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(54) PRESTRESSED PRESSURE VESSELS

(71) We, HOCHTEMPERATUR-REAKTORBAU GmbH, of 53—57 Hansaring, 5000 Köln 1, Federal Republic of Germany, a body corporate organised under the laws of the Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention concerns prestessed pressure vessels with a closure assembly for openings in the vessels.

The underlying task of the invention is to provide improved closure assemblies for openings of pressure vessels.

According to the invention there is provided a prestressed pressure vessel comprising a penetration or cavity provided with a lining and a closure assembly therefor, said assembly including a sealing cover provided with a flange and bearing a support cover which in use is subject to the load caused by the pressure prevailing inside the vessel, the sealing cover being sealed to said lining by way of a welded lip seal arranged between the periphery of the flange and the periphery of the said lining, the flange of the sealing cover being provided on its face adjacent to the said lining with annular grooves for accommodating further sealing elements.

By means of the tendons acting in the longitudinal direction of the pressure vessel, and which may pass through the supporting cover itself, this latter is pressed, on the one hand, against the sealing cover and on the other hand, the sealing cover is pressed with its flange against the liner of the vessel cavity. The thus produced sealing effect is enhanced by means of welded lip seal that is provided according to the invention between the liner and the flange of the sealing cover as well as by the seals arranged in the flange.

Advantageously, the supporting cover is held, in a manner known *per se*, by vertical tendons of the prestressed vessel which accommodate, via coupling pieces, portions of the tendons that are arranged within the supporting cover. To maintain permanent control of the functioning of the closure assembly, the space between the individual seals in the flange of the sealing cover and between one of these seals and the welded lip seal is expediently monitored as regards pressure and leakage via a control duct.

Centering of the sealing cover with respect to the liner of the cavity or to the opening may advantageously be carried out by means of bolts. The bolts are journalled in projections arranged at the end of the liner.

To protect the sealing cover against an inadmissible temperature rise, it is expedient to provide it with a cooling device, such as cooling pipes.

The sealing cover may be of double-walled construction with stiffeners provided between the two walls. The cooling pipes may in that case also be arranged between the two walls. Preferably, pressure-equalising apertures are provided in the lower wall of the sealing cover so that the sealing cover is always in pressure equilibrium with its stiffened part.

If the pressure vessel accommodates a nuclear reactor, connection constructions for such vessel installations, e.g. nuclear reactors may be arranged on the sealing cover provided with stiffenings. The sealing cover then functions in addition to its sealing function, as a support construction for the reactor installations.

If the closure assembly embodied in the invention is provided with a duct e.g. for the installation of blowers or turbines for the primary circuit of a nuclear reactor disposed in the pressure vessel, then a pressure-bearing vessel pipe is provided in this duct which pipe is bolted to the supporting cover, according to a further embodiment of the invention, by a bolt connection located above the sealing cover.

The closure assembly may be advantageously provided with a retaining cover arranged above the supporting cover, in addition to the sealing cover and the supporting cover. In this construction the bores, which are otherwise provided in the sup-

porting cover for accommodating the tendons may be dispensed with.

The retaining cover may be expediently held by tendons of the prestresssed pressure vessel. These tendons may also be subdivided, their individual portions being connected to each other via coupling pieces.

It is of advantage to fill out the joint between the supporting cover and the prestressed pressure vessel with any suitable sealing means in order to ensure the best possible transmission of the pressure forces from the supporting cover to the prestressed concrete vessel.

According to another embodiment of the invention, means are provided in the supporting cover for permitting locally acting pressure forces between the supporting cover and the sealing cover to be limited and determined and to ensure a better load distribution. These means may consist of spring-loaded support elements e.g. support rings journalled in the supporting cover or supporting plates also installed in the supporting cover, which plates are arranged along a circular arc around the axis of the supporting cover. By the aforementioned means only a limited pressure load of the total prestress forces of the vertical clamping members acting on the support cover is exerted in the region of the flange of the sealing cover.

For this purpose hydraulic or pneumatically operated elements may also be employed instead of the resiliently loaded support elements.

It is advantageous to provide between the flange of the sealing cover and the liner of the cavity or the passage a compensator seal with the aid of which horizontal and vertical relative displacements of the sealing cover and the liner can be equalised. Overloads in the critical regions are thereby avoided. The aforementioned relative movements arise for various reasons such as e.g. the horizontal and vertical prestressing of the pressure vessel, creep of the concrete in prestressed concrete pressure vessels due to this prestressing, the fastening of the supporting cover and the internal pressure of the vessel.

There are various possible embodiments for the compensator seal. Thus e.g. the gap between the flange of the sealing cover and the liner can be kept as narrow as possible and can be bridged by an annular resilient seal element which is welded not only to the flange but also to the liner. A narrow gap between the aforesaid elements can be obtained e.g. by compensating plates or contact masses between the supporting and sealing covers or by machining of the contact faces between the said covers.

In another embodiment of the compensator seal, the gap between the flange and liner may be subdivided into a plurality of gaps and a number of resilient sealing elements are provided by means of which the gaps are bridged over on both sides. Thus, the stress on the compensator seal is spread over several sealing elements and is substantially reduced on the individual elements.

In all embodiments of the compensator seal mentioned above, the resilient seal elements may be formed with double walls and the space between their walls can be filled, in a *per se* known way, with a sealing gas, e.g. helium.

Preferred embodiments of the closure apparatus according to the invention are illustrated in the accompanying drawings, wherein:

Figure 1 illustrates a vertical section of the closure apparatus consisting of a sealing cover and a supporting cover,

Figure 2 is an enlarged fragmentary portion of Figure 1 with spring-loaded support elements,

Figure 3 is a horizontal section across Figure 1 in the region of the support elements with an annular support element,

Figure 4 is a horizontal section across Figure 1, in the region of the support elements, with a plurality of plate-shaped support elements,

Figure 5 is a vertical section of closure apparatus consisting of sealing supporting and retaining covers, with individual clamping members,

Figure 6 is a vertical section of closure apparatus consisting of sealing supporting and retaining covers, with individual clamping elements,

Figure 7 is a fragment of closure apparatus without retaining cover, with a pressure-bearing duct,

Figure 8 is a fragment of closure apparatus according to the invention, with a centering device,

Figure 9 is a fragment of closure apparatus with a compensator seal, and

Figure 10 is a fragment of closure apparatus with a compensator seal of another design.

Figure 1 shows closure apparatus consisting of a sealing cover 1 and a supporting cover 2 for a cavity 29 formed in a prestressed concrete pressure vessel 7. The cavity 29 is clad with a metallic liner 6 the support end of which widens into an out-turned flange Inside the prestressed concrete pressure vessel 7 e.g. a (non-illustrated) nuclear reactor is installed. Vertical clamping members or tendons 12 are passed through the prestressed concrete pressure vessel 7 and are connected via coupling members 13 with other clamping member or tendon portions 12*a*. These latter, as well as the coupling members 13 are arranged in the supporting cover 2 which is made of concrete. A sealing joint 16 is disposed between

the supporting cover 2 and the prestressed concrete pressure vessel 7.

The sealing cover 1 which is of metal, is provided on its periphery with a flange 3 bearing against the flange of the liner 6 and has a plurality of annular grooves 11 on its end which faces the liner 6, as shown in Figure 2. Seals 4 are inserted into the grooves 11. A further seal 5 is provided between the liner 6 and the flange 3: it is in the form of a torus made up of welded lips projecting into a recess between the liner 6 and the flange 3. Control lines 28 are provided for monitoring the pressure and the leakage respectively in the space 17 between the seals 4 and between the radially outermost seal 4 and the welded lip seal 5.

Figure 2 also illustrates that the sealing cover 1 is of double-walled construction. Between the two walls of the sealing cover 1 stiffeners 8 are welded in place. The chambers bounded by the stiffeners 8 and the walls of the sealing cover 1 are provided with pressure-equalising apertures 27 formed in the lower wall (as viewed) of the cover 1. In addition, a cooling system consisting of cooling pipes 10 is installed within the chambers.

In order to limit the pressure force between the supporting cover 2 and the sealing cover 1, the supporting cover 2 has a recess in which a support element biased by springs 24 is arranged. The support element may be an annular support element 25, as shown in Figure 3, or it may comprise a plurality of support plates 26 arranged on a circular arc around the axis of the supporting cover 2. This embodiment is illustrated in Figure 4.

In Figure 5 there is illustrated a closure apparatus consisting of three parts comprising, again, a sealing cover 1 and a supporting cover 2 and, additionally, a retaining cover 19. Functionally similar parts are designated here as well as in the further illustrated embodiments described below by like reference numbers. The retaining cover 19 is secured in this embodiment by the clamping members 12 of the prestressed concrete pressure vessel. The supporting cover 2 has no throughgoing bores.

In the closure apparatus shown in Figure 6 and consisting likewise of a sealing cover 1, a supporting cover 2 and a retaining cover 19, the vertical clamping members holding the retaining cover 19 are divided into clamping member portions 20 and 21, which are connected to each other by coupling pieces 22. The coupling pieces 22 are located in a recess within the prestressed concrete pressure vessel 7.

The closure apparatus illustrated in Figure 7 has a throughgoing aperture 23 in which a pressure-bearing ducting 14 of the vessel is installed. This ducting 14 is connected with the supporting cover 2 by means of a bolt connection 15 through the sealing cover 1. The sealing cover 1 is also provided with a coupling 9 constructed as a supporting construction for reactor installations e.g. for supporting a structural element 14*a* connected to the ducting 14 of the vessel.

The closure apparatus shown in Figure 8 may within the framework of the invention be of any desired construction i.e. it may consist of two or three closure elements and may have divided or undivided clamping members. The Figure shows that the sealing cover 1 is centred with respect to the liner 6 of the cavity 29 by a plurality of bolts 18. These are inserted in a projection 30 welded to the flange 3 and engage in bores located in a projection 31 fixed to the liner 6.

Figure 9 also shows a sealing cover 1 with a flange 3 above which a supporting cover 2 is arranged. The latter has a base 40 to which anchor bolts 41 are fitted. In this closure apparatus the supporting cover 2 is also provided with a cooling system 42 and the liner 6 also has a cooling system 42*a* located on its side facing the concrete. In order to minimise the gap 32 between the flange 3 and the flange-like widening 43 of the liner 6, filling plates 44 are arranged between the base 40 of the supporting cover and the sealing cover 1. A compensator seal, constructed in the form of an annular resilient seal element 33, bridges the gap 32, and it is welded on one side to the flange 3 and on the other side to the flange-like widening 43 of the liner 6. The space 45 between the resilient seal element 33 and the welded lip seal 5 is filled with a sealing gas e.g. helium, which is supplied to this space via a pipeline 46. The liner 6 is provided on its surface remote from the concrete witth thermal insulation 47. The sealing cover 1 is also provided with thermal insulation 47*a*.

A further embodiment of closure apparatus according to the invention is illustrated in the fragmentary sectional view of Figure 10 which shows a compensating flange 48 arranged between the flange 3 of the sealing cover 1 and the flange-like widening 43 of the liner 6, the compensating flange 48 being spaced from flange 3 by a narrow gap 49. The compensating flange 48 includes a plurality of gaps 32*a* which are bridged over on both of their sides by resilient seal elements 34. The oppositely lying seal elements are mutually offset such that a continuous sinuous space 50 is formed which is filled with a sealing gas. This is supplied to the space 50 via a duct 51. In the illustrated embodiment five gaps 32*a* are provided. For bridging the gap 49 between the flange 3 of the sealing cover 1 and the compensator flange 48, a double-walled resilient seal element 34*a* is welded to both flanges. The space 39 between the two walls of the resilient seal element 34*a*

is also filled with a sealing gas from a duct 52. The resilient seal elements 34*a* may have a multi-position construction.

For the sake of clarity, the annular seals 4 and grooves 11 in the flange 3, which are present in all the above-described embodiments have not been shown in Figures 5, 7, 9 and 10.

Reference is made to our co-pending Application No. 8578/79 (Serial No. 1,590,997) divided out from the present application in which is described and claimed a prestressed pressure vessel comprising a penetration provided with a lining and a closure assembly therefor, said assembly including a sealing cover provided with a first flange and bearing a support cover which in use is subject to the load caused by the pressure prevailing inside the vessel, said sealing cover having an additional two-part flange secured between the first flange of the sealing cover and the said lining, and a resilient sealing element secured to both parts of said additional flange.

WHAT WE CLAIM IS:—

1. A prestressed pressure vessel comprising a penetration or cavity provided with a lining and a closure assembly therefor, said assembly including a sealing cover provided with a flange and bearing a support cover which in use is subject to the load caused by the pressure prevailing inside the vessel, the sealing cover being sealed to said lining by way of a welded lip seal arranged between the periphery of the flange and the periphery of the said lining, the flange of the sealing cover being provided on its face adjacent to the said lining with annular grooves for accommodating further sealing elements.

2. Prestressed pressure vessel according to claim 1 wherein vertical tendons are provided for restraining the support cover in position against the stresses resulting from the pressure prevailing inside the vessel, said vertical tendons incorporating tendon portions arranged inside the support cover and coupled thereto by coupling elements.

3. A pressure vessel according to claim 1 or 2 wherein the spaces between the further sealing elements and between one of the seals and the welded lip seal are monitored with respect to pressure and leakage via control lines.

4. A pressure vessel according to any preceding claim wherein the sealing cover is centred with respect to the liner by bolts.

5. A pressure vessel according to any preceding claim wherein the sealing cover is provided with cooling pipes.

6. A pressure vessel according to any preceding claim wherein the sealing cover is double-walled and is fitted with stiffeners.

7. A pressure vessel according to claim 6, wherein pressure equalising apertures are provided in the lower wall of the sealing cover.

8. A pressure vessel according to any preceding claim, wherein the sealing cover is provided with a coupling for supporting a structural element connected to ducting of the pressure vessel.

9. A pressure vessel according to claim 1 or 8, wherein the vessel accommodates pressure-bearing ducting connected to the supporting cover by a bolted connection via the sealing cover.

10. A pressure vessel according to any preceding claim wherein a retaining cover is arranged over the supporting cover

11. A pressure vessel according to claim 10 wherein tendons extending through the retaining cover are divided into portions coupling pieces.

12. A pressure vessel according to any preceding claim wherein of the total stressing force of the tendons only a limited pressure force is exerted by the supporting cover in the region of the flange of the sealing cover.

13. A pressure vessel according to claim 12, wherein a supporting ring biased by springs is journalled in the supporting cover.

14. A pressure vessel according to claim 12, wherein spring-loaded support plates are provided in the supporting cover which plates are arranged on a circular arc around the axis of the supporting cover.

15. A pressure vessel according to any preceding claim, wherein, in addition to the welded lip seal, a compensator seal is provided between the flange of the sealing cover and the liner.

16. A pressure vessel according to claim 15, wherein a gap exists between the flange and the liner and is kept as narrow as possible and is bridged by an annular resilient seal element which is welded to the flange as well as to the liner.

17. A pressure vessel according to claim 15, wherein the gap between the flange and the liner is divided into a plurality of gap portions and there is provided a number of resilient seal elements that bridge the gap portions from both sides.

18. A pressure vessel according to claim 16 or 17, wherein the resilient seal elements are double-walled and the space between these walls is filled with a sealing gas.

19. A pressure vessel according to claim 1 substantially as hereinbefore described with reference to and as shown in Figures 1 to 4 or Figure 5 or Figure 6 or Figure 7 or Figure 8 or Figure 9 or Figure 10 of the accompanying drawings.

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1590996 COMPLETE SPECIFICATION
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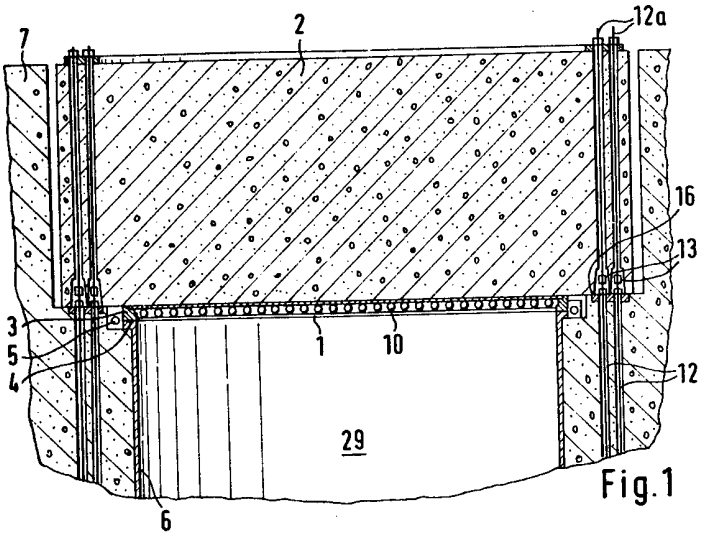
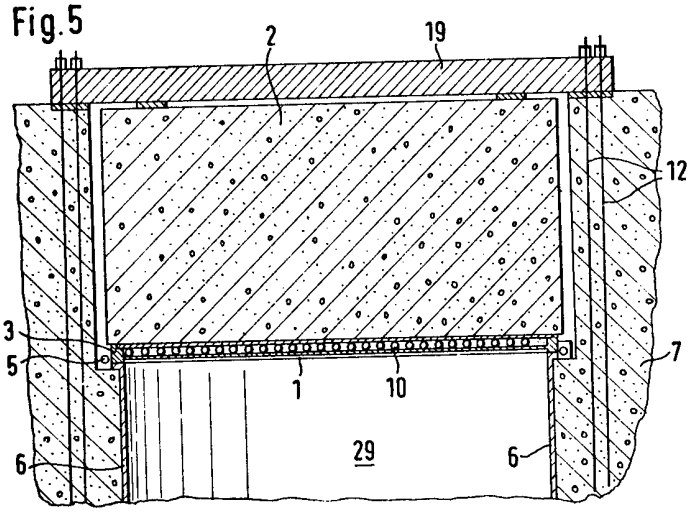


Fig.1

Fig.5



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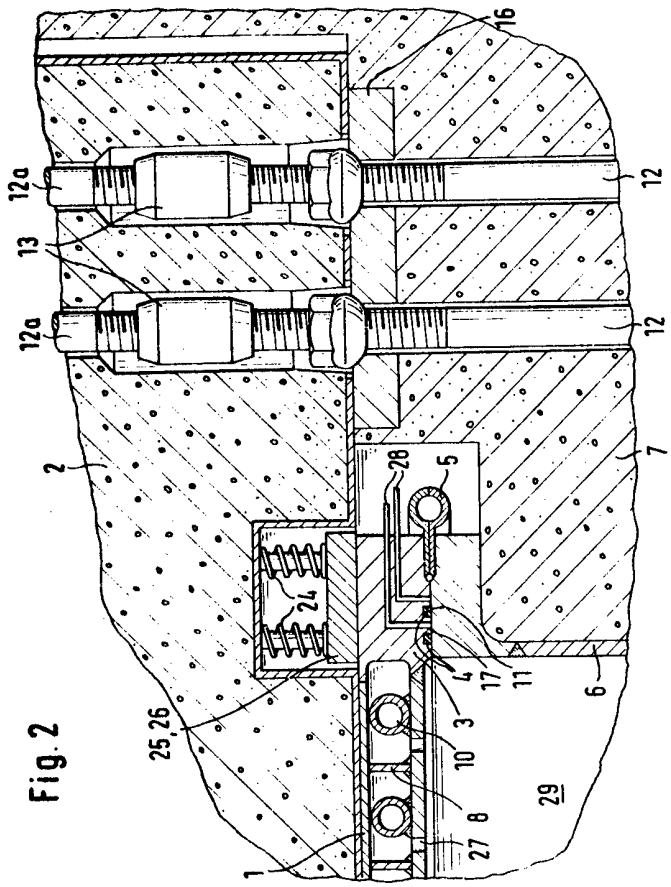


Fig. 2

Fig.3

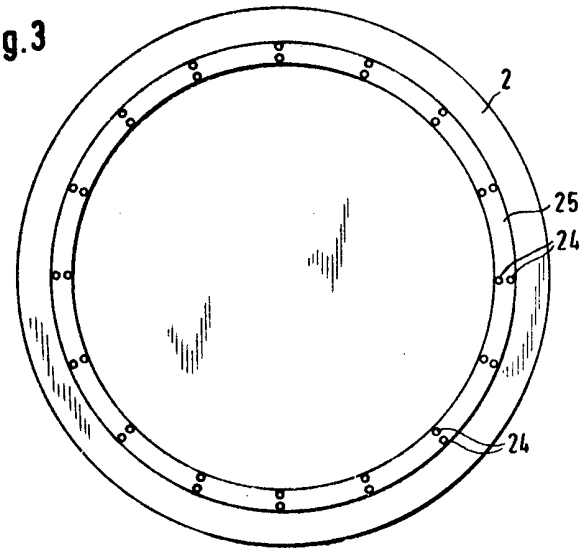


Fig.4

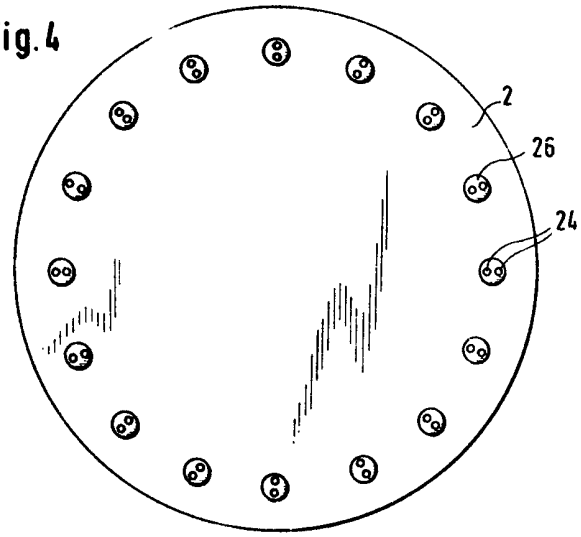
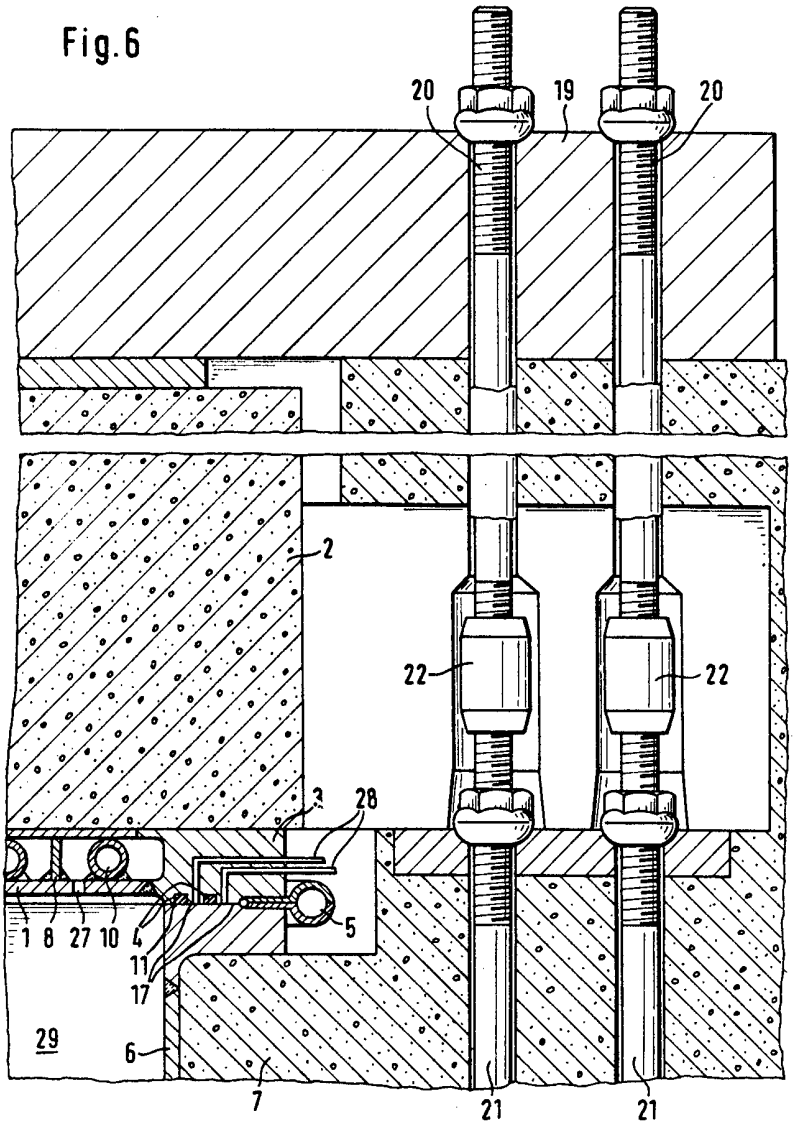


Fig.6



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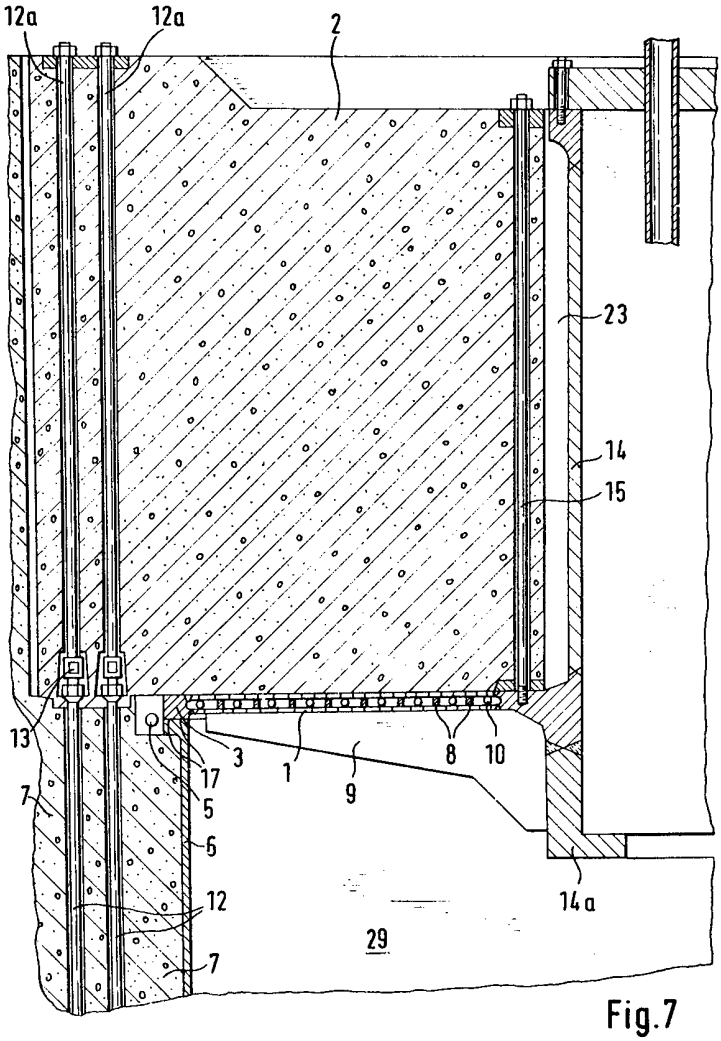

Fig.7

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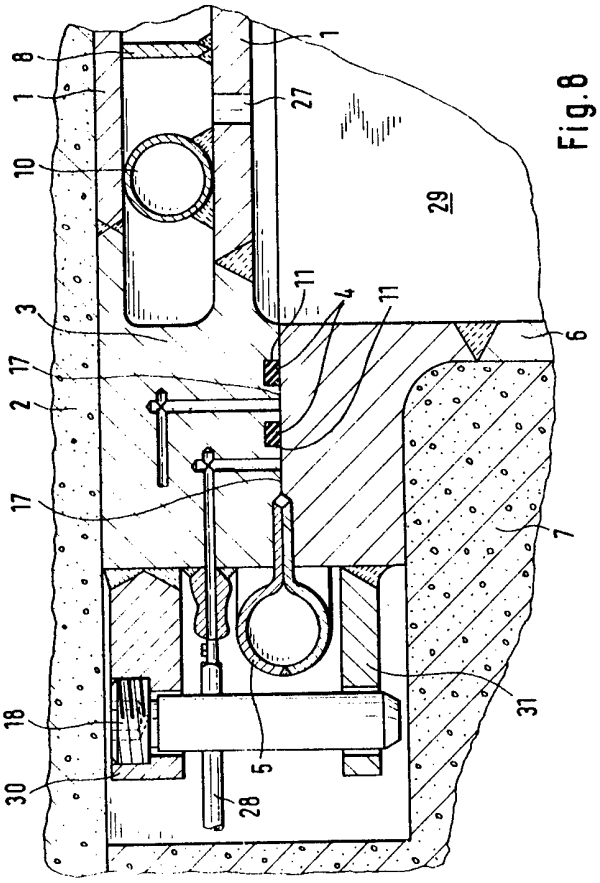

Fig.8

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Sheet 7

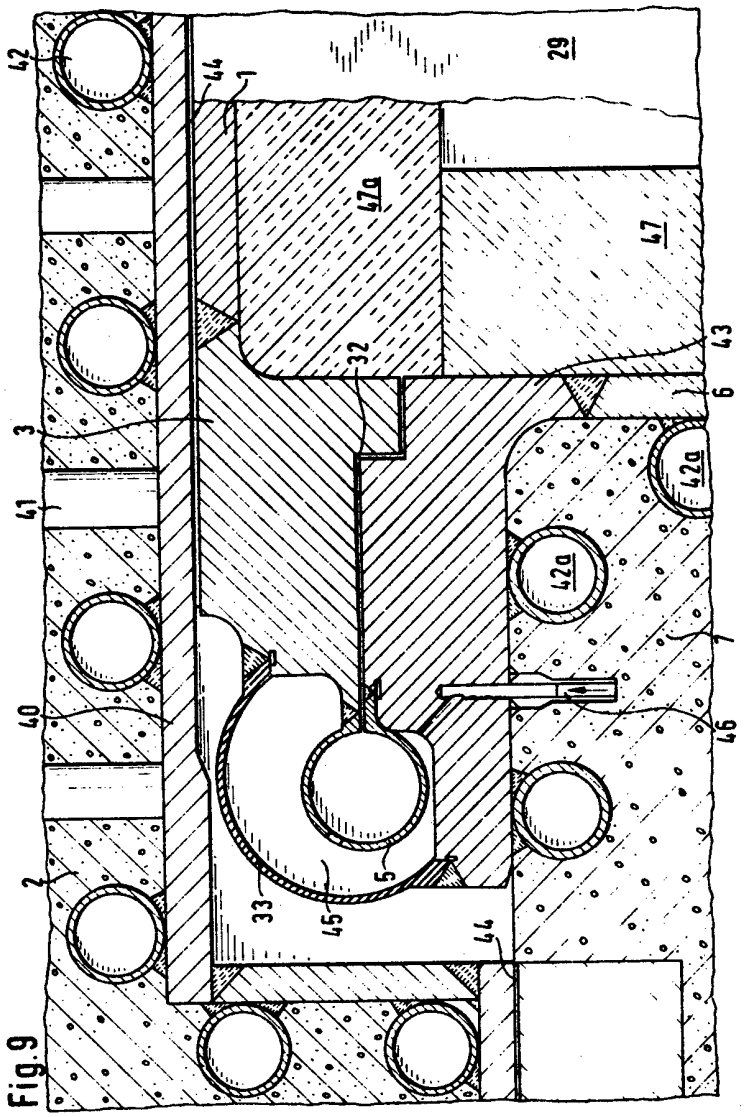

Fig.9

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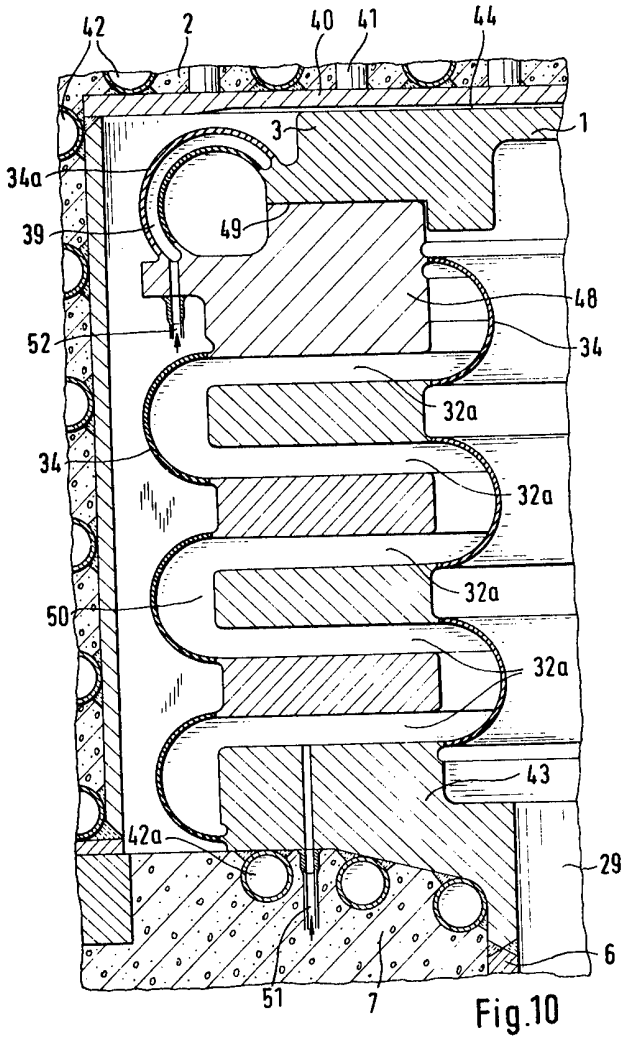

Fig.10