United States Patent

Krismer, Jr.

[15] **3,657,897**

[45] **Apr. 25, 1972**

[54] TUNNELLING SHIELD

[72] Inventor: **Josef Krismer, Jr.,** Uferstr. 1-10, 6500 Landeck/Tirol, Austria

[22] Filed: **Feb. 16, 1971**

[21] Appl. No.: **115,399**

[30] **Foreign Application Priority Data**

Feb. 25, 1970 Austria 1748

[52] **U.S. Cl.** **61/85,** 61/42

[51] **Int. Cl.** **E21d 11/10**

[58] **Field of Search** 61/84, 85, 42, 43, 45, 63; 299/33

[56] **References Cited**

UNITED STATES PATENTS

1,505,060	8/1924	Quayle	61/84
3,005,314	10/1961	Cunningham	61/42
3,472,036	10/1969	Khodosh et al.	61/85

FOREIGN PATENTS OR APPLICATIONS

26,804	2/1899	Great Britain	61/85

Primary Examiner—Dennis L. Taylor
Attorney—Kelman & Berman

[57] **ABSTRACT**

A tunnelling shield mainly consists of a heavy steel tube provided with cutting segments about its front rim and having an annular collar on its outer axial wall near the rim. Pouches of elastomeric material are distributed about the rear face of the collar and can be inflated by means of hydraulic fluid. Concrete injecting conduits terminate in orifices in the outer tube wall which are directed toward the rear face of the collar so that a tunnel lining can be poured in the space behind the collar bounded by the shield in a radially inward direction, and the shield can be driven forward by expansion of the pouches abutting against the last-cured concrete section.

10 Claims, 5 Drawing Figures

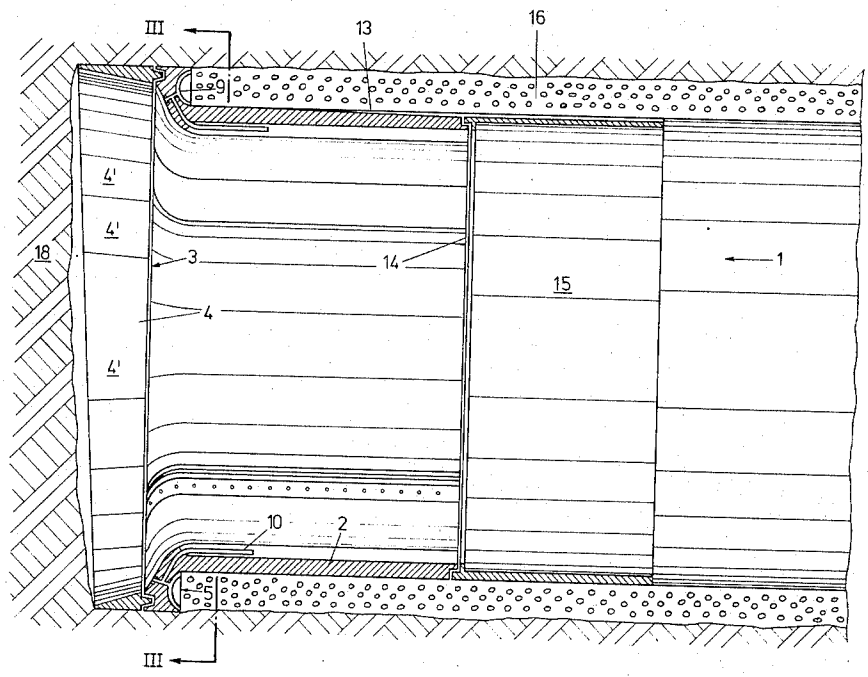
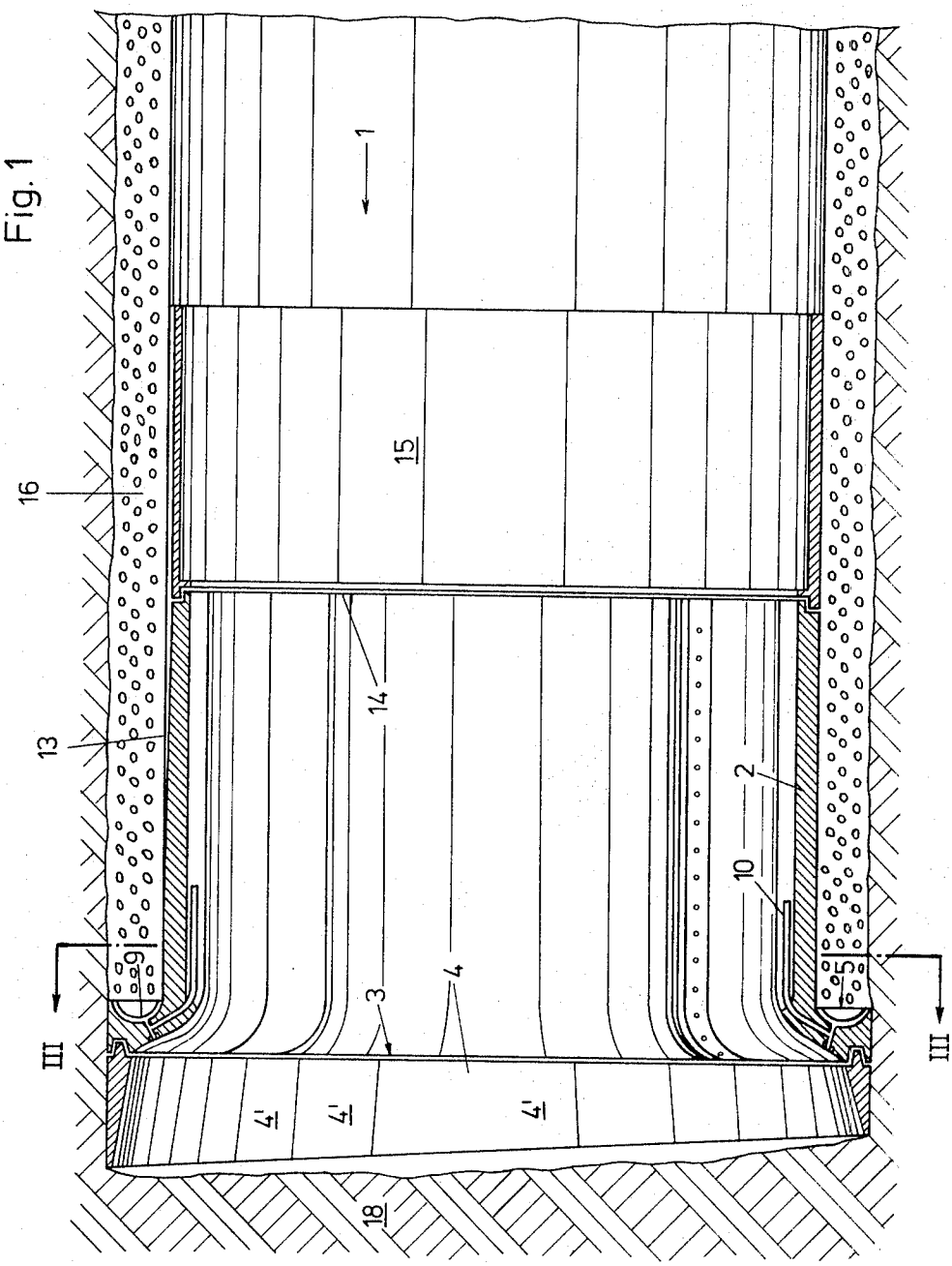


Fig. 1



INVENTOR
Josef Krismer, Jr.
BY Kelman and Berman,
Agents

Fig. 5

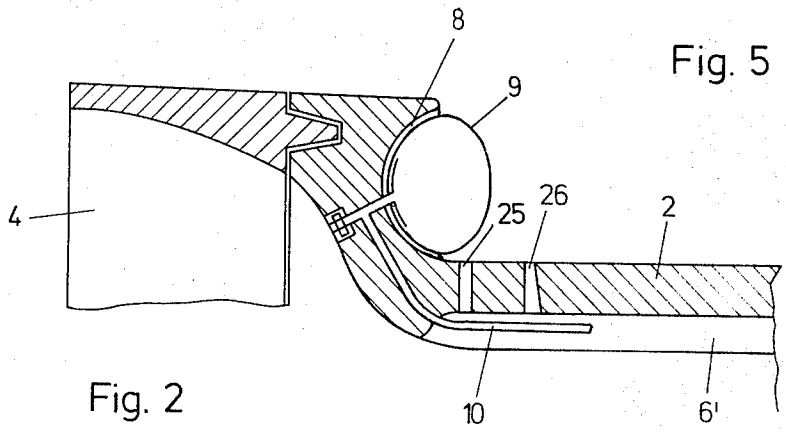
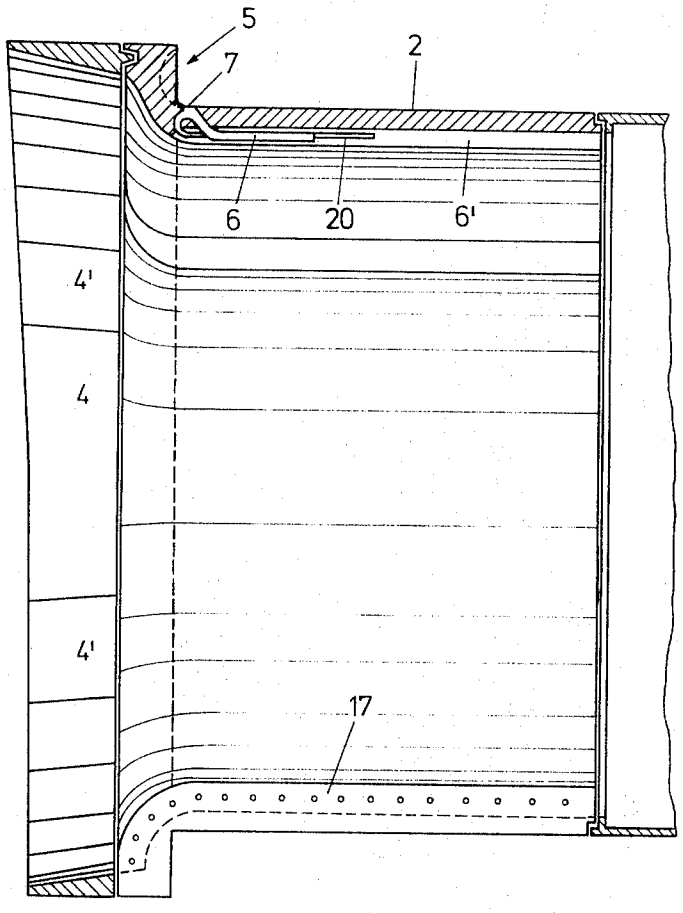


Fig. 2



INVENTOR
Josef Krismer, Jr.
BY Kelman and Berman,
Agents

Fig. 4

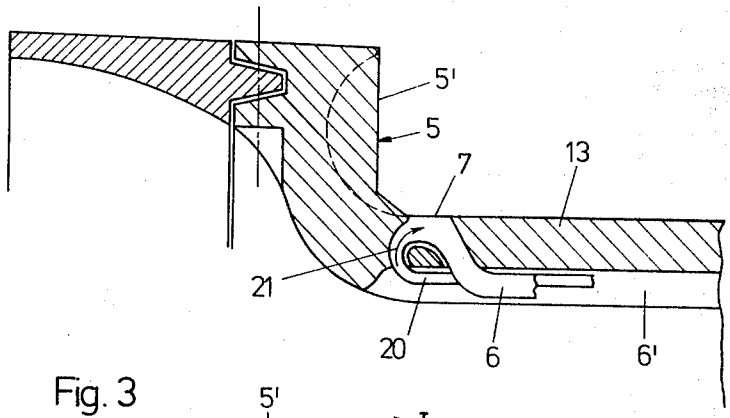
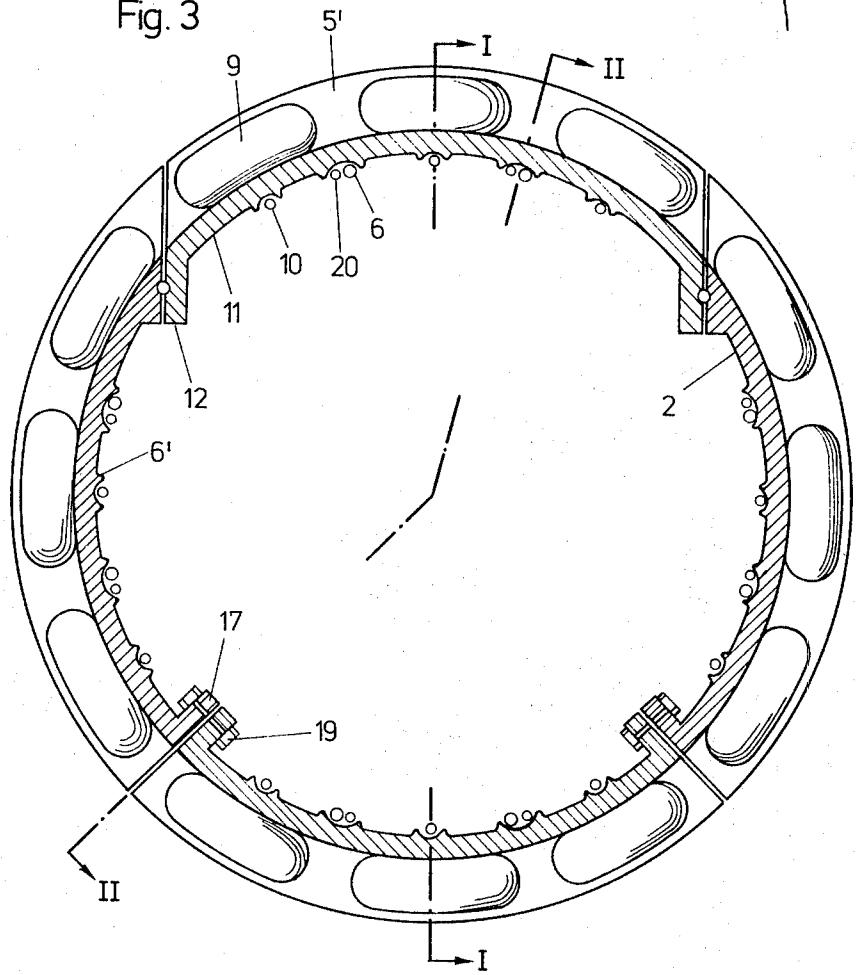


Fig. 3



INVENTOR
Josef Krismer, Jr.
BY
Kelman and Berman,
Agents

TUNNELLING SHIELD

This invention relates to tunnelling equipment, and particularly to an improved tunnelling shield.

In a known tunnelling shield, the tubular shield body is provided with a collar near its front rim and the cutting edge on the same. Conduits terminate in the space bounded by the body of the shield in a radially inward direction and by the collar in a forward axial direction, and concrete is injected into the space through the conduits under pressure to form a liner for the tunnel. The pressure of the injected concrete provides the sole propelling force for the known shield.

This apparatus has not found significant practical use because the concrete is compacted in the feed conduits under the high pressure necessary for overcoming the resistance of the soil to advance of the shield, and hardens in the conduits before it can be removed.

The tunnelling shields commonly employed heretofore are heavy steel cylinders which are open at both ends and are each equipped with a structural diaphragm at approximately midlength. Hydraulic jacks arranged in the shield abut against the diaphragm and portions of the previously built structure for advancing the tube whose front rim is equipped with a cutting edge. The interior of the tube accomodates devices for breaking the soil and for removing the debris. As the shield advances, the walls of the tunnel so formed are lined with concrete.

The last-described conventional shields are costly in their construction and operation. They can be used only where they ultimately break out of the ground, or they must be dug out from the surface they cannot be moved backward. They cannot be used conveniently for driving blind tunnels because they are not readily disassembled under ground. The hydraulic jacks provide limited driving force even though they may encumber a substantial portion of the tunnel section.

A basic object of this invention is the provision of a tunnelling shield which is free of the shortcomings of the known types of apparatus briefly described above.

With this object and others in view, as will hereinafter become apparent, the invention provides a tunnelling shield whose tubular body portion is equipped with a cutting device axially projecting from the front rim of the body portion. A collar projects from the outer axial wall of the body portion adjacent the front rim in a radially outward direction. The collar, which is integral with or otherwise fixedly fastened to the body portion, has a radially extending, rearwardly directed annular face. An expansion device on the rear face of the collar includes at least one element of elastomeric material which encloses a sealed cavity to which a fluid may be supplied for expanding the element in an axial direction. Concrete mixture may be injected into the space bounded in part by the rear face of the collar and the outer axial wall of the body portion from a feed conduit having an orifice adjacent the elastomeric body.

Other features, additional objects, and many of the attendant advantages of this invention will readily become apparent as the invention is better understood by reference to the following detailed description of a preferred embodiment when considered in connection with the appended drawing in which:

FIG. 1 shows a tunnelling shield of the invention in side-elevational section on the line I — I in FIG. 3;

FIG. 2 shows the shield in fragmentary section on the line II — II in FIG. 3;

FIG. 3 illustrates the shield of FIG. 1 in rear-elevational section on the line III — III; and

FIGS. 4 and 5 respectively illustrate portions of the devices of FIGS. 2 and 1 on a larger scale.

Referring now to the drawing in detail, and initially to FIG. 1, there is seen a tunnelling shield 1 of the invention whose tubular body portion 2 is circular in cross section. The axial steel walls of the body portion 2 terminate in an annular front rim 3 on which a ring 4 of cutting segments 4' is arranged. A collar 5 on the front end of the body portion 2 near the rim 3 is provided with a groove in its front face which is engaged by corresponding projections on the segments 4', the segments being held in position by wedges, not shown.

The rearwardly directed face 5' of the collar 5 is provided with 12 trough-shaped recesses 8. Each recess is elongated circumferentially of the face 5', the recesses are distributed equiangularly about the axis of the shield, and they hold respective conforming pouches 9 of heavy synthetic rubber, best seen in FIG. 3, and reinforced by non-illustrated steel springs.

Three groups of conduits extend axially along the inner wall of the body portion 2 and terminate in or near the pouches 9. They are protected against mechanical damage by integral, axial ribs 6' on the inner wall.

Relatively wide conduits 6 lead from a non-illustrated concrete pump to flaring orifices 7 in the outer axial wall 13 of the body portion 2 which are directed obliquely against the rear face 5' of the collar 5, as is best seen in FIGS. 2 and 4. Rinsing water lines 20 enter respective orifices 7 in a direction opposite to the direction of flow of concrete mixture from the conduits 6 outwardly of the orifices 7 as indicated by the curved arrow 21 in FIG. 4.

Pressure lines 10 connect a non-illustrated hydraulic pump and control valve to each pouch 9 so that the pouch may be expanded toward the condition illustrated in FIG. 3 in which the pouches project from the recesses 8 in the rear face 5', and drained of fluid until they collapse into the shape shown in FIG. 5 by their own resiliency and that of the built-in springs, not shown. Radial apertures 25,26 near the rear face 5' extend through the wall 13 of the body portion 2 near the collar 5 for purposes presently to be described.

The body portion 2 is circumferentially split into four segments connected to each other by flanges 17 and bolts 19, as is best seen in FIG. 3. The flanges project radially into the interior of the body portion 2, and extend over the entire axial length of the portion. The segment 11 which forms the roof of the body portion 2 in the normal operating condition abuts against the circumferential adjacent segments by means of flat faces of flanges 12 which converge in a readially outward direction so that the segment 11 may be pulled into the interior of the body portion after release of non-illustrated fastening bolts on the flanges 12, corresponding to the bolts 19.

The rear portion 15 of the shield 1 (FIG. 1) is releasably fastened to the rear rim 14 of the body portion 2 in a conventional manner, not shown. It is of uniformly cylindrical shape and of smaller wall thickness and smaller average diameter than the body portion 2. Both portions 2 and 15 carry vibrators, not illustrated and conventional in themselves.

The tunnelling shield of the invention is operated as follows, starting from the condition shown in FIG. 1 in which a tubular concrete lining 16 for the tunnel extends rearwardly from the collar face 5' and envelopes the body portion 2 and the rear portion 15 of the shield 1, and is itself surrounded by soil 18 which also extends across the cutting ring 4 at the open front end of the shield.

Hydraulic fluid is pumped into the pouches 9 so that the pouches expand outward of the associated recesses 8, abuttingly engage the annular front face of the previously poured and cured concrete tube 16, and thereby inch the entire shield toward the left, as viewed in FIG. 1, the cutting ring 4 breaking the soil 18. When the pouches 9 are thereafter collapsed by release of the hydraulic fluid, an annular space is formed which is radially bounded by the soil 18 and the axial wall 13, and axially by the rear face 5' and the tubular concrete lining 16. The space is filled with concrete mixture discharged from the orifice 7 while the shield 1 stands still, and the conduits 6 are promptly thereafter purged of concrete mixture by water discharged from the pipes 20 into the concrete feed conduits 6 whose non-illustrated rear ends are vented simultaneously, while water from the pipes 20 cannot penetrate into the freshly poured, confined concrete ring.

The concrete mixture is quickly cured by suitable choice of ingredients, and preferably by being heated in a known manner as it flows through the conduits 6. As soon as the

newly poured ring has sufficiently hardened, a new cycle may begin with expansion of the pouches 9. Adhesion of the concrete to the body portion 2 and the rear portion 15 is held to a minimum or prevented by the use of the aforementioned, non-illustrated vibrators, and release of the body portion 2 from the last-poured concrete ring is facilitated by a slight, conical, rearward taper of the outer axis wall 13. A small plug of concrete normally hardens in each orifice 7. It is broken off from the ring during forward movement of the shield, and ejected when the next batch of concrete mixture is discharged from the orifice.

Each concrete ring has 12 projections on its front face corresponding to the collapsed pouches 9 and the contours of the recesses 8, and these projections engage corresponding recesses in the next-poured annular concrete section, thereby locking the sections to each other. If it is desired to provide for some flexibility in the concrete lining, a self-curing resilient sealing composition may be injected from time to time instead of concrete into the space partly bounded by the rear face 5' of the collar 5 and the outer axial wall 13 of the body portion 2 through the radial aperture 25. The apertures 26, farther from the face 5', have been used for introducing continuous, reinforcing steel rods into the concrete lining 16.

The conventional devices which break the face of the soil 18 ahead of the shield 1 and transport the debris through the completed tunnel section out of the working area have not been illustrated and need no description. In the absence of hydraulic jacks within the shield, ample space is available for such equipment and for the workmen who operate it.

Yet, the power available for pushing the shield through the soil 18 is greater than can be achieved with practical hydraulic equipment of the conventional type. At a hydraulic pressure of 500 kg/cm^2 which is readily available, the pouches on a shield of the invention having a diameter of 8.4 m and otherwise correspondingly dimensioned, as is evident from the drawing, develop a propelling force of 42,000 metric tons. This is far beyond the value heretofore available in conventional shields.

If the non-illustrated control valves in the hydraulic circuits of the pouches 9 are individually operated, the propelling force need not be distributed uniformly about the circumference of the cutting ring 4, but may be varied to suit soil strata of different resistance, and also to extend the tunnel not in a straight line but in an arc.

The body portion 2 is readily dismantled underground by withdrawing the roof section 11 toward the shield axis, and by thereafter separating the other segments along the flanges 17. It is therefore possible to use the shield of the invention in building blind tunnels which are required, for example, in subways.

While a tunnelling shield of circular cross section has been illustrated and described, it will be appreciated that the invention is not limited to the specific cross sectional shape of the shield, and that shields of elliptic or other cross section may be similarly constructed and operated.

It should be understood, therefore, that the foregoing disclosure relates only to a preferred embodiment of the invention, and that it is intended to cover all changes and modifications of the example of the invention herein chosen for the purpose of the disclosure which do not constitute departures from the spirit and scope of the invention set forth in the appended claims.

What is claimed is:

1. A tunnelling shield comprising, in combination:
   a. a tubular body portion having an axis, and an outer axial wall and an annular front rim about said axis;
   b. cutting means axially projecting from said rim in a forward direction;
   c. a collar projecting from said outer wall adjacent said front rim in a radially outward direction, said collar being fixedly fastened to said body portion and having a radially extending, rearwardly directed face;
   d. expansion means on said face, said expansion means including at least one element of elastomeric material enclosing a sealed cavity, and supply means communicating with said cavity for supplying to said cavity a fluid under pressure and for thereby expanding said element in an axial direction; and
   e. injecting means for injecting concrete mixture into a space bounded by said face and said wall, said injecting means including a feed conduit having an orifice adjacent said element.

2. A shield as set forth in claim 1, wherein said face is annular about said axis, and said expansion means include a plurality of elements of said material circumferentially distributed about said face and each communicating with said supply means.

3. A shield as set forth in claim 1, said collar being formed with a plurality of circumferentially elongated, circumferentially offset recesses in said face, said elements being received in said recesses respectively.

4. A shield as set forth in claim 2, wherein said injecting means have a plurality of orifices respectively adjacent said elements.

5. A shield as set forth in claim 1, further comprising rinsing means for rinsing said feed conduit of concrete mixture, said rinsing means including a conduit entering said orifice in a direction opposite to the direction of flow of said mixture from said conduit outwardly of said orifice.

6. A shield as set forth in claim 1, wherein said outer wall tapers in an axial direction away from said front rim.

7. A shield as set forth in claim 1, wherein said body portion is formed with a radial aperture therethrough connecting the interior of said body portion with said space.

8. A shield as set forth in claim 1, wherein said orifice is directed toward said face.

9. A shield as set forth in claim 1, wherein said body portion is constituted by a plurality of circumferential segments, one of said segments having two circumferentially spaced end faces abuttingly engaging corresponding faces of adjacent segments, said end faces of said one segment converging in a radially outward direction at an angle sufficient to permit said one section to be withdrawn inward toward the axis of said body portion, and fastening means releasably securing said one body portion in abutting relationship of said end faces thereof with said corresponding faces.

10. A shield as set forth in claim 1, further comprising a tubular rear portion substantially coaxial with said body portion and extending rearward from the same, the cross section of said rear portion being smaller than the cross section of said body portion.

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