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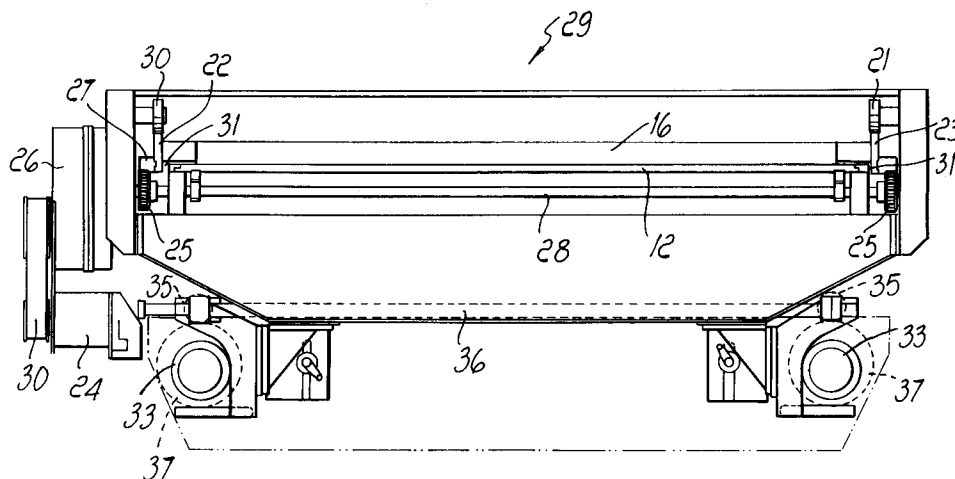
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CH DE ES FR GB IT LI PT SE(71) Applicant: **S.I.T.I. S.p.A. Società Impianti
Termoelettrici Industriali
Via Sempione 82
I-28040 Marano Ticino (Novara)(IT)**(72) Inventor: **Walchhütter, Ulrico
Piazza Giolitti 6
I-20133 Milano(IT)**(74) Representative: **Forattini, Amelia et al
c/o Internazionale Brevetti Ingg. ZINI,
MARANESI & C. S.r.l. Piazza Castello 1
I-20121 Milano (IT)**(54) **Device for loading powder to be pressed and pressing apparatus.**

(57) The present invention relates to a device for loading powder to be pressed into a pressing apparatus and to the pressing apparatus itself. The device comprises a carriage (16), which can move along two guides (18), and a powder-carrying grid (11) suitable for being moved by the carriage (16), so as to slide above a powder-carrying plate (12) and above the molds (13) to be loaded. The carriage

(16) is moved by a hydraulic motor (24) which is mechanically connected to a pinion (25) which engages a rack (27), so that a movement of the carriage (16) is in linear proportion to a rotation of the hydraulic motor (24). The carriage (16) is very fast and reliable, and is preset for control by means of a closed-loop circuit.

*Fig. 1***EP 0 531 683 A2**

The present invention relates to a device for loading powder to be pressed into a pressing apparatus and to said pressing apparatus. The term "powder to be pressed" is used to indicate, for the purposes of the present invention, a loose granular material, of any grain size, which can be dry-pressed, so as to produce a pressed material having a shape which is defined by the mold and is the result of the compaction and consequent agglomeration of the particles of the granular material due to the pressure and possibly the temperature of the mold. In most applications, the granular material is in powder form and the pressed material is in the form of ceramic tiles.

The device is furthermore suitable for unloading the formed, pressed and agglomerated material from the mold area.

The loading and unloading operations use a carriage which can move along two guides and a so-called powder-carrying grid which is open above and below and is provided with a plurality of receptacles for the accumulation of the granular material to be loaded into the molds. The direction in which the carriage can move is hereinafter termed longitudinal, whereas the direction perpendicular and horizontal to said direction is termed transverse.

The powder-carrying grid, after being appropriately loaded with the granular material to be pressed, is moved by the carriage in a longitudinal direction, so as to slide above a so-called powder-carrying plate until it reaches, again by sliding, the lower molds. In this manner, the granular material, which has been retained downward inside the powder-carrying grid by the powder-carrying plate, can deposit itself inside the lower molds in the most uniform possible manner. The powder-carrying plate therefore has the function of preventing the granular material from falling out of the powder-carrying grid before reaching the lower molds.

During the return step of the carriage and of the powder-carrying grid, the granular material inside the molds is skimmed flush by the return movement of the grid. Perfection in the distribution of the granular material in the molds and in its skimming depends on the speed and acceleration of the powder-carrying grid and accordingly of the carriage in the various points of its stroke. Naturally, as speed and acceleration increase, precision in loading and skimming rapidly decreases.

It is evident that the environment in which said carriage operates is very aggressive, due to all the problems related to friction or abrasion in the presence of powder. The powder in fact tends to accumulate in certain regions and to rapidly wear or jam all the moving parts and in particular the motion transmission elements, which are the most heavily stressed.

The kinematic conditions are also stressing since in a standard press the time allowed for both forwards and backwards strokes is less than 4 seconds and generally about 2 seconds and each stroke is about 600 mm; accelerations should be high enough to achieve the required speed in a short time.

Also dynamic conditions should be considered, since the weight of the carriage can range for example from 100 to 300 kg and the friction of the grid filled of powder on the powder-carrying plate may be very relevant and depends upon the speed.

As regards all the details of a pressing apparatus suitable for being loaded by a device as described above, reference is made to the pressing apparatus described in the patent application PCT No. WO 89/11969 which integrates and is considered part of the present specification.

The above is in summary the main field of industrial use of the invention, but said field does not constitute a limitation of its scope, since the device and apparatus according to the invention, in particular as hereinafter described and claimed, can be advantageously used in any other equivalent field in which granular or powder-like material must be loaded into the molds of a dry-pressing apparatus.

A device and an apparatus as described above are known from the Italian patent No. 719423 dated April 11, 1964, wherein the carriage is actuated by a motorized crank the end of which can slide within a slot defined in the carriage. This type of carriage actuation has been practically the only one in widespread use for over 25 years in the above indicated field of industrial use of the invention, since it has been found to be the only one capable of withstanding an environment as aggressive as the one in which granular or powder-like materials are processed.

However, these known apparatuses have some problems. First of all, control of the motion of the carriage with a closed-loop control circuit and with a crank-like actuation entails:

- the need to recalculate the position of the carriage for every movement of the actuation element in an extremely brief time.
- the need to recalculate a different electronic gain in each position, and
- the presence of inertias in thrust transmission.

Furthermore, the length of the crank cannot exceed a maximum limit, which is determined by half the width of the carriage, so that the length of the carriage's stroke is limited as well. The speed furthermore reaches the maximum allowed value only when the crank is arranged perpendicular to the direction of the carriage, whereas the carriage

moves along the entire remaining path at speeds which can be even much smaller than the maximum allowed value, following to a sinusoidal curve.

The Italian patent No. 717878 dated June 22, 1965 describes the actuation of a carriage by means of a hydraulic piston. However, this solution has had no practical success; in fact, besides entailing the same space occupation problems as the crank system described above, it has been found to be inadequate in withstanding the aggressive action of powder in the course of time.

U.S. patent No. 2,256,081 describes the actuation of a carriage by means of two racks coupled with gears which are connected to a third rack actuated by a pneumatic cylinder. However also this solution has had no practical success; in fact, according to this solution, it is impossible to reach the actuation power required to move a standard carriage at the above identified speed, because the air compressibility in the cylinder causes a very relevant delay between the state of the rate of air flow to the cylinder and the state of the pressure inside the cylinder. The order of magnitude of this delay is of seconds, whereby it is impossible to achieve a closed loop control of the movement of the carriage.

U.S. patent 2,270,829 describes a carriage which is moved by an electric motor. However this arrangement cannot be used for the purposes of the invention because the magnetic hysteresis of the electric motor is not compatible with the precision required for the closed-loop control of the movement of the carriage, particularly if the power of the electric motor is high enough to fulfil the cited kinematic and dynamic conditions of the movement of the carriage.

U.S. patent 3,788,787 describes a vertical support for adjusting the position of a powder-carrying plate with respect to the plane of the mould. However this support is clearly unsuitable for a carriage according to the present invention.

The aim of the present invention is to overcome the above described problems by providing a device and an apparatus wherein the motion of the carriage can be easily controlled by means of a closed-loop control circuit, fulfilling the cited kinematic and dynamic conditions.

Another object is, for an equal stroke, to reduce space occupation by half, and in any case to allow to program the length of the stroke according to the requirements, without being limited to a preset length.

Another object is to reduce the duration of the cycle for an equal maximum speed compatible with the handling of the powder in the grid.

Another object is to allow to extract the carriage very easily for cleaning or maintenance.

Another object is to allow a simple and reliable connection with the actuation element for controlling both position, speed and acceleration.

Not least object is to obtain an execution which is extremely simple in construction and reliable in operation.

This aim, these objects and others are achieved by the device according to the invention, for loading powder or granules to be pressed into a pressing apparatus and for unloading the pressed material from said apparatus, comprising: a carriage which can move on two guides; a powder-carrying grid which is suitable for being moved by said carriage so as to slide above a powder-carrying plate and above the molds to be loaded; a hydraulic motor mechanically connected to a pinion which engages a rack, so that a movement of said carriage is entrusted to said hydraulic motor and is in linear proportion to a rotation of said hydraulic motor; an encoder mechanically connected to said hydraulic motor so that a rotation of said encoder is in linear proportion to a rotation of said hydraulic motor; a valve for controlling a liquid flow fed to said hydraulic motor; control means connected with said encoder to adjust said valve according to a signal of said encoder.

Preferably, the carriage supports the rack, whereas the hydraulic motor is rigidly connected to the carriage's supporting structure. In this manner it is possible to obtain a lighter construction.

Preferably, the rack is supported by a longitudinal side of the carriage. In this manner it is possible to leave the region above the carriage free from space occupations.

The device preferably comprises a longitudinal slot which is arranged between said powder-carrying plate and said rack. In this manner the excess powder can be eliminated without accumulating.

Preferably, both of the longitudinal sides of the carriage support a rack with the set of teeth directed downward: said racks are engaged by pinions which are rigidly associated with a drive shaft which is arranged transversely below said racks and is actuated by said hydraulic motor. It is thus possible to ensure a perfectly equal movement on both sides of the carriage. More preferably, said racks are arranged outside said two guides, so that the racks are better protected against the damage caused by the powder, since said guides act as protection.

Preferably, a hydraulic accumulator is connected with said valve, so that a source of power is provided which is particularly simple and reliable.

Preferably, the device comprises a gearmotor which is arranged between said hydraulic motor and said pinion or said pinions. More preferably, the rpm rate of said pinion is comprised between 10% and 50% of the rpm rate of said hydraulic

motor and even more preferably between 20% and 50% of the rpm rate of said hydraulic motor. It is thus possible to use a smaller hydraulic motor which operates at a lower pressure.

Preferably, the device comprises vertical adjustment means for adjusting the alignment between the level of said powder-carrying plate and the level of said molds. More preferably, said vertical adjustment means comprise two parallel eccentric bodies which are directly supported by said pressing apparatus, and a frame for supporting said carriage is supported on said eccentric bodies. It is thus possible to easily adjust the alignment between the carriage and the level of the matrix of the molds, furthermore ensuring a perfect parallel arrangement between the powder-carrying plate and the mold plane. Furthermore, it is thus possible to mount or remove the carriage frame on or from the structure of the press with an extremely rapid operation which does not entail the tightening of bolts etc.

Preferably, the rotation of said two eccentric bodies is adjusted by a single adjustment shaft which is arranged perpendicular to said two eccentric bodies, allowing to adjust the vertical position of the carriage and of the powder-carrying plate with a very simple operation despite keeping the carriage always perfectly horizontal.

Preferably said valve is a flow-control valve, particularly a modulating valve or a servovalve.

Preferably said valve has a response time lower than 90 milliseconds, more preferably lower than 45 milliseconds, still more preferably lower than 25 milliseconds for passing from completely closed to completely open conditions. The above response times of the valve are important for achieving a fast speed of the carriage.

Preferably said control means comprise an electronic circuit with a sampling interval lower than 2000 microseconds and more preferably lower than 1000 microseconds and still more preferably lower than 500 microseconds. The above sampling intervals of the electronic circuit are important for achieving a fast speed of the carriage.

The pressing apparatus for pressing powder-like materials which comprises a device as described above can operate faster and more reliably. This is particularly important, since the mold loading and unloading steps are those which require the longest time in the budget of the pressing cycle.

Further characteristics and advantages of the invention will become apparent from the following description of a preferred but not exclusive embodiment of the device and of the apparatus, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

Figure 1 is a front view of the device according to the invention;

Figure 2 is an enlarged and partially sectional front view of the device of Figure 1;

Figure 3 is a partially sectional side view of the device of figure 1;

Figure 4 is an enlarged and partially sectional side view of the detail of the grid of the device of figure 1;

Figure 5 is an enlarged and partially sectional side view of the detail of the eccentric support of the device of Figure 1;

Figures 6, 7 and 8 are schematic side views of the device of Figure 1;

Figure 9 is a diagram of the operation of the device according to the invention and according to the known art; and

Figure 10 is a schematic view of the mechanical, hydraulic, and electric connections according to the invention.

With reference to Figures 1 to 8 and 10, the hopper 10 contains the powder with which the powder-carrying grid 11 must be filled; said powder-carrying grid can slide above the powder-carrying plate 12. The powder-carrying plate is arranged at the same level as the upper plane of the molds 13 of the press 14, so that the grid 11 can slide continuously until it is above the lower molds and can thus fill with powder all of the space comprised between the lower molds 15 and the upper plane of the molds 13. During the return motion, the grid 11 performs a shaving of the powder at the level of the upper plane of the molds 13.

The movement of the grid 11 is actuated by the carriage 16. The carriage 16 furthermore unloads the formed part or parts after pressing with its front part 17 and pushes them beyond the mold area onto a conveyor element which is not described. The carriage 16 can move along two guides 18 and 19, each of which comprises a roller 20 and 21 and a rail 22 and 23. Each roller slides on its respective rail, thus forming a guide 18, 19 for the carriage 16. In particular, one of the two rails and the respective roller have complementary profiles, so as to act as guides both in a vertical direction and in a transverse direction.

Movement of the carriage 16 is assigned to a hydraulic motor 24 which actuates a pinion 25 to which it is mechanically connected by means of a gearmotor 26. The hydraulic motor 24 is connected to the gearmotor 26 by means of the toothed belt 30. The hydraulic motor 24 is supported by the structure 29 on which the carriage 16 slides. Each pinion 25 engages the respective rack 27. There are two racks 27, each supported by a longitudinal side of the carriage 16; in particular, each rack 27 is fixed on the outside of the respective rail 22 and

23 and is directed downward. The two pinions 25 are mutually mechanically connected by means of the shaft 28, which is arranged below the racks and below the powder-carrying plate and is directly actuated by the gearmotor 26.

A longitudinal slot 31 is provided between the powder-carrying plate 12 and each rack 27, is open downward and allows to discharge the powder.

The vertical adjustment means for adjusting the alignment between the level of the powder-carrying plate 12 and the level of said molds 13 comprise two parallel eccentric bodies 33 which are directly supported by the press 14 by means of the element 34 which inserts itself directly and rigidly in the body of the press in a fixed manner. Each of the two eccentric bodies 33 comprises two rigidly associated eccentric disks 37.

The supporting frame 29 of the carriage 16 is simply rested on the eccentric bodies 33 by means of the free rollers 35, the axis whereof is rigidly associated with the frame 29. In this manner, the frame 29 can be separated from the press 14 simply by lifting it. The height of the frame 29 is adjusted by rotating the eccentric bodies 33. In order to synchronize rotation on both sides of the carriage, there is a single adjustment shaft 36 which is arranged perpendicular to the two eccentric bodies 33. More in particular, said shaft 36 is coupled to a pair of gears 40, 41 for each of the eccentric bodies 33.

With particular reference to Fig 10, an encoder 50 is mechanically connected to the gearmotor 26 and, by pinion 49, to hydraulic motor 24. The encoder 50 is connected to electronic circuit 51 by digital connections 56.

The electronic circuit 51 forms the control means which control valve 52 by lines 55, and is fed by lines 57. The electronic circuit may be based on a dedicated motion-control processor which can for example be formed by a LM628 Precision Motion Controller manufactured by National Semiconductor Corporation.

Other per se known service functions can be added to the processor, such as memory, feed, logic, input and output functions.

The valve 52 can be for example a D661 servovalve having a linear motor with permanent magnet manufactured by Moog.

The device has been found to be perfectly suitable for being controlled by means of an electronic closed-loop control system based on supplying the hydraulic motor 24 by means of proportional valves and on real-time control of the positions, speeds and accelerations actually attained by means of the above described encoder, thus automatically adapting the opening of the proportional valves so as to assuredly reach the preset values.

For the description of the pressing apparatus suitable for comprising a device according to the invention, complete reference is made to the description and drawings of the patent application PCT No. 89/11969.

Operation is described with particular reference to Figures 6-8. In particular, Figure 8 is a view of the pressing action, when the carriage 16 and the grid 11 are in rearward position. Figure 7 is a view of the unloading of the pressed parts and of the loading of fresh powder into the molds; both operations are performed with a single movement of the carriage 16. Figure 8 illustrates the return stroke of the carriage, with the consequent skimming of the powder deposited in the preceding step. The subsequent step is a new pressing according to Figure 6.

With reference to Figure 9, two curves are illustrated in a diagram wherein the axis of the abscissas always represents the maximum allowable speed of the carriage in meters per second. Said maximum allowable speed depends on the type of product to be pressed, on its dimensions, desired quality, etc. The axis of the ordinates represents the total duration of a pressing cycle in seconds.

The curve indicated by the triangles represents the operation of the carriage according to the known art, which provides the use of a crank actuated by a motor which rotates at a constant speed. No restrictions have been placed on this curve as regards acceleration, since it is not possible to adjust acceleration independently of maximum speed.

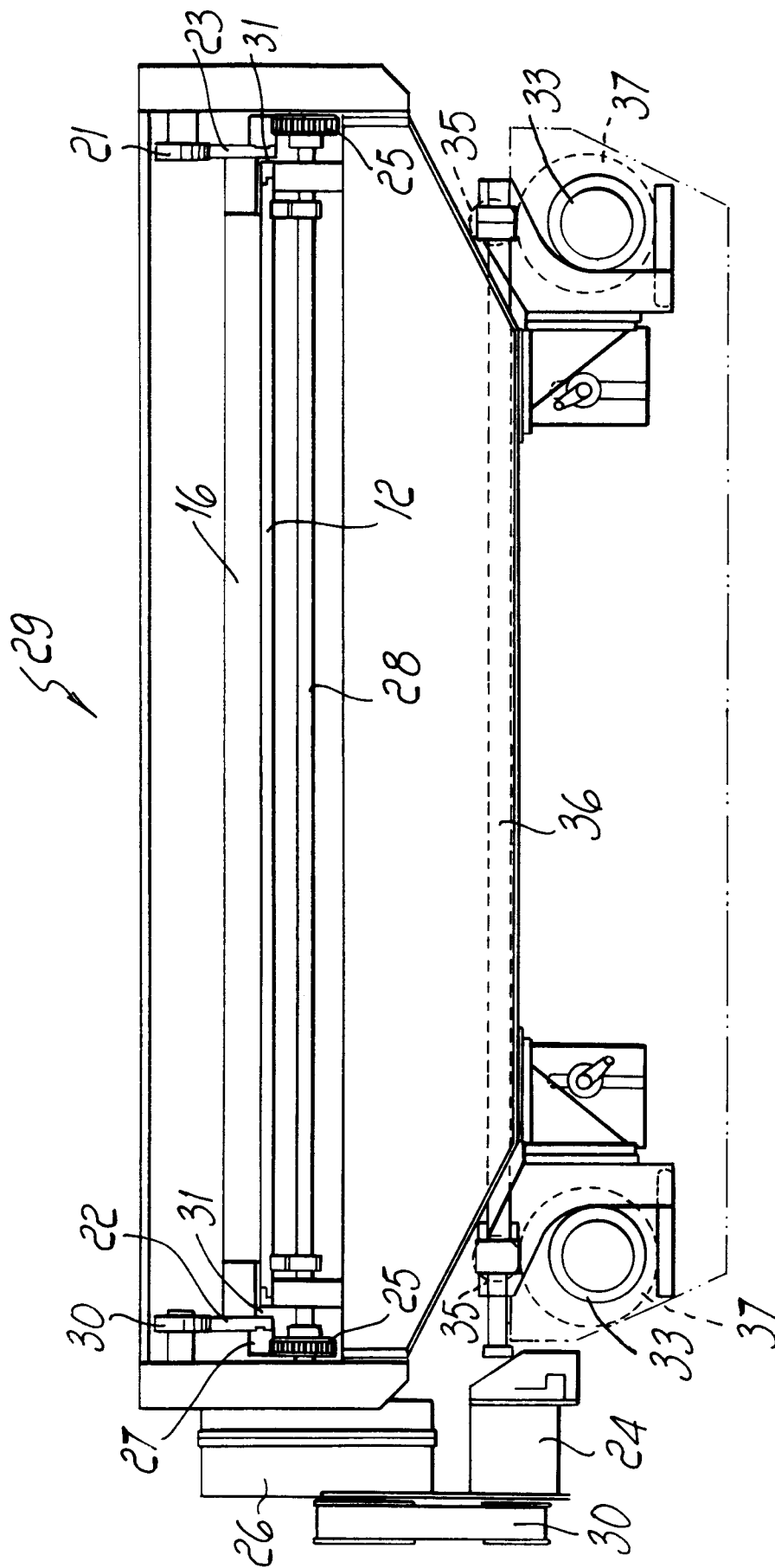
The curve indicated by the crosses represents the operation of the carriage according to the invention when setting a maximum acceleration value of 10 meters per second² in order to better preserve the quality of the final product, ensuring a better distribution and uniformity of the powder in the mold.

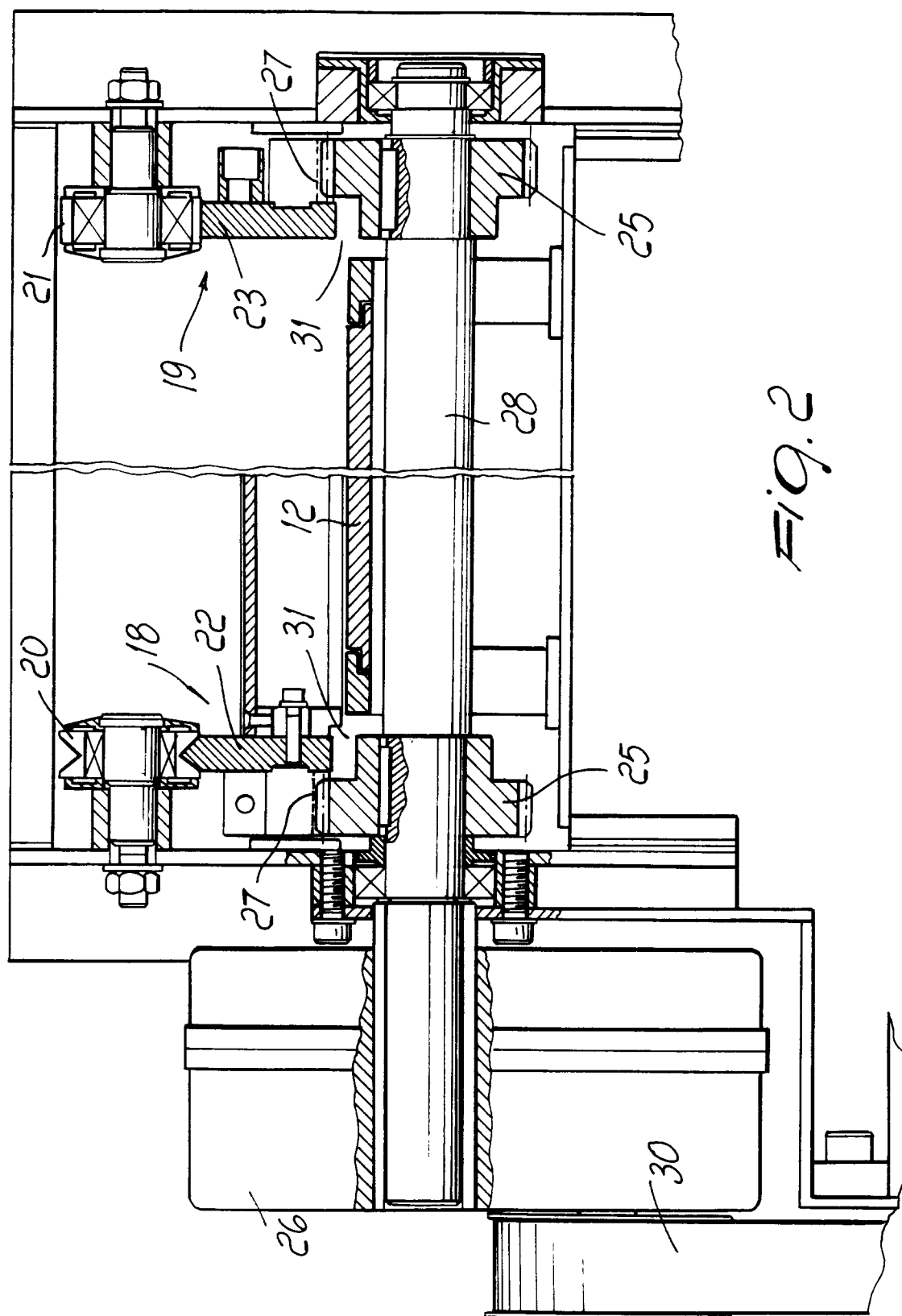
As can be seen, the carriage according to the invention is significantly faster for any allowable maximum speed. As the maximum allowable speed increases, the speed advantage of the invention apparently decreases only because the carriage according to the known art exceeds the acceleration of 10 meters per second² in various points of its path, thus entailing a decrease in the quality of the product.

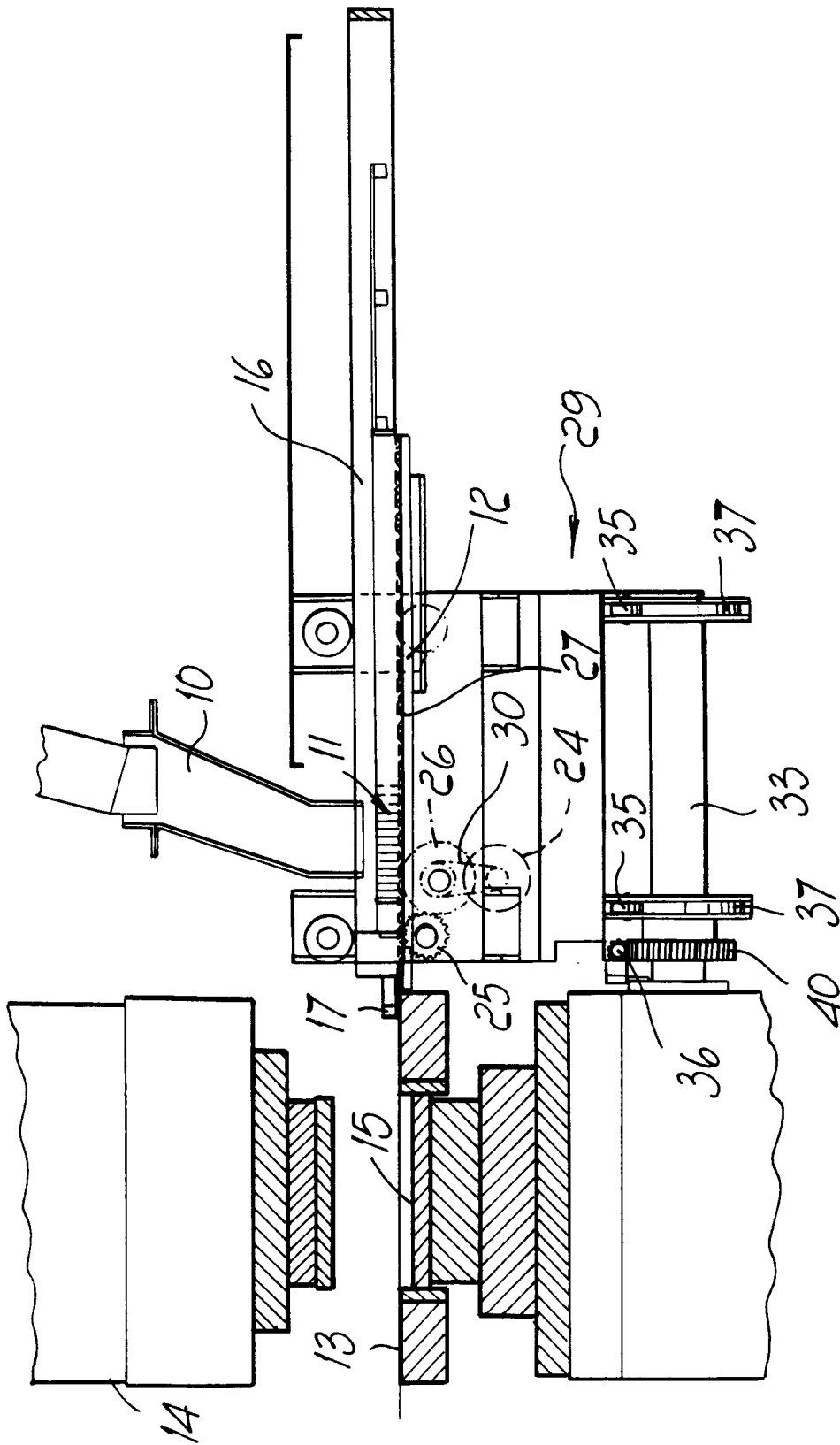
The invention is susceptible to numerous modifications and variations, all of which are within the scope of the inventive concepts indicated in the claims, so that the mechanical details may be replaced with other equivalent ones, so for example the encoder 50 can be connected to the rack 27, instead of to the gearmotor 26.

Claims

1. Device for loading powder or granules to be pressed into a pressing apparatus and for unloading the pressed material from said apparatus, comprising: a carriage (16) which can move on two guides (18); a powder-carrying grid (11) which is suitable for being moved by said carriage (16) so as to slide above a powder-carrying plate (12) and above the molds (13) to be loaded; a hydraulic motor (24) mechanically connected to a pinion (25) which engages a rack (27), so that a movement of said carriage (16) is entrusted to said hydraulic motor (24) and is in linear proportion to a rotation of said hydraulic motor (24); an encoder (50) mechanically connected to said hydraulic motor (24) so that a rotation of said encoder (50) is in linear proportion to a rotation of said hydraulic motor (24); a valve (52) for controlling a liquid flow fed to said hydraulic motor (24); control means (51) connected with said encoder (50) to adjust said valve (52) according to a signal of said encoder (50). 5 10 15 20 25
2. Device according to claim 1, wherein said carriage (16) supports said rack (27), said hydraulic motor (24) being rigidly connected to said carriage's supporting structure (29). 30
3. Device according to claim 2, wherein said rack (27) is supported by a longitudinal side of said carriage (16). 35
4. Device according to claim 3, comprising a longitudinal slot (31) which is arranged between said powder-carrying plate (12) and said rack (27). 40
5. Device according to one or more of the preceding claims, wherein both of the longitudinal sides of said carriage (16) support a rack (27) with its set of teeth directed downward: said racks being engaged by pinions which are rigidly associated with a drive shaft (28) which is arranged transversely below said racks and is actuated by said hydraulic motor (24). 45
6. Device according to claim 5, wherein said racks are arranged on the outside of said two guides (18). 50
7. Device according to one or more of the preceding claims, comprising an hydraulic accumulator connected with said valve (52). 55
8. Device according to one or more of the preceding claims, comprising a gearmotor (26) which is arranged between said hydraulic motor (24) and said pinion (25) or said pinions.
9. Device according to claim 8, wherein the rpm rate of said pinion (25) is comprised between 10% and 50% of the rpm rate of said hydraulic motor (24) and preferably between 20% and 50% of the rpm rate of said hydraulic motor (24).
10. Device according to one or more of the preceding claims, comprising vertical adjustment means (33) for adjusting the alignment between the level of said powder-carrying plate (12) and the level of said molds (13).
11. Device according to claim 10, wherein said vertical adjustment means comprise two parallel eccentric bodies (33) which are directly supported by said pressing apparatus: a carriage supporting frame (29) being rested on said eccentric bodies.
12. Device according to claim 11, wherein the rotation of said two eccentric bodies is adjusted by a single adjustment shaft (36) which is arranged perpendicular to said two eccentric bodies.
13. Device according to at least one of the preceding claims in which said valve (52) is a modulating valve or a servovalve. cording to at least one of the preceding claims
14. Device according to at least one of the preceding claims in which said valve (52) is a flow-control valve.
15. Device according to at least one of the preceding claims in which said valve (52) has a response time lower than 90 milliseconds, preferably lower than 45 milliseconds, more preferably lower than 25 milliseconds for passing from completely closed to completely open conditions.
16. Device according to at least one of the preceding claims in which said control means comprise an electronic circuit (51) with a sampling interval lower than 2000 microseconds and preferably lower than 1000 microseconds and more preferably lower than 500 microseconds.







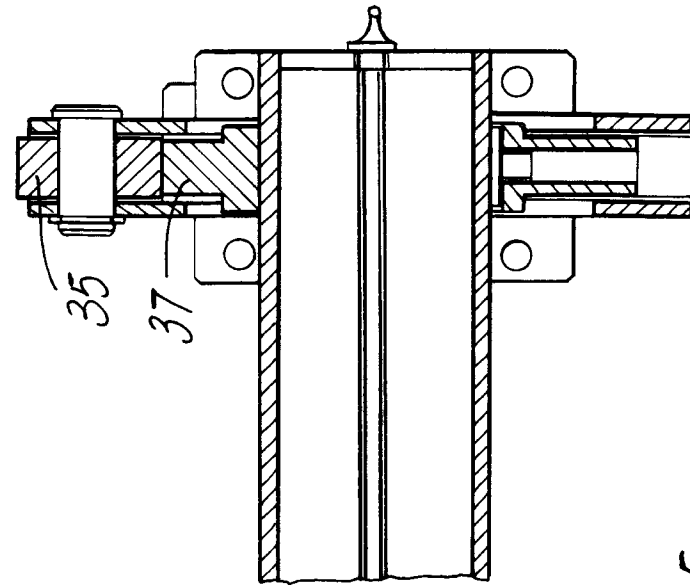


Fig. 5

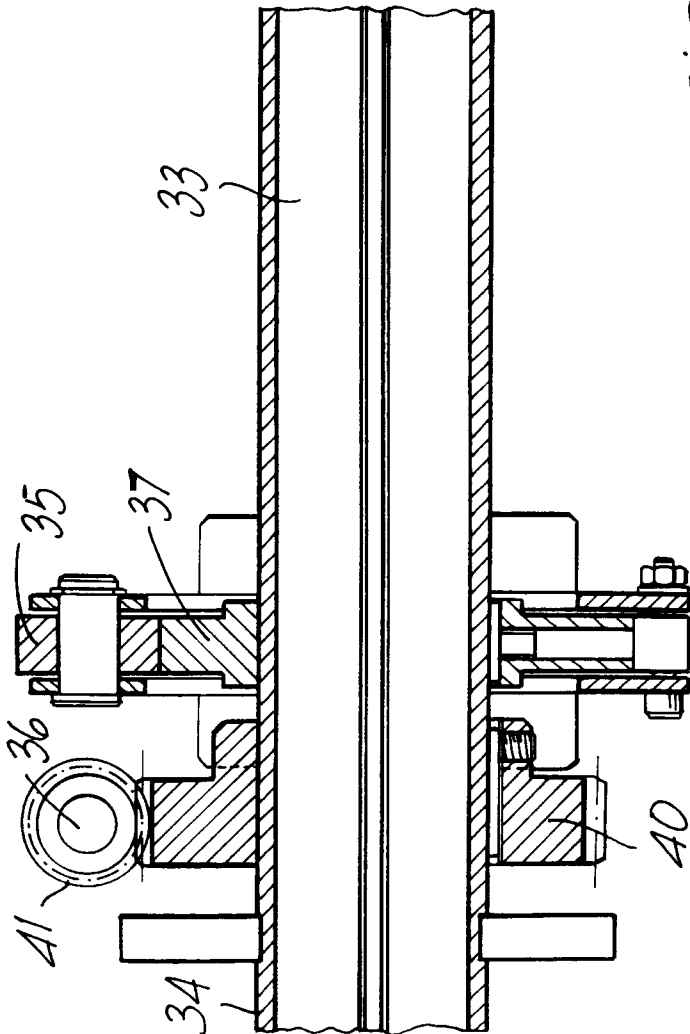
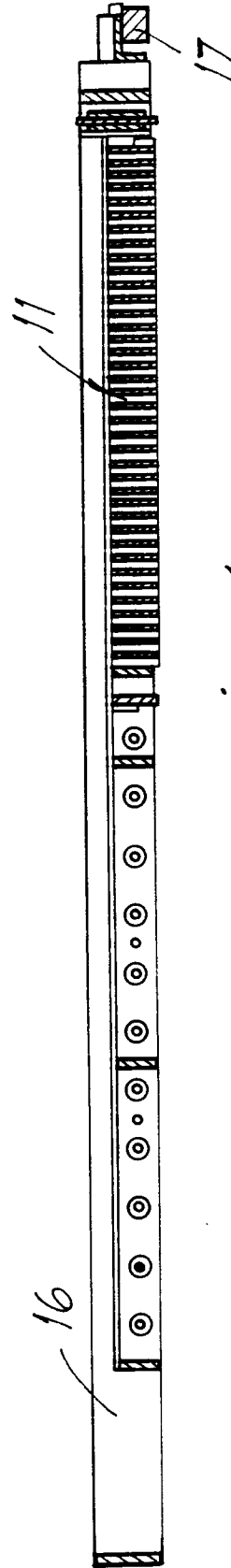


Fig. 4



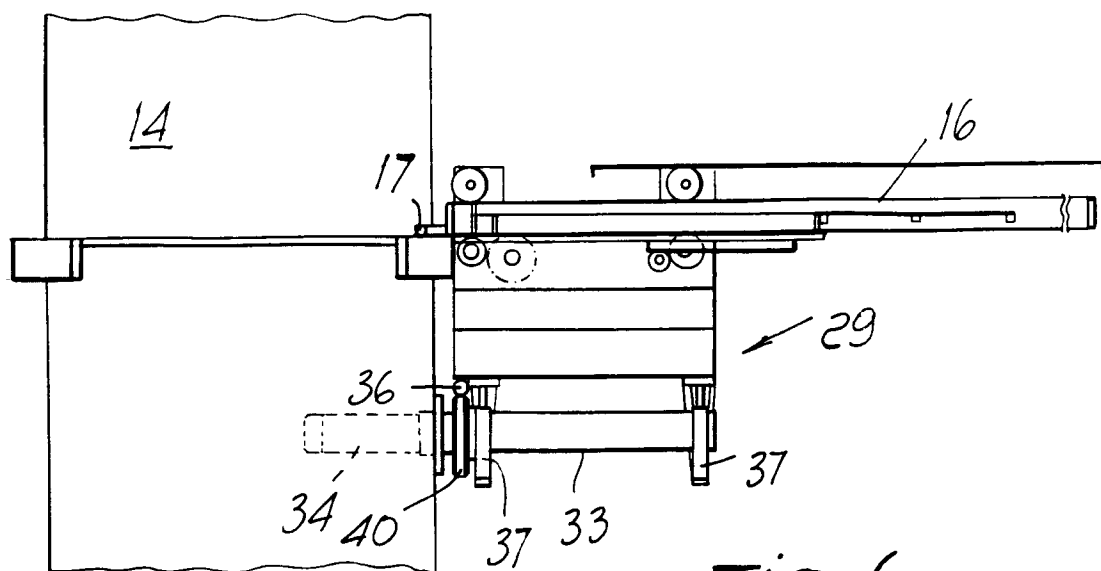


Fig. 6

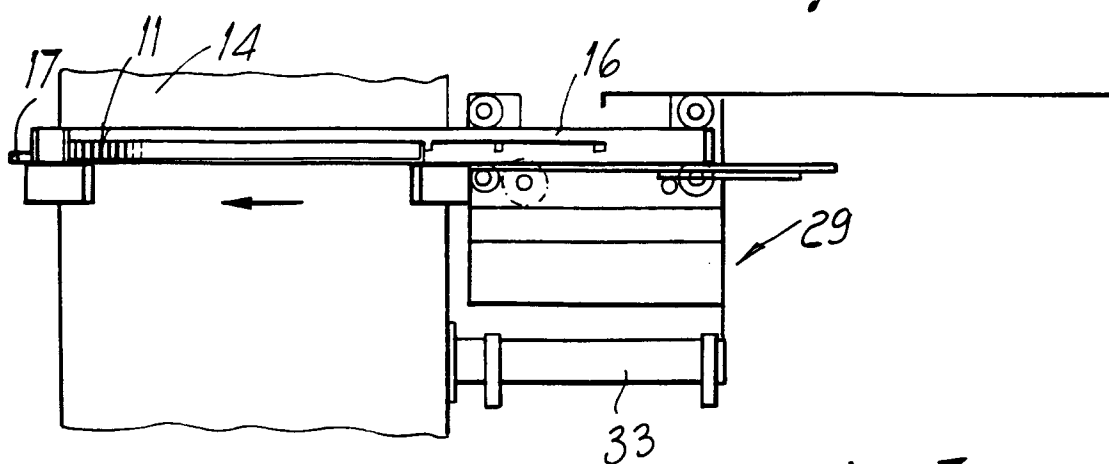


Fig. 7

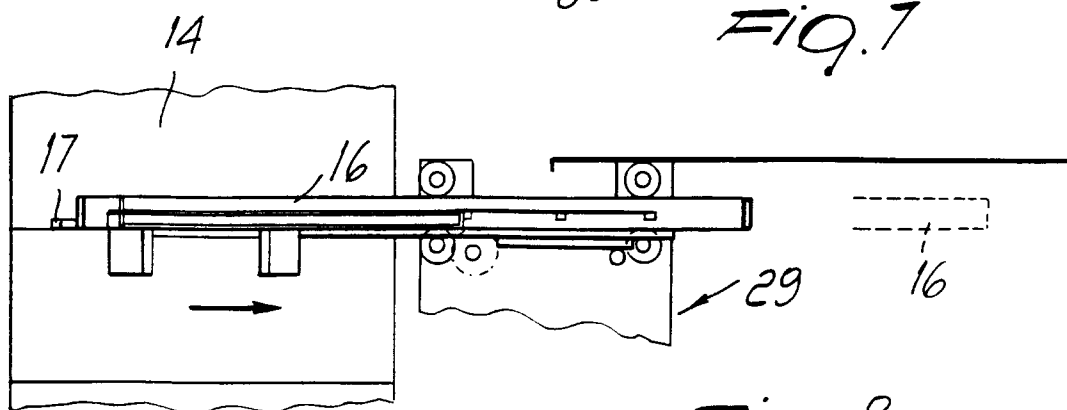


Fig. 8

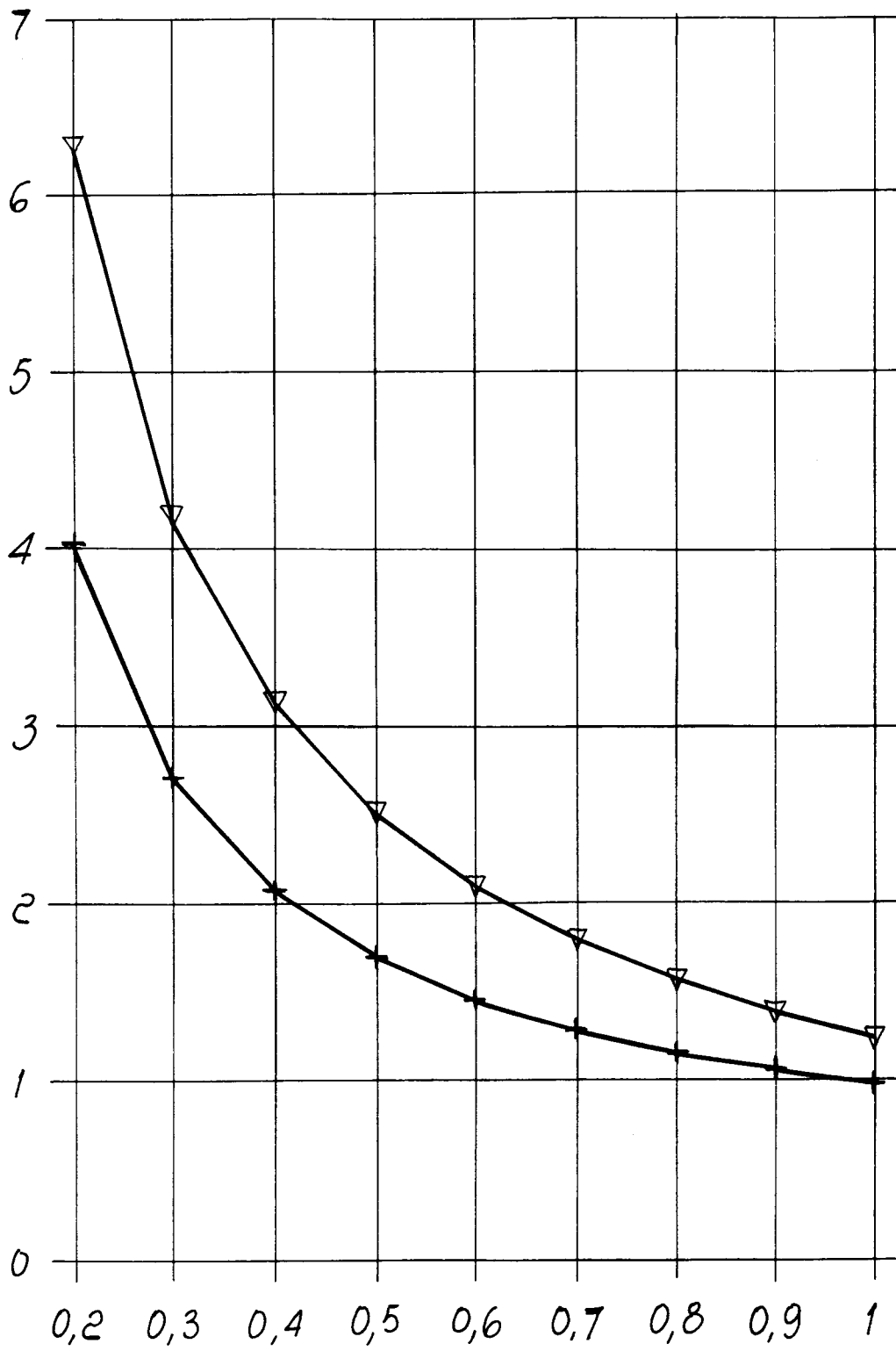


Fig. 9

