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PATENT SPECIFICATION (11) 1 506 600

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(54) STEAM DRUMS

(71) We, TAYLOR WOODROW CONSTRUCTION LIMITED, a British company, of 345 Ruislip Road, Southall, Middlesex UB1 2QX, England, 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:—

This invention relates to steam drums and is particularly concerned with steam drums that are utilized in power stations; for example in the steam generating heavy water reactors of nuclear power stations to receive a steam/water mixture *via* riser headers from the reactor core and provide, by means of separators and driers, steam with typically 0.5% moisture content for driving turbines.

It is known to construct such a steam drum as a closed steel shell cylinder, typical dimensions for this cylinder being 3.0 internal diameter by 20.0 m long and typically with an operating pressure of 64.8 atmospheres and an operating temperature of 282°C.

It is, of course, essential that such a steam drum should not fail, and it is necessary with present steel drums that an internal inspection be carried out at regular intervals, typically bi-annually, with each weld being inspected. As a further safety precaution, the main circumferential and longitudinal welds are fitted with ultrasonic detectors that move automatically to and fro along the welds throughout the life of the drum, say thirty years. It is also currently proposed to provide two steel drums so that in the event of fast fracture failure of one, there is not complete loss of coolant from the core. A further problem with steel drums is that the drums and thus the area immediately surrounding them are highly radioactive and during operation can only be approached by personnel wearing suitable protective clothing.

According to the present invention there is provided a steam drum that is a prestressed concrete pressure vessel. In a prestressed concrete pressure vessel the failure of one or a few only of the prestressing elements does not significantly affect the overall strength of the structure, so that there is no necessity constantly to check the condition of the structure. If necessary the prestressing elements can be changed or supplemented during the life of the structure. There is no need to provide a plurality of drums, since the pressure vessel can be easily made of sufficient size, and can be simply compartmented if so desired. The concrete of the walls of a prestressed concrete pressure vessel acts as a shield to radioactivity and hence the radioactivity in adjacent areas can be held at an acceptable level.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the diagrammatic drawings accompanying the Provisional Specification in which:—

Figure 1 is a sectional side view of a first form of steam drum,

Figure 2 is a typical sectional end view of the drum of Figure 1,

Figure 3 is a side view on a larger scale of a detail of the drum of Figures 1 and 2,

Figure 4 is a view, similar to Figure 1, of a second form of steam drum,

Figure 5 is a view, similar to Figure 2, of the steam drum of Figure 4,

Figure 6 is a sectional side view drawn to a larger scale of a detail of the drum of Figures 4 and 5,

Figure 7 is a side view to a larger scale than Figures 4 and 5 of a further detail of the second form of drum,

Figure 8 is a view, similar to Figure 1, of a third form of steam drum,

Figure 9 is a view similar to Figure 2, of the drum of Figure 8,

Figure 10 corresponds to Figure 3 and illustrates a detail of the drum of Figures 8 and 9, and

Figure 11 is a sectional side view of the detail encircled at X1 in Figure 8, drawn to a larger scale than Figure 8.

Throughout the Figures like parts in the various embodiments are indicated by the same reference numerals.

Referring first to Figures 1 to 3, the prestressed concrete steam drum shown therein is of an elongated cylindrical configuration and is supported horizontally by spaced apart concrete supports 1. The structural concrete 2 of the drum is cast in-situ and is prestressed by longitudinal tendons 3 and circumferential tendons 4 passed through ducts 5 in the concrete 2. The longitudinal tendons 3 are anchored in the opposite ends of the drum and the circumferential tendons 4 are anchored in ribs 6 that extend along opposite sides of the drum.

Within the concrete 2 there is a steel liner 7 from which steam and water inlet and outlet pipes 8 extend through the structural concrete 2 to the outside of the drum.

Between the liner 7 and structural concrete 2 there is a layer of insulating concrete 9 of low thermal conductivity properties such as so-called "lightweight" concrete. This insulating concrete 9 is separated from the structural concrete 2 by an expanded metal shutter 10 (Figure 3) which also serves as a support for cooling pipes 11 to which inlet and outlet pipes 12 and 13 (Figure 2) are connected. The liner 7 is anchored to the structural concrete 2 by studs 14 passing through the insulating concrete 9 and welded to the liner 7, there being longitudinal and hoop reinforcing members 15, 16 in the structural concrete 2 at the bases of the studs 14.

The ends of the liner 7 are typically hemispherical though these can be of flat construction and are closed by bolted flanged closure caps 17 that lie at the ends of man-access ducts 18 extending through the structural concrete 7 and insulating concrete 9, and which are closed at their outer ends by concrete shielding plugs 19.

The drum is constructed by setting in position the liner 7 complete with its inlet and outlet pipes 8 and the other components that are carried by the liner. Shuttering for the concrete is placed around the liner and the tendon ducts 5 are set in position. The concrete is then placed.

After the concrete has hardened the tendons 3, 4 are passed through the ducts 5, anchored by the structure prestressed.

As an alternative to fitting the inlet and outlet pipes 8 initially, penetration sleeves can be provided to extend through the structural concrete 2, and the pipes 8 installed after the concrete has hardened, the pipes being welded to the liner from the inside and grouted in the sleeves.

The ribs 6 can be formed to extend to the top of the drum to terminate in a common level surface serving as a working platform.

Turning to Figures 4 to 7, the steam drum is again supported horizontally on supports 1 but in this form the drum is made-up of an assembly of pre-cast ring units 20 having a common liner 7. Each unit 20 has circumferential prestress applied by winding layers of wire 21 (Figure 6) under tension around the unit in a channel 22. Each unit is also provided with its own individual liquid cooling system 11/12/13 supported on a length of shutter 10; and internal reinforcement 23 for its structural concrete 2.

The drum is constructed by setting the liner 7, provided with nozzles to receive the steam and water inlet and outlet pipes 8, horrizontal and installing the pre-cast ring units 20 with half-circular notches 24 (Figure 7) in the end faces of the units in registry to form oversize penetration holes for the pipes 8, and with ducts 5 for longitudinal tendons 3 aligned, these ducts at each face of each unit terminating in bellmouth 5A so that a small amount of mis-match can be tolerated. The bellmouths 5A of each pair of opposed bellmouths are connected by bellows 25 so that a continuous duct is formed. An annular gap between the liner 7 and the units 20, into which studs 14 welded to the liner 7 extend, is filled with insulating concrete 9, and the gaps between adjacent units 20 are filled with concrete, grout or resin 26, except where the pipes 8 are to be installed. At each of these positions a penetration sleeve 27 (Figure 7) is formed by overlapping the protruding expanded metal from the half-circular notches 24 of adjacent units. The pipes 8 are installed, welded to the liner 7, and the gaps between the pipes and the sleeves 27 lining their penetration holes grouted as shown at 28 in Figure 7.

After the grout has hardened the longitudinal tendons 5 are placed, anchored and stressed.

As an alternative to mounting the pipes 11 of the liquid cooling system on the shutter 10, these can be mounted on the studs 14 (as shown by chain lines 11A in Figure 7) to be embedded in the insulating concrete 9.

Access to the interior of the drum is provided as in the form of Figures 1 to 3.

A difficulty with end-access as provided in each of the forms so far described arises in that the dimensions are necessarily such as to permit man access only. In the form of Figures 8 to 11 a much larger access is provided through which internal plant can be removed. In this form the drum is vertical, supported at its base on concrete supports 1A, and is made up of a concrete bottom end cap 30 which is cast in-situ to form a support for outer pre-cast ring-form units 31 incorporating wire winding channels 22A. During construction the lowermost of the units 31 are mounted over

the base cap 30 and the remainder stacked on these lowermost units. The liner 7A complete with associated components 10 to 16 as described with reference to Figures 1 to 3 is then mounted vertically within the stack of units 31 along with tendon ducts 5A and a concrete barrel 32 is cast in-situ. Steam and water inlet and outlet pipes 8 are provided in any of the various ways already described, as is insulating concrete 9. Prestress is effected by fitting and stressing vertical tendons 3A and winding-on wire circumferentially under tension in the channels 22A. As an alternative to winding-on wire in-situ pre-cast, pre-wire wound units as described with reference to Figures 4 to 7 could be utilized.

The top of the drum is closed by a removable concrete wire wound end cap 33 which is held in position by extensions 3A' of the longitudinal tendon 3A which extensions run from intermediate anchors 34 (Figure 11) at the top of the concrete barrel 32 through ducts 5A' to anchors 35 at the top of the cap, this closure being similar to that described in our Application No. 49186/74 (Serial No. 1 486 239).

In the drum closed condition illustrated in Figure 8 the tendons 5A/5A' are anchored at the upper anchors 35 and the intermediate anchors 34 are clear of seatings 36 at the top of the concrete barrel 32. When it is desired to remove the cap the load in the tendons 5A/5A' is released so that the intermediate anchors 34 engage in their seatings 36 whereby pre-stress is maintained in the structural concrete of the drum, but the cap 33 is freed for removal.

Whilst in all the embodiments described both a liquid cooling system, and insulating concrete, are provided, the liquid cooling system could be omitted and further alternative schemes utilized in which the prestressed concrete structure is designed to accommodate the whole of the temperature crossfall.

WHAT WE CLAIM IS:—

1. A steam drum that is a prestressed concrete pressure vessel.

2. A steam drum as claimed in claim 1, wherein within the concrete of the drum there is a steel liner from which steam and water inlet and outlet pipes extend through the drum concrete to the outside of the drum.

3. A steam drum as claimed in claim 2, wherein the inlet and outlet pipes pass through sleeves in the drum concrete.

4. A steam drum as claimed in claim 2 or 3, wherein between the steel liner and structural concrete of the drum there is a layer of insulating concrete of low thermal conductivity properties.

5. A steam drum as claimed in claim 4, wherein the liner is anchored to the structural concrete by studs passing through the insulating concrete.

6. A steam drum as claimed in claim 5, wherein there are longitudinal and hoop reinforcing members in the structural concrete at the bases of the studs.

7. A steam drum as claimed in claim 4, 5 or 6, wherein the insulating concrete is separated from the structural concrete by an expanded metal shutter.

8. A steam drum as claimed in claim 7, wherein the shutter serves as a support for cooling pipes of a liquid cooling system.

9. A steam drum as claimed in any one of claims 4 to 7, wherein cooling pipes of a liquid cooling system are embedded in the insulating concrete.

10. A steam drum as claimed in any one of claims 1 to 9, wherein the drum concrete is prestressed by tendons extending longitudinally of the drum, and tendons extending circumferentially of the drum.

11. A steam drum as claimed in claim 10, wherein the tendons are passed through ducts in the drum concrete.

12. A steam drum as claimed in any one of claims 1 to 11, wherein the drum concrete is cast in-situ.

13. A steam drum as claimed in any one of claims 1 to 10, wherein the drum concrete is composed of an assembly of pre-cast ring units.

14. A steam drum as claimed in claim 13 as appended to claim 10, wherein the circumferential tendons are disposed in channels in the circumferences of the units, and wherein the longitudinal tendons are passed through aligned ducts in the units.

15. A steam drum substantially as hereinbefore described with reference to Figures 1 to 3, or Figures 4 to 7, or Figures 8 to 11, of the drawings accompanying the Provisional Specification.

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1506600 PROVISIONAL SPECIFICATION
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Sheet 1

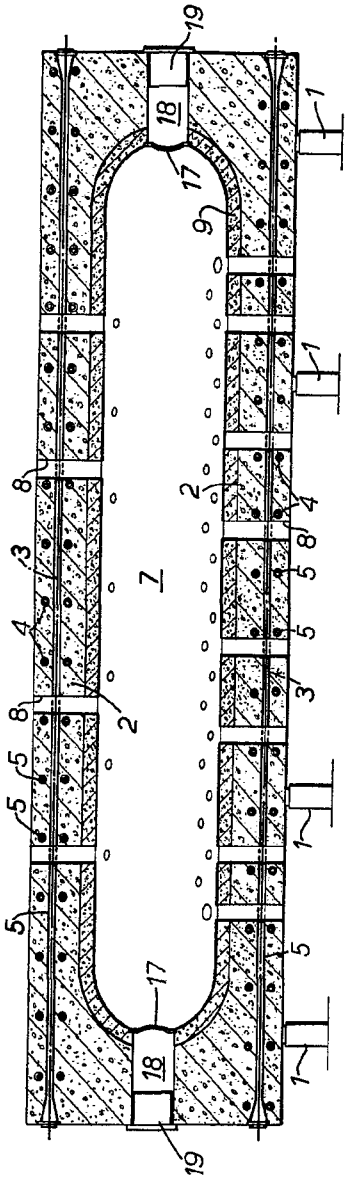


FIG. 1.

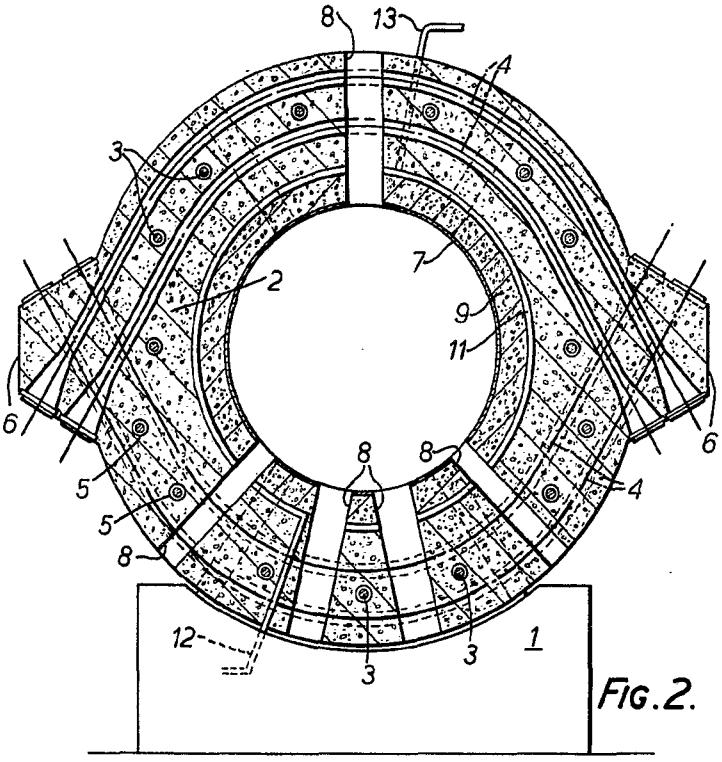


FIG. 2.

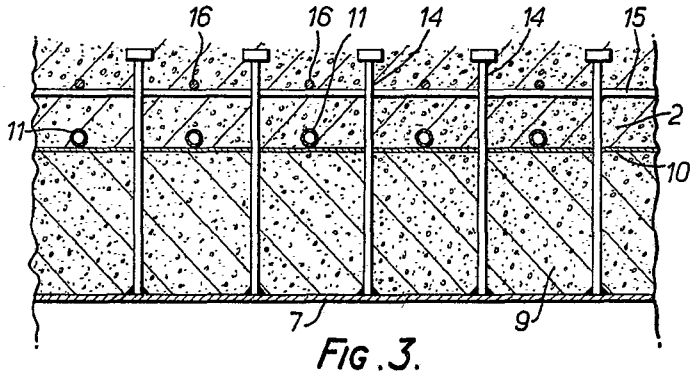


FIG. 3.

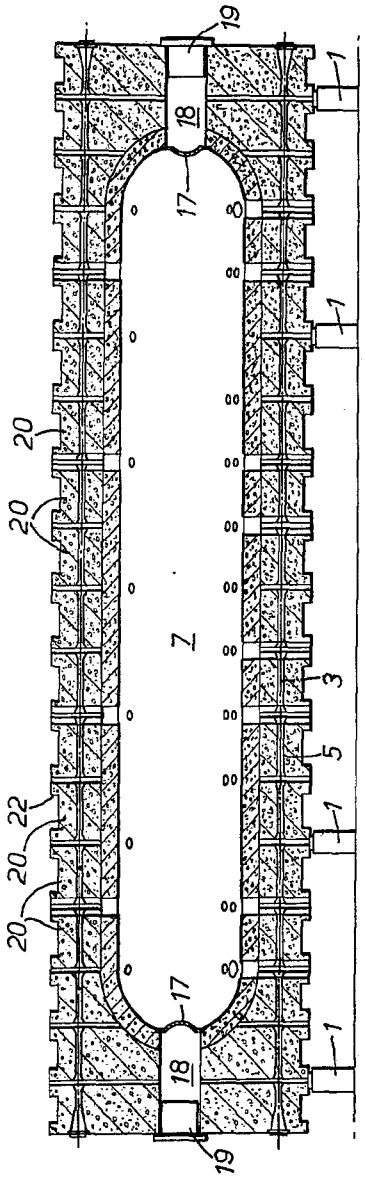


FIG 4.

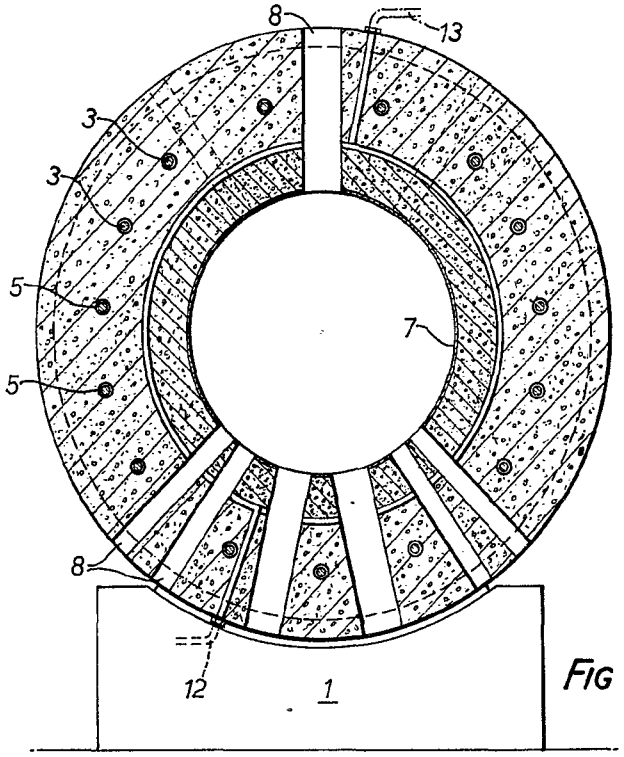


FIG .5.

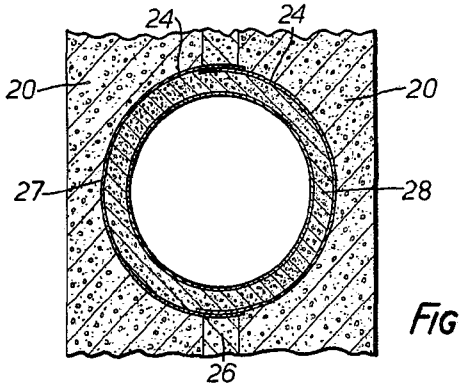
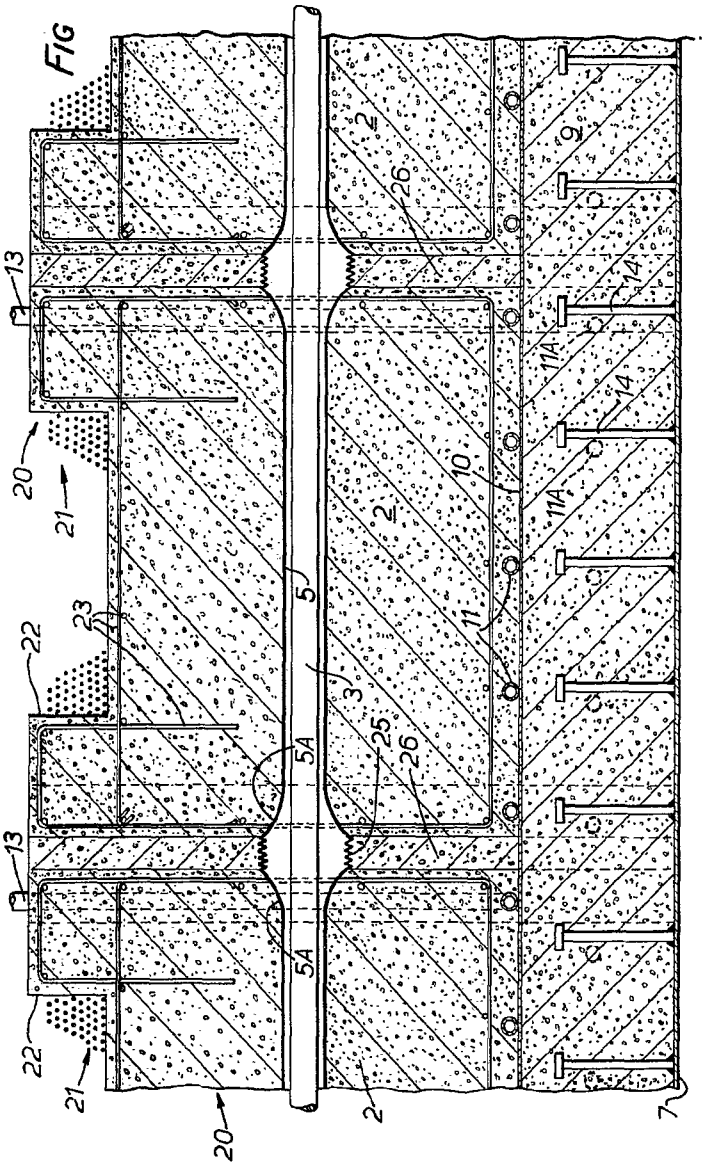


FIG .7.

1506600 PROVISIONAL SPECIFICATION
8 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 5

FIG. 6.



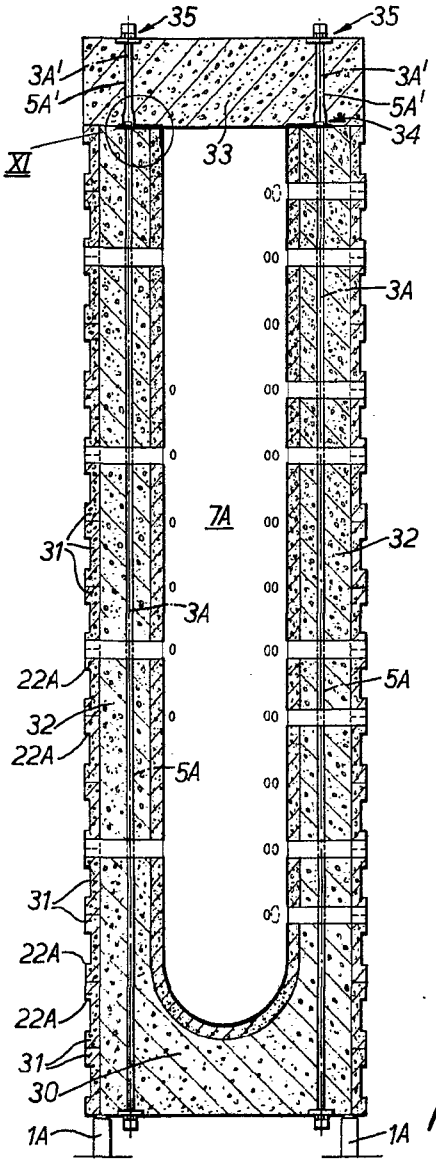

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Fig. 8.

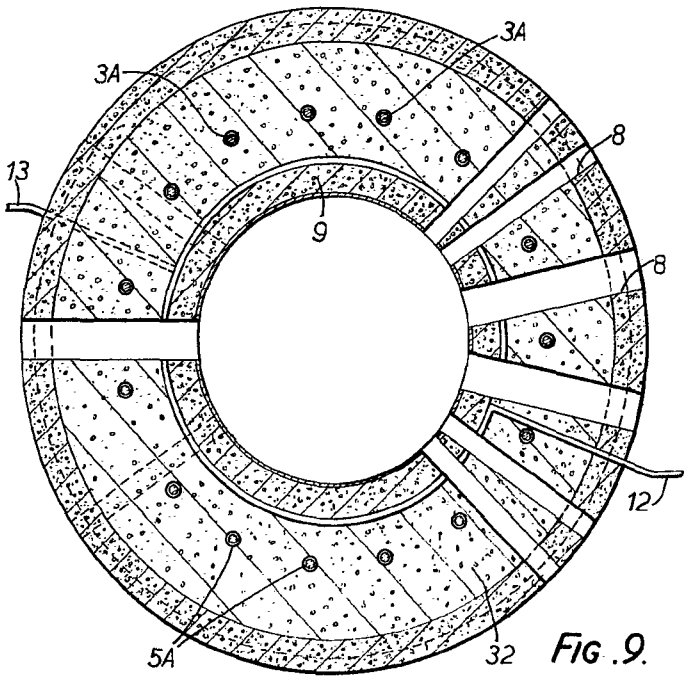

FIG. 9.

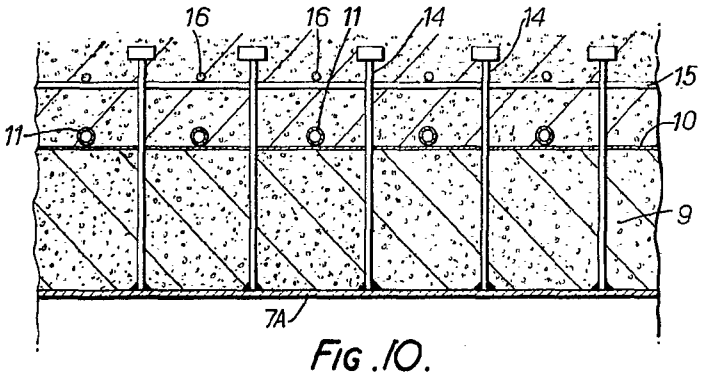

FIG. 10.

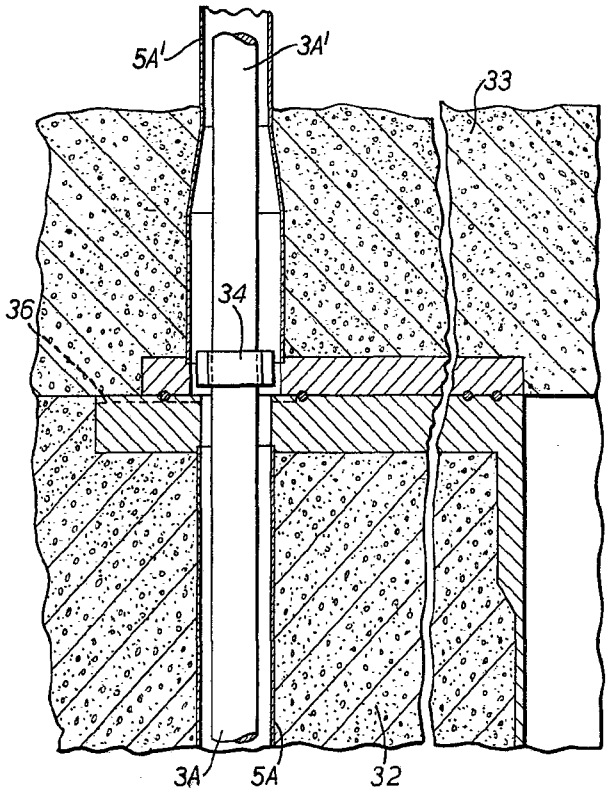

FIG .11.