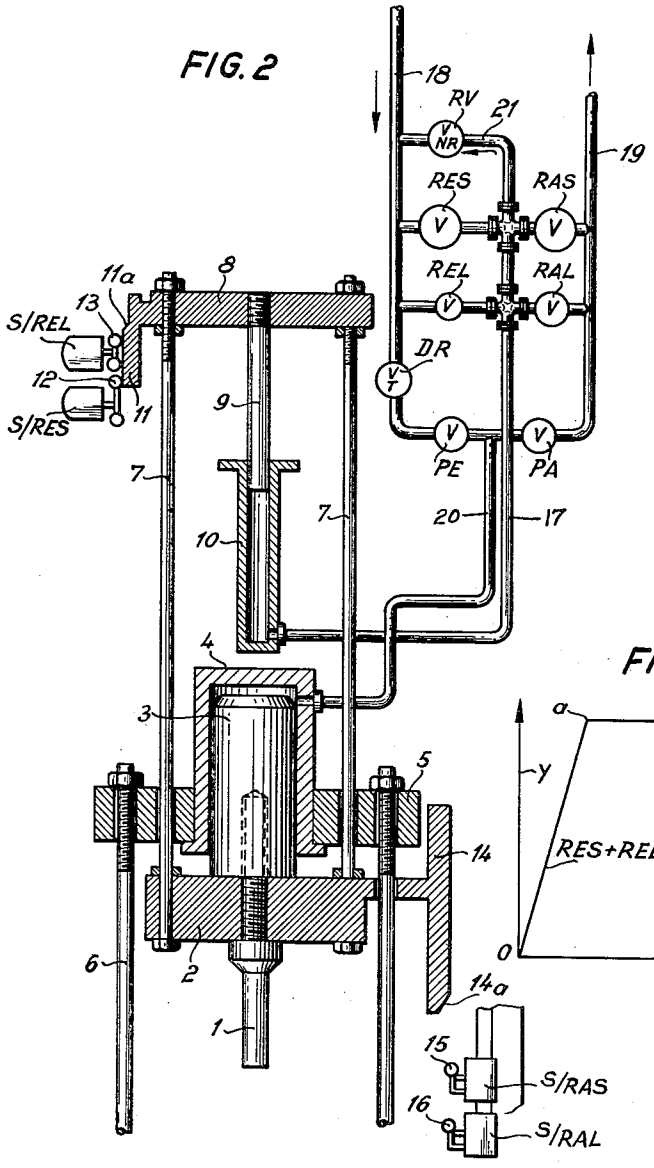
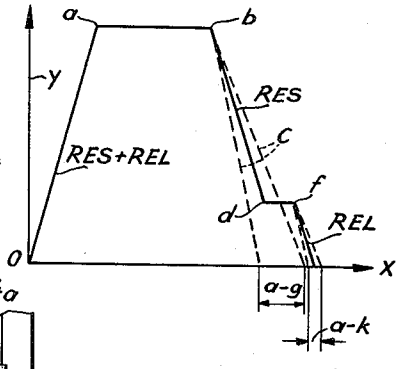


FIG. 1



INVENTORS

H. Robra

P. Billen

M. Arenz

By Glascock Downing Seebold

ATTYS.

Aug. 1, 1961 H. ROBRA ET AL 2,994,303

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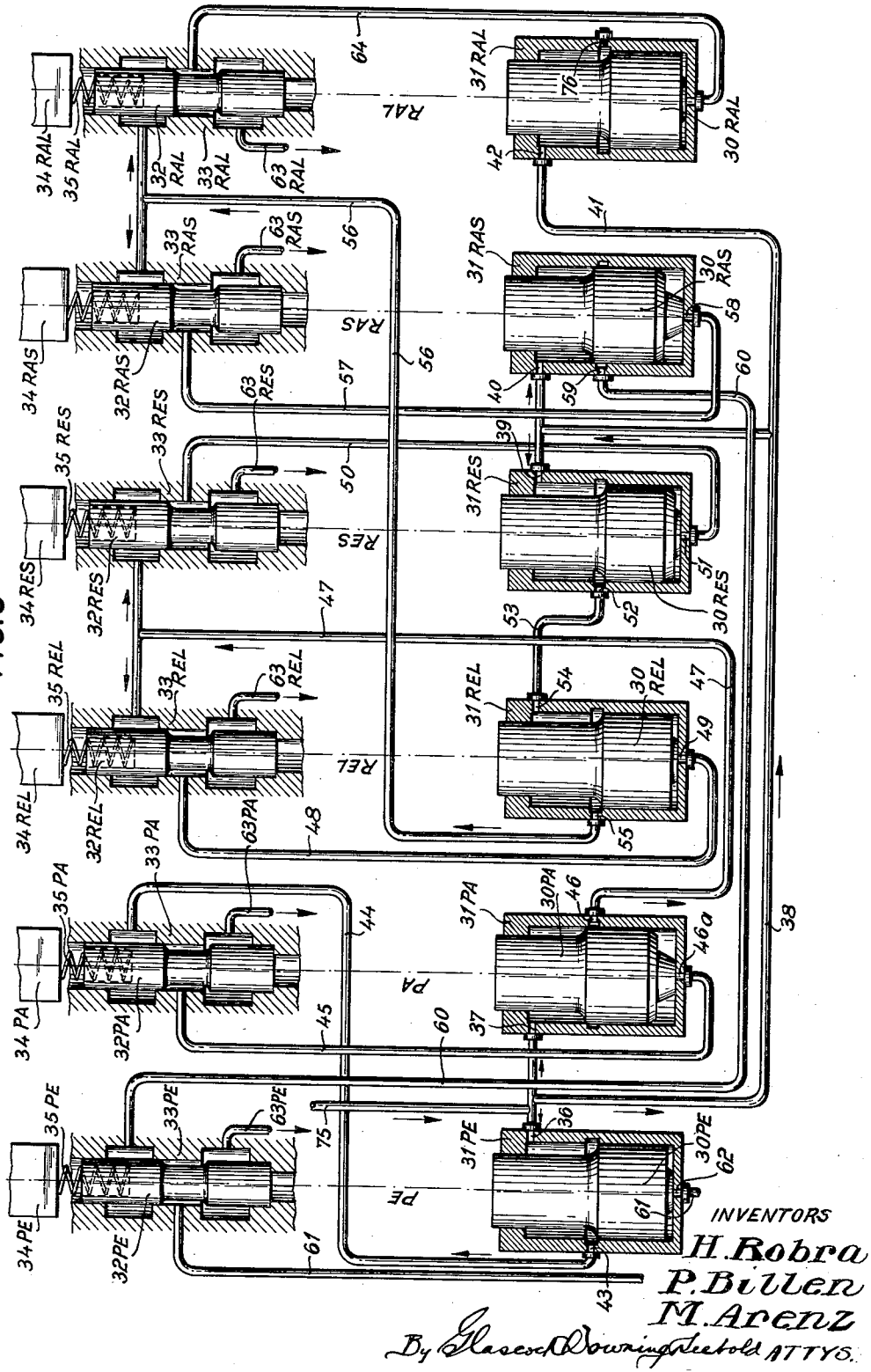


FIG. 3

INVENTORS
H. Robra
P. Biller
M. Arenz
By Glascock Downing & Seebold ATTYS.

Aug. 1, 1961 H. ROBRA ET AL 2,994,303

HYDRAULIC PRESSES WITH VALVES OPERATED BY SERVO-MOTORS

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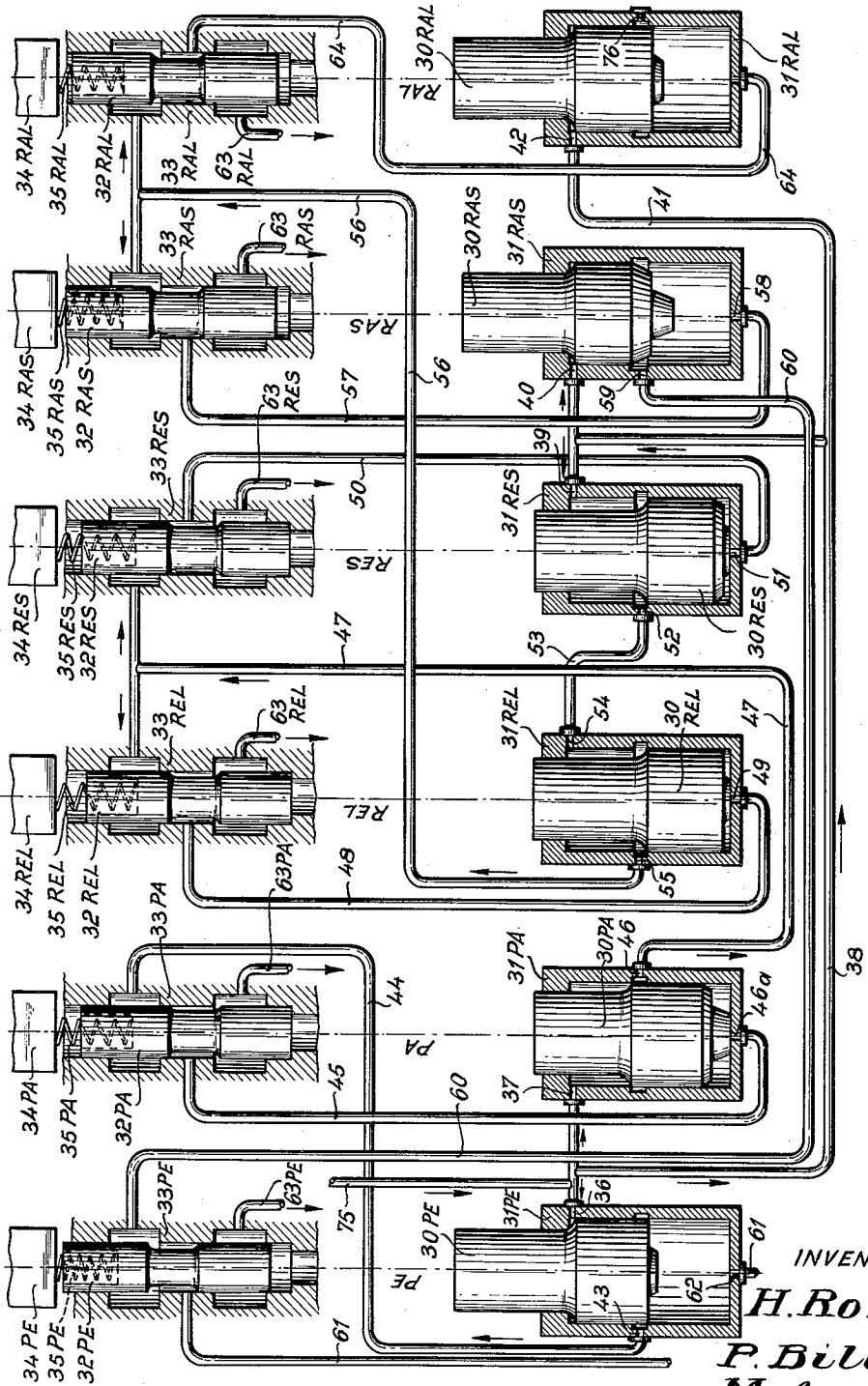


FIG. 4

INVENTORS
H. Robra
P. Billen
M. Arenz
By Glascock Downing Seebold
ATTYS

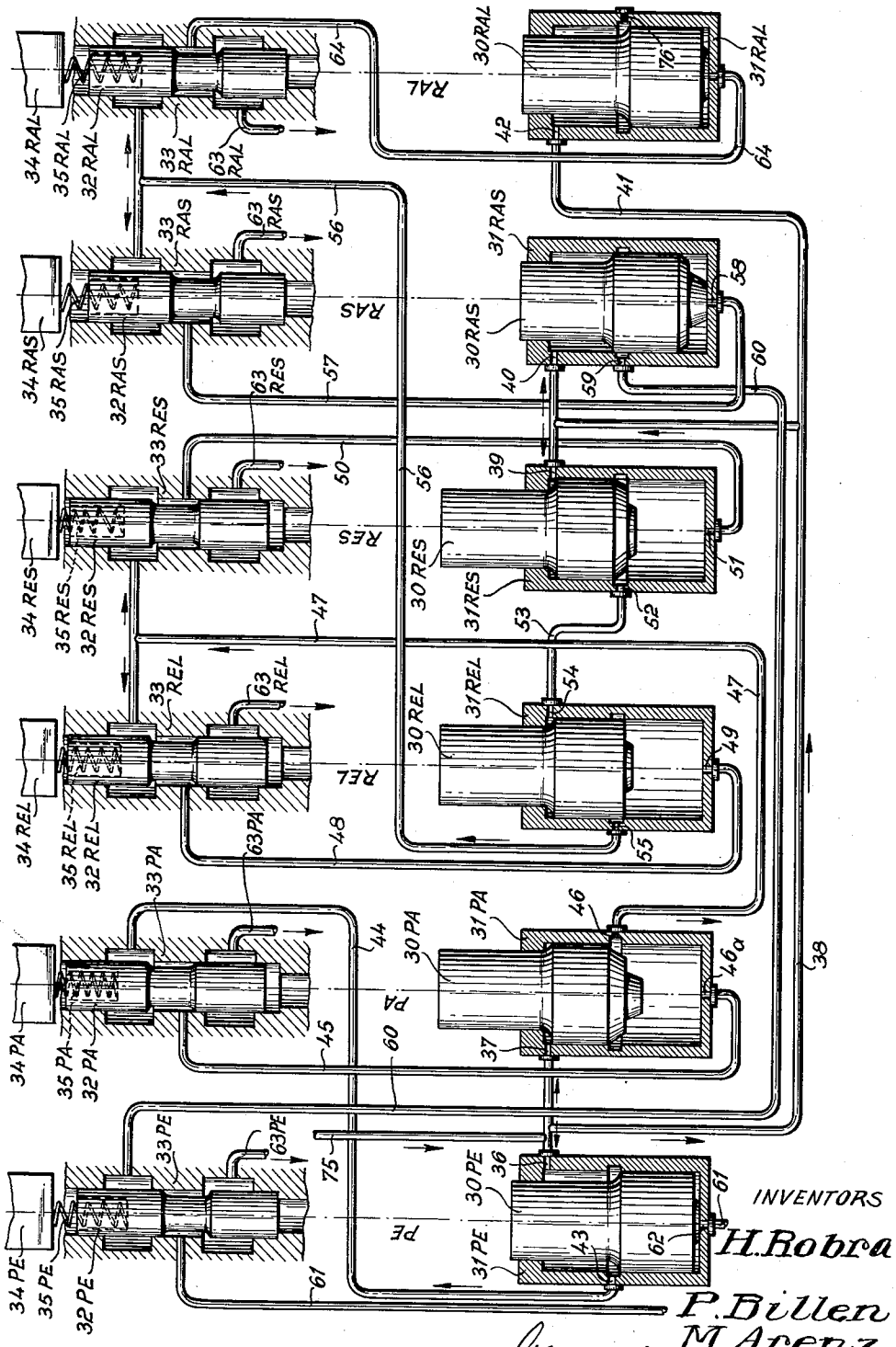
Aug. 1, 1961 H. ROBRA ET AL 2,994,303

HYDRAULIC PRESSES WITH VALVES OPERATED BY SERVO-MOTORS

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FIG. 5



INVENTORS

H. Robra

P. Billen

M. Arenz

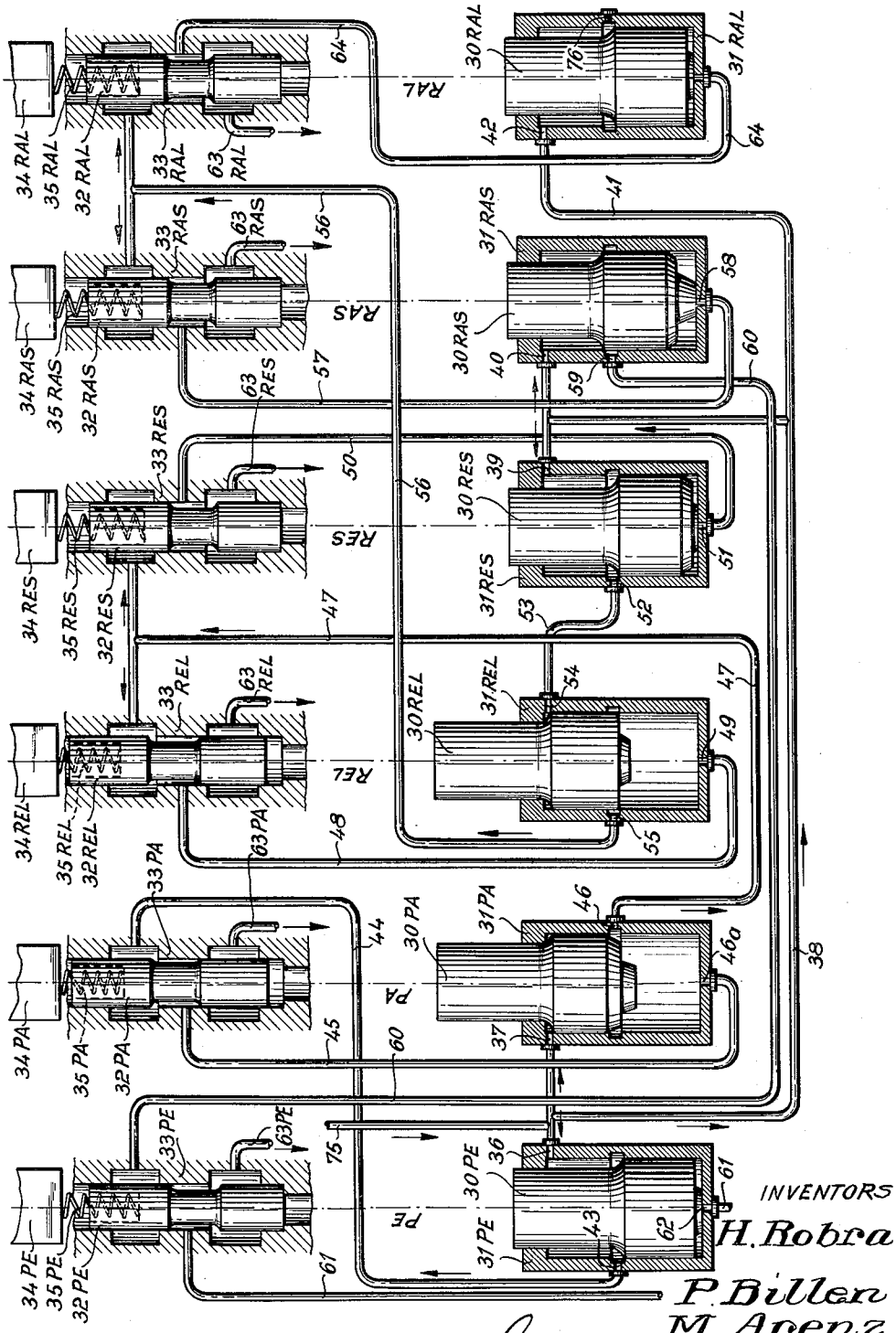
By Glascock Downing Seebold

ATTYS

Aug. 1, 1961 H. ROBRA ET AL 2,994,303

HYDRAULIC PRESSES WITH VALVES OPERATED BY SERVO-MOTORS

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F/G. 6

INVENTORS
H. Robra
P. Billen
M. Arenz
By Glascock Downing & Seebold
ATTYS

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2,994,303

HYDRAULIC PRESSES WITH VALVES OPERATED BY SERVO-MOTORS

Helmut Robra, Mulheim (Ruhr), Peter Billen, Leverkusen-Kuppersteg, and Matthias Arenz, Dusseldorf-Lintorf, Germany, assignors to Schloemann Aktiengesellschaft, Dusseldorf, Germany

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Claims priority, application Germany Apr. 20, 1957
7 Claims. (Cl. 121—38)

It is continually being required nowadays of hydraulic presses that their movements should be faster. For this purpose their valves have to be given comparatively large cross-sectional areas. In particular, if the valves are to be opened or closed automatically by servo-motors in dependence upon the particular press position reached, rapid valve opening and closing movements are requisite for the attainment of definite end positions of the press. The controlling of the servo-motors in dependence upon the particular press position reached is preferably effected, by electrical or mechanical or hydraulic means, by the co-operation of stationary abutments with abutments that follow the movements of the press.

Since however the resistances that oppose the movement of the press are not always of the same magnitude, a controlling impulse released by the co-operation of stationary and movable abutments as the press passes through a definite position may not produce a stoppage at the exact point required. The stoppage is effected instead wthin a comparatively large range of uncertainty, which, for many kinds of work, is greater than is desirable. This range of uncertainty might be reduced by diminishing the cross-sectional areas of the valves, but this would have the disadvantage of resulting in very low press speeds.

The invention obviates this great range of uncertainty, without relinquishing high press speeds, and it consists in the feature that in parallel with the main withdrawal admission valve a withdrawal admission valve of smaller cross-sectional area is connected, and in parallel with the main withdrawal outlet valve a withdrawal outlet valve of smaller cross-sectional area is connected. Each of these valves has its own servo-motor, controlled by stationary and movable abutments, which close the smaller valve in each case later than the valve of larger cross-sectional area. With correspondingly small dimensioning of the cross section of the small valve, the range of uncertainty can be reduced to approximately zero, so that in this way the desired end point of the movement of the press is reliably maintained. The proportions may for example be so selected that the cross-sectional area of the small valve amounts to about from 1/50 to 1/200 of the cross-sectional area of the large valve.

The distribution of the admission and the discharge between two unequal and differently controlled valves does however bring with it a risk of faulty controls, which must be avoided in order always to solve the said problem with certainty. The invention therefore also relates to means for obviating such faulty controls, consisting particularly in arranging locking means on press valves, which are releasable only in definite positions of other press valves. In order to prevent the withdrawal outlet being opened before the supply of water under pressure is shut off, the two valves of the withdrawal outlet are each provided with locking means preventing opening thereof except when both the admission valves are completely closed. The withdrawal admission valves in their turn may correspondingly be capable of being locked in dependence upon the outlet valves.

If the invention is applied to presses with hydraulic servo-motors which are controlled by way of hydraulic

control members, control slide valves for example, and by the pistons and cylinders of which the supply of pressure liquid to other servo-motor control slide valves can be shut off, then the pressure liquid for the control slide valves of the outlet servo-motors is preferably supplied by way of the cylinders of the two admission servo-motors. The same applies conversely to the supplying of the pressure liquid to the control slide valves of the admission servo-motors.

In order to attain the result that the valves of large cross-sectional area open earlier than the valves of small cross-sectional area connected in parallel with them, the controlling means is preferably so designed that the pressure liquid passes first through the cylinder of that servo-motor which opens the valve of large cross-sectional area, and then through the cylinder of that servo-motor which opens the valve of smaller cross-sectional area. A non-return valve may be provided to permit water to be returned from the withdrawal cylinder to the pressure pipe in the event of pressure water being admitted to the press cylinder at a time when the withdrawal outlet valves are closed. The need for this may be obviated by the servo-motor of a withdrawal outlet valve preventing admission of pressure water to the press cylinder whenever the withdrawal outlet valve is closed, even if the controlling slide valve of the press cylinder is open.

This arrangement is provided in the constructional example hereinunder described, although in the constructional example a non-return valve RV is shown.

In the accompanying drawings FIGURE 1 is a diagrammatic representation of the controlling operation attained according to the invention;

FIGURE 2 is a diagrammatic representation of a press-control means according to the invention; and

FIGURES 3 to 6 are diagrammatic representations of the servo-motors and of the control slide valves for the individual servo-motors in various operative positions, namely:

FIGURE 3 in the control position "Halt;"

FIGURE 4 in the control position "Press;"

FIGURE 5 in the control position "Quick withdrawal;" and

FIGURE 6 in the control position "Slow withdrawal."

The individual press valves, to each of which one servo-motor and one control slide valve according to the FIGURES 3 to 6 pertains, may be constructed in the same way as the valves of a prior patent application Serial No. 710,320 of the same applicants, filed on January 21, 1958, and claiming the priority of January 30, 1957.

In FIGURE 2, an extrusion press is diagrammatically illustrated. The invention also relates however to other presses, for instance to forging presses and to swaging presses.

A press ram **1** is rigidly connected with a cross-bar **2** and with a press plunger **3**, which is movable in a working cylinder **4**. The cylinder **4** is rigidly connected with a stationary cross-bar **5** which is connected by anchoring rods **6** with a counter-holder, not shown. The counter-holder or bolster holds a container, out of which extrusion material is to be extruded by means of the press ram **1**, for the purpose of producing a rod, a tube or the like. The cross-bar **2** is rigidly connected by way of rods **7** with a withdrawal cross-bar **8**, which carries a withdrawal piston **9**, which extends into a stationary withdrawal cylinder **10**. The additional cross-bar **8** carries an abutment in the form of a control bar **11**, with an inclined surface or ramp **11a**, which serves to actuate in succession, towards the end of the return stroke of the cross-bar **8**, stationary abutments in the form of switch cams **12** and **13**. The switch cam **12** opens in its turn a switch S/RES, and thereby serves to close the

withdrawal admission valve RES. The switch cam **13**, on the other hand, actuates a switch S/REL, which serves to close the withdrawal admission valve REL. These two withdrawal admission valves, as their name implies, admit water to the withdrawal cylinder **10** for the return stroke of the ram, but the cross-sectional area of the valve REL amounts to a fraction, for instance one-hundredth part, of the cross-sectional area of the valve RES, so that by the closing of the large valve RES while the valve REL remains open, the withdrawal movement is greatly slowed down.

The cross-bar **2** carries another abutment in the form of a control bar **14**, which has an inclined surface or ramp **14***a*, and with it can act, towards the end of the extrusion stroke, upon stationary abutments in the form of switch cams **15** and **16**, for the purpose of opening switches S/RAS and S/RAL. These switches control two withdrawal outlet valves, one of which, RAS, is of large cross-sectional area, while the other, RAL, is of quite small cross-sectional area, for exhausting water from the cylinder **10**.

Into the withdrawal cylinder **10** leads a pressure pipe **17**, which can be connected, by way of the pipe RES, with a pressure pipe **18** coming from a hydraulic accumulator or some other source of pressure. In parallel with the valve RES, which is of large cross-sectional area, is connected, between the pipes **17** and **18**, the valve REL, which is of small cross-sectional area. Between a waste-water pipe **19** and the pressure pipe **17** are connected in parallel with one another the two valves RAS, of large cross-sectional area, and RAL, of small cross-sectional area.

The press admission valve PE is located between a pipe **20** leading to the working cylinder **3** and the pressure-supply pipe **18**; whilst the press outlet valve PA is located between the pipe **20** and the waste-water pipe **19**. The valves RES and REL can be by-passed by a by-pass pipe **21**, with a non-return valve RV, which connects the pipe **17** with the pipe **18** in such a way that liquid under pressure can be forced back out of the pipe **17** into the pressure-supply pipe **18** when pressure liquid is introduced into the working cylinder **4** with the valves RES and REL closed. Since the piston **3** in the working cylinder **4** is of much greater cross-sectional area than the piston **9** in the withdrawal cylinder **10**, the piston **3** is of course able, when it is supplied with pressure liquid, to draw the withdrawal piston **9** along with it, in which case the piston **9** then pushes the pressure liquid out of the withdrawal cylinder **10**, through the pipe **17** and through the non-return valve RV, into the pressure pipe **18**. By DR is denoted a throttle valve for adjusting the working speed of the press.

The import of the parallel-connected valves RES and REL for the withdrawal movement, and RAS and RAL for the forward movement, will be understood by reference to the diagram in FIGURE 1. On the abscissa axis *x* are marked distances which the press traverses, while on the ordinate axis *y*, speeds are marked. If at the zero point the two parallel-connected withdrawal admission valves RES and REL are opened, the press moves in the withdrawal direction with gradually increasing speed, as the valves open, and the hydraulic pressure overcomes the inertia of the moving parts. Next the press moves along the path from the point *a* to the point *b* at a constant speed, while both these valves are fully opened. Now if both the inlet valves RES and REL were closed at the point *b*, or if only a single large withdrawal admission valve was provided at all, the press would come to a standstill after a short travel. The point at which the press would in fact come to a standstill admits however of being only inexactly determined, owing to the frictional resistances of the press. It would lie within a range of uncertainty which is indicated by the two dotted straight lines *c*, which intercept underneath, on the abscissa axis *x*, the distance *a–g*. This range of uncertainty is so large that for many kinds of work it cannot be used, particularly in the case of a semi-automatic or fully automatic press, for the movement of which the same starting points must always be given. A procedure is therefore adopted such that after reaching the point *b*, only the withdrawal admission valve of large cross-sectional area RES is closed. The closing movement is represented by the straight line marked RES, when the speed dies away in the manner indicated, though the line representing the closing movement may be located in any other position between the two dotted lines *c*. After reaching the point *d*, since the large valve RES is now completely closed, the press will execute only a slow further movement, represented by the horizontal straight line joining the point *d* to the point *f*, since now only the admission valve of small cross-sectional area, namely REL, is still opened. The control is so arranged that, at the point *f*, the valve REL is also closed, by the switch S/REL. Obviously, even after the closing of the valve REL, the ultimate position of the press is located within a certain range of uncertainty, but this range of uncertainty is kept vanishingly small if the difference between the cross-sectional areas of the valves RES and REL is great, for instance if the areas are in a ratio ranging from 50:1 to 200:1. As will be clear from FIGURE 2, during the movement of the press, the valve of large cross-sectional area RAS or RES is on each occasion closed first, whereas the associated valve RAL or REL of small cross-sectional area is closed subsequently. With the opening of the valves the reverse is the case; but the arrangement might alternatively be made such, according to the diagrammatic representation of FIGURE 1, that the associated valves RES and REL for instance are opened at the same time.

FIGURES 3 to 6 further illustrate the invention. In each of these figures, at the bottom are represented the servo-motors, the pistons of which, during their ascent, fully open the associated valves, not shown, and permit the valves, during their down-strokes, to close. At the top, in each of the FIGURES 3 to 6, are shown the associated control slide valves. Right over on the left are shown the control members for the press admission valve PE. Then, in order from left to right, are the control members for the press outlet valve PA, for the withdrawal admission valve REL of small cross section, for the withdrawal admission valve RES of large cross section, for the withdrawal admission valve RES of large cross section, for the withdrawal outlet valve of large cross section RAS, and for the withdrawal outlet valve RAL of small cross section. The control pistons of the servo-motors are each marked **30**, with the associated index PE, PA and so forth. Each of the control pistons **30** is slidable in a control cylinder **31**, with one of the indices PE etc. The projections at the lower ends of the servo-motor pistons serve to fix the lowest position of each piston. They are of course so constructed that they do not close the bottom aperture of the cylinder. They may fr insance be formed with a transverse groove, not shown, on the under side. To each servo-motor **30**, **31**, pertains a slide-valve control, consisting essentially of a piston valve **32** and a piston-valve casing **33**, together with a magnet **34**, which is capable of lifting the slide-valve piston **32** against the action of a spring **35**. When the magnet **34** is de-energised, the piston valve **32** sinks back into the position shown in FIGURE 3. The magnets **34** are influenced by the switches S/RES, S/REL, S/RAS and S/RAL, and also by two further switches, not shown, for the press admission and outlet valves PA and PE.

The pressure liquid for the controlling means is supplied through the pipe **75**. From here it can enter through an aperture **36** into the servo-motor cylinder **31PE**, and through an aperture **37** into the servo-motor cylinder **31PA**. The pressure liquid from the pipe **75** can furthermore enter through the pipe **38** into the apertures

39 and 40 of the control cylinders 31RES and 31RAS, and also through the pipe 41 into the aperture 42 of the control cylinder 31RAL. The aperture 76 of the cylinder 31RAL is permanently shut off. In the position as illustrated in FIGURE 3 of the servo-motor piston 30PE, pressure liquid flows out again through the aperture 43, and is supplied through a pipe 44 to the piston valve 32PA. In the position shown, the further path for the pressure liquid is now closed by the piston 32PA. If however the piston 32PA were to be raised by exciting the magnet 34PA, the pressure liquid could enter through the pipe 45 into the lower aperture 46*a* of the servo-motor cylinder 31PA, and would raise the piston 30PA, by means of which the press outlet valve PA is opened. After the piston 30PA has reached its uppermost position, the path for the pressure liquid through the aperture 46 is set free, so that the pressure liquid can penetrate then by way of the pipe 47 to the two control slide-valve casings 33REL and 33RES. If the valve piston 32REL is raised by exciting the magnet 34 REL, the pressure liquid could then flow out of the control casing 33REL and through the pipe 48 to the lower aperture 49 of the servo-motor cylinder 31REL, so that the servo-motor piston 30REL would tend to open the withdrawal admission valve REL with the small aperture. If the control piston 32RES was raised by exciting the magnet 34RES, the pressure liquid supplied through the pipe 47 would flow through the pipe 50 and would pass through the aperture 51 below into the servo-motor cylinder 31RES, so that the latter would now open the withdrawal admission valve RES of large cross-sectional area of flow.

With simultaneous raising of the slide valves 32REL and 32RES, however, the pressure liquid that tends to escape at 54 from the cylinder 31REL cannot escape through the aperture 52 after the servo-motor piston 30RES has begun to ascend until the piston 30RES is in its uppermost position. From there the liquid is discharged by way of the aperture 51 of the cylinder 31RES and the control slide valve 32RES into the pressure oil pipe 47. As long as the servo-motor piston 30REL is in the lower position shown in FIGURE 3, pressure liquid can flow through the aperture 55 and the pipe 56 to the two control appliances for the withdrawal outlet, which consist of the control slide valves 32RAS and 32RAL, together with the control slide-valve casings 33RAS and 33RAL and the magnets 34RAS and 34RAL. So long as the control-valve pistons 32RAS and 32RAL remain in the position shown, the pressure liquid cannot flow further. If however the slide-valve piston 32RAS is raised by excitation of the magnet 34RAS, the control liquid flows through the pipe 57 and the aperture 58 into the servo-motor cylinder 31RAS, and thus raises the servo-motor piston 30RAS, so that the corresponding withdrawal outlet valve RAS is opened. After the withdrawal outlet valve RAS has been fully opened, pressure liquid can flow through the aperture 59 of the servo-motor cylinder 31RAS and can pass from here through the pipe 60 into the control cylinder 33PE of the press inlet. If the control piston 32PE is raised by exciting the magnet 34PE, pressure liquid can flow through the pipe 61 and the aperture 62 into the servo-motor cylinder 31PE, so that the press admission valve PE is raised, owing to the ascent of the servo-motor piston 30PE. A further flow of the pressure liquid is not possible, since the piston 30 PE, in its upper position, does not set free the aperture 43.

By 63PE, 63PA and so forth are denoted waste-water pipes, which can discharge control liquid from the casings 33PE, 33PA etc. of the control appliances into any convenient collecting tank.

FIGURE 3 shows the holding position, in which all the magnets 34 are switched off. It is an important feature that after all the magnets are switched off, all the servo-motor pistons 30 should be located in the lower

position, so that all the valves are closed. This involves that in the event of failure of current, all the valves are immediately closed, which is of considerable importance for the safety of a fully automatic or semi-automatic press control.

When pressing is to be effected, the magnet 34PE is energized by closing a switch not shown, and the magnets 34RAL and 34RAS are simultaneously energized by closing the switches S/RAS and S/RAL by hand. The piston valves 32PE, 32RAL and 32RAS are hereby simultaneously drawn upwards, as shown in FIGURE 4. Pressure liquid now passes from the pipes 75 and 38 through the ducts 39, 52, 54, 55, the pipe 56 and the control slide-valve casings 33RAS and 33RAL into the pipes 57 and 64, from which it passes through the apertures below the servo-motor pistons 30RAS and 30RAL, and thus opens the withdrawal outlet valves RAS and RAL. At the end of the stroke of the piston 30 RAS the path of the pressure liquid is set free by this means from the duct 59 to the pressure pipe 60 and through the valve casing 33PE and the pipe 61 to the duct 62, so that the pressure liquid now passes to the under side of the servo-motor piston 30PE, so that the latter is supplied with liquid in the valve-opening direction. At this point the valve PE opens, and the press works at a press speed adjustable by means of the throttle valve DR.

Towards the end of the extrusion, the valves RAS and RAL are closed by the action of the ramp 14*a* on the switch cams 15 and 16, while the valve PE may be closed by hand, and in a similar manner the valve PA is opened by means of a switch not shown, and the valves RES and REL are opened, as shown in FIGURE 5 by closing the switches S/RES and S/REL. Pressure liquid passes out of the pipe 75, through ducts 36 and 43 into the pipe 44, and upon the control slide valve 32PA being opened, passes by way of the pipe 45 and the duct 46*a* to the under side of the servo-piston 30PA. After the up stroke of the servo-motor piston 30PA, the duct 46 is set free. Pressure oil then passes through the pipe 47, the slide valves 32REL and 32RES, and the pipes 48 and 50, to the under side of the pistons 30REL and 30RES. These two pistons begin moving at the same time, until the piston 30RES overlaps the bore 52. The piston 30REL now stays in its intermediate position until the rear edge of the piston 30RES again uncovers the duct 52. The piston 30REL can then expel its oil from the withdrawal space by way of the duct 54, the pipe 53, the ducts 52 and 51 and the pipe 50, and by way of the slide valve 32RES into the pipe 47.

If the press is to be impelled to a definite holding point, the valve RES must be closed shortly before this holding point; and then impelling must be effected with the valve REL alone up to the holding point. In order to obtain this result, as shown in FIGURE 6, the magnet 34RES is switched off. This is effected automatically by the abutment 11 coming into contact with the switch S/RES, while the switch S/REL is still untouched (FIGURE 2). The control valve piston 32RES now descends, and the servo-motor piston 30RES consequently descends, that is to say, the withdrawal admission valve RES of large cross-sectional area closes. The servo-motor piston 30REL of the withdrawal admission valve of small cross-sectional area thereby receives pressure from above through the apertures 52 and 54 and the pipe 53, but cannot yet descend, since the space underneath the piston 30REL is not yet connected by the control-valve piston 32REL to the discharge 63REL. The press therefore continues to run at the low speed conditioned by the cross-sectional area of the valve REL, until the slide-valve piston 32REL, descends, owing to the control voltage of the magnet 34REL being switched off by actuation of the switch S/REL by the ramp 11*a* of the control bar 11 engaging the switch cam 13. The closing of the press outlet valve PA is effected preferably together with the closing of the withdrawal outlet

valve REL of small cross-sectional area, in order that the press may then be prepared for forward travel.

For the forward movement of the press in the direction of pressing with low pressure, the magnets 34RAS and 34RAL are excited by closing the switches S/RAS and S/RAL, this being effected by hand. The control slide-valve pistons 32RAS and 32RAL are thereby caused to ascend, that is to say, they permit the pressure oil to act by way of the servo-motor casings 31RES and 31REL upon the servo-motor pistons 30RAS and 30RAL. By this means these two pistons ascend simultaneously. The press now advances quickly, until the ramp 14*a* causes the switch cam 15 to act upon the switch S/RAS, and thereby switches off the magnet 34RAS. Consequently the control slide valve 32RAS quickly sinks down, so that the associated servo-motor piston 30RAS likewise descends, whereby the withdrawal outlet valve RAS of large cross-sectional area closes. The press then continues to advance, but only at a low speed, since only the magnet 34RAL is still receiving current, so that only the outlet valve RAL is still open. The press consequently travels slowly until the ramp 14*a* causes the switch cam 16 to open the switch S/RAL, and thereby de-energises the magnet 34, and thus also closes the withdrawal outlet valve RAL of small cross-sectional area.

This invention admits of being correspondingly adopted for adjusting movements of other press parts, for instance of the die-holder and the container of extrusion presses, and of the saddle and the table of forging presses. With these arrangements the admission is then provided with one valve of large and one of small cross-sectional area, and in this way the admission is finely controlled. In the main press drive according to the constructional example, however, the press outlet is finely controlled, since the inlet must admit alternately make-up water (idle motion) and pressure water. The speed of the press is thus regulated by the throttle valve DR.

What is claimed is:

1. A hydraulic press, comprising: a stationary hydraulic working cylinder, a press plunger slidable in the said cylinder, a press ram rigidly connected with the press plunger, a hydraulic withdrawal cylinder and a piston slidable therein for retracting the ram, a withdrawal admission valve of large cross-sectional area for admitting pressure water to the hydraulic withdrawal cylinder to retract the ram, a substantially smaller withdrawal admission valve in parallel with the said large withdrawal admission valve, a withdrawal outlet valve of large cross-sectional area for exhausting water from the said hydraulic withdrawal cylinder, a substantially smaller withdrawal outlet valve in parallel with the said large withdrawal outlet valve, four separate servo-motors for operating the said four withdrawal valves, control valves regulating the admission of pressure liquid to the servo-motors and co-operating fixed and movable abutments for actuating the said control valves and thereby so controlling the servo-motors that the smaller withdrawal outlet valve is closed later than the corresponding larger valve, whereas the smaller withdrawal admission valve is closed not sooner than the corresponding larger valve.

2. A hydraulic press as claimed in claim 1, further comprising: locking means preventing the opening of either of the withdrawal outlet valves except when both the withdrawal admission valves are completely closed.

3. A hydraulic press as claimed in claim 1, further comprising: hydraulic piston valves controlling the supply of pressure liquid to the servo-motors operating the withdrawal outlet valves, and means for conveying pressure liquid to the said piston valves from the cylinders of the two servo-motors operating the two withdrawal admission valves.

4. A hydraulic press as claimed in claim 3, wherein the means for conveying pressure liquid from the withdrawal admission servo-motor cylinders to the piston valves causes the pressure liquid from the cylinder of the servo-motor operating the larger withdrawal admission valve to pass through the cylinder of the servo-motor operating the smaller withdrawal admission valve on its way to the piston valves.

5. A hydraulic press as claimed in claim 1, further comprising a press outlet valve controlling the exhausting of water from the working cylinder, and means for simultaneously closing the said press outlet valve and the smaller withdrawal admission valve.

6. A hydraulic press as claimed in claim 5, further comprising: a press admission valve for admitting pressure water to the working cylinder, a press admission servo-motor for operating this press admission valve, and controlled by the servo-motor of the larger withdrawal outlet valve for preventing the press admission servo-motor opening the press admission valve so long as the said withdrawal outlet valve is not open.

7. A hydraulic press as claimed in claim 5, further comprising: a press outlet valve, and means controlled by the press outlet valve for locking the opening movement of the two servo-motors controlling the two withdrawal admission valves so long as the press outlet valve is not fully opened.

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