

[54] **A FORM FOR PRODUCING A CONCRETE LINING OF MINE GALLERIES, TUNNELS, SHAFTS OR THE LIKE**

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[22] Filed: **Dec. 20, 1972**

[21] Appl. No.: **316,715**

[30] **Foreign Application Priority Data**

Dec. 22, 1971 Germany..... 2163740

[52] U.S. Cl..... **61/84, 61/42**

[51] Int. Cl..... **E01g 5/16**

[58] Field of Search 61/84, 85, 42, 45 R, 63

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Primary Examiner—Dennis L. Taylor

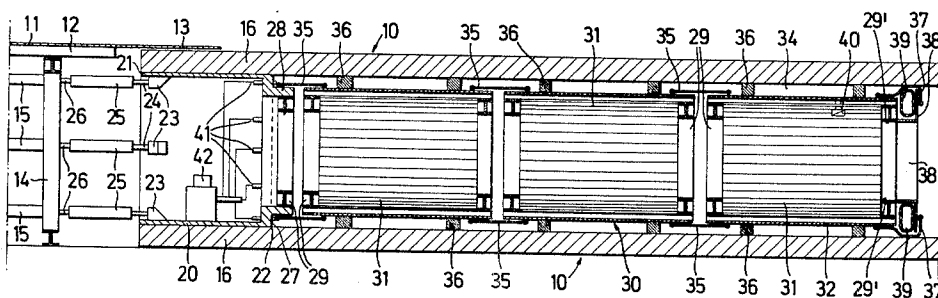
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[57]

ABSTRACT

A shuttering or form for producing a concrete lining in galleries, tunnels, shafts or the like, in which the concrete is introduced between an inner shuttering and the natural soil, the concrete lining being supported by the form until the concrete has reached its desired strength.

17 Claims, 6 Drawing Figures



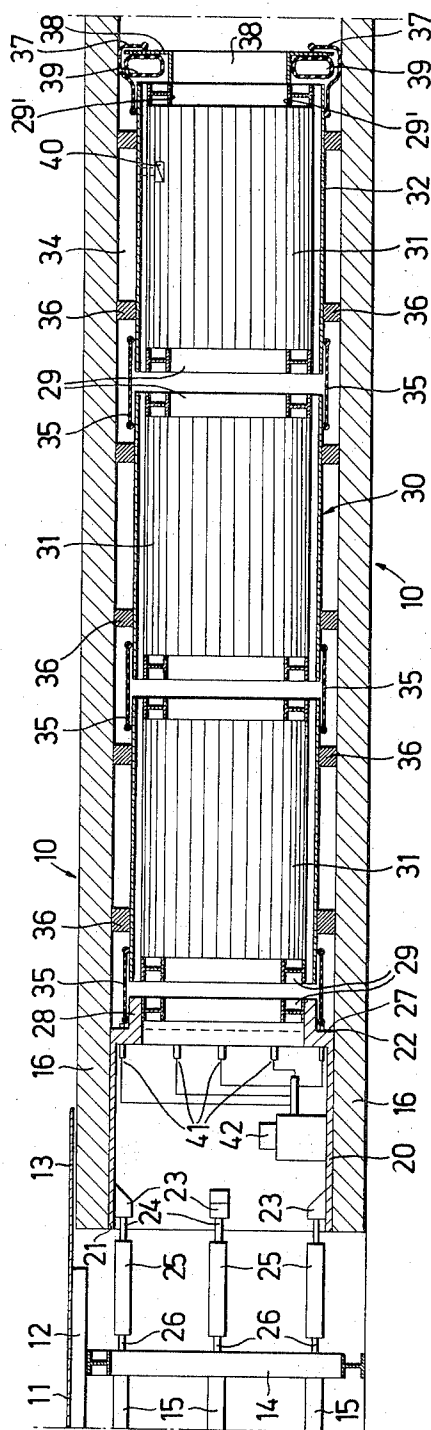


FIG. 1

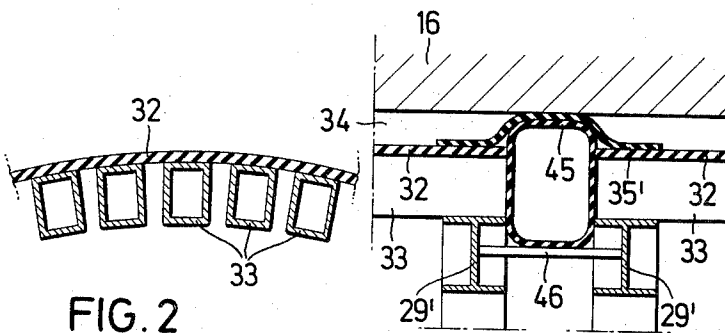


FIG. 2

FIG. 3

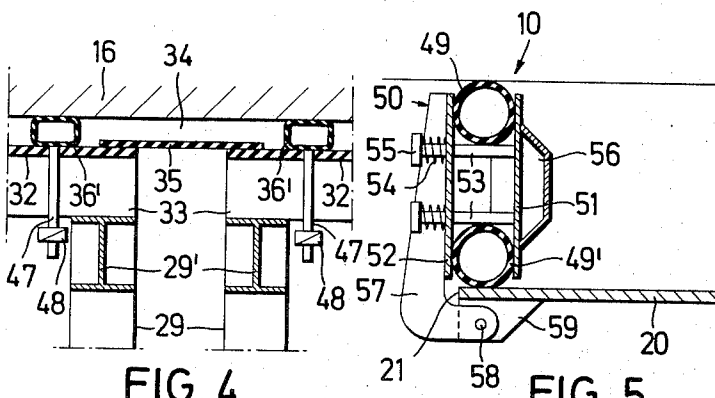


FIG. 4

FIG. 5

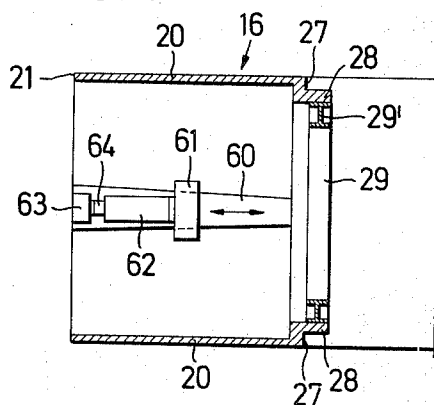


FIG. 6

A FORM FOR PRODUCING A CONCRETE LINING OF MINE GALLERIES, TUNNELS, SHAFTS OR THE LIKE

It is known to line galleries with concrete by means of a continuously or stepwise forwardly travelling inner shuttering. This inner shuttering consists of a shuttering skin corresponding to the inside profile of the gallery and provided with a strengthening transverse frame. This inner shuttering is propelled forward by means of hydraulic rams which are supported against retaining members which are clamped securely in the concrete lining at the rear which has already attained the desired strength. The concrete of the lining must, when it leaves the rear end of the inner shuttering, already have reached its desired strength, i.e. it must already be in a position to absorb the external forces which act on the gallery for example from earth pressure, traffic loading, water pressure, etc. This means that the inner lining must either be very long if a rapid rate of concreting progress is desired or can only be shorter if a slower rate of concreting progress and hence a long building time are accepted. A long inner shuttering which permits of a rapid rate of concreting progress does however require quite considerable forward thrust forces for the inner shuttering and can be used only if the gallery extends in a straight line. Where the gallery follows a curved path, only short internal shutterings are in fact possible, and the rate of structural progress is correspondingly slower.

The invention is based on the problem of providing a method of and a shuttering from the production of concrete lining in galleries, tunnels, shafts or the like, which permits of a rapid stepwise or also continuous progress of construction in rectilinear or arcuate galleries, shafts or the like, the forces necessary to propel the internal shuttering being relatively small. From the introduction of the in situ concrete until the concrete lining attains its desired strength, the shuttering should support the concrete perfectly, the intention being to allow relatively minimal labour costs for the internal supporting of the concrete lining until the desired strength is attained.

In order to resolve this problem, the method according to the invention envisages applying the loading of a pressurised fluid, preferably a highly viscous pressurised fluid, to the inside of the concrete lining between the place where the concrete has set sufficiently that it is of stable form (green strength) and a place where the concrete has reached its intended strength and can in consequence absorb the external loadings, such as for example earth pressure.

Therefore, whereas the conventional methods of building provided for the concrete lining—as is conventional in concrete construction—should be supported on the inside sufficiently long by a shuttering skin which is strengthened and which bears rigidly against the inside of the concrete lining, the method according to the invention proposes to apply to the inside of the concrete the loading of a pressurised fluid between the place where the concrete lining has reached its green strength and the place where the concrete has reached its desired strength which is sufficient to accommodate external loadings, those external forces which cannot as yet be accommodated by the concrete being borne by the said pressurised fluid. This fluid could be a pressurised gas but it is expedient however

for it to be a high viscosity pressurised fluid with which on the one hand the sealing problems are reduced and, on the other, the fluid may be of such a type that it not only extracts no water from the concrete but may even furnish it with water or any other additives which pass into the concrete from the pressurised fluid.

In the case of a shuttering according to the invention, the problems posed are resolved in that the inner shuttering consists of a rigid forming member at the leading end which extends in the longitudinal direction from the point of introduction of the concrete as far as that place where the concrete has set to the state of form-stability, and in that the inner shuttering furthermore consists of a thrust member connected tightly and traction-resistantly to the forming member, the thrust member being flexible like a hose or an articulated pipe and having a fluid-tight, compression-resistant outer skin located at a distance from the inside face of the concrete lining, and at the rear end, a seal closing the intermediate space between the outer skin and the inside face of the concrete lining, the intermediate space between the outer skin of the thrust member and the inside face of the concrete lining being filled with a fluid which is subject to over-pressure, preferably a highly viscous pressurised fluid.

Therefore, in the case of the shuttering according to the invention, the length of the forming member need be only relatively small, being just sufficient to allow the concrete to set to a form-stable condition (green strength), without being able to absorb any external loads. Once this green strength has been attained and until the final or desired strength of the concrete is attained, the pressurised fluid applies a loading to the inside face of the concrete lining, so that the external forces acting on the concrete are accommodated by the pressurised fluid and are transmitted by this to the thrust member, the pressurised fluid serving at the same time as a "lubricant" for the thrust member which, as concreting proceeds, is towed behind the forming member without any noteworthy friction. The forces which arise in the forward feeding of the inner shuttering are therefore extremely small and virtually no personnel are required for the inner shuttering, since the thrust member runs like a worm behind the forming member. The short length of the forming member makes it possible to negotiate even tight curves at a lively rate of concreting progress without very high forward feed forces occurring. Therefore, the shuttering according to the invention can be drawn forwards by means of drives, for example hydraulic rams, which are attached to a supporting frame in the driving zone of the gallery.

According to a currently preferred form of shuttering construction according to the invention, it is envisaged that the thrust member consists of a plurality of tightly and traction-resistantly but articulately connected links which are in themselves rigid.

The outer skin of the thrust member or of its links consists preferably of an elastic expediently reinforced skin of rubber or the like, on the inside of which are fixed longitudinally extending stiffening supports which are disposed at an interval from one another and which are in turn mounted on rigid transverse frames.

It is a good idea to provide on the outside of the outer skin of the thrust member spaced sliding members for central guiding of the thrust member in the concrete lining. These spaced sliding members may for example

be inflatable annular hoses which then, if a leak forms, can be used as an emergency seal for the pressurised liquid.

The seal at the rear end of the thrust member is preferably an inflatable annular hose.

For emergency sealing, however, an inflatable annular hose can also be disposed on an inner supporting surface between the links which form the thrust member.

The forming member, particularly for continuous forward feeding of the forming member, expediently has a frustoconical form with a larger cross-sectional area on its front end, the distance between the forming member and the external profile of the hole or of the external shuttering at that location being equal to the desired thickness of the concrete lining when this lining has reached its green strength condition.

The forming member may have at least one wedge-shaped wall portion which widens towards the front end and which can, in order to vary the diameter of the forming member, be extensible and retractable in a longitudinal direction by means of a force drive, e.g. a hydraulic ram, so that after breaks in the concreting work, in order to separate the forming member from the inside face of the concrete lining, this can be briefly retracted, i.e., its diameter can be reduced.

According to a preferred form of embodiment of the invention, a pressurised fluid pump which maintains the pressurised fluid in the intermediate space between the thrust member and the concrete lining at a constant pressure and which may if necessary continuously add further pressurised fluid, is provided, so that if pressurised fluid escapes for any reason, this pump constantly maintains the necessary internal pressure in the pressurised fluid.

It is a good idea to provide at the rear end of the thrust member at least one air vent and pressure relief valve through which, when construction commences, the air can be dispersed and which subsequently acts as a pressure relief valve when the pressure in the pressurised fluid exceeds its maximum admissible limit.

In the case of the shuttering according to the invention, it is possible to provide as an end shuttering to the forming member at least one inflatable annular hose at the leading end of the forming member. As an expedient further development of this proposal, the end shuttering may consist of an endless I-profile in which two inflatable hoses are concentrically located, of which one bears against the cross-section of the hole while the other bears against the outside face of the forming member, while the I-profile constitutes the connection between these two hoses.

In order to hold this end shuttering, lockable support arms which are mounted to pivot outwardly may be mounted on the forming member.

Further objects, features and advantages of the invention will become manifest from the ensuing description of examples of embodiment which serve to explain and not in any way to restrict the idea underlying the invention, reference being made in the description to the attached drawings, in which:

FIG. 1 is a diagrammatic longitudinal section through a shuttering according to the invention, in the case of a concrete lining being produced in a tunnel;

FIG. 2 shows an enlarged partial cross-section through an embodiment of the outer skin of the thrust member;

FIG. 3 is a partial longitudinal section through the joint between two adjacent portions of the thrust member in an alternative embodiment of the invention;

FIG. 4 is a partial longitudinal section through a further alternative shuttering according to the invention;

FIG. 5 is a partial longitudinal section through an embodiment of end shuttering of the forming member, and

FIG. 6 is a diagrammatic longitudinal section through the forming member in a preferred form of embodiment thereof.

FIG. 1 shows the cross-section of a gallery hole 10. Here, it is assumed that this gallery is being produced by the cutter tunnelling method, the tunnelling cutter 11 with its reinforcing ribs 12 being partly indicated at the left-hand end of FIG. 1. The cutter tails 13, which have no reinforcing ribs 12, project into the region of the concrete lining 16. The tunnelling cutters 11 are stiffened by means of supporting frames 14 which are connected to one another by longitudinal struts 15.

The inner shuttering according to the invention consists essentially of two parts, namely the forming member 20 and the thrust member which is generally designated by reference numeral 30. The forming member 20 is a rigid tube, the outer profile of which corresponds to the inside cross-sectional profile of the tunnel which is to be made, it being preferably envisaged that this forming member 20 be of frustoconical shape, i.e., be at its leading end 21 larger in diameter than it is at its rear end 22. The difference in diameters between the two ends 21 and 22 is relatively small, amounting to only a few centimetres. The outside diameter of the forming member 20 is then at that place identical to the desired inside cross-section of the gallery where the concrete has reached what is described as its green strength condition, i.e., where the concrete has set sufficiently that it is indeed stable in form but still cannot accommodate external loads.

On the inside face of the forming member 20, at three places at least which are at equal distances from one another, there are consoles 23 on which tie rods 24 are articulately mounted, being connected to the piston rods of hydraulic rams 25, the cylinders of which are in turn secured by tie rods 26 to the last supporting frame 24 of the tunnelling cutters 11. These hydraulic rams 25 serve to pull the shuttering which consists of the forming member 20 and the thrust member 30 forwards stepwise or continuously with the progress of the concreting work.

At the rear end 22, the forming member 20 has an inwardly projecting annular web 27, on the inner edge of which there is in turn secured a ring 28, the outside diameter of which is smaller than the outside diameter of the forming member 20. This ring 28 may be strengthened by a rigid supporting frame 29.

The thrust member 30 may be constructed as a flexible fluidtight compression resistant hose but according to the preferred form of embodiment illustrated in FIG. 1, the thrust member 30 consists of a plurality of elements 31 which in themselves are rigid and stiff and are articulately connected to one another. Each of the elements 31 has an outer skin 32 which consists of an elastic fluid-tight annular band consisting for example of a reinforced rubber, such as is used for conveyor belts. Disposed at intervals alongside one another on the inside face of the outer skin 32 (see particularly

FIG. 2), there are longitudinally extending strengthening ribs 33, made perhaps from structural steel, the distance between the ribs being so great that the outer skin 32 can be shaped according to the inside profile of the concrete lining 16 without the strengthening ribs 33 abutting one another. The reinforcing ribs therefore stiffen the outer skin 32 and are themselves in turn mounted on supporting frames 29 which consist of a marginal or annular carrier 29' which if necessary also has stiffenings. The reinforcing ribs 33 and the annular carriers 29' are so dimensioned that they can easily accommodate the thrust of the pressurised fluid on the outside of the relevant element 31.

The outside diameter of the outer skin 32 of the elements 31 is smaller than the inside diameter of the concrete lining 16, so that between the two there is all round a gap 34 which is filled with a fluid which is pressurised. This fluid is preferably a highly viscous liquid, for example bentonite, although naturally it is also possible to use gases as the pressurised medium. If gases and low viscosity liquids are used, however, sealing problems occur.

The distances between the individual elements 31 are bridged by sealing rings 35 which are in themselves elastic and which are attached in sealing-tight manner to the adjacent elements 31. To transmit the traction forces acting between the individual elements 31, there are either additionally (not shown) tension strips between the elements 31 or the sealing ring 35 is provided with appropriate traction inlays, for example steel inlays.

In order to maintain the thrust member 30 approximately centrally within the concrete lining 16, there are disposed around the elements 31 spacing members 36 which offer the minimum possible friction to the inside face of the concrete lining 16, but which prevent the elements 31, under the effect of their own weight, allowing their outer skin 32 to rest on the bottom of the concrete lining 16.

The rear end of the thrust member 30 is provided with a seal 37 which closes off the gap 34 at the back. This seal 37 consists of an abrasion-resistant strip which is pressed against the inside face of the concrete lining 16 by means of a hose 39 which can be inflated by a pressurised medium and which is supported on the inside against a thrust member 38, in order to prevent the pressurised medium emerging at the rear end of the thrust member 30.

Close to the rear end of the thrust member 30, in the last element 31, there is disposed at least on the upper side a venting and pressure limiting valve 40 through which, when construction commences, the air can be let out from the intermediate space 34, and which can if necessary also act as a pressure relief valve should the pressure in the intermediate space 34 become too high.

The pressurised medium is introduced through pipes or hoses 41 into the intermediate space 34, these hoses 41 being connected to a fluid pump 42. According to a preferred form of embodiment of the invention, this pump 42 is so constructed that it provides for continual further feeding of the pressurised medium if the pressure in the intermediate space 34 drops. Therefore, if a leakage occurs anywhere, the pump 42 ensures that fluid is supplied to the necessary extent, no damage being caused to the inner lining 16.

For a man skilled in the art, the manner in which the shuttering according to the invention functions will be readily obvious from the above description of its component parts. In the region of the forming member 20, the concrete is introduced and by the time it reaches the rear end 22 of the forming member, the concrete will have reached its green strength condition. If the forming member 20 is of frustoconical construction, the pressurised medium can still apply pressure against the inside face of the concrete lining 16 at the rear part of the forming member 20. In the region of the thrust member 30, the pressurised medium exerts on the inside face of the concrete lining 16 such a pressure that all externally acting forces are removed and the concrete can therefore achieve its desired strength without hindrance. As the shuttering is moved forwards, the thrust member 30 is pulled along behind the forming member 20 without any labour being required in this zone. With the shuttering according to the invention, it is possible to concrete both straight and twisting galleries, shafts and the like, even with rapid rates of progress. If bentonite or the like is used as the pressurised fluid, the concrete of the concrete lining 16 can if necessary absorb any water it requires from this pressurised fluid, the water given up by the pressurised fluid being replaced accordingly. The pressurised fluid can also have any necessary additives incorporated in it which can act on the concrete as it hardens in order to seal it, smooth it or suchlike according to requirements.

Should a leak happen to occur in any part of the gap 34, then greater damage can be obviated by, according to FIG. 3, disposing between the elements 31 an annular hose 45 which can be inflated by a pressurised medium on an inner thrust plate 46 so that when the annular hose 45 is inflated, it deforms the sealing ring 35', pressing it against the inside face of the concrete lining 16 and in consequence seals off that part of the gap 34 which is located to the left of the annular hose 45.

Another alternative embodiment, according to the illustration in FIG. 4, provides for the spacing members to be constructed as inflatable annular hoses 36' which, when a leak occurs, seals off the gap 34 by inflating the hoses 36' through a pipe 47 fitted with a valve 48, so that they are pressed against the inside face of the concrete lining 16.

FIG. 5 diagrammatically shows a preferred form of embodiment of the end shuttering 50 at the leading end 21 of the forming member 20. This end shuttering can consist of a single annular hose inflatable by a pressurised medium, but in the case of the example of embodiment shown in FIG. 5, two concentric inflatable annular hoses, 49, 49', are so disposed between two webs 51, 52, that the outer annular hose 49 presses against the cross-section 10 of the hole, whereas the inner annular hose 49' presses against the outside face of the forming member 20, the intermediate space being sealed by the webs 51, 52. These two webs 51, 52 are connected by bolts 53, springs 54 being braced against heads 55 of the bolts 53, bearing against the outside face of the web 52, so that both webs are pressed against the annular hoses 49, 49'. It is possible to dispose on the inside face of the web 51 projections 56 which form corresponding recesses in the end face of the concrete so that a serration of the portions of concrete is achieved.

This end shuttering 50 is supported by support arms 57 which are mounted to pivot about pivot pins 58 on consoles 59 which are disposed on the inside face of the forming member 20. A locking means not shown maintains the support arms 57 in the supporting position shown in FIG. 5.

If the concreting operation is not taking place continuously or has been discontinued once, then it can happen that the outside face of the forming member 20 sticks to the inside face of the concrete lining 16. In order to counteract this problem, it is possible according to the illustration in FIG. 6 to dispose in the forming member 20 at least one extensible wedge-shaped wall portion 60 which widens out towards the leading end 21. Attached to a tie plate 61 which bridges the wall portions 60 is a hydraulic ram 62, of which the piston rod 64 is attached to a console 63 mounted on the wall portion 60. If the forming member 20 sticks to the concrete lining 16, then using the hydraulic press 62 in FIG. 6, the wall portion 60 is moved leftwards, so that the outside diameter of the forming member 20 is diminished and the latter separates from the concrete lining 16. Then the wall portion 60 is pulled back again with the hydraulic ram 62 and the concreting process can be continued.

This detachment of the forming member 20 from the concrete lining 16 can however also be achieved by (see FIG. 5) inflating the annular hoses 49, 49' particularly hard for a short time. In consequence, the widening of the annular hoses 49, 49' causes the forming member 20 to be pressed away from the inside face of the concrete lining, from which it therefore becomes separated.

The invention is naturally not restricted to the details of the example of embodiment illustrated and can experience all manner of modifications within the framework of the ability of a man skilled in the art, without departing from the idea on which the invention is based.

I claim:

1. A form for producing a concrete lining in mine galleries, tunnels or the like, that form being adapted to be pulled lengthwise and comprising, in combination, a rigid tubular forming member having an outer surface spaced from an inner surface of the mine gallery according to the thickness of the concrete lining to be produced and having a leading end at which concrete is introduced between said inner and said outer surface, and a trailing end, and a length sufficient so that the concrete introduced at the leading end has set sufficiently to form stability as it reaches said trailing end; a tubular flexible compression resistant thrust member fluid-tightly and traction-resistantly connected at one end to said trailing end of said forming member, said flexible thrust member having an outer surface radially inwardly spaced from the inner surface of the concrete lining so as to form an annular space with said inner surface; a seal at the other end of said thrust member for closing said annular space at said other end of said thrust member; and means communicating with said annular space for filling the latter with a pressurized fluid, the overall length of said form being such that the concrete introduced at the leading end of said forming

member will have reached a desired strength at the other end of said thrust member.

2. A form as defined in claim 1, wherein said tubular thrust member comprises a plurality of rigid elongated members arranged closely adjacent each other and articulatedly connected to each other.

3. A form as defined in claim 1, wherein said tubular thrust member comprises an elastic outer skin, a plurality of longitudinally extending stiffening members secured circumferentially spaced from each other to the inner surface of said outer skin, and a plurality of longitudinally spaced rigid frames extending transversely through said tubular thrust member and supporting said stiffening members.

4. A form as defined in claim 3, wherein said outer skin is made from rubber.

5. A form as defined in claim 3, and including reinforcing means reinforcing said outer skin.

6. A form as defined in claim 3, and including a plurality of longitudinally spaced spacing members connected to the outer surfaces of said skin for centrally guiding said thrust member in said concrete lining.

7. A form as defined in claim 6, wherein said spacing members comprise a plurality of inflatable annular hoses.

8. A form as defined in claim 1, wherein said seal comprises an inflatable annular hose.

9. A form as defined in claim 3, wherein said stiffening members are arranged in longitudinally spaced groups and including an inflatable hose sandwiched between said groups and connected to said outer skin.

10. A form as defined in claim 1, wherein said forming member is of frustoconical shape having a larger cross-sectional area at its leading end.

11. A form as defined in claim 10, wherein said forming member has at least one wedge-shaped wall portion which widens toward said leading end, and means for moving said wall portion in longitudinal direction of said forming member.

12. A form as defined in claim 11, wherein said moving means comprises a hydraulic ram connected to said wedge-shaped wall portion.

13. A form as defined in claim 1, wherein said means for filling said annular space with a pressurized fluid comprises pump means constructed for maintaining a constant pressure in said annular space.

14. A form as defined in claim 1, and including a pressure relief valve communicating with said annular space in the region of said other end of said thrust member.

15. A form as defined in claim 1, and including at least one inflatable annular hose surrounding the leading end of said forming member.

16. A form as defined in claim 1, and including an I-shaped endless profile and two annular inflatable hoses concentrically supported by said profile about the leading end of said forming member.

17. A form as defined in claim 16, and including lockable means for pivotally supporting said profile and said hoses supported thereon.

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