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(54) **Slipforming extruder for hollow-core concrete elements.**

(57) This publication describes a slipforming extruder for production of hollow-core concrete elements (23), movable in respect to a casting bed (4) and comprising a frame (18) which is movable, e.g. supported by wheels (19), and provided with at least two adjacent auger flights (2, 25) with flights (5) and core-forming mandrels (3), mounted to the final end of each auger flight (2). Furthermore, the machine comprises a primary drive and power train system (7, 15, 16, 17) for rotating the auger flights (2) and a feed apparatus attached to the frame (18), e.g. a hopper (1), for feeding the auger flights (2) with the concrete mix to be cast. According to the invention, a secondary drive and power train system (8...14) is adapted to move the core-forming mandrel extensions (3) of the adjacent auger flights (e.g. 2 and 25) in a synchronized and counter-phased reciprocating manner in the axial direction with respect to each other so as to make an annular slot (29) remaining between the final end of auger flights (2, 25) and corresponding core-forming mandrels (3, 30) alternately widen and narrow due to the relative movement between the auger flight (2, 25) and the corresponding counterphased moving core-forming mandrel (3, 30), thus mixing the concrete.

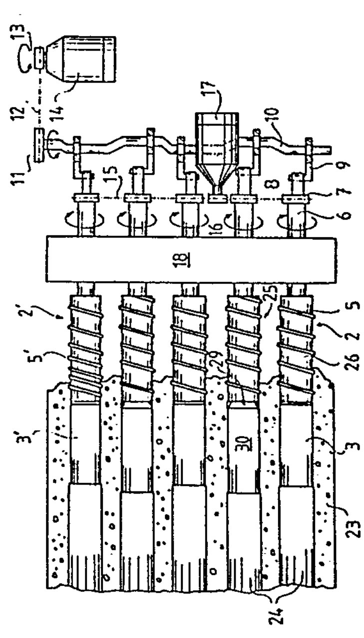

Fig. 2

EP 0 229 751 A2

Description

Slipforming extruder for hollow-core concrete elements

The present invention relates to a concrete slab extruder in accordance with the preamble of claim 1.

Casting of hollow-core concrete elements with sliding molds, especially hollow-core slabs, is based on extruding the concrete mix onto the casting bed by using one or several core-forming members, e.g. a core-forming mandrel and/or a trowel tube. The concrete mix is compacted by utilizing the pressure generated by the auger flight.

In the prior art there exist several basically similar constructions of slipforming extruders for hollow-core elements in which the concrete mix is extruded by means of auger flights. The extruder moves on rails on a bed. The auger flights are conical by their flight sections so as to make the flight expand towards the end of the flight. This kind of a construction achieves an effective compaction of the concrete. A forming member extension is provided immediately next to the auger flight, e.g., a core-forming mandrel, which is vibrated by means of a vibrator mounted inside the mandrel. In addition, a vibrator beam atop the cover part of the machine is vibrated, which combines with the vibration of the core-forming mandrels to effect the final compaction of the concrete. The core-forming mandrel is accompanied with a trowel tube, whose duty is to support the shell walls of the hollow-core slab at the final end of the extruder machinery.

Due to the high vibration frequency, however, the drawbacks of the extruder construction of the hollow-core forming mandrel type include a high noise level, high energy consumption, and a low efficiency of vibration power used for compaction.

The present invention aims to overcome the disadvantages found in the prior-art constructions and to present a completely new type of extruder which is especially applicable for the compaction of a soil-wet concrete mix.

The invention is based on moving the core-forming mandrel extensions of adjacent auger flights used for concrete extrusion in a synchronized and counterphased reciprocating manner in the axial direction in respect to the auger flights. Then, the annular slot or recess between the final end of the auger flight and the core-forming mandrel alternately becomes wider and narrower, thus mixing the concrete contained in this space. The auger flights in accordance with the invention, and especially their core parts, have an approximately constant diameter, thus deviating from the conventional constructions of conical shape.

In addition, the difference between the outside diameter of auger flights and the diameter of the auger core is small as compared to the conventional auger construction, which allows a relatively large diameter for the auger core. The auger length is also preferably relatively long.

A special feature of the invention proposes a decreasing pitch of flights towards the final end of the auger flight. This decrease of pitch is preferably constant, which makes the pitch progressively smaller towards the final end of the auger. Consequently, the pitch of auger flights is essentially smaller at the final end of the auger than at the initial end of the auger.

In addition to the increasing compaction of concrete at the final end of the auger flight, the compaction is furthermore amplified by the axially reciprocating movement of the auger flights.

More specifically, the slipforming extruder in accordance with the invention is characterized by what is stated in the characterizing part of claim 1.

The invention provides remarkable advantages. Thus, the noise level generated by an extruder machine in accordance with the invention is essentially lower than in hollow-core extruders based on vibration compaction with a vibration frequency in the range of 150...250 Hz. In addition, the slipforming extruder in accordance with the invention is especially applicable to both the production of prestressed hollow-core slabs of the aforementioned type and production of steel-reinforced hollow-core concrete slabs.

In the following, the invention will be examined in more detail by means of exemplifying embodiments.

Figure 1 shows a partly schematic cross-sectioned side view of a slipforming extruder in accordance with the invention.

Figure 2 shows a partly schematic top view of a slipforming extruder with a slightly different construction from that shown in Figure 1.

Figure 3 shows a cross-sectional view with expanded scale an auger flight with the core-forming mandrel withdrawn.

Figure 4 shows an auger flight depicted in Figure 3 with the core-forming mandrel expulsed.

In the following, the constructions shown in Figures 1 and 2 are examined in parallel using an analogous reference numbering system.

The slipforming machine shown in Figure 1 is adapted movable on a casting bed 4. The machine comprises a frame 18, which is supported on wheels 19 and movable on rails 20. With bearings rotatably secured to the frame 18, it has five parallel auger flights 2, 25 with relatively low-profile flights 5. Consequently, a core member 26 of the auger flights 2 has an appreciably large and approximately constant diameter in the axial direction. The flights 5 have a constant pitch over the entire length of the auger 2. Each final end of the augers 2 carries a core-forming mandrel 3 and/or a trowel tube, both mounted axially movable and rotatable in respect to the auger.

The drive and power train system 7, 15, 16, 17, which is provided for rotating the auger flights 2, is arranged on the movable frame 18. This drive and power train system comprises an electric motor 17, which drives the auger flights 2, 25 via a chain sprocket 16 and a chain 15 by chain sprockets 7, which are mounted onto shafts 6 of auger flights 2, 25.

The concrete poured from a hopper 1 is adapted to flow to the initial end of the auger flights 2. A hollow-core slab 33 to be cast is bordered from below by a bed 4, from the sides by side members which are not shown, and from above by vibrating top beams 21 and 22. As the slipforming extruder machine moves from left to right during the casting operation in accordance with Figure 1, a core-forming mandrel 3 forms a void 24.

The frame 18 also carries a secondary drive and power train system 8...14. It comprises an electric motor 14 together with a crankshaft assembly 10, which is driven by the motor and is effectual on shafts 6 of the adjacent auger flights 2, 25. The assembly is connected via connection rods 9 to ends of bars 8 passing through hollow shafts 6 of the auger flights 2 so as to make the adjacent core-forming mandrel 3 and 30 move in a synchronized and counterphased reciprocating manner in the axial direction with respect to the corresponding auger flights 2 and 25 during the operation of the slipforming extruder machine.

The frequency of the reciprocating movement of core-forming mandrels 3 and 30 is 0.3...100 Hz, preferably 5...10 Hz. The amplitude of the reciprocating movement (stroke length) is 0.5...50 mm, preferably about 10 mm.

The reciprocating movement at the final end of the extrusion phase performs an extremely effective compaction of concrete. The reciprocating movement of core-forming mandrels 3, 30 creates pressure variations in the concrete by achieving internal mixing of concrete by means of an alternately increasing and decreasing annular space 29 between the final end of auger flights 2, 25 and corresponding core-forming mandrels 3, 30. This also forces the concrete aggregates to perform a shearing flow in the direction transverse to the axial flow. The core-forming mandrel 3 gives the void 24 a desired form. If the core-forming mandrel 3 has a cross-section of circular shape or rotates with the auger flight 2, the void 24 will have a cylindrical shape.

In the exemplifying embodiment shown in Figures 3 and 4, the core-forming mandrel 3 may also be nonrotational. Then, the bar 8 passing through the hollow shaft 6 of the auger flight 2 moves only the core-forming mandrel 3 in respect to the auger flight 2. In order to implement this axial movement, the intruding portion of the mandrel 3 outer surface is provided with axial splines 27 and the envelope portion inner surface of the final end of the auger flight 2 is provided with corresponding key members 28. When a nonrotational mandrel 3 is used, core voids, different from a cylindrical shape, are also possible.

The aforementioned progressively decreasing pitch is exemplified in the upper auger 2′ of Figure 2. In this embodiment, the pitch of a flight 5′ is decreased in the feed direction so as to achieve at the final end of the auger 2′ a pitch of 30...70 %, preferably about 50 %. of the pitch at the initial end of the auger 2′. The auger 2 has a flight profile 5 with a height of, for instance, 3...10 % of the diameter of the auger 2.

The scope of the invention entails constructions different from the exemplified embodiment. Thus, in addition to the reciprocating movement of the core-forming mandrels 3, the corresponding auger flights 2 may also move simultaneously in a counterphased manner in respect to the mandrels. In this case, too, the relative mutual movement of the auger flights 2 and the core-forming mandrels 3, is implemented. The core-forming mandrels 3 may also be actuated by a rotational movement, e.g. a oscillating rotational movement, which is different from that of the corresponding auger flights 2.

Claims

1. A slipforming extruder applicable to the production of hollow-core concrete elements (23) with a movable construction in respect to a casting bed (4) and comprising
- a frame (18), which is movable and, for instance, supported by wheels (19),
- at least two augers (2, 25) with flights (5), parallel mounted on bearings in the frame (18),
- a core-forming mandrel (3) attached to the final end of each auger flight (2),
- a primary drive and power train system (7, 15, 16, 17) for rotating the auger flights (2), and
- a feeder apparatus attached to the frame (18), e.g. a hopper (1), for feeding the concrete mix to be cast onto the auger flights (2),

characterized in that the core-forming mandrel extensions (3, 30) of the adjacent auger flights (2, 25) are arranged by means of a secondary drive and power train system (8...14) to move in a synchronized and counterphased manner in the axial direction with respect to each other so that an annular slot (29) remaining between the final end of auger flights (2, 25) and corresponding core-forming mandrels (3, 30) alternately widens and narrows due to the relative movement between the auger flight (2, 25) and the corresponding counterphased moving core-forming mandrel (3, 30).

2. A slipforming extruder as claimed in claim 1, **characterized** by a secondary drive and power train system comprising a power actuator (14), preferably an electric motor, together with a crankshaft assembly (10), driven by the motor and effectual on rod shafts (8) connected to adjacent core-forming mandrels (e.g. 3 and 30) and passing through the corresponding auger flights (2 and 25).

3. A slipforming extruder as claimed in claim 1, **characterized** in that the frequency of the reciprocating movement of core-forming mandrels (3) is 0.3...100 Hz, preferably 5...10 Hz.

4. A slipforming extruder as claimed in claim 1, **characterized** in that the amplitude of the reciprocating movement (stroke length) of the core-forming mandrels (3) is 0.5...50 mm, preferably about 10 mm.

5. A slipforming extruder as claimed in claim 1, **characterized** by a progressively decreasing

pitch of the flight (5′) of each auger flight (′) in the feed direction.

6. A slipforming extruder as claimed in claim 5, **characterized** in that the pitch of the flight (5′) at the final end of the auger flight (2′) is 30...70 %, preferably about 50 %, of the pitch of the flight (5′) at the initial end of the auger flight (2′).

7. A slipforming extruder as claimed in claim 1, **characterized** in that each auger flight (2) and its core member (26) have a construction of an approximately constant diameter.

8. A slipforming extruder as claimed in claim 1, **characterized** in that the profile height of the flight (5) is 3...10 % of the diameter of the auger flight (2).

9. A slipforming extruder as claimed in claim 1, **characterized** in that the auger flights (2, 25) are adapted to move in a syncronized and counter phased reciprocating manner with respect to their corresponding core-forming mandrels (3, 30).

10. A slipforming extruder as claimed in claim 1, **characterized** in that the core-forming mandrels (3, 30) are adapted to move in an oscillating rotational movement, unrelated to the movement of the corresponding auger flights (2, 25).

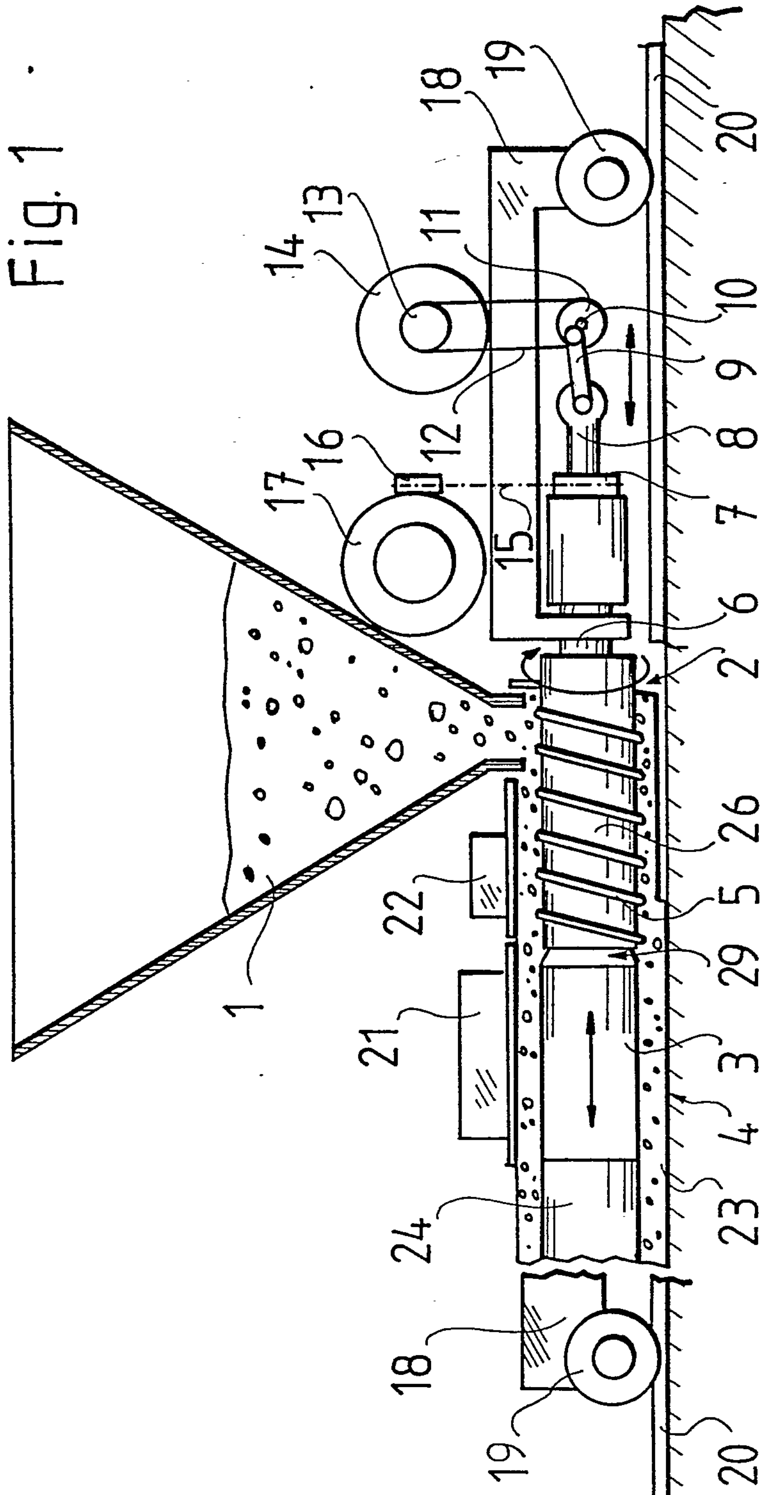

Fig. 1

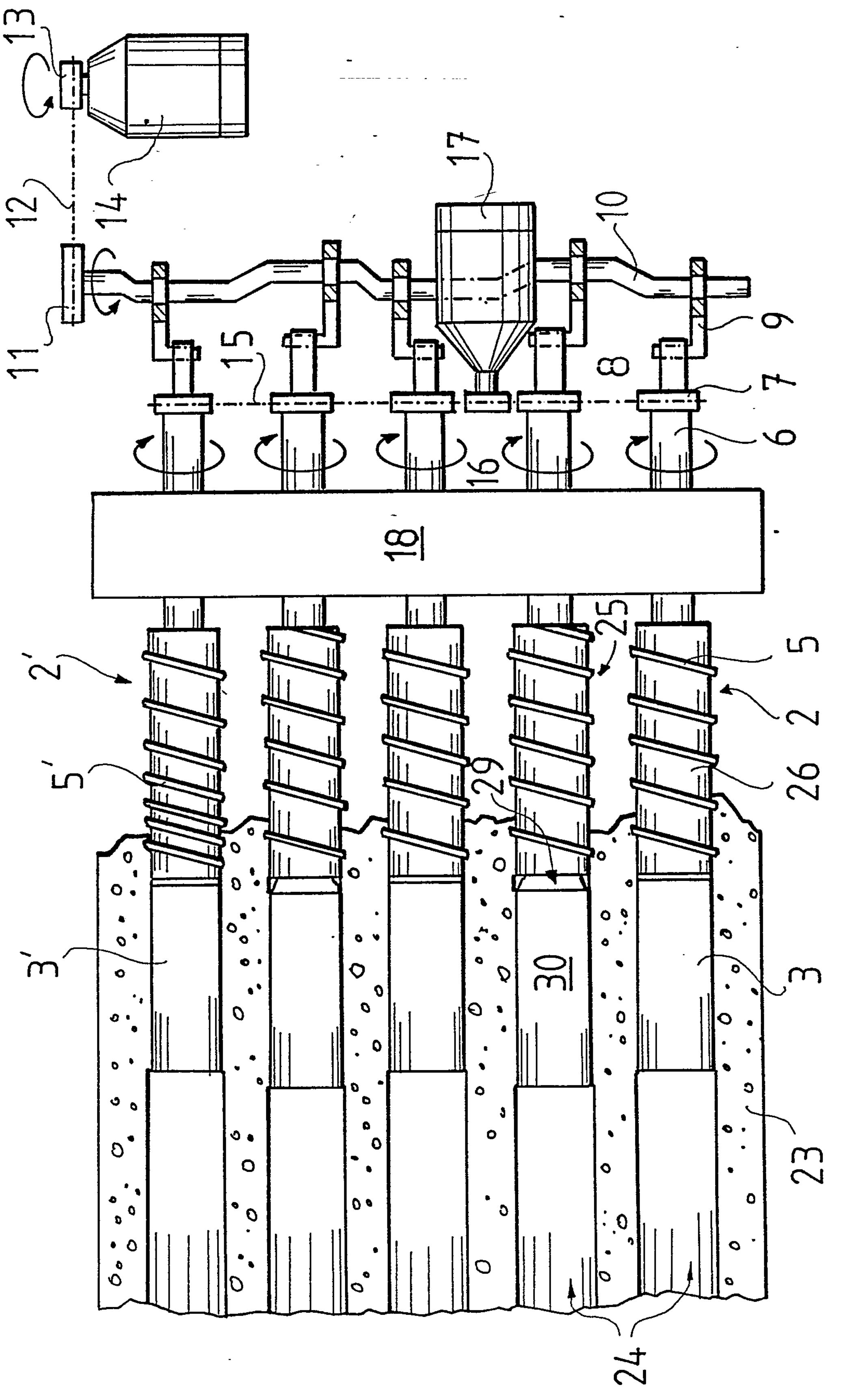

Fig. 2

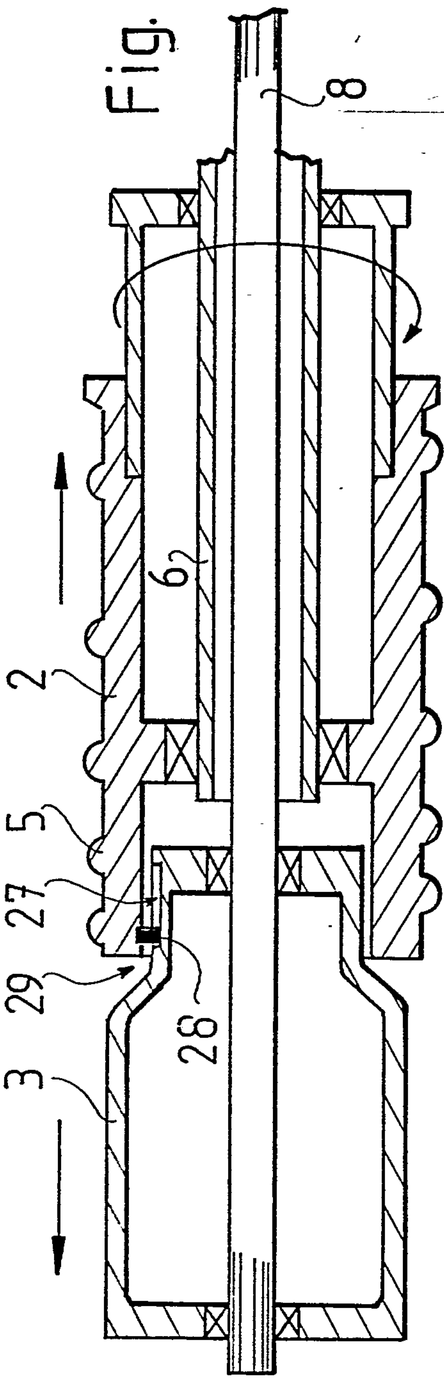

Fig. 3

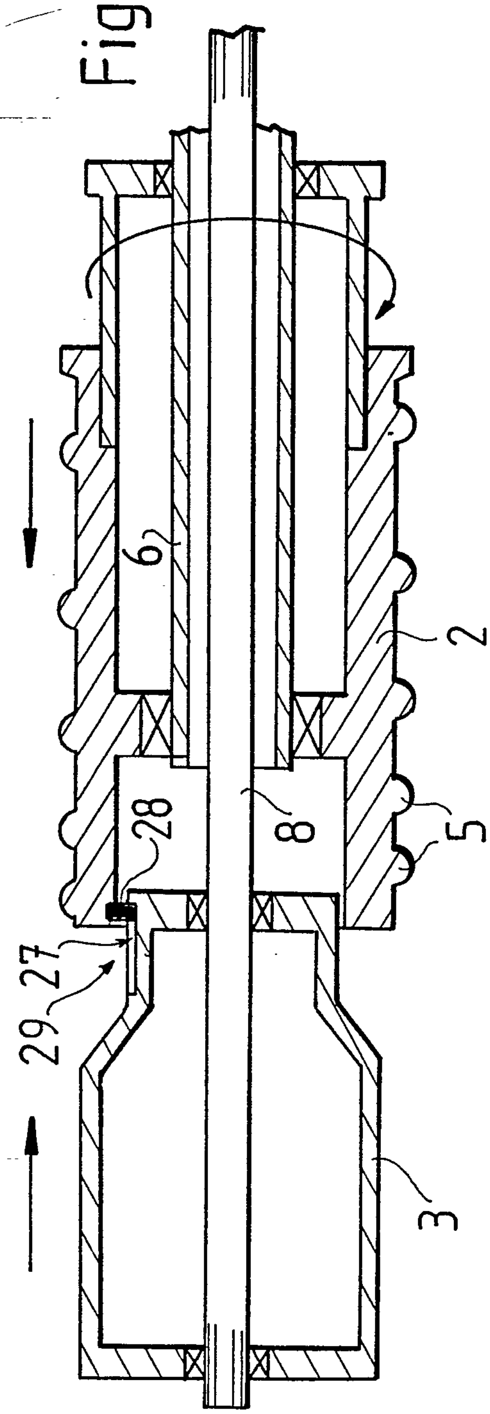

Fig. 4