

3,468,133

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EXCAVATION TYPE SHIELD WITH NO ROTARY CUTTERS

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Fig. 2

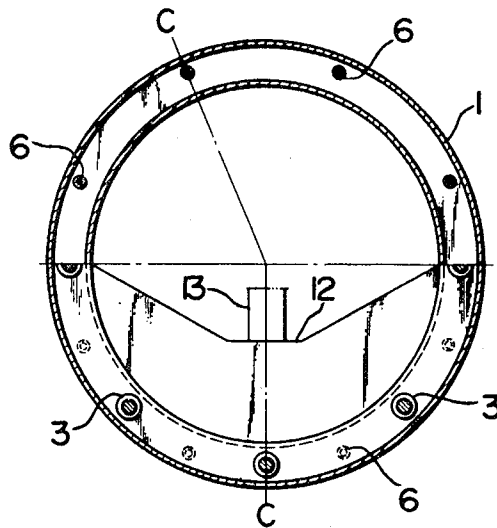


Fig. 3

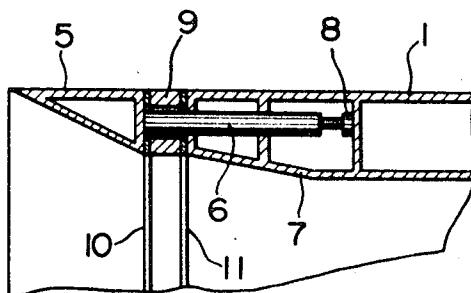
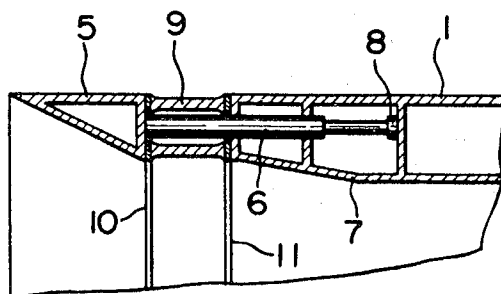


Fig. 4



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Fig. 5

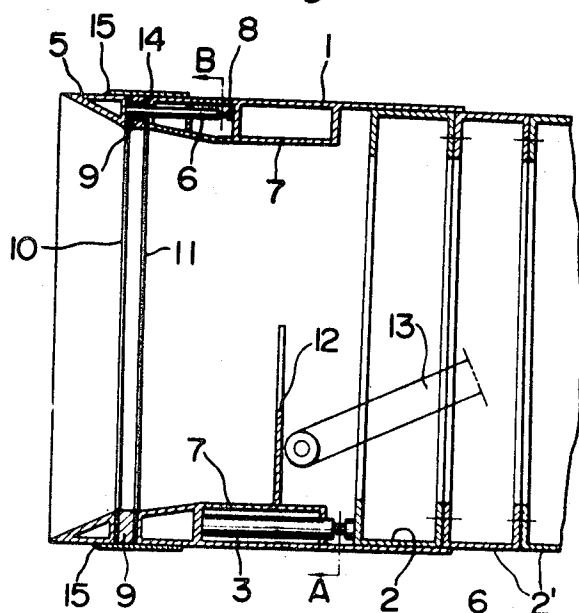
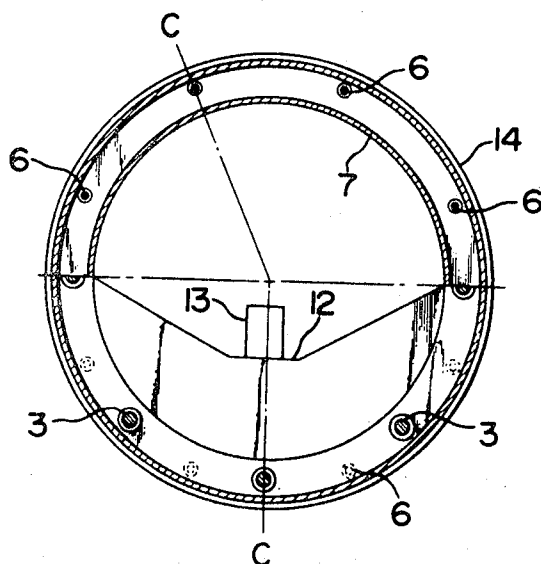
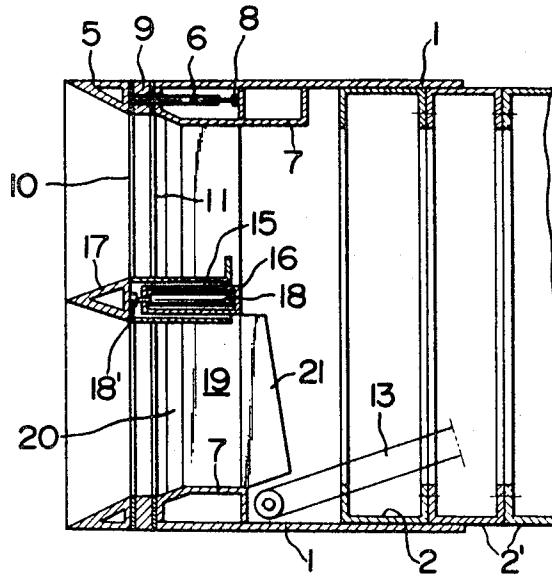
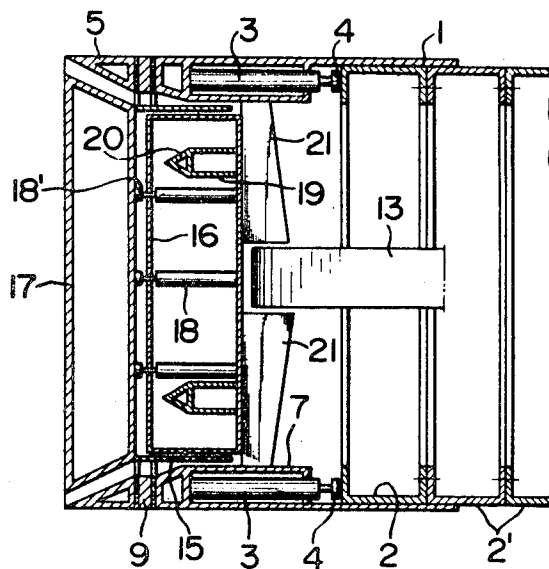


Fig. 6



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Fig. 9

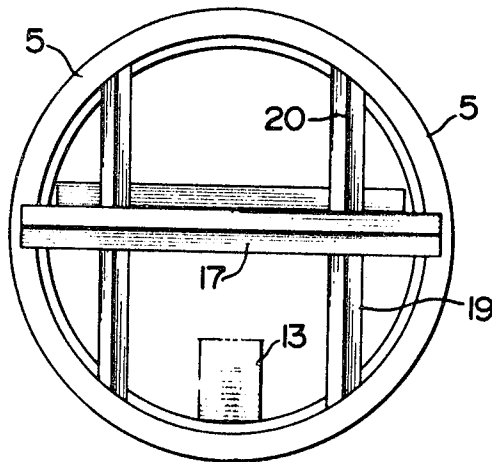
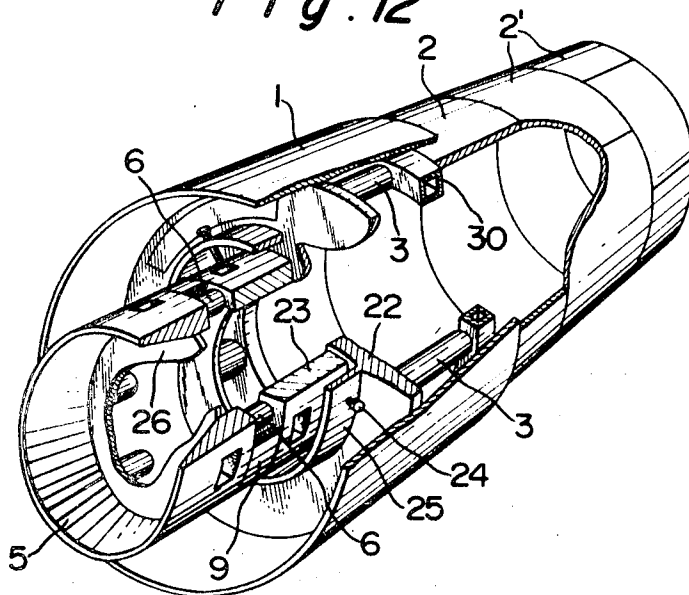


Fig. 12



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Technical drawing of a mechanical assembly in cross-section, showing a housing (1) with internal components (2, 2', 3, 13, 24, 25, 26, 27, 28, 29, 30). The assembly includes a central shaft (23) with multiple bearings (24, 25, 26, 27) and a central component (28). The housing (1) has a flange (29) and a cover (30). The drawing is labeled with various numbers indicating different parts and features.

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EXCAVATION TYPE SHIELD WITH NO ROTARY CUTTERS

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U.S. Cl. 61—85

5 Claims

ABSTRACT OF THE DISCLOSURE

An excavation type shield comprising a shield operatively connected through an elastic rubber ring to an annular cutting member, a main oil jack and a second oil jack adapted to forward move the shield and the annular cutting member, respectively. The forward movement of the annular cutting member is allowed within the elastic limit of the elastic rubber ring.

This invention relates to an excavation type shield with no rotary cutters for use in excavating tunnels in the non-cohesive ground of soil or sand bed other than cohesive rock bed without rotating the shield.

In this kind of excavation shield a rotary cutter is used. Thus, it is necessary to rotatably journal the rotary cutter at the center of the space inside the shield with the aid of radial and thrust bearings for the purpose of distributing excessive thrust to be subjected to the rotary cutter, which results in disadvantages that the excavation type shield becomes complex in construction and that the muck of ground produced in the course of excavation of the tunnel could not easily be discharged through the rotary cutter owing to the presence of the rotary cutter itself and bearings thereof.

An object of the invention is to provide an improved excavation type shield with no rotary cutters for use in excavating tunnels, and which is particularly constructed so as to excavate tunnels without making use of the rotary cutter.

A feature of the invention is the provision of such an improved excavation type shield which comprises a shield, a main oil jack for forwards moving the shield, an annular cutting member slidably supported by the shield and provided at its front end with a knife edge having a conical opening and projected out of the shield, and a second oil jack for forward moving the annular cutting member relative to the shield, and an elastic rubber ring operatively connected to said annular cutting member and said shield and said second oil jack having a cylinder extending through said elastic rubber ring and secured to said annular cutting member.

Other objects, features and advantages of the invention will become apparent from a consideration from the following specification, when the specification is considered in conjunction with the accompanying drawing, which illustrates in:

FIG. 1 is an embodiment of the excavation type shield with no rotary cutters according to the invention shown in cross section taken on line C—C of FIG. 2;

FIG. 2 is a cross section taken on line A—B of FIG. 1;

FIG. 3 shows a position taken by the annular cutting member when the second oil jack becomes contracted;

FIG. 4 shows a forward position taken by the annular cutting member when the second oil jack becomes elongated;

FIG. 5 is another embodiment of the excavation type shield with no rotary cutters according to the invention shown in cross section taken on line C—C of FIG. 6;

FIG. 6 is a cross section taken on line A—B of FIG. 5; FIG. 7 is a further embodiment of the excavation type shield with no rotary cutters according to the invention shown in longitudinal cross section;

FIG. 8 is its transverse sectional view;

FIG. 9 is its end view;

FIG. 10 is a still further embodiment of the excavation type shield with no rotary cutter according to the invention shown in longitudinal cross section;

FIG. 11 is its end view;

FIG. 12 is a perspective view of a modification of the embodiment shown in FIGS. 10 and 11.

Referring to FIGS. 1 and 2 showing an embodiment of the invention, 1 represents a shield; 2 a cover ring consisting of a number of segments and adapted to be assembled together at the inner surface of the tail end of the shield 1 and cover the inner wall of the tunnel excavated when the shield 1 has passed over it; and 3 a number of main oil jacks mounted along the periphery of the shield 1 and each adapted to move forwards the shield 1 by oil pressure with its plunger end 4 rested against the cover ring 2.

In the embodiment shown, provision is made of an annular cutting member 5 provided at its front end with a knife edge for excavating the ground bed. The annular cutting member 5 is so constructed that the outer diameter thereof is equal to that of the shield 1 and that the inner diameter thereof is decreased towards the rear end so as to form a conical opening. The annular cutting member 5 is secured at its rear end to the front end of the cylinder of a number of second oil jacks 6 each interposed between the main oil jacks 3 along the periphery of the shield and projected out of the shield 1 and slidably supported by a frame 7 formed at the inner front side of the shield 1. The plunger end 8 of the second oil jack 6 is rested against the frame 7. Thus, the second oil jack 6 is capable of causing to move forwards the cylinder thereof relative to the frame 7, that is, the shield 1. The cylinder of the second oil jack 6 is freely extended through an elastic rubber ring 9 made of a vibration proof rubber. The elastic rubber ring 9 is inserted between a ring plate 10 secured to the rear end surface of the annular cutting member 5 and another ring plate 11 secured to the front end surface of the shield 1 and firmly adhered to these ring plates 10 and 11 by means of a suitable cementing agent. Thus, the forward movement of the annular cutting member 5 is allowed within the elastic limit of the elastic rubber ring 9. 12 designates a sheathing panel secured to the frame 7 of the shield 1 and adapted to dam up the muck of ground produced during the excavation effected by the forward movement of the annular cutting member 5 and arrived at through the conical opening thereof. 13 shows a conveyor with its charging end arranged within the space formed inside the shield 1 for the purpose of conveying rearwards the muck of ground overflowing the sheathing panel 12.

The operation of the above described embodiment of the invention is as follows:

After the segments have been assembled together to form a new cover ring 2 connected to the existing cover ring 2', each second oil jack 6 is made operated to push its plunger end 8 against the frame 7 of the shield 1, which results in forward cutting movement of the annular cutting member 5 towards the ground bed from a position shown in FIG. 3 to a position shown in FIG. 4 where the elastic rubber ring 9 is deformed into an elongated state within its elastic limit. The muck of ground produced is transferred through the conical opening of the annular cutting member 5 to the conveyor 13.

Then, the second oil jack 6 is made inoperative, while at the same time each main oil jack 3 becomes operated

to push the plunger end 4 thereof against the cover ring 2 this forwards moving the shield 1 from the position shown in FIG. 4 to a position where the elastic ring 9 and the second oil jack 6 are brought into the original position shown in FIG. 3. Successive forward movements of the annular cutting member 5 and the shield 1 are thus repeated.

After the shield 1 has moved forwards a distance corresponding to one stroke of each first oil jack 3 segments are assembled together to form a new cover ring 2 and this new cover ring 2 is connected to the existing cover ring 2'. Then, another successive forward movement of the annular cutting member 5 and the shield 1 are repeated.

As above explained the embodiment shown in FIGS. 1 to 4 makes it possible to excavate the ground bed by means of successive forward movements of the annular cutting member 5 and the shield 1 with the aid of the first and second oil jacks 3 and 6, thereby obviating the use of any rotary cutter.

In the excavation shield, if the rotary cutter is used all of the reaction force of the shield due to the propulsion thereof is directly transmitted to the cover ring. Thus, it is necessary to reinforce the cover ring such that it can withstand the above mentioned reaction force and also the pressure subjected by the ground bed.

Contrary to such conventional excavation shield which makes use of the rotary cutter, in the embodiment shown all of the reaction force produced during excavation by means of the forward movement of the annular cutting member 5 caused by the second oil jack 6 is absorbed by the shield 1 which is frictionally in contact with the ground bed so that it is sufficient to construct the cover ring 2 such that it can withstand the reaction force produced during the forward movement of the shield 1 caused by the main oil jack 3 and the pressure subjected by the ground bed. This ensures decrease of the effective cross sectional area of the segments for forming the cover ring 2 and provides the important advantage that assembling of the segments into the cover ring 2 can simply and economically be effected by using segments which are small in size and light in weight. Since the elastic rubber ring 9 serves to close the space formed between the shield 1 and the annular cutting member 5, it is possible to prevent the water in the ground from entering into a shield 1 and also prevent the muck of ground produced in the course of excavation from pushing into the space formed between the shield 1 and the annular cutting member 5, which results in an easy advancement of the shield 1.

If it is desired to protect the elastic rubber ring 9 from becoming wear owing to friction with the ground bed the annular cutting member 5 may be provided at the rear peripheral surface thereof with a drum 14 made of sheet steel as shown in FIGS. 5 and 6. The drum 14 is secured at the front edge thereof 15 to the annular cutting member 5 and has such a width that the rear edge is always in sliding contact with the shield 1 even when the second oil jacks 6 become extended and the annular cutting member 5 is forwards moved.

In case of excavating the ground containing substantially no water the elastic rubber ring 9 may be omitted and the drum 14 may be made always in sliding contact with the shield 1 with a closed relation.

In the embodiment shown in FIGS. 7 to 9, provision is made of at least one horizontal stage 15 each of which is adapted to divide the space inside the shield 1 into upper end lower portions and is sliding contact with a horizontal frame 16 formed integral with the frame 7 of the shield 1. The stage 15 is provided at its front end with a knife edge 17 and adapted to be forwards moved by means of a number of third oil jacks 18. The cylinder of each third oil jack 18 is secured to the frame 16 and the plunger end 18' is rested against the rear end of the knife edge 17 of the stage 15. 19 designates vertical columns each provided at its front edge with a knife edge

20 which ensures easy forward movement of the vertical columns 19, that is, the shield 1. 21 shows guide plates made of iron and secured to the frame 7 of the shield 1. The guide plates 21 serve to guide the muck of ground excavated and transferred through upper and lower openings formed between the annular cutting member 5 and the stage 15 to the conveyor 13.

The operation of the embodiment of the invention shown in FIGS. 7 to 9 is substantially the same as that explained with reference to FIGS. 1 to 4 except that each third oil jack 18 is made operated to push its plunger end 18' against the rear end of the knife edge 17 of the stage 15 at the time when each second oil jack 6 is made operated to push its plunger end 8 against the frame 7 of the shield 1, which results in forward cutting movements of the knife edge 17 of the stage 15 and of the annular cutting member 5 towards the ground bed within the elastic limit of the elastic rubber ring 9. Then, the second and third oil jacks 6 and 18 are made inoperative, while at the same time each main oil jack 3 becomes operated to push the plunger end 4 thereof against the cover ring 2 thus forwards moving the shield 1 in the same manner as explained with reference to FIGS. 1 to 4.

After the shield 1 has moved forwards a distance corresponding to one stroke of each first oil jack 3 segments are assembled together to form a new cover ring 2 and this new cover ring 2 is connected to the existing cover ring 2'. Then, successive forward movements of the annular cutting member 5 and the knife edge 17 of the stage 15 at one hand and the shield 1 at another hand are repeated.

During forward movements of the annular cutting member 5 and the knife edge 17 of the stage 15 the latter serves to divide the muck of ground excavated by the annular cutting member 5 into the upper and lower portions, thus preventing the upper muck from becoming collapsed. Moreover, the stage 15 plays a role of preventing up and down movements of the shield 1 during excavation of the ground bed, which ensured a safety forward movement of the shield 1. Moreover the muck of ground on the stage 15 can easily be transformed onto the conveyor 13 due to the gravity acting on this muck of ground.

FIGS. 10 and 11 show another embodiment of the invention which makes use of a partition wall 22 secured to the shield 1 and adapted to divide the space inside the shield 1 into two portions, one for enclosing two concentric annular cutting members, 5, 5 and the other for enclosing the main oil jack 3. In FIGS. 10 and 11 the same reference numerals as those shown in FIG. 1 to 4 denote the same parts.

In the embodiment shown in FIGS. 10 and 11, the two concentric cutting members, 5, 5 are supported by the partition wall 22 and the outer diameters of these two concentric annular cutting members 5, 5 are made smaller than that of the shield 1. Each annular cutting member 5 is slidably connected to the forward end of the second oil jack 6 whose rear end in turn secured to a supporting cylinder 23 which is adjustably secured through bolts 24 to a cylindrical frame 25 formed integral with the partition wall 22. By adjusting the bolts 24 the position of the supporting cylinder 23, i.e. the position of the annular cutting member 5 with respect to the shield 1 can be changed to adjust the direction of the forward cutting movement of the annular cutting member 5. The elastic rubber ring 9 is inserted between the annular cutting member 5 and the supporting cylinder 23 and firmly adhered to this member 5 and cylinder 23 by means of a suitable cementing agent. Each of the conical opening of the center annular cutting member 5 and the conical opening formed between the center annular cutting member 5 and the outer annular cutting member 5 is closed by a sheathing plate 26 provided with a normally closed door 27.

The partition wall 22 is provided at its part in opposition to the center normally closed doors 27 with openings also normally closed by doors 28. The partition wall 22 is also provided at its parts between the outer annular cutting member 5 and the shield 1 with openings normally closed by doors 29. The main oil jack 3 enclosed in the space behind the partition wall 22 is rested at its contractable end through a supporting ring 30 against the cover ring 2.

The operation of the embodiment of the invention shown in FIGS. 7 and 8 is as follows:

After the segments have been assembled together to form a new cover ring 2 connected to the existing cover ring 2', each center second oil jack 6 is first operated to move forwards the center annular cutting member 5 and then each outer second oil jack 6 is operated to move forwards the outer annular cutting member 5. Finally, each main oil jack 3 is operated to move forwards the shield 1.

The forward movements of each annular cutting member 5 is allowed within the elastic limit of the elastic rubber ring 9. After the shield 1 has moved forwards a distance corresponding to one stroke of each first oil jack 3 segments are assembled together to form a new cover ring 2 and this new cover ring 2 is connected to the existing cover ring 2'. Then, another successive forward movements of each of the center and outer annular cutting members 5, 5 and the shield 1 are repeated. The muck of ground produced is transferred through each conical opening of the center and outer annular cutting members 5, 5 to the sheathing plate 26, thus forcedly opening the normally closed door 27 and introduced into the space inside inside the supporting cylinder 23. The muck of ground newly introduced into the space inside the supporting cylinder 23 causes to discharge the existing muck of ground in the space inside the supporting cylinder 23 through now opened normally closed door 28 of the partition wall 16 onto the conveyor 13. The muck of ground newly introduced into the space between the shield 1 and the outer supporting cylinder 23 causes to discharge the existing muck of ground in this space through now opened normally closed door 29 of the partition wall 16.

As explained above the center and outer sheathing panels 26 with normally closed doors 27 and the partition wall 22 with normally closed doors 28, 29 serve to dam up the muck of ground produced during the excavation effected by the successive forward movements of the center and outer annular cutting members 5, 5 and of the shield 1 and arrived at through the conical openings thereof. Thus, the present embodiment renders it possible to excavate collapsible ground bed such as river bed or sea bed in a safety sheathing manner.

FIG. 12 shows a modification of the embodiment shown in FIGS. 10 and 11, wherein provision is made of one annular cutting member 5 instead of providing the two concentrically arranged annular cutting members 5, 5 shown in FIGS. 10 and 11. The other constitutional elements of the embodiment shown in FIG. 12 are the same

as those shown in FIGS. 10 and 11 and designated by the same reference numerals.

It may be clear that the invention is not restricted to the embodiments described and that many variations are possible for those skilled in the art without leaving the scope of the invention.

What I claim is:

1. An excavation type shield comprising a shield, a number of main oil jacks for forwards moving said shield, an annular cutting member slidably supported by said shield and provided at its front end with a knife edge having a conical opening and projected out of said shield, and a number of second oil jacks for forwards moving said annular cutting member relative to said shield and an elastic rubber ring operatively connected to said annular cutting member and said shield, each of said second oil jacks having a cylinder extending through said elastic rubber ring and secured to said annular cutting member.

2. An excavation type shield as set forth in claim 1 and further comprising a drum made of sheet steel and secured to said annular cutting member and having such a width that its rear edge is always in sliding contact with said shield.

3. An excavation type shield as set forth in claim 1 wherein said shield includes a horizontal stage slidably supported by said shield and provided at its front end with a knife edge and for dividing the space inside said shield into upper and lower portions, said horizontal stage being moved forwards by means of a number of third oil jacks.

4. An excavation type shield as set forth in claim 1 wherein said shield includes a partition wall secured thereto and integrally formed with a cylindrical frame, and a supporting cylinder adjustably secured through bolts to said cylindrical frame and connected through said elastic rubber ring to said annular cutting member.

5. An excavation type shield as set forth in claim 1 wherein said shield includes upper and lower center members and two side members, and joints between said cutter member and said side member which are operatively connected together and reinforced.

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JACOB SHAPIRO, Primary Examiner

U.S. Cl. X.R.