

(18)



Europäisches Patentamt

European Patent Office

Office européen des brevets

(11) Publication number:

**0 142 227  
B1**

(12)

## EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: **11.01.89**

(51) Int. Cl.<sup>4</sup>: **E 21 D 11/08, E 21 D 11/40**

(21) Application number: **84305742.3**

(22) Date of filing: **22.08.84**

(54) **Tunnelling machines.**

(30) Priority: **22.08.83 GB 8322524**

(43) Date of publication of application:  
**22.05.85 Bulletin 85/21**

(45) Publication of the grant of the patent:  
**11.01.89 Bulletin 89/02**

(84) Designated Contracting States:  
**AT DE FR GB IT**

(56) References cited:  
**DE-A-2 354 899  
DE-A-3 113 648  
GB-A-1 070 773  
US-A-3 833 251  
US-A-4 166 648**

(70) Proprietor: **Draper, Andrew Roger  
Honeyside Golf Drive  
Camberley Surrey (GB)**

(70) Proprietor: **Smith, Brian  
4 Albany Court Ackworth Road  
Pontefract West Yorkshire (GB)**

(72) Inventor: **Draper, Andrew Roger  
Honeyside Golf Drive  
Camberley Surrey (GB)**  
Inventor: **Smith, Brian  
4 Albany Court Ackworth Road  
Pontefract West Yorkshire (GB)**

(74) Representative: **Bayliss, Geoffrey Cyril et al  
BOULT, WADE & TENNANT 27 Furnival Street  
London EC4A 1PQ (GB)**

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European patent convention).

Courier Press, Leamington Spa, England.

**EP 0 142 227 B1**

## Description

This invention relates to tunnelling machines for digging tunnels which are lined with rings of arcuate tunnel lining segments of concrete, each ring being formed by, for example, twelve such segments.

A known tunnelling machine of the kind described in DE—A—3 113 648 has at the head thereof an excavator within a tunnelling shield which is advanced through the ground as digging proceeds. Immediately behind the excavator and shield stage of the machine, there is provided a tunnel lining stage, which includes an assembly rotatable about the axis of the tunnel having a pick-up head. In operation, segments are fed along the tunnel and placed on the floor of the tunnel at the tunnelling lining stage. The assembly is rotated so that the pick-up head is adjacent the segment, and the segment is then picked up by the pick-up head. The assembly is then rotated to swing the segment to the desired position around the ring of segments being constructed and the pick-up head is moved radially outwardly to place the segment in position against the tunnel wall. The segment is held in position and the pick-up head is then released from the segment. Further segments are then picked up from the bottom of the tunnel and put in place to complete the ring.

In the known machine, the pick-up head comprises a pair of movable jaws which are hydraulically operated to grip the segment by its edges therebetween at the floor of the tunnel and which are released when the segment has been positioned against the tunnel wall. The jaws are then moved away from the segment, and the final position of the segment is adjusted.

In the present invention at least one suction pad is used instead of the movable jaws, and accordingly the present invention provides a tunnelling machine having a tunnel lining stage for installing a ring of arcuate tunnel lining segments to line the tunnel, the tunnel lining stage comprising an assembly supported for rotation about a longitudinal axis of the machine, and a pick-up device mounted on the assembly for picking up such tunnel lining segments from the floor of the tunnel and, after rotation of the assembly and installation of each segment, releasing the segment the pick-up device comprising at least one suction pad facing generally radially outwardly from said longitudinal axis and adapted to engage the concave surface of the segment so that the suction pad and segment form a sealed cavity, and means being provided to evacuate the cavity to hold the segment against the suction pad.

The machine according to the invention overcomes two main problems found in the known machines. Firstly, in the known machines the force with which the jaws grip the segment must be carefully controlled. If gripped too hard, the segment crumbles, and, if not gripped with sufficient force, the segment will slide from the jaws.

Especially when using segments having a bitumen coating, it has sometimes been found impossible to pick up the segments without crumbling. In the case of the present invention, substantially more lifting force than is necessary can be applied to the segments without adverse effects. Secondly, when using the known machine, the final position of the segments has to be adjusted after the jaws had been removed. In the case of the present invention, there are no lifting jaws at the edges of the segments to hinder the positioning of the segments, and thus the segments can be installed in one stage in their proper position.

A specific embodiment of the present invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a schematic view of the lining stage of a tunnelling machine in a tunnel after installation of a ring of lining segments, looking in the direction of advance of the machine but not showing the excavator and shield stage of the machine;

Figure 2 is a schematic plan view of the pick-up head of the machine, looking in the direction 2 in Figure 1;

Figure 3 is an end view of part of the pick-up head;

Figure 4 is a partial section end view of the pick-up head taken along the section line 4—4 in Figure 2;

Figure 5 is a partially sectioned elevation of a modified suction pad;

Figure 6 is a plan view of the modified pad;

Figure 7 is a rear view of a modified pick-up head; and

Figure 8 is a sectioned elevation of the modified pick-up head.

Referring to the drawings, the lining stage 10 of the machine is used to install a ring of arcuate cast concrete tunnel lining segments. The ring consists of nine identical segments 12, and three further segments 14, 16, 18. The edges 20, of the segments extend in the longitudinal direction of the tunnel, whereas one edge 22 each of segments 14, 16 is tapered to form half-wedge segments, and both edges 24 of the upper segment 18 are correspondingly tapered to form a full-wedge key segment. The method of installation of the ring is to position segment 12 (1) on the tunnel floor, to lift segment 12 (2) from the tunnel floor into position and hold it there temporarily by a hydraulic ram, and sequentially to lift into position and temporarily hold segments 12 (3) to 12 (9), 14 and 16. The key segment 18 is then slid longitudinally into position to lock the ring in place. The hydraulic rams temporarily holding segments 12, 14, 16 can then be released.

The lining stage 10 which carries out the operation described above comprises an annular member 26 mounted for rotation about the axis of the tunnel, for example by guide rollers 28 mounted on the machine chassis. The member 26 is located slightly forwardly of the ring of segments to be installed. A motor 30 is provided to

rotate the annular member 26 as desired, in either direction for example by means of a pinion 32 engaging internal toothing on the member 26. A pick-up device is mounted on the rotatable member 26. The pick-up device comprises a part cylindrical plate 34, the axis of which is generally coincident with the tunnel axis. The plate is mounted by means of a hydraulic ram 36 which can move the plate radially as denoted by the arrow R and also by means of a joint 38 which permits a limited small amount of free tilting movement of the plate 34, denoted by the arrow T.

Referring now more particularly to Figures 2 to 4, two suction pads 40 are mounted on the convex side of the plate 34. Each suction pad comprises a rectangular sheet 42 of rubber having a peripheral flange-like lip 44 projecting away from the plate 34. The sheet 42 is sandwiched between the plate 34 and a further plate 46, and this sandwich is held together by fasteners extending there-through. Each pad 40 is provided with a port 48, which ports are both connected to a common vacuum pump.

In order to install a segment 12, 14, 16, the segment is conveyed to the tunnel floor beneath the pick-up device 34 with the concave surface of the segment uppermost. The ram 36 is then extended so that the lips 44 of the suction pads engage the concave surface of the segment and so that each pad forms with the segment a sealed cavity. The cavity is then evacuated by operation of the vacuum pump so that the segment is held against the suction pads. The ram 36 is then retracted, lifting the segment clear of the tunnel floor, and the motor 30 is operated to swing the segment to the desired angular position around the ring. The ram 36 is then extended to instal the segment against the tunnel wall, where it is temporarily held, as described above. The suction is then released; the ram 36 is retracted and the pick-up device is returned to the lowermost position ready to lift a further segment.

A typical segment may weigh about 350 lb (160 kg). With such a segment, it has been found satisfactory to use suction pads which apply suction to the concave surface of the segment over a total area of about  $in^2$  ( $450\text{ cm}^2$ ). When operating at a pressure of  $10\text{ lb/in}^2$  ( $0.7\text{ kg/cm}^2$ ) below atmospheric pressure, the suction pads can cause a lifting force of a little under 700 lb (320 kg) to be applied to the segment. It will be noted that the suction pads must not only be able to overcome the weight of the segment when the machine is in the angular position shown in Figure 1, but also be able to prevent sliding of the segment from the pads when the member 26 has been rotated by  $90^\circ$  from that position.

The pick-up head may be modified, for example by using a single suction pad or more than two suction pads.

Referring now to Figures 5 and 7, there is shown a modified suction pad 40, comprising a generally square dished rubber moulding 50 bonded to a plane metal back-plate. The sealing

lip 44 of the moulding is wider than that shown in Figure 4 and is formed with a series of four peripheral grooves 52 which improve the seal which can be obtained. A vacuum port 48 is formed through the back-plate 34 and rubber moulding, and a threaded hole 54 is provided in the back-plate 34 by which the suction pad can be attached to the pick-up head.

Referring now to Figures 7 and 8, there is shown a modified pick-up head including a pair of suction pads 50 as shown in Figures 5 and 6. The pick-up head comprises upper and lower elongate members 56, 58 and three upright members 60 which are welded together to form a framework 64 of two side-by-side squares in which the suction pads 50 are located. Two pairs of plates 62 extend rearwardly from the framework to provide mountings for the suction pads 50. A bearing block 66 is pivotally mounted between each pair of plates 62 and a support shaft 68 extending rearwardly from each suction pad 50 is slidably mounted in a respective one of the bearing blocks 66. Each support shaft 68 is held captive in the respective bearing block 66 by a nut 70 and washer, and a compression spring 72 is mounted on each shaft 68 between the respective bearing block 66 and the back-plate 34 of the respective suction pad.

The springs 72 urge the suction pads normally to a position to the left of that shown in Figure 7 so that the sealing lips of the pads stand proud of the framework 64 and can engage the concrete lining blocks. As the pads are brought into engagement with the lining blocks, the pads can retract into the framework to a position where the sealing lips are flush with the framework and the framework engages the lining block. Further pressure applied by the pick-up head on the lining block is then transmitted by the framework rather than by the suction pads and thus the framework protects the rubber lips of the suction pads from damage during application of the pick-up head to the concrete block.

## Claims

1. A tunnelling machine having a tunnel lining (10) stage for installing a ring of arcuate tunnel-lining segments (12, 14, 16, 18) to line the tunnel, the tunnel lining stage comprising an assembly (26) supported for rotation about a longitudinal axis of the machine, and a pick-up device (34) mounted on the assembly for picking up such tunnel lining segments from the floor of the tunnel and, after rotation of the assembly and installation of each segment, releasing the segment, characterised in that the pick-up device comprises at least one suction pad (40) facing generally radially outwardly from said longitudinal axis and adapted to engage the concave surface of the segment so that the suction pad and segment form a seal cavity, and means (48) being provided to evacuate the cavity to hold the segment against the suction pad.

2. A machine as claimed in Claim 1, wherein at

least two such suction pads (40) are provided to engage respective portions of the concave surface of the segment.

3. A machine as claimed in Claim 1 or 2, wherein the or each suction pad (40) has a resilient peripheral lip (44) to engage and seal against the concave surface of the segment.

4. A machine as claimed in any preceding claim wherein the pick-up device further comprises a part-cylindrical backing plate, the axis of which is generally coincident with the longitudinal axis of the machine, and the or each suction pad (40) being mounted on the backing plate.

5. A machine as claimed in any preceding claim, wherein the pick-up device further comprises a framework (64) encircling the or each suction pad (40), the pad being arranged to stand proud of the framework and being mounted (at 66) so as to be able to retract to a position in which the suction pad (40) is flush with the framework.

### Patentansprüche

1. Tunnelvortriebsmaschine mit einer Tunnelauskleidungsbühne (10) zum Anbringen eines Rings aus bogenförmigen Tunnelauskleidungssegmenten (12, 14, 16, 18), um den Tunnel auszukleiden, wobei die Tunnelauskleidungsbühne einen Aufbau (26) umfaßt, der abgestützt ist zur Drehung um eine Längsachse der Maschine, und eine Aufnahmevorrichtung (34) umfaßt, die auf dem Aufbau angebracht ist zum Aufnehmen solcher Tunnelauskleidungssegmente vom Boden des Tunnels und, nach Drehung des Aufbaus und Anbringung jedes Segments, zum Freigeben des Segments, dadurch gekennzeichnet, daß die Aufnahmevorrichtung zumindest ein Saugkissen (40) aufweist, das im allgemeinen von der Längsachse radial nach außen gerichtet ist, und angepaßt ist, um mit der konkaven Oberfläche des Segments so in Eingriff zu stehen, daß das Saugkissen und das Segment eine abgedichtete Höhlung bilden, und daß Mittel (48) vorgesehen sind, um die Höhlung zu evakuieren, um das Segment an dem Saugkissen zu halten.

2. Maschine nach Anspruch 1, dadurch gekennzeichnet, daß zumindest zwei solcher Saugkissen (40) vorgesehen sind, die an entsprechenden Bereichen der konkaven Oberfläche des Segments angreifen.

3. Maschine nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß das oder jedes Saugkissen (40) eine elastische Umfangslippe (44) hat, um mit der konkaven Oberfläche des Segments in Eingriff zu stehen und gegen diese abzudichten.

4. Maschine nach einem der vorstehenden Ansprüche, dadurch gekennzeichnet, daß die Aufnahmevorrichtung eine teilzylinderförmige Spannplatte aufweist, wobei die Achse derselben

im allgemeinen mit der Längsachse der Maschine übereinstimmt, und daß da oder jedes Saugkissen (40) auf der Spannplatte angebracht wird.

5. Maschine nach einem der vorstehenden Ansprüche, dadurch gekennzeichnet, daß die Aufnahmevorrichtung weiterhin ein Rahmenwerk (64) umfaßt, das das oder jedes Saugkissen (40) einfaßt, wobei das Kissen so angeordnet wird, daß es aus dem Rahmenwerk vorsteht und so angebracht wird (bei 66), daß es in eine Position zurücktreten kann, in der das Saugkissen (40) mit dem Rahmenwerk bündig ist.

### Revendications

1. Une machine de creusement de tunnel ayant un poste de coffrage de tunnel (10) pour installer un anneau de segments (12, 14, 16, 18) de coffrage en arc pour coffrer le tunnel, le poste de coffrage de tunnel comportant un montage (26) supporté pour rotation autour d'un axe longitudinal de la machine, et un dispositif de prise (34) disposé sur le montage pour prendre de tels segments de coffrage sur le radier du tunnel et, après rotation du montage et installation de chaque segment, relâcher le segment, caractérisé en ce que le dispositif de prise comporte au moins un tampon à succion (40) faisant face généralement radialement vers l'extérieur depuis ledit axe longitudinal et adapté à porter sur la surface concave du segment de sorte que le tampon à succion et le segment forment une cavité étanche, et des moyens (48) étant disposés pour mettre sous vide la cavité pour maintenir le segment contre le tampon à succion.

2. Une machine selon la revendication 1, dans laquelle sont disposés au moins deux tels tampons à succion (40) pour porter sur des parties respectives de la surface concave du segment.

3. Une machine selon l'une des revendications 1 et 2, dans laquelle le ou chaque tampon à succion (40) possède une lèvre périphérique souple (44) pour porter et former joint contre la surface concave du segment.

4. Une machine selon une quelconque des revendications précédentes, dans laquelle le dispositif de prise comporte en outre une plaque de dos en secteur de cylindre, dont l'axe est sensiblement coïncidant avec l'axe longitudinal de la machine, et le ou chaque tampon à succion (40) étant monté sur la plaque de dos.

5. Une machine selon une quelconque des revendications précédentes, dans laquelle le dispositif de prise comporte en outre un cadre (64) entourant le ou chaque tampon à succion (40), le tampon étant agencé pour se tenir en saillie du cadre et étant monté (en 66) en sorte d'être apte à se rétracter dans une position où le tampon à succion (40) est à ras du cadre.

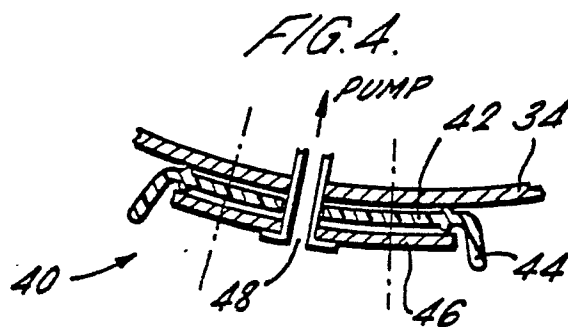
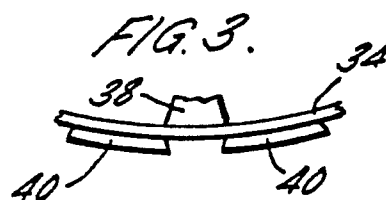
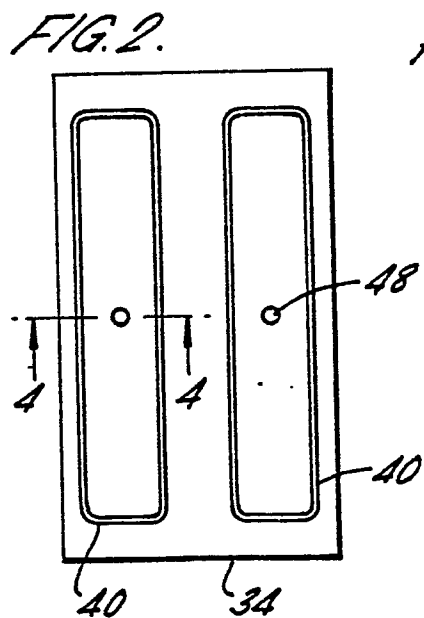
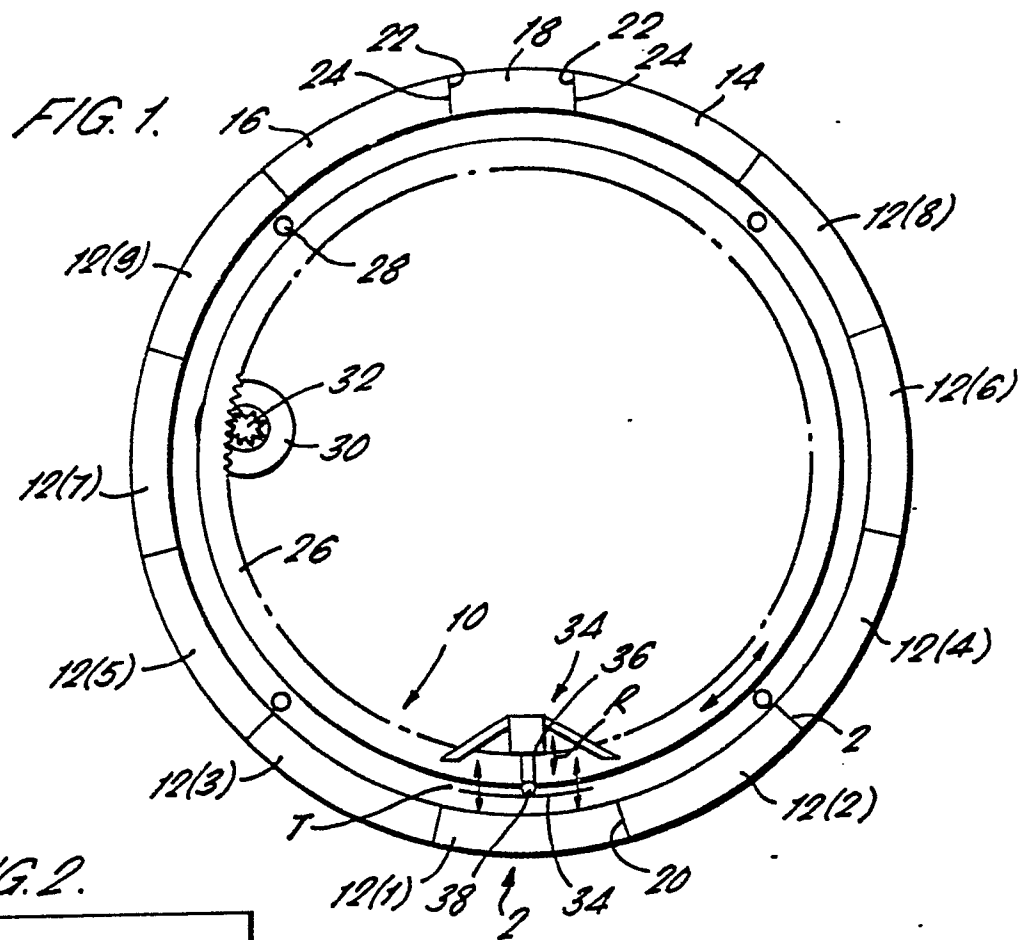


FIG. 5.

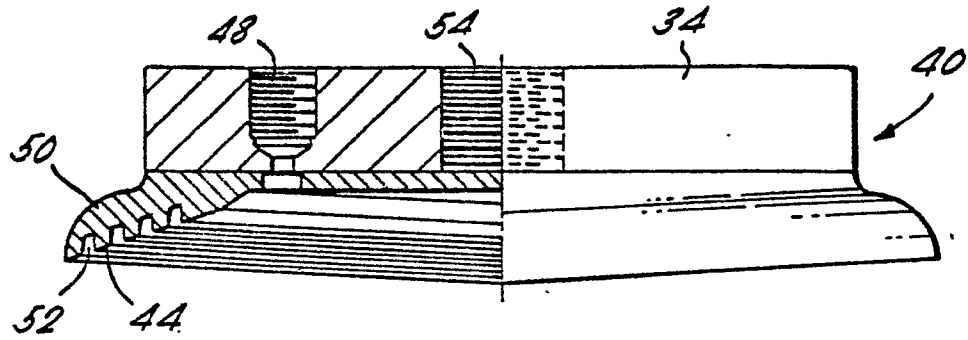


FIG. 6.

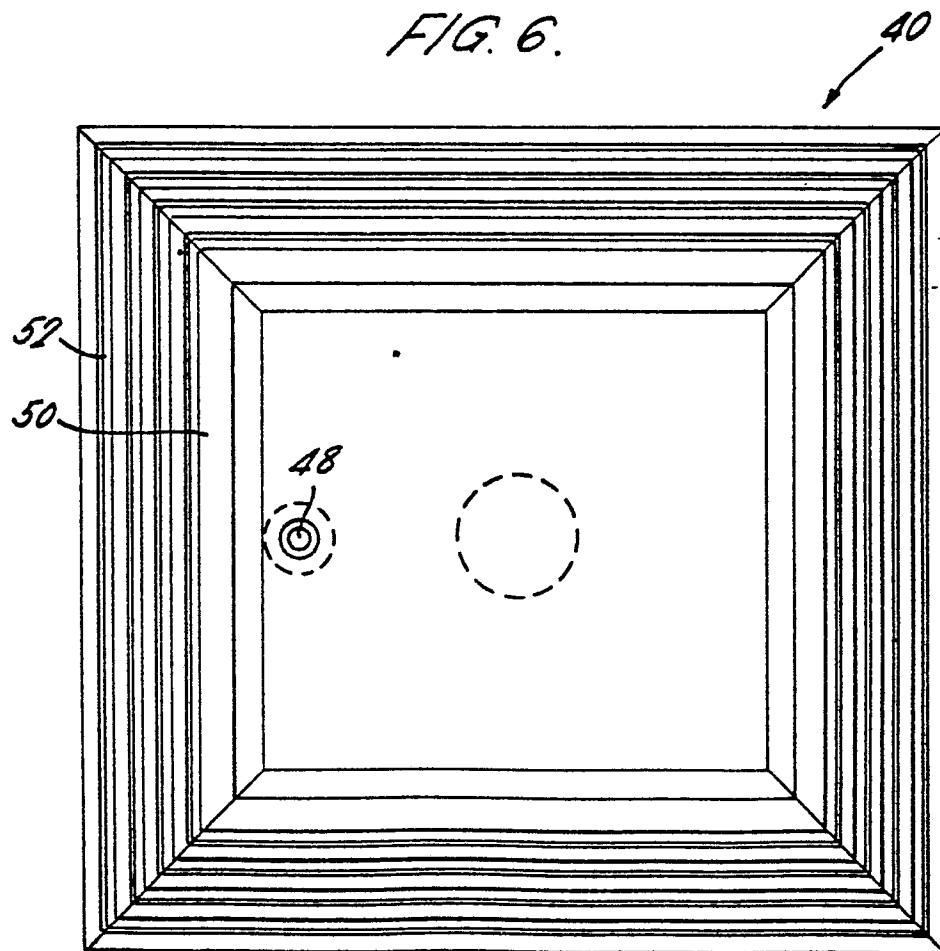


FIG. 7.

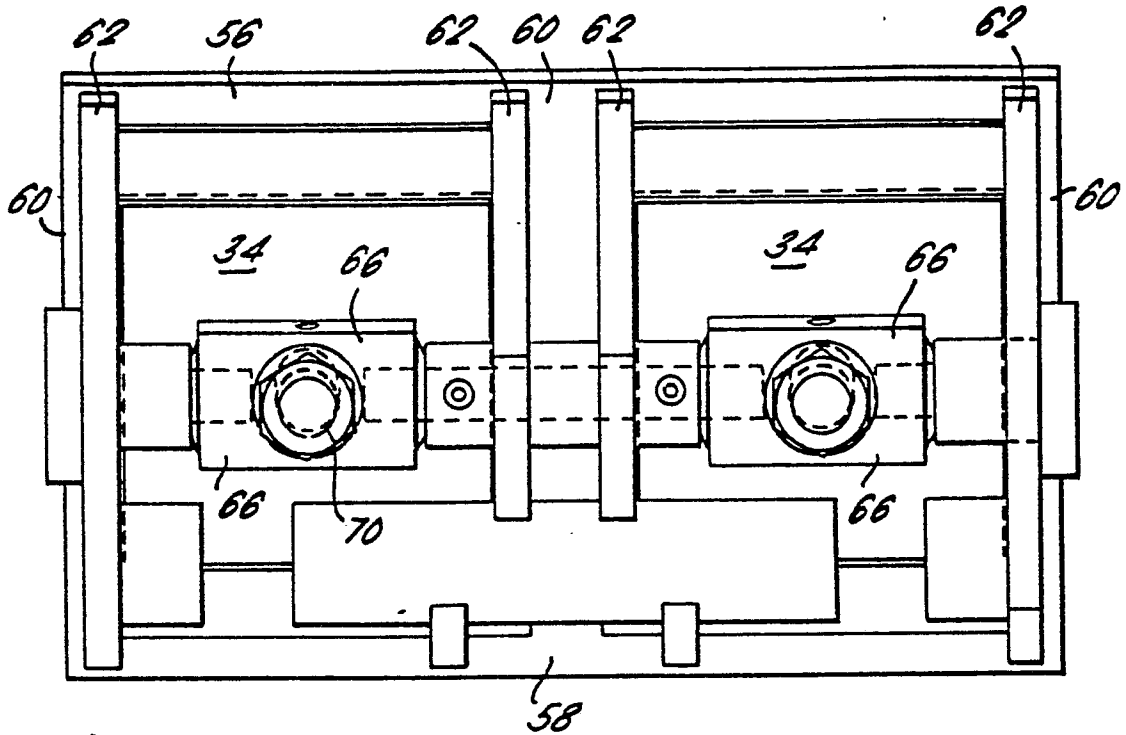


FIG. 8.

