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(54) DEEP-DRAWING PRESS WITH HOLDING-DOWN DEVICE

(71) We, HERMANN ETSCHEID GmbH, Fernthal, D-5466 Neustadt/Wied, German Federal Republic a limited liability company organised under the laws of the German Federal Republic, a limited liability com-invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present inveltntion relates to a holding-down device on a deep-drawing press.

As is known, during deep-drawing particularly of heavy metal sheets, the holding-down of the sheet by the sheet holder is of very great importance for the quality of the workpiece. The application of the correct holding down force decides whether the workpiece afterwards comes out of the deep-drawing press smoothly and without folds or fractures at the drawing flange and in the deformation zone. Too great a holding-down force makes the reduction of the workpiece diameter, arising in the course of the deep-drawing, more difficult and therefore overstresses the deformation zone near the edge. Too low a holding-down force leads to the formation of folds.

Hitherto, steel springs in the form of helical springs and plate springs have been clamped between the press plate of the deep-drawing press and the sheet holder as a holding-down device. Rubber springs have also been used. All these springs have the disadvantage that their spring force increases relatively steeply in the course of the spring travel.

An optimum deep-drawing action is brought about only when the holding-down force is regulated in accordance with the material and tool and when this force remains constant during the entire deep-drawing process. This cannot be realized with steel or rubber springs, because their spring characteristic is ideal at only a single point in their travel, and the holding-down force exerted by such springs is too small over the travel ahead of this point and too great after the ideal point. If the springs were applied without bias, the holding-down force exerted by them would be equal to zero at the start of the deep-drawing process.

A further disadvantage of known holding-down devices consisting of spring elements is that the inherently short effective spring travel becomes even shorter as a consequence of the unavoidable bias. Because of such short spring travel, it is necessary to carry out the deep-drawing process in several operations unless flat workpieces are concerned.

In recognition of this state of affairs, there has been developed in recent years gas springs which display a flatter characteristic. Such a pneumatic holding-down device has become well known on the market. It consists of a number of piston-cylinders, the cylinder spaces of which communicate with a pressure medium container. The piston-cylinder and pressure container are filled with nitrogen under a pressure in the order of 100 bar. The total volume of all piston-cylinders is appreciably smaller than the volume of the pressure container associated therewith. Given this premise, plunging of all of the pistons into the piston cylinders produces only a relatively small alteration of the total pressure. When the piston-cylinders are mounted as holding-down devices between the press plate and the sheet holder, the gas resistance against the piston travel will remain nearly constant, provided that the container volume is sufficiently larger than the sum of the cylinder volumes. The characteristic of this known nitrogen spring element deviates only slightly from the optimum characteristic.

The very considerable pressure required outside the piston-cylinder is a particular difficulty with this system. The pressure container of large volume, as well as the pressure hoses leading from this container to the piston-cylinders, must for safety reasons be appropriately dimensioned and are then correspondingly expensive. Moreover, it is awkward and expensive for a works to have in stock a special supply of highly compressed nitrogen which has no other use in the works.

The operating theory of the known nitrogen gas spring is based on the Boyle-Mariotte law. This law, however, refers to a theoretical ideal gas and applies only with restrictions to an actual gas, such as nitrogen. A usable approximation presupposes, for example, that the gases under high pressure display a certain temperature, specific for each gas, the so-called Boyle temperature. For nitrogen, the Boyle temperature amounts to 56°C.

During the deep-drawing process, the temperature of the nitrogen present in a piston-cylinder will rapidly rise to very much higher values. The nitrogen disposed in the pressure container thereagainst remains at room temperature; due to the low thermal conductivity of the gas, the heat generated by the piston-cylinder cannot be transmitted to the nitrogen in the pressure container, because there is no flow in the closed system. The two Boyle-Mariotte volumes consequently operate at vastly different temperatures. The consequence is that the relationship of the volume of the pressure container to the volume of the piston-cylinders must be kept very large to ensure adherence to the Boyle-Mariotte law with adequate approximation.

Generally, for reasons of cost and safety, in practice a different approach is taken: the pressure container of the nitrogen gas spring elements is built into a so-called base plate, on which the spring elements are mounted as holding-down elements. By this measure, the cumbersome and expensive high-pressure hoses are avoided, but as a result there is an unfavourable volume ratio and a correspondingly greater deviation from the ideal characteristic. A further disadvantage is that the deep-drawing process with this arrangement can only take place from below to above, and therefore cannot be carried out with many presets.

According to the present invention there is provided a deep-drawing press comprising pressure applying means to apply a draw-pressing pressure to a metal blank to be deep drawn and provided with a holding-down device to hold down the blank, the holding-down device comprising a pressure chamber, which—in use—contains hydraulic fluid and which communicates through an adjustable flow-regulating valve and a compensating valve with a closed compensating chamber, which—in use—contains hydraulic fluid and gas and is disposed under substantially constant pressure, the regulating valve being arranged to so allow a regulable flow of hydraulic fluid from the pressure chamber to the compensating chamber and the compensating valve being arranged to so allow a flow of the fluid from the compensating chamber back into the pressure chamber that the pressure in the pressure chamber is maintained substantially constant, and a pressure element which in use rigidly engages the pressure applying means and is disposed on the same side of the blank as the pressure chamber, the pressure element being actuable by the pressure applying means to transmit part of the draw-pressing pressure through the fluid in the pressure chamber as a holding-down force for holding down the blank. Such a holding-down device may be simple constructionally and to operate and require no great expenditures. The holding-down device, may during the entire deep-drawing travel, exert a holding-down force which constantly remains equal and regulable in simple manner, and the device may be capable of managing a precisely metered holding-down of the edge of the blank even with deep workpieces without stepwise interruption of the deep-drawing process. Apart from the press pressure, the holding-down device can use as a pressure source the compressed air plant of the works; when such is not available, the holding-down device can even manage without. In a special embodiment suitable for rapid mass production, the holding-down device can make a separate sheet or blank holder redundant.

Expediently, the compensating space is disposed in direct connection with a pressure generator, preferably with the compressed air plant of the works.

In a preferred embodiment, the holding-down device comprises several holding-down elements, which are settable up beside one another and which each comprise a cylindrical housing, which contains a central cylindrical chamber and a compensating chamber arranged co-axially therewith and having the shape of a cylindrical shell, closed off by a lid to be pressure tight, and in the central pressure chamber of which plunges a pressure piston resting on the hydraulic fluid, the annular gas-containing part of the compensating space being connected through a pressure hose with a compressed air plant.

The regulating valve connecting the pressure chamber with the compensating chamber can be screwed into a radial bore, formed in the base of the housing and partly provided with thread, and can be constructed as a needle-shaped valve, which is arranged to be longitudinally displaceable by means of a regulating handle disposed at the outside wall of the housing, the radial bore connecting a bore present in the housing base of the central pressure chamber to a bore present in the housing base of the compensating chamber.

The compensating valve, which can be screwed into the housing base of the compensating chamber, can open out into a radial bore formed in the base of the housing and can be connected to the pressure chamber through this radial bore and through a bore substantially parallel to the axis of the pressure chamber in the base of that chamber, the radial bore being sealed off outwardly to be pressure-tight by a stuffing bush capable of being screwed in. Similarly, an excess pressure valve, which is screwed into the housing base of the compensating chamber, can open out into a radial bore, which is present in the housing base, is sealed off outwardly to be pressure-tight by means of a stuffing bush, and which is connected with a bore arranged in the central pressure chamber.

For the purpose of the fastening of the holding-down element to the blank or sheet holder, a fastening stub provided with a thread can be formed at the outside of the housing base.

In a particularly advantageous embodiment, the holding-down device is constructed as a blank or sheet holder to be laid directly on the blank, in that the housing displays a central, continuous cylindrical base, which is provided for the passage of a drawing die of the press and around which a pressure and a compensating chamber, having the shape of cylindrical shells and equipped with a common annular bottom and a common annular housing lid, are co-axially arranged and connetced with one another through a regulable reducing valve, a compensating valve and an excess pressure valve, wherein a pressure piston, having the shape of a cylindrical shell and sealed off to be pressure-tight by means of sealing rings, plunges into the inner pressure chamber and rests on the hydraulic fluid filling, while a gas space is present above the hydraulic fluid disposed in the outer compensating chamber.

Finally, a sealing plug can be screwed in place of the hose stub into the threaded bore leading to the gas filled part of the compensating chamber.

Embodiments of the present invention will now be more particularly described by way of example with reference to the accompanying drawings, in which:

Fig. 1 a schematic diagram comparing the characteristics of known spring type holding-down devices with the ideal characteristic of a holding-down force;

Fig. 2 is a perspective view of a holding-down element of a holding down device in a deep-drawing press according to a first embodiment of the invention;

Fig. 3 is a cross-section on the line X—X of Fig. 2;

Fig. 4 is a cross-section on the line Y—Y of Fig. 2;

Fig. 5 is a cross-section, on the line Z—Z of Fig. 6, of a holding-down device assembled from holding-down elements of Figs. 1 to 3;

Fig. 6 is a side elevation of the holding-down device of Fig. 5 set up under a press plate and on a drawing matrix of the press;

Fig. 7 is a side elevation of a holding-down element of a holding-down device of a deep-drawing press according to a second embodiment of the invention;

Fig. 8 is a cross-section on the line U—U of Fig. 7; and

Fig. 9 is a partly sectioned side elevation of a holding-down device of a deep-drawing press according to a third embodiment of the invention.

Referring now to the drawings, in Fig. 1 the line I running parallel to the abscissa represents the ideal characteristic of a holding-down force P in a given deep-drawing process. The holding-down force P remains constant over the entire deep-drawing travel *s*. The known characteristics such as A and B of, respectively, the helical spring and plate spring employed as holding-down elements cut the ideal line I at points I_A and I_B, i.e., the holding-down elements concerned fulfil their tasks in optimum manner merely at these points. During the deep-drawing travel *s* of the drawing die into the drawing matrix, the spring forces of the helical spring (A) and plate spring (B) are not up to the set task of holding-down up to the attainment of the respective optimum point I_A and I_B; there is therefore a risk of fold formations at the drawing flange and at the deformation zone. After passing through the optimum point, the holding-down elements each exert a greater holding-down force than required. When the holding-down force increases too steeply, it obstructs the drawing of the blank to a smaller cross-section, with the consequence that the deformation zone at the matrix edge experiences too great a loading and suffers fractures.

Fig. 1 also shows the afore-described nitrogen gas spring element, which possesses an appreciably flatter spring characteristic, such as C, than the steel springs. However, also this spring element has an optimum holding-down function, i.e. one exactly corresponding to the task of the holding-down, only at the intersection point I_C.

The supremacy of the nitrogen spring elements relative to the conventional steel spring elements is apparent from Fig. 1. In relation to the earlier state of the art, the nitrogen spring element represent considerable progress. However, the fact remains that the characteristic of the nitrogen gas spring deviates not inappreciably from the ideal line, the inclination from the ideal line being about 10%, i.e., corresponding to an angle of about 6°, according to the journal "bänder bleche rohre", page 449/1974.

By contrast, a holding-down device embodying the invention has a holding-down force P, which remains constant over the entire deep-drawing travel *s* and which is steplessly settable and can thus be set to the most favourable P_I value.

In Figs. 2 to 4, there is shown a holding-down element which, with other such elements, forms a holding-down device, the element comprising a cylindrical housing 1 in which an inner cylindrical wall 3 is arranged co-axially with an outer cylindrical wall 2. The housing 1 is provided with a housing lid 4 with a central bore 5. The internal space of the housing 1 is divided up into an inner cylindrical pressure chamber 6 and an outer annular compensating chamber 7 having the shape of a cylindrical shell; c.f., Fig. 4 in particular. The housing lid 4 is sealed off to be pressure-tight against the ends of the walls 2 and 3 by means of sealing rings 8.

As shown in Fig. 3, hydraulic oil (Oe) is present in the chamber 6 as well as in the chamber 7, while an annular air space L is present above the oil level in the chamber.

A pressure piston 9 with a piston rod 10 plunges into the inner chamber 6. A fastening stub 11 provided with a helical thread can be formed at the lower part of the housing.

A threaded bore 12, into which is screwed a stub pipe 13 connected with a pressure hose 14 and sealed to be pressure-tight by a seal 15, is disposed at the upper part of the wall 2. The pressure hose 14 leads to a compressed air plant 16 of the works.

The base of the housing 1 has two radially extending valve bores 17 and 18. The valve bore 17 connects a vertical bore 19 of the chamber 7 with a vertical bore 20 of the chamber 6. The valve bore 17 is provided with a thread 21 between the wall 2 and the vertical bore 19. A reducing valve 22, constructed as a needle-shaped member, is screwed into the thread 21 and sealed to be pressure-tight by means of a seal 23. By rotation of a regulating knob 24, the passage cross-section of the valve bore 17, and thereby the speed of flow of the oil flowing therethrough, can be regulated. The speed of flow is decisive for the magnitude of the effective holding-down force, because the pressure in the chamber 6 depends on it.

The valve bore 18 is connected through a vertical bore 25 with the chamber 6 and through two further vertical bores with the chamber 7. The vertical bores 26 and 27 are provided with threads. Screwed into the vertical bore 26 is a compensating valve 28, which opens when the pressure in the chamber 7 exceeds the pressure prevailing in the chamber 6. The passage opening of the compensating valve 28 has a relatively large cross-section and allows the oil to pass through rapidly. The threaded bore 27 receives an excess pressure valve 29, the passage of which is directed into the opposite direction of pressure and is set to a maximum safe pressure referred to the chamber 6. The valve bore 18 is closed off outwardly to be pressure-tight by means of a closure screw 30 and a seal 31.

Figs. 5 and 6 show a number of such holding-down elements, which are mounted on an annular metal sheet or blank holder 32 and in their entirety form a holding-down device. A blank 34 to be processed is mounted between the holder 32 and a drawing matrix 33. A drawing die 35 with a die rod 36 rests on the blank 34, and a press plate 37 of the hydraulic drawing press (otherwise not shown) rests on the die rod 36 as well as on the piston push rods 10 of the holding-down elements. The valves 22 are set to a holding-down force appropriate to the blank concerned and the given deformation task.

When the press plate 37 urges the drawing die 35 and the piston push rods 10 of the holding-down elements downwardly, the pressure piston 9 in each holding-down element expels hydraulic oil out of the pressure chamber 6 though the regulable valve 22 and into the compensating chamber 7. The pressure arising in the chamber 6 is constant during the entire piston travel and proportional to the press pressure. The proportionality is determined by the setting of the valve 22; the more rapidly the oil flows away into the chamber 7, the smaller is the component of pressure which is exerted on the base of the housing and which acts as a holding-down force on the holder 32 and the edge of the blank.

The oil flowing into the chamber 7 effects a gradual rise of the oil level therein and a reduction in the annular air space L. In that case, the pressure remains unaltered because the air space L is connected with the compressed air system of the works. The pressure in the air space L, as indeed in the entire chamber 7, is therefore constantly equal to the pressure prevailing in the compressed air plant of the works, normally 8 to 15 bar. The height of this pressure is in itself without significance, it only having to remain substantially constant and preferably at least 2 bar, as shall be explained later.

The oil which flows out of the chamber 6 through the valve 22 and into the chamber 7 impinges in the latter chamber against a constant counter pressure and therefore has a constant speed of flow from the start to the end of the piston travel. The holding-down force in consequence remains constant during the entire deep-drawing process and has the characteristic I illustrated in Fig. 1. By setting of the valve 22, the optimum characteristic I_P for a particular deep drawing task and blank can be obtained.

When the deep-drawing pressure ceases after completion of the deep-drawing process, and the drawing die 35 as well as the piston push-rods 10 and pistons 9 move upwardly, the pressure in each chamber 6 falls abruptly to zero or is changed to an underpressure, while the pressure of the compressed air plant now prevails in the chamber 7. This pressure opens the compensating valve 28 and expels the oil suddenly out of the chamber 7 back into the chamber 6. The deep-drawing process can then be repeated from the beginning.

As already mentioned, the holding-down force is regulated by adjusting the press pressure transmitted by means of the valve 22 to the chamber 6 to a pressure corresponding to the desired holding-down force. As a setting value, a pressure value determined by a pressure gauge 38 can be used, the pressure gauge being connected by a pressure duct 381 with the chamber 6; c.f., Fig. 3. The illustration of Fig. 3 is, however, to be considered only as symbolic since in practice the manometer would more likely be connected with the valve bore 18, possibly by way of the plug 30. In any case, the pressure gauge 38 is preferably arranged in the proximity of the regulating knob 24.

Fig. 9 shows an integral holding-down device which also serves as a holder for the blank to be deep drawn, this embodiment being advantageous for mass production at a high operating speed. The device comprises a housing 101 containing a relatively large central, upwardly and downwardly open, cylindrical bore, which is defined by an inner cylindrical wall 301. A cylindrical shell pressure chamber 601 is disposed between the inner wall 301 on an intermediate wall 302, and an outer cylindrical shell compensating chamber 701 is disposed between the intermediate wall 302 and an outer wall 201. The chambers 601 and 701 have a common annular base 40 and the chamber 701 has an annular housing lid 401.

Analogously with the description of the embodiment of Figs. 2 to 6, disposed in the base 40 are radial bores 17 and 18, which in already previously described manner are connected with vertical bores 19, 26 and 27 in the base of the chamber 701 and with vertical bores 20 and 25 in the base of the chamber 601. Similarly, the radial bores 17 and 18 interconnect the chambers through a reducing valve 22, compensating valve 28 and excess pressure valve 29, as explained in detail in the description of the first embodiment.

A pressure piston 901, having the shape of a cylindrical shell and provided with sealing rings 41, plunges into the pressure chamber 601 and rests on the oil filling Oe of the pressure chamber. The compensating chamber 701 contains up to 50 to 70% of oil, and above the oil there is an air space L which is connected by means of a hose stub 13 and a pressure hose 14 with the compressed air plant 16 of the works. The pressure, usually 5 to 15 bar, present in the compressed air plant 16 constantly prevails in the compensating chamber 701.

The blank 34 is arranged between the drawing matrix 33 and the holding-down device, the holding-down device also serving as holder for the blank. The drawing die 35 with die rod 36, mounted in the open bore of the holding-down device, is set up on the blank 34. The press plate 37 rests on the die rod as well as on the edge of the pressure piston 901.

The manner of operation of this arrangement is analogous with that previously explained with reference to the Figs. 2 to 6, the principal basic difference being that the holding-down device comprises merely one holding-down element, which receives the drawing die and acts as a blank holder. The one-piece construction entails the advantage that the press plate, drawing die and holding-down device can be incorporated into one entity which enables rapid placing-on and lifting-off.

If the works does not posses a compressed air system, as makeshift the hose stub 13 can be replaced by a sealing plug (not shown). The annular air space L is then filled with compressed air at a pressure of at least 2 bar. This initial pressure is necessary so that adequate pressure is present towards the end of the deep-drawing process, in order to force the oil rapidly through the compensating valve 28 and into the pressure chamber 6 or 601. Otherwise, it is expedient to set the initial air pressure as low as possible in order to keep the spring action of the relatively small air mass within small limits.

In this particular case, a small spring effect, which influences the characteristic and imparts an inclination thereto will be present in the holding-down device. The following numerical example explains how large this inclination is: The flow taking place through the valve 22 is resisted by the counter-pressure prevailing in the compensating chamber 7 or 701. When the compensating chamber is connected to the compressed air plant of the works, the magnitude of the counter-pressure plays no part, since the pressure prevailing in the pressure chamber 6 or 601 is very much greater and the counter-pressure remains constant. When, however, an appreciable difference exists between initial counter-pressure and final counter-pressure, the speed of flow and thereby the resulting holding-down force is influenced.

When the volume of the annular air space L in the course of the piston travel is, for example, reduced to half, the compensating chamber 7 or 701 being substantially greater than the pressure chamber 6 or 601, and the initial counter-pressure, as previously stated, amounts to 2 bar, the final pressure rises to about 4 bar. A pressure difference between initial counter-pressure equal to 2 bar thus comes into being, i.e. a counter-force, which is greater than at the start by 0.08 kiloponds, act on the flow in in end phase of the deep-drawing process in the case of an effective flow cross-section of 4 square millimetres in the valve 22. The flow takes place under a pressure between 50 and 100 bar and in consequence generates a force between 2 and 4 kiloponds at the passage cross-section. The characteristics resulting from this form an angle of 1° and 2°, respectively, with the ideal line I of Fig. 1, corresponding to an inclination of 2% and 4%, respectively.

A weak spring effect, which is of a magnitude without significance in most deep-drawing process, is however acceptable. Nevertheless, it is to be emphasised that only in an exceptional case is such a compromise concerned, since most deep drawing plants are equipped with compressed air plants.

Contrary to the known holding-down elements of the steel spring type, the effectiveness of the holding-down element described in the embodiments of the present invention is not restricted to a limited length of draw, as this holding-down element can be adapted, in respect of length of the piston travel, to any deep-drawing depth performable in practice. Fig. 7 shows as an example an element of greater length than that of the holding-down element illustrated in Figs. 2 to 6, while Fig. 8 illustrates a cross-section of the element of Fig. 7. A desirable condition with such a slim construction is that the ratio of the volume of the compensating chamber 7 to that of the pressure chamber 6 should not fall below 4:1 (this ratio is 5:1 in the embodiment of Figs. 2 to 6, and 4:1 in the embodiment of Figs. 7 and 8).

In the use of the holding-down device illustrated in Figs. 5 and 6 with circularly round die and matrix cross-section, blank holders can be rapidly and effortlessly equipped for every feasible die outline with holding-down elements according to Figs. 2 to 4. If several workpieces are to be produced with such holders, the holder can be provided with threaded bores which exactly correspond to the outline, and the fastening stubs 11 of the holding-down elements can be screwed into these bores.

Hitherto, the maxim prevailed in expert circles of the deep-drawing technology that a holding-down device could be made up only of spring elements, and thus would inevitably have to be elastically yielding. The present invention, however, recognises that this maxim is in contradiction to the requirement of a holding-down force which is constant during the entire deep-drawing travel, because the characteristic of every spring, be it a steel or a gas spring, forms an angle with the co-ordinate axis of the spring travel; c.f. Fig. 1. This fact lies founded in the nature of the spring tension and cannot be altered by any technical artifice. The present invention provides an inelastic holding-down device in conscious departure from the prevailing expert opinion. The holding-down force is not transmitted by elastic members, but by inelastic hydraulic fluid columns, which in phase with the progressing drawing die become steplessly shorter, while constantly exerting the same pressure. This pressure is regulable and can be set appropriately to the material, the structure of the workpiece to be formed, and the press pressure. In this holding-down device, the holding-down force is contant during the entire deep-drawing travel (alternatively, the air space L is hermetically enclosed as a makeshift whereby a small deviation takes place), the holding-down force is regulable in a simple manner, and the device is simple constructionally and in operation and requires little effort in terms of costs. Compared with the holding-down devices provided by steel spring elements, a holding-down device embodying the present invention is much more accurate and enables practically all feasible deep-drawing processes to be performed in a single operation, i.e., without steps. The holding-down device can in all cases be employed for a deep-drawing from above to below as well as from below to above, and can be integrally structured and constructed as a blank holder centrally receiving the drawing die.

WHAT WE CLAIM IS:—

1. A deep-drawing press comprising pressure applying means to apply a draw-pressing pressure to a metal blank to be deep drawn and provided with a holding-down device to hold down the blank, the holding-down device comprising a pressure chamber, which—in use—contains hydraulic fluid and which communicates through an adjustable flow-regulating valve and a compensating valve with a closed compensating chamber, which—in use—contains hydraulic fluid and gas and is disposed under substantially constant pressure, the regulating valve being arranged to so allow a regulatable flow of hydraulic fluid from

the pressure chamber to the compensating chamber and the compensating valve being arranged to so allow a flow of the fluid from the compensating chamber back into the pressure chamber that the pressure in the pressure chamber is maintained substantially constant, and a pressure element which in use rigidly engages the pressure appplying means and is disposed on the same side of the blank as the pressure chamber, the pressure element being actuable by the pressure applying means to transmit part of the draw-pressing pressure through the fluid in the pressure chamber as a holding-down force for holding down the blank.

2. A deep-drawing press as claimed in claim 1, wherein the pressure applying means comprises a press plate, the pressure element of the holding-down device being actuable by the press plate.

3. A deep-drawing press as claimed in either claim 1 or claim 2, wherein the compensating chamber of the holding-down device is of annular cross-section and chambers of the device are arranged in a housing with the compensating chamber surrounding the pressure chamber.

4. A deep-drawing press as claimed in claim 3, wherein the regulating valve of the holding-down device comprises a valve member extending into a duct, which is arranged in a base of the housing and which interconnects the chambers.

5. A deep-drawing press as claimed in claim 4, wherein the duct comprises a bore extending radially of the compensating chamber, and two further bores each disposed below the radial bore and connecting the radial bore to a respective one of the pressure chamber and the compensating chamber.

6. A deep-drawing press as claimed in claim 5, wherein the valve member is threadedly engaged in the radial bore.

7. A deep-drawing press as claimed in either claim 5 or 6, wherein the valve member is adjustable externally of the housing for displacement longitudinally of the radial bore.

8. A deep-drawing press as claimed in any one of claims 4 to 7, wherein the valve member comprises a valve needle.

9. A deep-drawing press as claimed in any one of claims 3 to 8, wherein the compensating valve of the holding-down device comprises a respective valve unit, which is mounted on a portion of a base of the housing defining the floor of the compensating chamber and which communicates with the pressure chamber through a conduit in the base of the housing.

10. A deep-drawing press as claimed in claim 9, wherein the valve unit is threadedly engaged in said portion of the base of the housing.

11. A deep-drawing press as claimed in either claim 9 or claim 10, wherein the conduit communicating with the valve unit of the compensating valve comprises a bore extending radially of the compensating chamber, and a further bore arranged below the pressure chamber and extending substantially parallel to the axis of the compensating chamber to conect the radial bore to the pressure chamber.

12. A deep-drawing press as claimed in claim 11, comprising sealing means sealing the radial bore of the conduit at the radially outer end thereof to be pressure tight.

13. A deep-drawing press as claimed in claim 12, wherein the sealing means comprises a threaded member threadedly engaged in the radial bore.

14. A deep-drawing press as claimed in any one of claims 3 to 13, wherein the pressure chamber of the holding-down device further communicates with the compensating chamber through an excess pressure valve openable in the direction of flow of the hydraulic fluid from the pressure chamber to the compensating chamber.

15. A deep-drawing press as claimed in claim 14, wherein the excess pressure valve comprises a respective valve unit, which is mounted on a portion of a base of the housing defining the floor of the compensating chamber and which communicates with the pressure chamber through a conduit in the base of the housing.

16. A deep-drawing press as claimed in claim 15, wherein the valve unit of the excess pressure valve is threadedly engaged in said portion of the base of the housing.

17. A deep-drawing press as claimed in either claim 15 or claim 16, wherein the conduit communicating with the valve unit of the excess pressure valve comprises a bore extending radially of the compensating chamber, and a further bore arranged below the pressure chamber and extending substantially parallel to the axis of the compensating chamber to connect the radial bore to the pressure chamber.

18. A deep-drawing press as claimed in claim 17, comprising sealing means sealing the radial bore of the conduit at the radially outer end thereof to be pressure tight.

19. A deep-drawing press as claimed in any one of claims 3 to 18, wherein the housing is cylindrical in shape and the compensating chamber is arranged concentrically with the pressure chamber.

20. A deep-drawing press as claimed in any one of claims 3 to 19, wherein the housing is provided with a lid closing the compensating chamber to be pressure tight.

21. A deep-drawing press as claimed in any one of claims 3 to 20, wherein the pressure chamber is cylindrical in shape and the holding-down device comprises a

plurality of such housings, which are each provided with a respective pressure chamber communicating with a respective compensating chamber and which are arranged beside one another, a respective pressure element being associated with each of the pressure chambers.

22. A deep-drawing press as claimed in claim 21, wherein the pressure element comprises a respective piston slidably engaged in each pressure chamber to act on the hydraulic fluid therein, each of the pistons being provided with a push rod to transmit pressure from the pressure applying means.

23. A deep-drawing press as claimed in any one of claims 3 to 20, wherein the pressure chamber is of annular cross-section and surrounds an open-ended central cylindrical bore arranged in the housing for the passage therethrough of a drawing die of the press, the compensating chamber being arranged concentrically with the pressure chamber.

24. A deep-drawing press as claimed in claim 23, wherein the housing provided with a common annular base closing the pressure and compensating chambers and with an annular lid closing the compensating chamber, the housing being adapted to directly engage the metal blank to be deep drawn.

25. A deep-drawing press as claimed in either claim 23 or claim 24, wherein the pressure element comprises a sleeve-shaped piston slidably engaged in the pressure chamber to act on the hydraulic fluid therein.

26. A deep-drawing press as claimed in any one of claims 3 to 35, wherein the or each housing is provided on an outer wall thereof with a pressure gauge communicating with the pressure chamber of that housing.

27. A deep-drawing press as claimed in any one of the preceding claims, wherein the gas-containing part of the or each compensating chamber of the holding-down device is located above the hydraulic fluid-containing part of that chamber and is disposed in direct communication with a source of pressure.

28. A deep-drawing press as claimed in claim 27, wherein the gas-containing part of the or each compensating chamber communicates with the source of pressure through a pressure hose.

29. A deep-drawing press as claimed in claim 28, wherein the gas-containing part of the or each compensating chamber is connected with the pressure hose through a stub pipe.

30. A deep-drawing press as claimed in any one of claims 27 to 29, wherein the pressure source comprises a source of compressed air.

31. A deep-drawing press as claimed in any one of claims 3 to 26, wherein the or each housing is provided with a threaded inlet communicating with the gas-containing part of the or the respective compensating chamber, the or each inlet being closed by a threaded sealing plug threadedly engaged therein.

32. A deep-drawing press provided with a holding-down device substantially as hereinbefore described with reference to Figs. 2 to 6 of the accompanying drawings.

33. A deep-drawing press provided with a holding-down device substantially as hereinbefore described with reference to Figs. 7 and 8 of the accompanying drawings.

34. A deep-drawing press provided with a holding-down device substantially as hereinbefore described with reference to Fig. 9 of the accompanying drawings.

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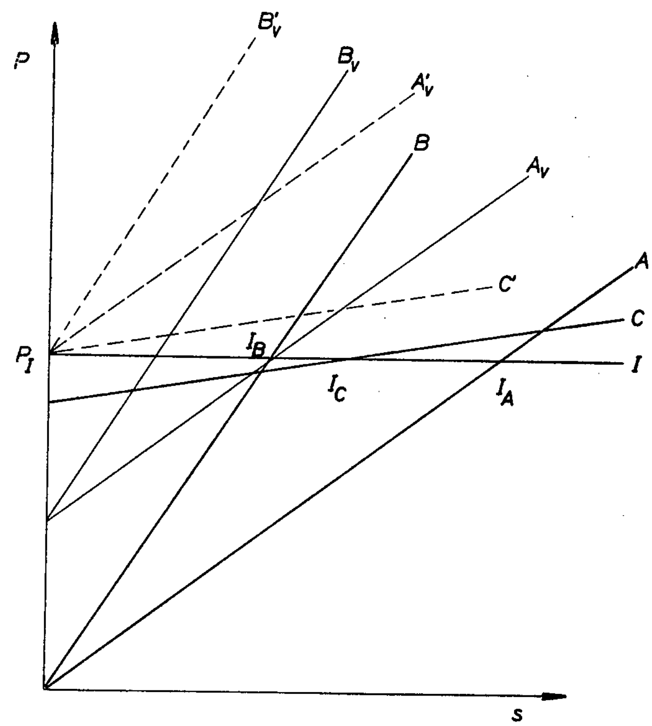

Fig. 1

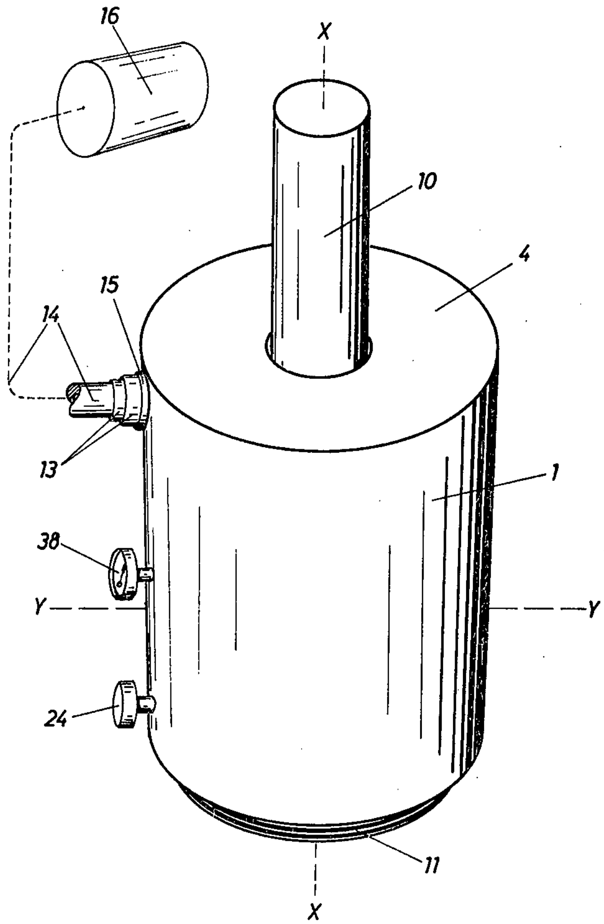

Fig. 2

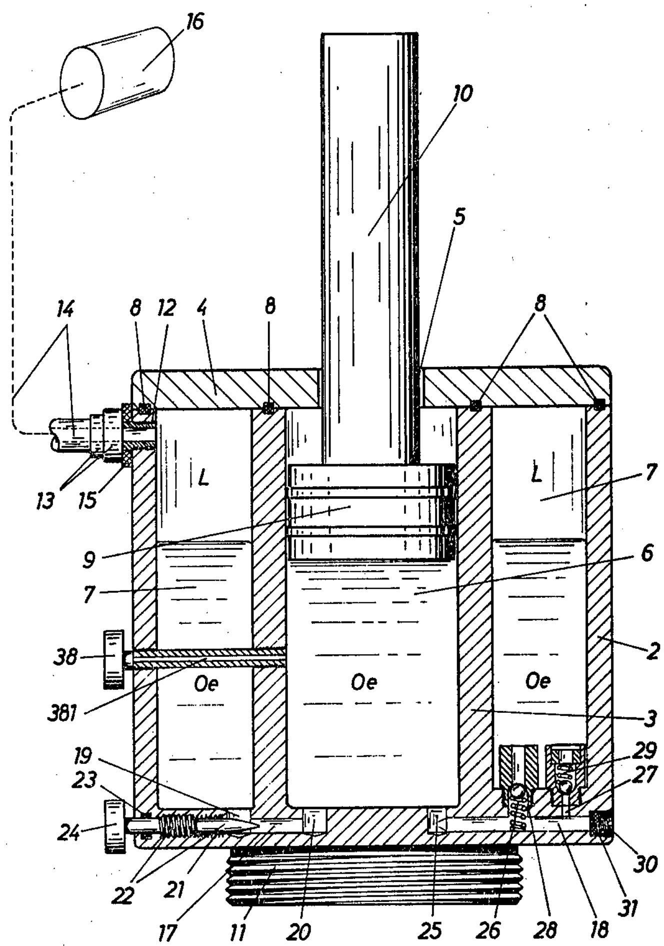
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Fig.3

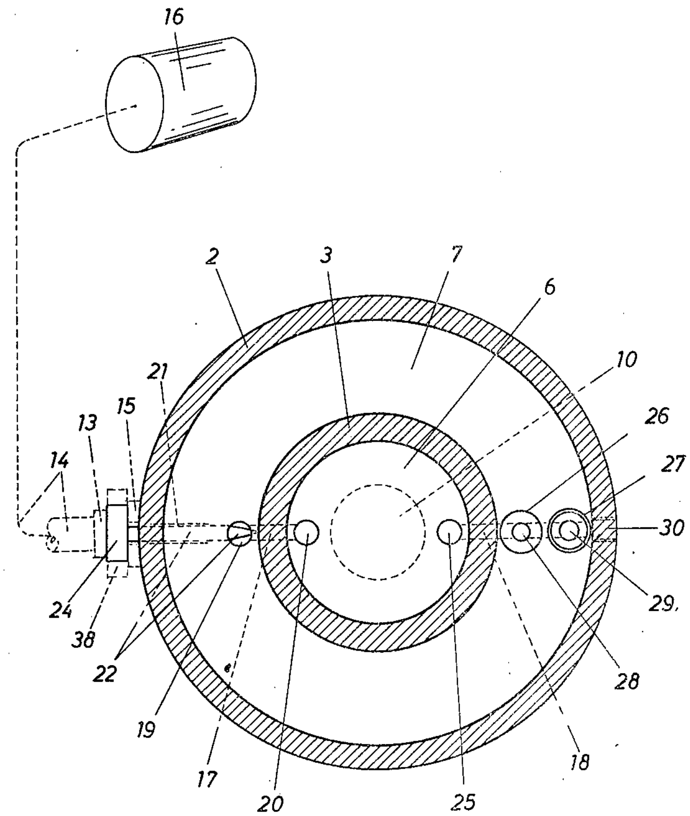

Fig. 4

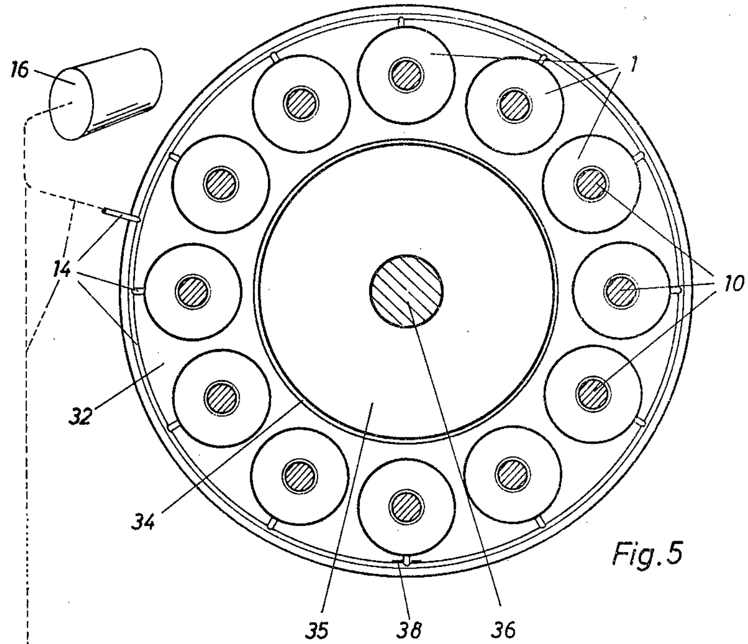

Fig.5

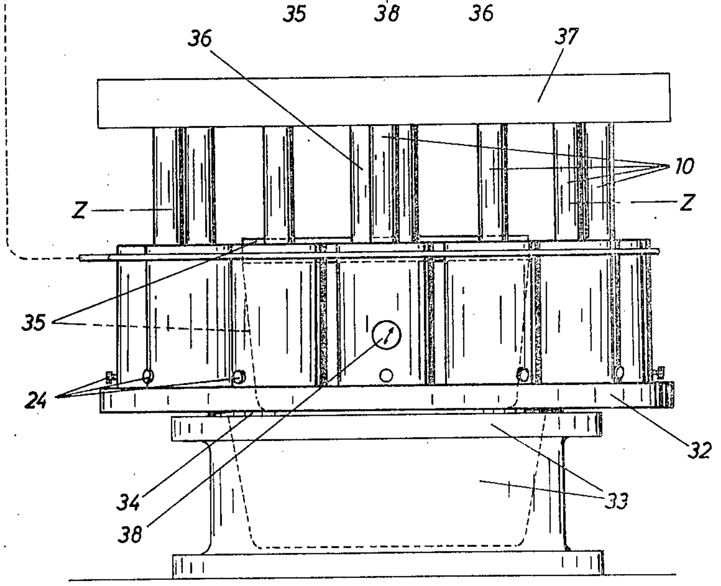

Fig.6

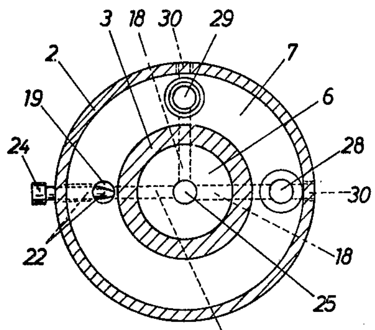

Fig. 8

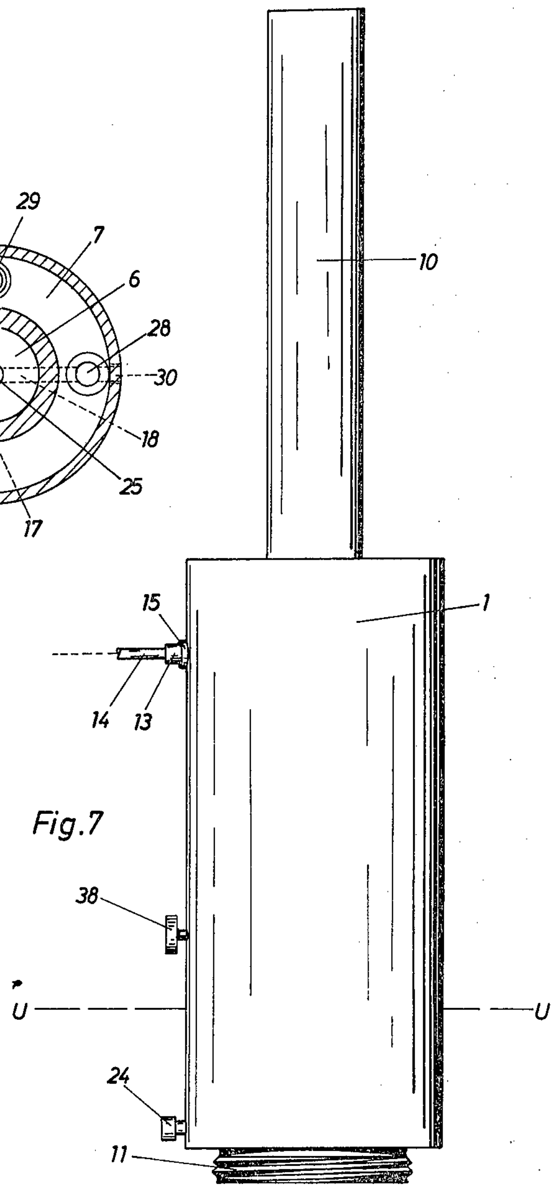

Fig. 7

1577855 COMPLETE SPECIFICATION

7 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 7

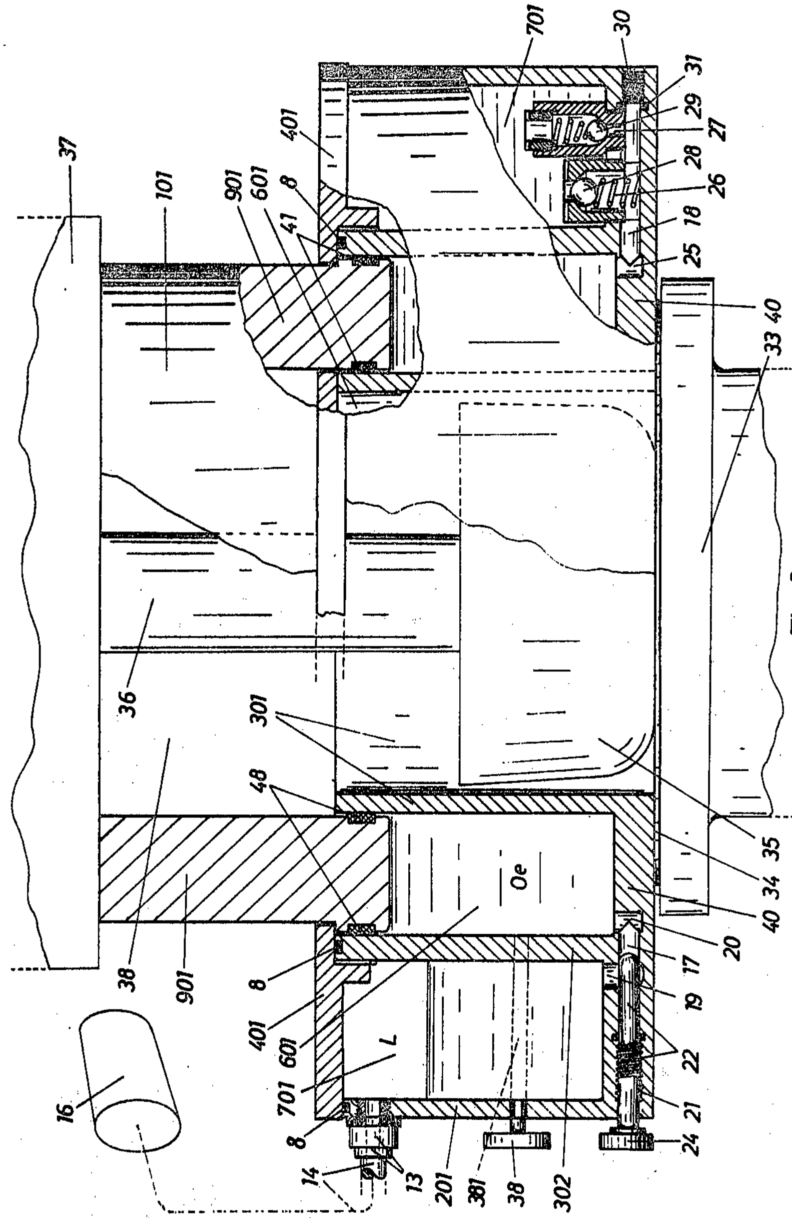

Fig.9