Title: CLOSING DEVICE OF PRESSURE FILTER AS WELL AS A METHOD FOR ITS CLOSING

Abstract: The invention relates to a closing assembly and a method implementing the closing of the same, particularly suited for a pressure filter, the filter comprising an openable/closable filter plate pack (1), a fixed end plate (4) and a movable end plate (5). The invention is characterized by having the movable end plate (5) equipped with one or a greater number of locking elements (11) with projections (12) made thereto. To accomplish locking of the movable end plate to the fixed end plate (4), a compatible number of locking means (9) are adapted on the end plate (4), the locking means comprising a rotatable locking member (14) having made thereto a number of projections (15) adapted to mesh with the projections (12) of the locking element (11) thus effecting the locking of the filter plate pack.
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
Closing device of pressure filter as well as a method for its closing.

The present invention relates to a closing assembly in accordance with the preamble of claim 1 particularly suited for use in a pressure filter, such a filter generally comprising an openable and closable filter plate pack, a fixed end plate and a movable end plate.

Pressure filters are used in the industry for removal of solid particles from liquids. A pressure filter is comprised of filter plates that are compressed between end plates into a tight pack thus forming filter chambers wherein filtration occurs. A typical filtration cycle comprises the steps of pumping sludge, compressing the formed solids cake, possibly washing the solids cake and drying the same by compressed air. Inasmuch these steps take place under a pressurized state in filter plates of a substantial area, it is necessary to use massive end plates and connecting structures therebetween to keep the filter plates in a sealed pack during filtration. After filtration, the filter plate stack is dismantled, the filter cakes formed during filtration are removed and the filter is closed for the next filtration cycle.

Conventional arrangements for closing a filter plate pack generally comprise a massive fixed end plate, a beam or plate structure parallel to the end plates and fixed tension rods connecting the same, all of these components together acting as a load-bearing framework. Inside this framework is adapted a filter plate pack and a movable end plate that under actuation by a closing device serves to clamp the filter plate pack tightly together against the movable end plate.

One prior-art method for closing a filter plate pack is disclosed, e.g., in patent publication GB 1080461, wherein the closing and opening of the filter plate pack takes place by means of lever arms that are adapted mechanically movable by means of a screw. A disadvantage of this closing/opening mechanism is the slow pace at which its movements take place, since the forces acting on the lever arms and the screw vary depending on the position of the arms, thus in practice excluding the implementation of comparatively fast closing movements. As the closing mechanism is disposed below the
filter plate pack, it is exposed to leaks from the pack. This, together with possible lubrication failures, may cause premature wear of the clamping screw and nut combination.

Another prior-art closing mechanism is based on a hydraulic cylinder serving to replace the mechanical lever system used in the former embodiment. In this latter arrangement, a single massive cylinder is used for closing/opening the filter plate pack and providing the clamping force required for sealing the pack during a filtration cycle. As the hydraulic cylinder must be very large to take the forces occurring during the filtration cycle, the opening/closing movements of the system obviously become slow in practicable embodiments. Moreover, such a massive system is subject to so large a mechanical yield under varying filtration pressures that it requires continuous and automated control during its actual use.

From patent publication FI 61632 is also known a closing device based on clamping the filter plate pack by means of a single-action hydraulic cylinder located under the pack, whereby the opening of the filter plate pack takes place gravitationally after the closing pressure is released. Positive locking of the filter plate pack is secured by a wedge driven by means of, e.g., a hydraulic cylinder, into a hole made to the piston rod of the hydraulic cylinder. A problem in this type of system arises from the proper selection of the tapering angle for the wedge so that, on one hand, a sufficiently long clamping stroke is attained and, on the other hand, the wedge remains securely stuck in the hole of the piston rod during the filtration cycle particularly if the tribological conditions between the wedge and the piston rod vary during the operation of the filter. As the hole made to the piston rod also passes into the interior of the cylinder, it causes wear to the cylinder seal.

Also known in the art is a system, wherein the filter plate pack is initially closed by means of a movable end plate which is actuated by fast-stroke hydraulic cylinders and is finally locked mechanically to the pull rods of the cylinders by way of, e.g., inserting pins located in the movable end plate into holes made to the pull rods. Due to wear of the filter plate seals, the filter plate pack does not retain its original leak-proofness if the geometry of its clamping mechanism is kept unchanged from time to time. Hence, the ulti-
Mating sealing of the filter plate pack is assured by means of a movable end plate adapted at the other end of the filter plate pack so as to be actuated by large short-stroke hydraulic cylinders. This system needs multiple cylinders with individual control, thus making the system relatively complicated and costly.

It is an object of the present invention to provide a closing assembly, wherein the above-described shortcomings are eliminated. The characterizing features of the assembly according to the invention are disclosed in the appended claims. According to the invention, it is now possible to construct a novel type of closing mechanism that allows the filter plate pack to be closed and mechanically clamped by means of a single set of hydraulic cylinders simultaneously utilizing the tube of the hydraulic cylinder as a force-transmitting structure.

The invention is directed to both a device and method of closing a filter plate pack, particularly in a pressure filter. In addition to a closable/openable filter plate pack, the filter comprises a movable end plate disposed against one end of the filter plate pack and a fixed end plate disposed at the opposite end of the filter plate pack, whereby the method comprises the steps of closing the filter plate pack by way of compressing the pack between a movable end plate and a fixed end plate disposed at the opposite end of the pack.

A filter equipped with a closing assembly according to the invention typically comprises a filter plate pack having a fixed, massive end plate disposed at one end of the filter pack. To the opposite end of the filter plate pack is adapted a movable end plate that in a closed filter compresses the plates of the filter plate pack tightly against each other and against the fixed end plate. When separated from each other into their other limit position, the filter plates become disposed apart from each other at a predetermined distance defined by links or the like members connecting the adjacent plates to each other.

In the above-described embodiment, the movable end plate is actuated by means of, e.g., four hydraulic cylinders that are located substantially close to the corners of the filter plate pack and are equipped with double-end, through-cylinder piston rods. One end of the piston rods of the cylinders is
connected to the fixed end plate, while the other end is connected to the framework of the filter, thus maintaining a constant geometrical distance between the piston rods of the cylinders.

The movable end plate is connected to each one of the tubes of the hydraulic cylinders. Hence, the closing/opening movements can be accomplished by means of a cylinder tube driven by hydraulic pressure. In a practicable construction, however, this arrangement as such is not sufficient to keep the filter plate pack tightly closed under a varying process pressure. Therefore, the construction according to the invention is based on complementing the moving cylinder tube, which is connected to the fixed end plate, with a mechanical clamping means that is operative in conjunction with the fixed end plate and is able to keep the filter plate pack clamped in its closed state. Herein, the cylinder tube acts as a force-transmitting element and prevents the end plates of the filter from becoming displaced apart from each other under variations in the process pressure.

According to the invention, the mechanical locking of the cylinder tube to the fixed end plate can be implemented by way of providing the end of the cylinder tube with two outward projections forming 90° sector fins on opposite sides of the central axis of the cylinder. The fixed end plate is respectively provided with a cylindrical member rotatable about the piston rod and having compatible inward sectoral projections in its interior. During the closing of the filter plate pack, the outward sectoral projections of the cylinder tube slide into the bore of the mating locking element disposed on the fixed end plate, whereupon the mating locking element is rotated by approx. 90° about its center axis. Hereby, the mating sectoral projections mesh with each other thus accomplishing the mechanical locking of the cylinder tube.

The construction disclosed herein offers rapid closing/opening of a filter plate pack. The mechanical locking of the pack takes place rapidly, and the cylinders used in the system may have a comparatively small diameter, whereby a fast opening/closing stroke can be attained without the need for hydraulic pumps of excessively large output. Resultingly, the construction is capable of cutting down the overall cycle time of the filter usage, consequently increasing the nominal capacity of the filter.
Furthermore, the locking arrangement is safe in use, because a loss of hydraulic pressure cannot release the locking mechanism. The mechanical locking of the filter end plates to each other is also stiff inasmuch it is not based on the use of hydraulic cylinders as the force-transmitting elements.

More specifically, the characterizing features of the closing mechanism and method according to the invention are disclosed in the appended claims.

In the following, the invention is described in more detail with the help of an exemplary embodiment by making reference to the appended drawings in which

FIG. 1 shows a pressure filter according to the invention in its open position;

FIG. 2 shows a pressure filter according to the invention in its closed position;

FIG. 3 shows a sectional view taken along line A-A of the construction of FIG. 2 prior to the locking of the filter plate pack;

FIG. 4 shows a sectional view taken along line A-A of the construction of FIG. 2 after the locking of the filter plate pack;

FIG. 5 shows a longitudinal section along line B-B of the configuration of FIG. 3; and

FIG. 6 shows a longitudinal section along line C-C of the configuration of FIG. 4.

Now referring to the drawings, a pressure filter according to the invention comprises an openable/closable filter plate pack 1. In FIG. 1 is illustrated such a filter in its open position, wherein the filter plates 2 of the pack connected to each other by, e.g., chain links (not shown), are disposed at a distance from each other, whereby a filter cloth 3 is adapted to pass between the plates in a zig-zag formation. In addition to the filter plate pack, the filter includes a fixed end plate 4 and a movable end plate 5 thus allowing the filter
plate pack 1 to be opened and closed through the mutual movement of these plates relative to each other. In a close vicinity of the corners of the plate pack are disposed hydraulic cylinders 6 that are equipped with a double-end, through-cylinder piston rod and are connected by their cylinder tubes 7 to the movable end plate 5. The piston rods 8 of the cylinders are connected by their lower ends to a locking means 9 mounted on the fixed end plate 4 and by their upper ends to a frame structure 10 thus securing the parallel alignment of the cylinder rods. By way of passing pressurized hydraulic fluid into the hydraulic cylinders 6, the cylinder tubes 7 with the movable end plate 5 connected thereto can be made to move up and down, thus respectively opening and closing the filter plate pack 1.

To the lower end of each cylinder tube 7 is connected a locking element 11 with a hollow center through which the piston rod 8 can move. To the locking element 11 are made projections 12, e.g., in the form of a disk sector spanning an angle of slightly less than 45° and separated from each other by an open sector of slightly larger than 45°. In the longitudinal direction of the piston rod 8, these sectoral projections 12 can be located, e.g., in three layers outdistanced from each other so that the gap between the projections of adjacent layers is slightly larger than the thickness of the fin-like sectoral projections.

Onto the fixed end plate 4 is mounted a locking means 9 having the lower end of the piston rod 8 centrally connected to the end of a cylindrical body part 13 of the locking means. Into the cylindrical interior of the body part 13 is adapted a rotatable locking member 14, whose exterior surface is cylindrical and interior bore is provided with inward projections 15 compatible with those of the locking element 11 mounted at the lower end of the cylinder tube 7. To the rotatable locking member is connected a link arm 16 extending to the exterior side of the body part 13 via an opening 17 made thereto. The height of the opening 17 is made equal to the height of the lever arm 16 and the width equal to the required angle of lever arm rotation, in the exemplary case 45°, plus the width of the lever arm. The lever arm actuator cylinder 18 is connected by its rear end to the frame by a pivotal joint 19, while its piston rod 20 is connected to the lever arm 16 of the locking means.
The filter shown in FIG. 1 in its open state can be closed in the manner shown in FIG. 2, whereby the locking elements 11 made to the lower ends of the cylinder tubes are driven in the manner shown in FIGS. 3 and 5 into the interior of the locking means 9 adapted on the end plate 4. Hereupon, cylinders 18 forming a part of the locking means 9 push the lever arms 16 so as to make the locking member 14 in the interior of the locking device to rotate thus causing in the manner shown in FIGS. 4 and 6 the projections 15 thereof to mesh with the compatible projections 12 made to locking elements 11 of the lower ends of the cylinder tubes. Subsequently, the filter plate pack remains locked into its closed position, wherefrom it cannot be open under varying process pressures even if the closing pressure applied to the cylinders 6 should disappear, because the locking elements 11 of the cylinder tubes 7 keep the rotatable locking members 14 tightly locked against a backing surface 21 machined to the fixed end plate. This arrangement maintains mechanical locking of the movable end plate 5 to the fixed end plate 4 via the cylinder tubes 7.

To a person skilled in the art it is obvious that the invention is not limited by the above-described exemplifying embodiment, but rather may be varied within the inventive spirit and scope of the appended claims. An essential feature of the invention is that to the movable end plate 5 are mounted one or more locking elements 11 having projections 12 made thereon and, to accomplish a positive locking of the filter plate pack to the fixed end plate 4, the end plate 4 is provided with a corresponding number of locking means 9 formed by a rotatable locking member 14 having projections 15 compatible with the projections 12 of the locking element 11 made thereto for the purpose of locking the filter plate pack. The disclosed closing assembly is further characterized by its use in conjunction with a locking method in which one or more locking elements 11, with projections 12 made thereto, of a movable end plate 5 is/are driven into the interior of locking means 9 placed on a fixed end plate 4 to accomplish the locking of a filter plate stack, whereby the interior projections 15 of a rotatable locking member 14 in the locking means assure positive clamping of the filter.

In the locking means, the number of projections may be varied in both the longitudinal and circumferential aspects, whereby the number of three
projections in the longitudinal direction and four sectoral projections in the cross-sectional plane, respectively, as described for the exemplary embodiment present no limitation to the function of the invention. Furthermore, the exemplary embodiment described above is implemented so that the meshing surfaces of the projections in the locking means are aligned in a plane perpendicular to the center axis of the cylinder thus rendering positive locking for a given distance between the end plates of the filter. Alternatively, the meshing surfaces of the projections may be made slightly inclined, whereby a small adjustment is possible in the mutual locked distance between the end plates.

While the rotation of the locking member 14 in the exemplary embodiment is arranged to take place by means of actuator cylinders 18, also other types of rotation actuation may be used. For instance, a portion of the outer surface of the locking member 14 can be made toothed, whereby the actuating force for rotation of the locking member is imposed by means of the motion of a meshing gear or toothed rod. The rotary movement of the locking member can also be implemented by way of adapting sealed chambers to the interface between the rotary locking member 14 and the nonrotary body part 13, whereby the rotary motion is actuated through passing pressurized fluid into these chambers. Obviously, the number of rotating actuators of the locking means is not limited to one, but in the above-described exemplary embodiment there could be, for instance, two rotating actuator cylinders 18 placed symmetrically on both sides of the locking means.

While the most natural number of locking means is four, one in each corner of the filter frame, also other quantities of locking means may be contemplated. E.g., in the case of low process pressures or small filter areas, only two locking means can be used placed in opposite corners of the filter plate pack. Respectively, it is also possible to provide only certain ones of the closing cylinders with the locking members. In contrast, more than four closing cylinders and locking means may be advantageously used to cope with large filter areas and/or high process pressures.

The closing assembly according to the invention may also be located in the top portion of the filter, above the filter plate pack. The locking system can
also be used in other types of pressure filters than those designed for a vertical closing action, e.g., for filter constructions known in the art as filter presses.

To a person skilled in the art it is obvious that the invention is not limited by the above-described exemplifying embodiment, but rather may be varied within the inventive spirit and scope of the appended claims.
What is claimed is:

1. Closing assembly particularly suited for a pressure filter, the filter typically comprising an openable/closable filter plate pack (1), a fixed end plate (4) and a movable end plate (5), characterized in that the movable end plate (5) is equipped with one or a greater number of locking elements (11) with projections (12) made thereto and that, to accomplish locking of the movable end plate to the fixed end plate (4), a compatible number of locking means (9) are adapted on the end plate (4), the locking means comprising a rotatable locking member (14) having made thereto a number of projections (15) adapted to mesh with the projections (12) of the locking element (11) thus effecting the locking of the filter plate pack.

2. Closing assembly according to claim 1, characterized in that the locking element (11) with the projections (12) made thereto is adapted to one end of the cylinder tube (7) of a hydraulic cylinder (6), while the other end of the cylinder tube is connected to the movable end plate (5).

3. Closing assembly according to claim 1 or 2, characterized in that at least one of the hydraulic cylinders (6) is equipped with a through-cylinder piston rod (8) and is most advantageously adapted to operate in a close vicinity of the corner(s) of the filter plate pack (1).

4. Closing assembly according to any one of claims 1 - 3, characterized in that to the fixed end plate (4) is machined a backing surface (21) allowing a mechanical locking contact to be established with the locking element (11) of the movable end plate (5).

5. Closing assembly according to any one of claims 1 - 4, characterized in that the mechanical locking between the movable end plate (5) and the fixed end plate (4) is established via the cylinder tube (7).

6. Closing assembly according to any one of claims 1 - 5, characterized in that, for locking the locking element (11) of the movable end plate (5) with the help of the rotatable locking member (14) to the backing surface (21) of the fixed end plate (4), to the locking member (14) is connected via,
e.g., a lever arm (16) an actuator cylinder (18) or the like drive means capable of rotating the projections (15) so as to mesh said projections with the projections (12).

7. Closing assembly according to any one of claims 1 - 6, characterized in that the locking means (9) is formed by a cylindrical body part (13) having adapted into its interior a cylindrical, rotatable locking member (14), whose interior surface has the projections (15) made thereto.

8. Method of closing a closing assembly particularly that of a pressure filter, in which method the closing/opening of the filter plate pack (1) is effected by a mutual movement between a fixed end plate (4) and a movable end plate (5), characterized in that, to effect locking of the pressure filter, one or a greater number of locking elements (11) of the movable end plate (5), with projections (12) made to the locking elements, are driven into locking means (9) adapted the fixed end plate (4) in order to effect locking between the end plates, whereupon projections (15) made to a rotatable locking member (14) lock the filter.

9. Method according to claim 8, characterized in that the method is used for controlling via the hydraulic cylinder (6) both the locking element (11) adapted to the cylinder tube (7) and having the projections (12) made thereto, as well as the movable end plate (5) connected to the other end of the hydraulic cylinder.

10. Method according to claim 8 or 9, characterized in that at least one of the hydraulic cylinders (6) equipped with a through-cylinder piston rod (8) is most advantageously adapted to operate in a close vicinity of the corner(s) of the filter plate pack (1).

11. Method according to any one of claims 8 - 10, characterized in that the locking element (11) of the movable end plate (5) is driven into the rotatable locking member (14) in order to establish mechanical locking to a backing surface (21) of the fixed end plate (4).
12. Method according to any one of claims 8 - 11, characterized in that the mechanical locking between the movable end plate (5) and the fixed end plate (4) is established via the cylinder tube (7).

13. Method according to any one of claims 8 - 12, characterized in that the locking element (11) of the movable end plate (5) is locked with the help of the rotatable locking member (14) to the backing surface (21) of the fixed end plate (4) by way of actuating, e.g., by an actuator cylinder (18) or the like drive means, a lever arm (16) connected to the locking member (14) to rotate the projections (15) so as to mesh said projections with the projections (12), thus accomplishing a positive locking between the end plates.
# INTERNATIONAL SEARCH REPORT

### A. CLASSIFICATION OF SUBJECT MATTER

**IPCG: B01D 25/19**
According to International Patent Classification (IPC) or to both national classification and IPC

### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

**IPCG: B01D**

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

**SE, DK, FI, NO classes as above**

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C. See patent family annex.

* Special category of cited documents:
  * "A" document defining the general state of the art which is not considered to be of particular relevance.
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Date of the actual completion of the international search: 26 November 2001

Date of mailing of the international search report: 27-11-2001

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