(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 069 566**
A2

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: 82303499.6

(22) Date of filing: 02.07.82

(51) Int. Cl.³: B 30 B 11/26

(30) Priority: 02.07.81 GB 8120513

(43) Date of publication of application:
12.01.83 Bulletin 83/2

(84) Designated Contracting States:
AT BE CH DE FR GB IT LI LU NL SE

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(54) **Extrusion process and apparatus.**

(57) Formable material such as pigment filter cake is extruded in filamentary form for drying by means of a ram extruder which eradicates local zones of inhomogeneity. Pressure may be applied by the ram in two stages; a lower pressure to homogenise the material followed by a higher pressure to extrude it.

Apparatus for carrying out the process comprises a container transportable in cage between a loading/unloading station and an extrusion station.

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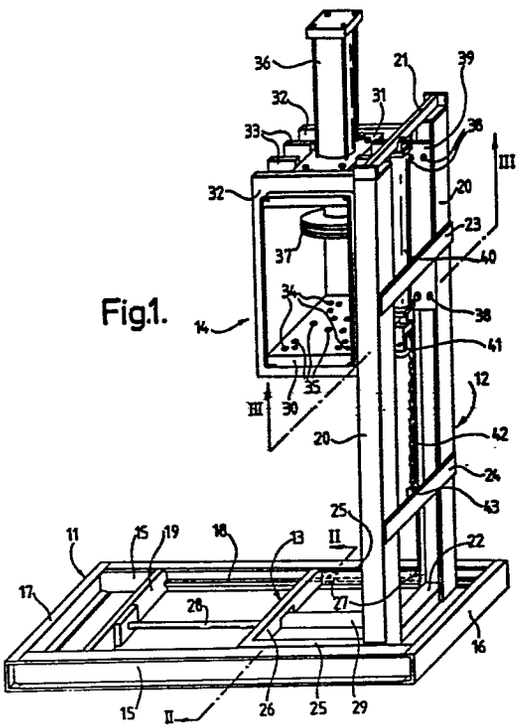
Fig.1.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EXTRUSION PROCESS AND APPARATUS

This invention relates to a process and apparatus for extrusion of a formable material and particularly provides means for extrusion of such a material where there is a need to minimise shear forces.

One such formable material occurs in the manufacture of pigments and particularly inorganic pigments such as cadmium sulphide pigments, in which one or more filtration and drying operations are required. In these drying operations, it is the usual practise to extrude what is called filter cake which is a formable material containing generally between 40% and 60% by weight of water by means of a screw extruder and to allow the extrudate, which has a filamentary or cord-like shape, to settle under the influence of gravity on to the moving conveyor belt of a belt drying oven. Ideally, the

consistency of the extrudate is such that it retains its three dimensional shape and settles on to the belt in a randomly-orientated mass of filament or cords, thus providing a high surface area and air being thus able to circulate readily through the mass to effect efficient drying. The speed of the belt may be adjusted relative to the speed of extrusion to allow control to be exercised over the depth of the extrudate on the belt.

One disadvantage of screw extruders is that extrusion pressure is applied only to that portion of material actually in the barrel of the extruder and in consequence any local zones of inhomogeneity in respect of water content of the material affect the quality of the extrudate, leading to poor drying, or adversely affecting the efficiency of the extrusion operation. Thus, a zone of excessive wetness will be extruded as a flowable material, or even as a slurry, which will not retain its three-dimensional shape on the conveyor belt and will in consequence not be properly dried. A zone of excessive dryness, on the other hand, will tend to block the extrusion holes of the extruder. Furthermore, screw extruders inherently apply substantially shear forces to the material which may have a serious rheological effect on the physical

form of the extrudate.

We have now found that these disadvantages may be overcome or at least substantially reduced by applying extrusion pressure to a larger volume of formable material by means of a ram, any local zones of inhomogeneity thus being eradicated before the extrusion operation is performed, and minimising shear forces.

GB 1375883 describes apparatus for compacting and extruding plastic and/or pulverulent material from a cavity by means of ram pressure, whereby the material is subjected to compaction at a compacting station and extrusion through a die orifice at an extrusion station. The apparatus contains two cavities disposed within a rotatable housing indexed so that compaction takes place in one cavity while extrusion takes place from the other, and separate compacting and extrusion rams are carried on a common support. In such apparatus, the die containing the extrusion orifice is separable from the housing and is located permanently at the extrusion station.

According to one aspect of the present invention, we provide a process for extrusion of a formable material through an extrusion orifice by means of ram-applied pressure, wherein the material is supplied to a loading/unloading station in a container a wall of which has one or more extrusion orifices formed therein, moving the container to an extrusion station and, thereafter, applying extrusion pressure to the material by means of a ram.

Preferably, pressure is applied in two stages, in which a lower pressure than that required for extrusion is first applied to compress the material and to cause any excess wetness, for example, to be exuded, and in which a higher pressure is then applied for extrusion.

We have found that pressure exerted by the extrusion ram is sufficient to compress substantially the entire charge of formable material in the container prior to extrusion to an extent sufficient to substantially eradicate any local zones of inhomogeneity in the charge. Any excess water, for example, in local zones is either distributed substantially throughout and taken up by the remainder of the charge or is expelled through extrusion holes prior to

extrusion of the formable material. The remaining formable material, on extrusion, preferably, has a consistency such that it retains its three dimensional shape and settles in a randomly-orientated mass or filamentary of cord-like material. Such a mass provides a high surface area for drying air, for example, to circulate readily. We have found that the most important factor governing the strength of the extrudate is the rate of extrusion. This may be controlled by regulating the extrusion pressure on the ram independantly of the pressure within the extrusion container which latter pressure is a function of the rheological properties of the formable material.

According to a second aspect of the invention, apparatus for ram extrusion of a formable material comprises a container for holding a quantity of extrudable material and having one or more extrusion orifices formed in a wall thereof and being adapted for location in a cage movable between a loading/unloading station and an extrusion station, and ram means for exerting extrusion pressure on the material when the container is at the extrusion station.

Preferably, apparatus according to the invention is used in combination with a conveyor belt or other carriage

means for receiving extruded material. Such a belt may be the belt of a belt drying oven. It is also preferred that the loading/unloading station is located at or near floor level and the extrusion station is located at an elevated position so that the extrudate settles under the influence of gravity on to the belt, or other receiving means.

The container may, for convenience, be a hollow right circular cylinder closed at one end, having extrusion holes disposed substantially axially through the closed end. If desired, however, additional or alternative holes may extend radially through the cylindrical wall. Optionally, the container may have a false internal bottom plate containing extrusion bushings which locate within holes in the closed end. One or more dowels or other location means are, preferably, carried on the underside of the container for location of the container in the cage. The ram preferably comprises a piston which is axially slidable within the cylinder, and which is fitted with suitable sealing means such as spring rings disposed circumferentially around the piston. The piston is connected via a piston rod to activating means which may be screw-operated, hydraulically operated or the like. We prefer to use a double-acting

hydraulic cylinder and piston assembly which acts directly or indirectly on the ram. Such an arrangement permits of a very fine degree of pressure control on the ram.

The cage preferably comprises a reinforced framework having a base and a roof section and at least one open side for facilitating loading with and unloading of the container. All extrusion forces are preferably confined within the cage. The base of the cage is provided with one or more holes generally larger in diameter than the extrusion holes of the container and positioned to be in registration with the said extrusion holes when the container is correctly located on the base of the cage and, when locating dowels are fixed to the underside of the container, is further provided with one or more corresponding holes for receiving the dowels.

One way of establishing movement between loading/unloading and extrusion stations is to mount the cage on a pylon for longitudinal sliding movement relative thereto, in a substantially vertical plane, with the pylon itself carried on a chassis for longitudinal sliding movement relative thereto in a substantially horizontal plane. Movement of the pylon and the cage relative to the pylon is each

preferably by means of a respective ram, for example, a hydraulic ram, which may act either directly or indirectly. Alternatively and preferably, movement of the cage on the pylon is controlled by means of a hydraulically-operated piston mounted substantially parallel to the longitudinal axis of the pylon and in the region of the upper end thereof, the lower end of the piston having attached thereto a pulley, one end of a chain or other flexible support means being attached to a mounting point towards the lower end of the pylon and the other end being passed over the pulley and attached to the cage, thus imparting a mechanical advantage to the movement of the cage relative to the movement of the piston.

Means for activating the extrusion ram may be mounted either on a structure fast with the upper end of the pylon so that the activating means is in registration with the ram when the container in the cage is at the extrusion station or, alternatively, activating means may be mounted directly on the cage. The latter arrangement is to be preferred due to the ram thus being capable of being securely attached to the ram activating means irrepective of the presence or absence of a container in the cage and

irrespective of whether the cage is at the extrusion station or at some other location. Further, with such an arrangement, the extrusion forces are confined to the cage and are not transmitted to the pylon.

To facilitate loading and unloading of the cage, locating dowels when fixed to the underside of the container are each provided at the lower end with a spherical castor or other bearing means and the pylon base section is provided with upstanding pegs corresponding in number and relative position with the container dowel locating holes in the base of the cage. Thus, with the cage at the loading/unloading station at the lower end of the pylon so that the underside of the cage rests on the pylon base section, the pegs displace the locating dowels of a container in the cage from within the locating holes. Each peg preferably has a flat upper surface which is adapted to be flush with the floor of the cage when the latter is at the loading/unloading station so that a container can be rolled on its spherical castors either in to or out of position relative to the pegs and hence to the locating holes.

The apparatus is suitable for use with a plurality of

containers to minimize downtime during container charging and handling operations. Thus, a container handling system suitable for use with apparatus according to the invention may include a charging station for charging an empty container with material to be extruded, and a holding station for holding a charged container pending loading into the cage of the apparatus, together with means for simultaneously removing an empty container at the loading/unloading station and transporting it to the charging station, transporting a charged container from the charging station to the holding station and transporting a further charged container from the holding station to the loading/unloading station. Such a handling system may be mechanically or manually operated.

Apparatus according to the invention will now be described by way of example with reference to the accompanying drawings, of which:-

Fig. 1 is a perspective view;

Fig. 2 is a section along the line II - II of Fig. 1;

Fig. 3 is a section along the line III - III of Fig. 1

Fig. 4 is a diagrammatic sectional view of the container located in the base of the cage;

Fig. 5 is a diagrammatic sectional view of the container at the loading/unloading station;

Fig. 6 is a diagrammatic illustration of the loading/unloading and extrusion stations, and

Figs. 7 and 8 show the location of limit switches on the apparatus.

Referring to Fig.1, apparatus according to the invention is shown consisting essentially of a chassis 11, a pylon comprising an upstanding section 12 and a base section 13, and a cage 14. Chassis 11 comprises a pair of longitudinal channel girders 15 suitably end-braced by girders 16 and 17. The inwardly-facing web surfaces of girders 15 are each provided with a runner 18 (one side only shown) for sliding movement of the pylon thereon (see also Fig. 2). The rummers extend longitudinally between end girder 16 and an intermediate cross-element 19.

The pylon upstanding section 12 comprises a pair of fabricated structures 20 suitably cross-braced at their ends (21 and 22) and at intermediate locations (23 and 24).

The upstanding section is rigidly secured to base section 13 which comprises a girder framework consisting of a pair of longitudinal angle girders 25 cross-braced at their ends, cross-brace girder 26 being remote from the upstanding section and cross-brace girder 22 being common with the lower end cross bracing girder of the upstanding section. The base section (see also Fig.2) is adapted to slide longitudinally between chassis girders 15 and is carried for this purpose on runners 18. Wheels or rollers 27 (shown in dotted outline in Fig.1) are provided on the outside of angle girders 25 for facilitating such sliding movement, which is controlled by means of piston rod 28 acting on cross-element 19 and powered hydraulically by two-way hydraulic cylinder 29.

The cage 14 consists essentially of a base member 30 and a roof member 31 held in spaced-apart relationship by means of a reinforced framework comprising end members 32 and intermediate reinforcing ribs 33. The cage is open-sided on at least one side for providing access for loading and unloading containers. The base is provided with four holes 34 (three only visible in Fig.1) for receiving locating dowels on the underside of the container. Further holes 35 are provided for passage therethrough of extruded material. A double-acting hydraulic cylinder 36 is secured to the roof of the cage and is connected with piston 37 for exerting ram extrusion pressure on the material in the container. The cage is mounted for longitudinal sliding movement with respect to the pylon upstanding section by means of rollers adapted to roll on the inner sides of the channel sections of the longitudinal fabricated structures, the roller axles being

secured by nuts 38 to plates 39 attached to the cage. Sliding movement is controlled by double-acting hydraulic cylinder 40 the piston rod of which is connected to a pulley 41 over which passes chain 42 secured at one end to the pylon at 43 and at the other end to the base of the cage.

Fig. 2 is a cross-section through the chassis and pylon base member to show the arrangement of the runners and the wheels. In addition to elements 15, 18, 25 and 27 already referred to, Fig.2 illustrates a longitudinal plate 44 secured to the upper surface of each girder 15 for acting as a cover for the runners and longitudinal bearing strip 45 secured to the inward-facing edge of each runner to prevent skewing of the pylon base section between the chassis longitudinal girders with consequential interruption to smooth running. The material of the bearing strip may be, for example, white metal or nylon.

Fig. 3 is a cross-section through the pylon showing part of the cage and the means by which sliding movement of the cage relative to the pylon is facilitated. The fabricated structures 20 each comprise a box girder 46 to which is attached a pair of longitudinal plates 47 to create longitudinal channel sections which are arranged to be inwardly facing. To the cage 14 is attached a pair of plates 39 on which there are rotatably mounted, by means of nuts 38, rollers 48 which bear on the inner sides of the channel sections. Elements 24 and 25 are respectively a pylon cross-brace and pylon base section longitudinal girders (see Fig.1).

Figures 4 and 5 are schematic representations of the containers. In Fig.4, the container 49 is located in and

is supported by the base 30 of the cage, locating dowels 50 being positioned in holes 34 (see Fig.1). Extrusion holes 51 are in registration with larger diameter holes 35 formed in the base of the cage. The dowels are equipped with spherical castors 52.

In Fig.5, the container is shown at the loading/unloading station standing with spherical castors 52 on upstanding pegs 53 located in a member itself secured to the base section of the pylon, the pegs having displaced the locating dowels 50 from holes 34 as the cage was lowered on to the said base section, the upper surface of pegs 53 being essentially flush with the floor (i.e. the upper surface of the base 30) of the cage to facilitate loading and unloading of the cage by rolling the container on castors 53.

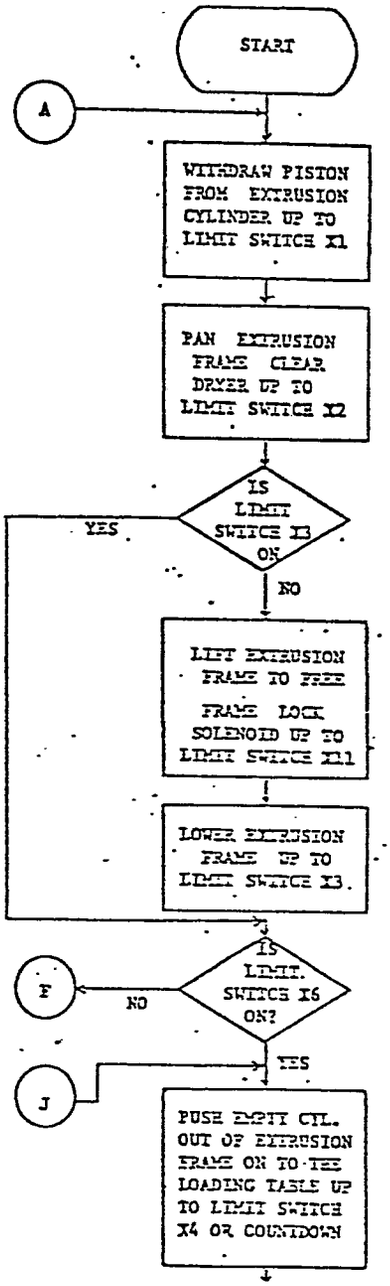
Figure 6 comprises two diagrams 6A and 6B showing the apparatus schematically in the loading/unloading station and the extruding station respectively in relation to the belt drying oven shown in cross-section at 54.

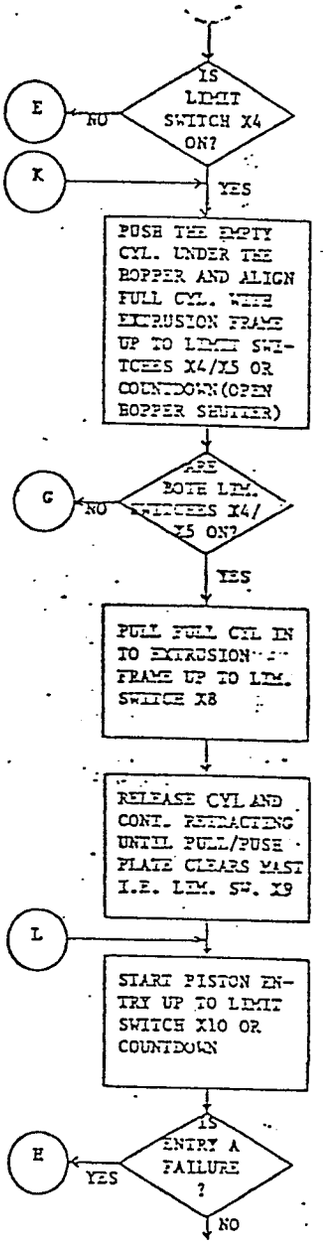
In a process according to the invention for extrusion of a plastic material, extrusion rate is controlled by controlling the extrusion ram pressure. Where extruded material is allowed to settle on a moving conveyor belt, for example, the belt of a belt drying oven, the depth of material on the belt may be controlled either by controlling the extrusion rate and/or by controlling the speed of the conveyor belt.

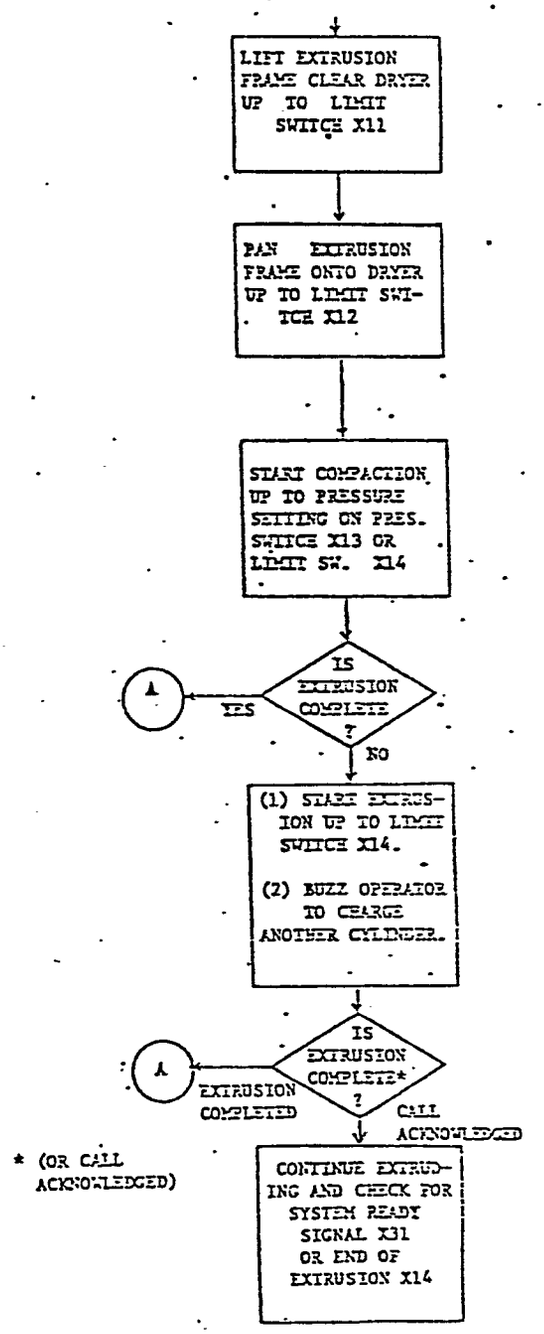
For the purpose of drying a pigment or a precursor thereof in a belt drying oven, the optimum depth of extrudate on the belt is normally about four inches.

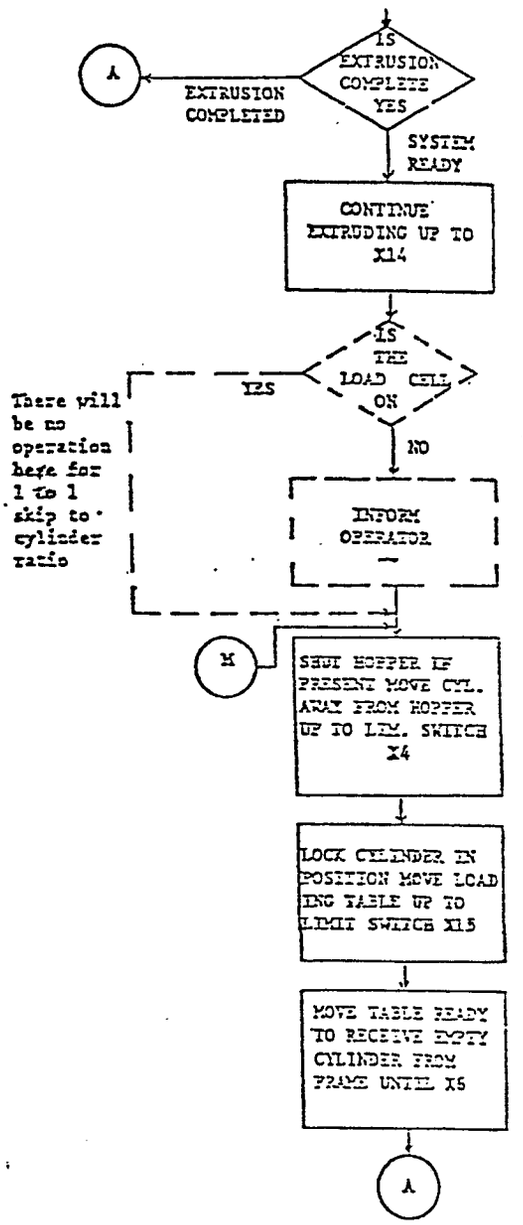
Apparatus according to the invention may be controlled by hydraulic control means in standard manner and its operation is facilitated by use of limit switches to indicate the position of various components of the apparatus at various stages in the process.

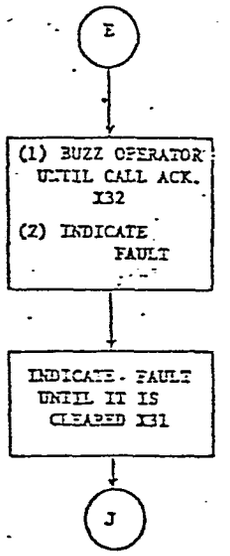
Figures 7 and 8 indicate the positions of limit switches X1 to X6 and X8 to X15 on the apparatus illustrated in Figure 1, the switches being involved in the various stages of the process of operating the apparatus now to be described. The various limit switches serve to initiate and terminate operation of electrically powered and/or controlled mechanisms used in the apparatus and detailed operation thereof is not included.

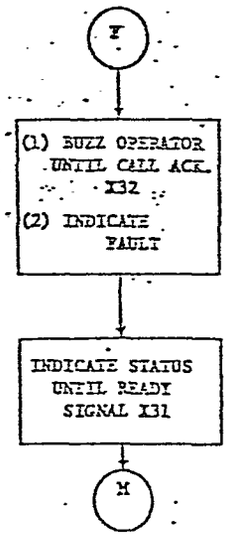

START
A
WITHDRAW PISTON FROM EXTRUSION CYLINDER UP TO LIMIT SWITCH X1
PAN EXTRUSION FRAME CLEAR DRYER UP TO LIMIT SWITCH X2
IS LIMIT SWITCH X3 ON?
YES
NO
LIFT EXTRUSION FRAME TO FREE FRAME LOCK SOLENOID UP TO LIMIT SWITCH X11
LOWER EXTRUSION FRAME UP TO LIMIT SWITCH X3.
IS LIMIT SWITCH X6 ON?
F
NO
YES
J
PUSH EMPTY CYL. OUT OF EXTRUSION FRAME ON TO TEE LOADING TABLE UP TO LIMIT SWITCH X4 OR COUNTDOWN

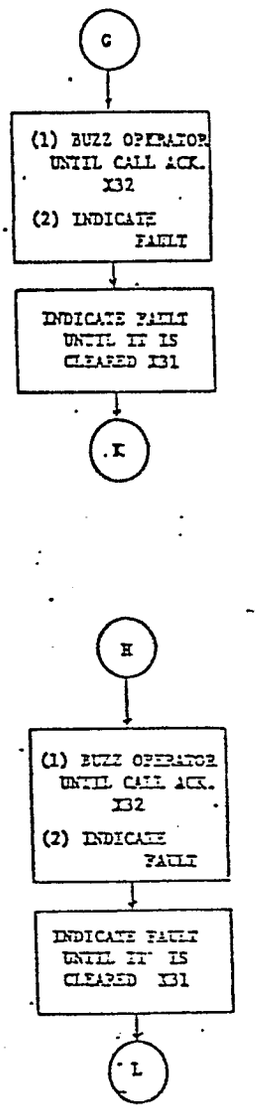

IS LIMIT SWITCH X4 ON?
E
NO
K
YES
PUSH THE EMPTY CYL. UNDER THE HOPPER AND ALIGN FULL CYL. WITH EXTRUSION FRAME UP TO LIMIT SWITCHES X4/X5 OR COUNTDOWN (OPEN HOPPER SHUTTER)
ARE BOTH LIM. SWITCHES X4/X5 ON?
G
NO
YES
PULL FULL CYL IN TO EXTRUSION FRAME UP TO LIM. SWITCH X8
RELEASE CYL AND CONT. RETRACTING UNTIL PULL/PUSH PLATE CLEARS MAST I.E. LIM. SW. X9
L
START PISTON ENTRY UP TO LIMIT SWITCH X10 OR COUNTDOWN
IS ENTRY A FAILURE ?
H
YES
NO


LIFT EXTRUSION FRAME CLEAR DRYER UP TO LIMIT SWITCH X11
PAN EXTRUSION FRAME ONTO DRYER UP TO LIMIT SWITCH X12
START COMPACTION UP TO PRESSURE SETTING ON PRES. SWITCH X13 OR LIMIT SW. X14
IS EXTRUSION COMPLETE ?
YES
A
NO
(1) START EXTRUSION UP TO LIMIT SWITCH X14.
(2) BUZZ OPERATOR TO CHARGE ANOTHER CYLINDER.
IS EXTRUSION COMPLETE* ?
A
EXTRUSION COMPLETED
CALL ACKNOWLEDGED
CONTINUE EXTRUDING AND CHECK FOR SYSTEM READY SIGNAL X31 OR END OF EXTRUSION X14
* (OR CALL ACKNOWLEDGED)


A
EXTRUSION COMPLETED
IS EXTRUSION COMPLETE YES
SYSTEM READY
CONTINUE EXTRUDING UP TO X14
IS THE LOAD CELL ON
YES
NO
There will be no operation here for 1 to 1 skip to cylinder ratio
INFORM OPERATOR
M
SEND HOPPER IF PRESENT MOVE CYL. AWAY FROM HOPPER UP TO LIM. SWITCH X4
LOCK CYLINDER IN POSITION MOVE LOADING TABLE UP TO LIMIT SWITCH X15
MOVE TABLE READY TO RECEIVE EMPTY CYLINDER FROM FRAME UNTIL X5
A


E
(1) BUZZ OPERATOR UNTIL CALL ACK. X32
(2) INDICATE FAULT
INDICATE FAULT UNTIL IT IS CLEARED X31
J


F
(1) BUZZ OPERATOR UNTIL CALL ACK. X32
(2) INDICATE FAULT
INDICATE STATUS UNTIL READY SIGNAL X31
M


G
(1) BUZZ OPERATOR UNTIL CALL ACK. X32
(2) INDICATE FAULT
INDICATE FAULT UNTIL IT IS CLEARED X31
K
H
(1) BUZZ OPERATOR UNTIL CALL ACK. X32
(2) INDICATE FAULT
INDICATE FAULT UNTIL IT IS CLEARED X31
L

CLAIMS:

1. A process for extrusion of a formable material through an extrusion orifice by means of ram-applied pressure wherein the material is supplied to a loading/unloading station in a container a wall of which has one or more extrusion orifices formed therein, moving the container to an extrusion station and, thereafter, applying extrusion pressure to the material by means of a ram.

2. A process as claimed in Claim 1 in which the extrusion pressure is applied in two stages in which a lower pressure than that required for extrusion is first applied to compress the material to eradicate any local zones of inhomogeneity, and in which a higher pressure is then applied for extrusion.

3. Apparatus for ram extrusion of a formable material comprising a container for holding a quantity of extrudable material and having one or more extrusion orifices formed in a wall thereof, a cage for housing the container and movable between a loading/unloading station and an extrusion station, and ram means for exerting extrusion pressure on the material when the container is at the extrusion station.

4. Apparatus as claimed in Claim 3 in combination with carriage means for receiving extruded material with the extrusion station located above the carriage means so that the extrudate settles under the influence of gravity on to the carriage means.

5. Apparatus according to Claim 4 wherein the carriage means is a conveyor belt.

6. Apparatus as claimed in Claim 3, 4, or 5 in which the cage is mounted on a vertical pylon for longitudinal sliding movement relative thereto, in a substantially vertical plane, and in which the pylon is carried on a chassis for longitudinal sliding movement relative thereto in a substantially horizontal plane.

7. A process for extrusion of a formable material substantially as herein described.

8. Apparatus for ram extrusion of a formable material constructed and arranged substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

Fig.1.

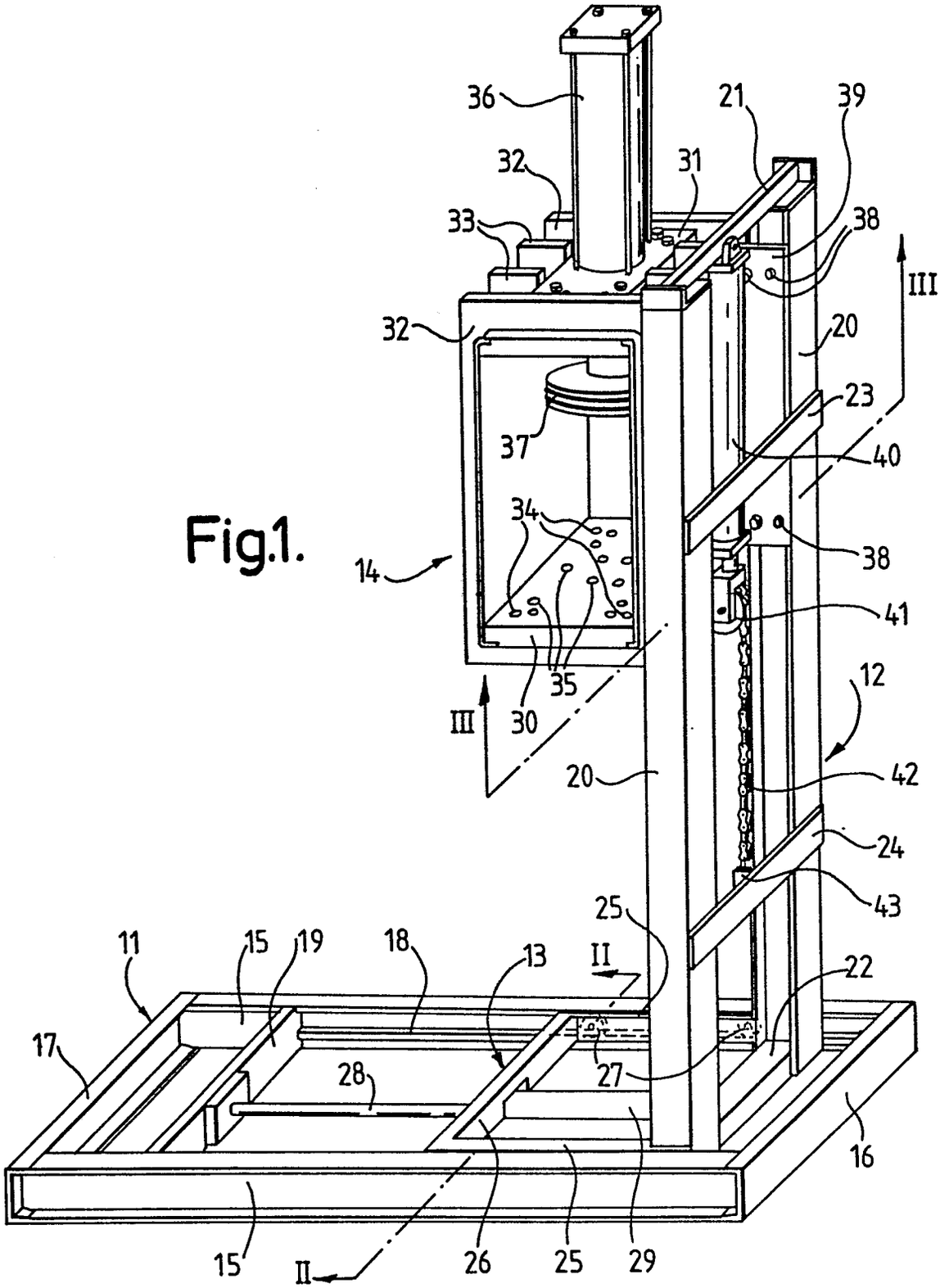

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Fig.2.

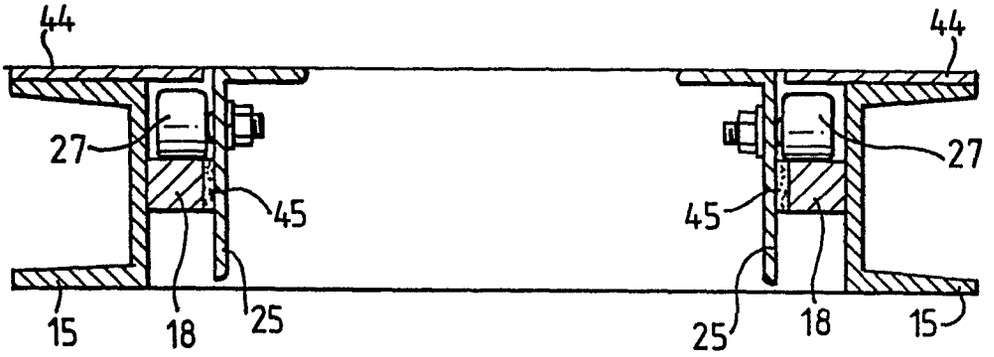
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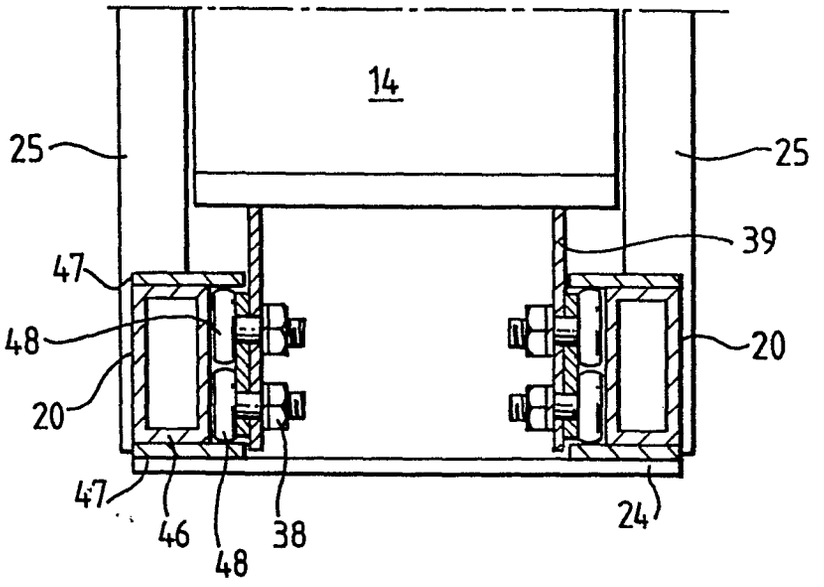
Fig.3.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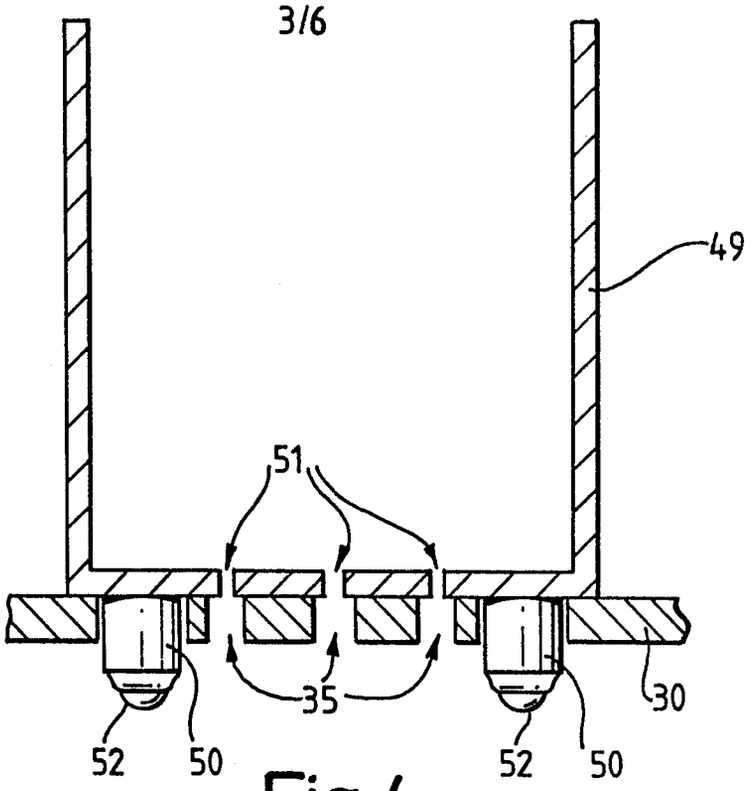


Fig.4.

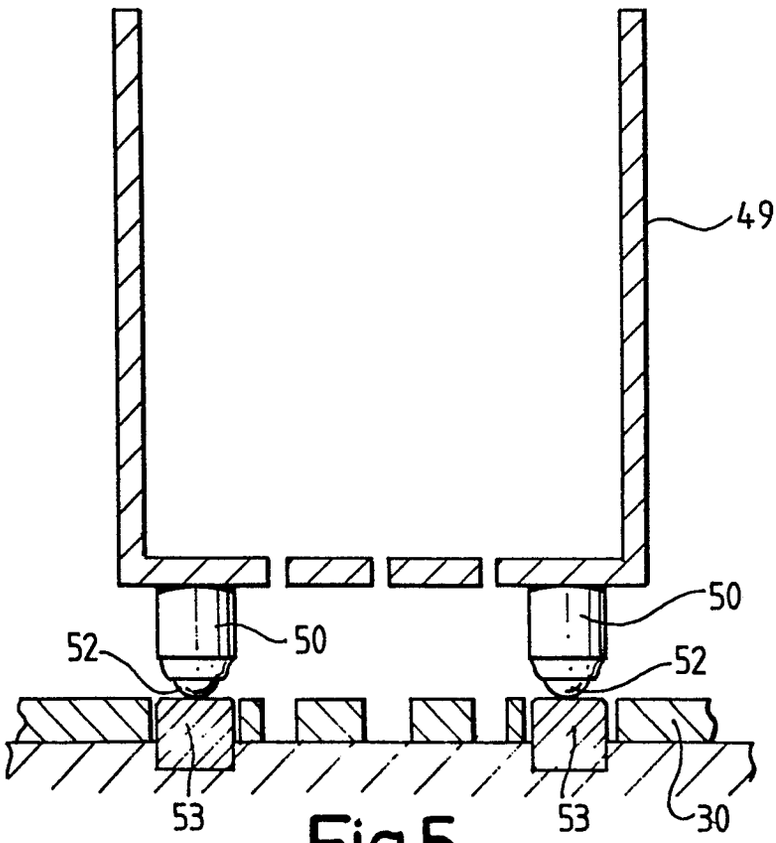
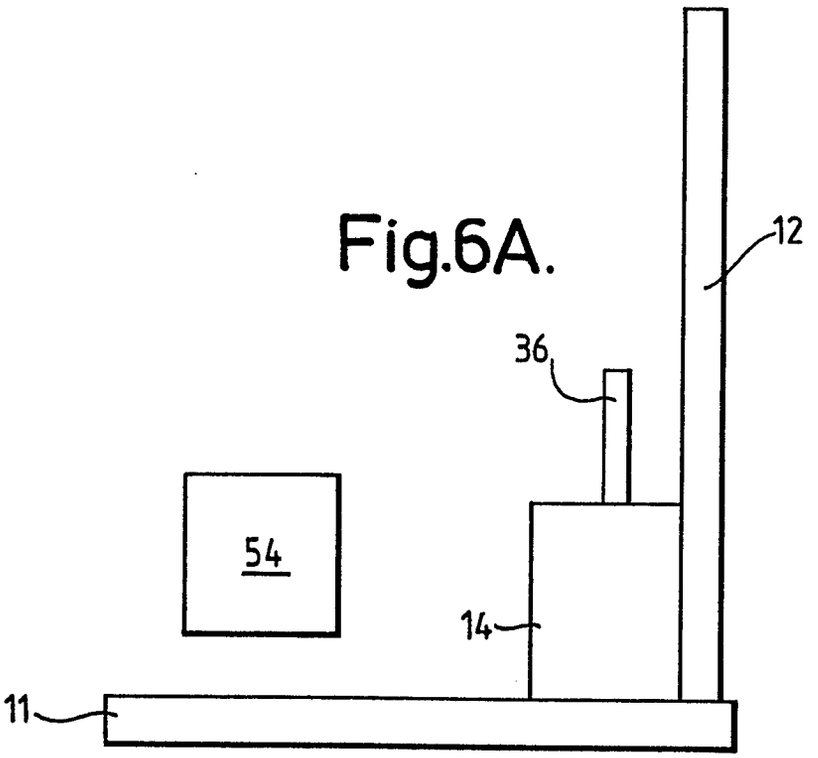


Fig.5.

Fig.6A.



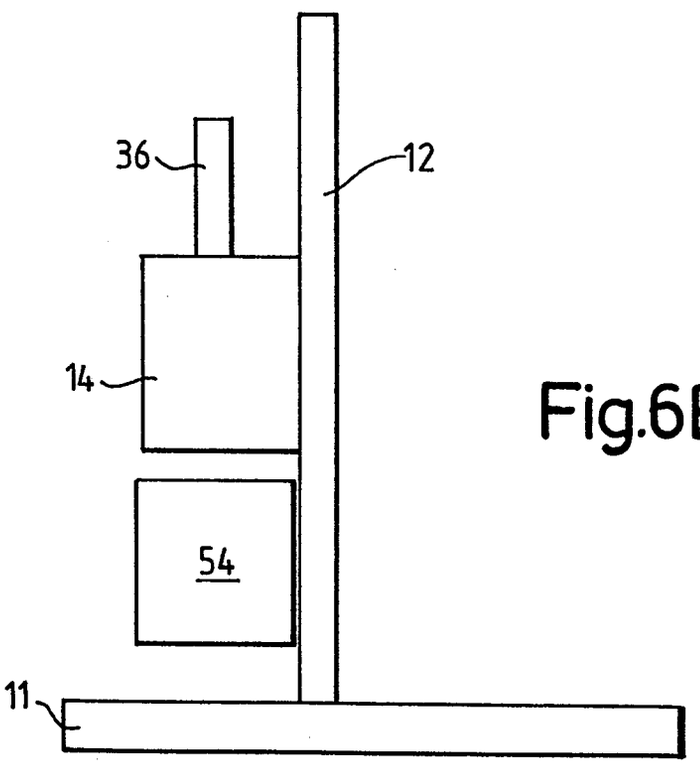


Fig.6B.

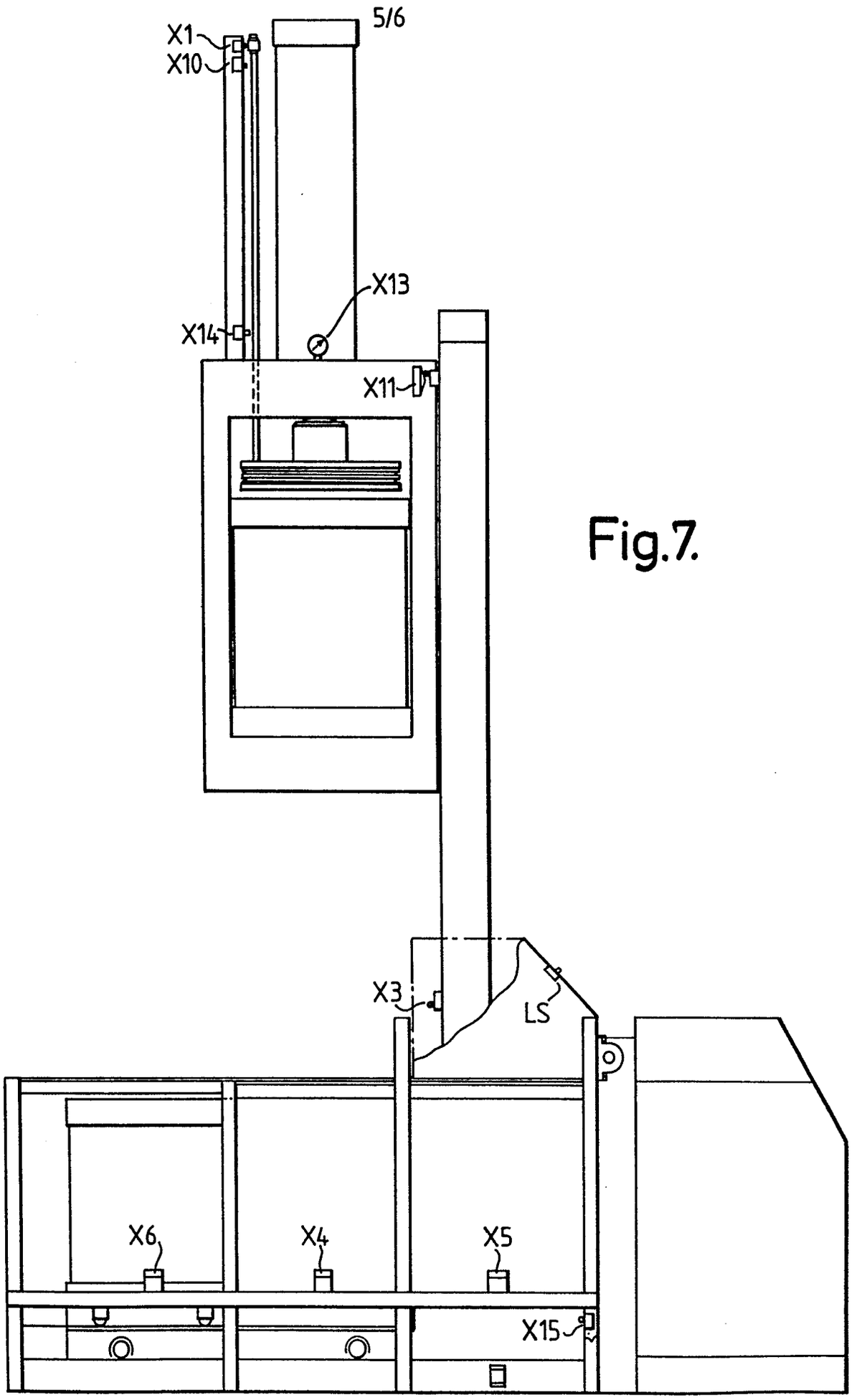


Fig.7.

Fig.8.