AUSTRALIA

PATENTS ACT 1990

PATENT REQUEST: STANDARD PATENT

I/We, the Applicant(s)/Nominated Person(s) specified below, request I/We be granted a patent for the invention disclosed in the accompanying standard complete specification.

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[54] Invention Title:
Method and Apparatus for Supporting an Overhead Load

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[31] Appl'n No(s):
94/0565

[33] Country:
ZA

[32] Application Date:
27 January 1994

Basic Applicant(s): BMS Mine Supports (Pty) Limited

DATED this TWENTY SEVENTH day of JANUARY 1995

BMS Mine Supports (Pty) Limited

By: [Signature]

Registered Patent Attorney

IRN: 292968
INSTR CODE: 55055

S 052716 270195
NOTICE OF ENTITLEMENT

I, John Gordon Hinde, of Spruson & Ferguson, St Martins Tower, 31 Market Street, Sydney, New South Wales, 2000, Australia, being the patent attorney for the Applicant(s)/Nominated Person(s) in respect of Application No 11424/95 state the following:-

The Applicant(s)/Nominated Person(s) has/have entitlement from the actual inventor(s) as follows:-

BEP Bestobell S A (Pty) Limited made the basic application and have assigned their rights in the invention including the priority rights insofar as Australia is concerned, accruing from the basic application to BMS Mine Supports (Pty) Limited.

The Applicant/Nominated Person is entitled to reply on the basic application listed on the Patent Request as follows:-

BEP Bestobell S A (Pty) Limited made the basic application and have assigned their rights in the invention including the priority rights insofar as Australia is concerned, accruing from the basic application to BMS Mine Supports (Pty) Limited.

The basic applications listed on the Patent Request is the first application made in a Convention Country in respect of the invention.

DATED this HINTH day of FEBRUARY 1995.

John Gordon Hinde

IRN: 292968 INSTR CODE: 55055
jlb/8264T
(12) PATENT ABSTRACT (11) Document No. AU-A-11424/95
(19) AUSTRALIAN PATENT OFFICE

(54) Title
METHOD AND APPARATUS FOR SUPPORTING AN OVERHEAD LOAD

International Patent Classification(s)
E21D 015/45

(21) Application No. : 11424/95
(22) Application Date : 27.01.95

(30) Priority Data
(31) Number (32) Date (33) Country
94/565 27.01.94 ZA SOUTH AFRICA

(43) Publication Date : 03.08.95
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(57) Claim

1. A re-usable apparatus for yieldably supporting an overhead load, which includes

   - a base portion and a plunger which are displaceable in relation to each other along a common axis;

   - a first chamber bounded at least partially by the base portion and/or the plunger;

   - a second chamber separated from the first chamber; and

   - first and second valves respectively interconnecting the first and second chambers with each other, the first valve being so designed as to admit fluid from the first chamber to the second chamber whenever the fluid pressure in the first chamber exceeds a predetermined value when the base portion and the plunger are subjected to an axial, compressive load, while the second valve is so designed as to allow the transfer of fluid from the second chamber to the first chamber when the base portion and plunger are drawn apart from each other.
FIELD OF THE INVENTION

This invention relates to a method and an apparatus for supporting an overhead load. More particularly, the invention relates to a method of yieldably supporting an overhead load in repetitive cycles, and an apparatus for practising this method.

BACKGROUND TO THE INVENTION

Underground mine workings at intermediate depths between approximately 500 and 1500 metres generally experience convergence between their hanging walls and footwalls in the order of 4 to 5 millimetres per day. In ultra-deep mines at depths exceeding 2000 metres daily convergences generally range from 15 to 20 millimetres, and may occasionally be as high as 50 millimetres.

In mine workings at intermediate depths mechanical props or roof supports may be re-used by relocating them approximately every second day in order to take up any ongoing convergence while work is in progress at the rockface. These roof supports will generally not tolerate convergences of the magnitude encountered in ultra-deep mines, and hydraulic props are generally used for this purpose.

Most known hydraulic props are charged with hydraulic fluid during installation to take up the space between a given hanging wall and footwall. As the props are subjected to increasing loads they release the hydraulic fluid to the environment through a controlled release valve, which is designed to release the fluid when the prop is subjected to a predetermined load of 8, 20, 30 or 40 tonnes, for example.

Used props may be salvaged by releasing a small amount of hydraulic fluid. The props are then re-charged for the next application, and any fluid lost during use causes an operating expense, which is generally undesirable.

The present invention seeks to address these shortcomings.

SUMMARY OF THE INVENTION

The present invention provides a method of yieldably supporting an overhead load in repetitive cycles, which includes the steps of
locating a substantially incompressible fluid in a first chamber located between a base portion and a plunger which are displaceable in relation to each other along a common axis;

- urging the fluid from the first chamber into a second chamber at a predetermined axial load; and

- returning the fluid from the second chamber to the first chamber by axially drawing the base portion and the plunger away from each other.

The invention extends to a re-usable apparatus for yieldably supporting an overhead load, which includes

- a base portion and a plunger which are displaceable in relation to each other along a common axis;

- a first chamber bounded at least partially by the base portion and/or the plunger;

- a second chamber separated from the first chamber; and

- first and second valves respectively interconnecting the first and second chambers with each other, the first valve being so designed as to admit fluid from the first chamber to the second chamber whenever the fluid pressure in the first chamber exceeds a predetermined value when the base portion and the plunger are subjected to an axial, compressive load, while the second valve is so designed as to allow the transfer of fluid from the second chamber to the first chamber when the base portion and plunger are drawn apart from each other.

The base portion and the plunger are preferably slideably displaceable in sealing relationship with each other. The base portion may include a tubular sleeve and the plunger may be of circular cross section, thereby rendering the apparatus telescopically extendible and retractable.

In a first preferred embodiment of the invention, the second chamber preferably has a fixed volume while the first chamber, being partially bounded by the plunger, has a variable volume.
In a further preferred embodiment of the invention, the volumes of both the first and second chambers are variable, the first chamber being bounded by the base portion and the plunger, while the second chamber is partially bounded by an inner bore defined by the plunger, and partially by a piston which is slideably displaceable within this bore.

5 BRIEF DESCRIPTION OF THE DRAWINGS

The invention is described below by way of example with reference to the accompanying schematic and diagrammatic drawings in which

- Figure 1 shows a schematic, sectional view, in side elevation, of a first apparatus according to the invention, being subjected to a compressive loading;

10 - Figure 2 shows a schematic, sectional view in side elevation of the apparatus of Figure 1 being axially drawn apart;

- Figure 3 shows a schematic, sectional view in side elevation of a further apparatus according to the invention being subjected to a compressive loading;

- Figure 4 shows a schematic, sectional view in side elevation of the apparatus of Figure 3 being axially drawn apart;

- Figure 5 shows a schematic, sectional view, in side elevation, of a yieldable roof support for use in underground mining operations, incorporating the apparatus of Figure 3; and

- Figures 6A, 6B and 6C show performance curves for a prototype roof support according to Figure 5.

DETAILED DESCRIPTION OF THE DRAWINGS

In the drawings, reference numeral 10 generally denotes a first apparatus according to the invention, which includes a tubular body portion 12 which is closed at one end and accommodates a tubular plunger 14 of circular cross section. The plunger 14 is slideably displaceable in relation to the body portion 12 along a common longitudinal axis 16. The plunger 14 is fitted with a sealing ring 18, which maintains a continuous fluid seal between the plunger and the inner walls of the body portion 12.
A circular partitioning plate 20 is located within the body portion 12, and is welded to its inwardly facing walls. The plate 20 separates from each other a first chamber 22 extending between the plate and the plunger 14, and a second chamber 24 of substantially constant volume, which is completed by the base of the body portion 12. The apparatus 10 is charged with an incompressible hydraulic fluid, generally denoted by reference numeral 26, which resides in the chambers 22 and 24, and is reversibly transferable between these in the manner described below.

The plate 20 carries a valve assembly 28 which projects into chamber 24 and provides a closable fluid passage between the chambers 22 and 24.

The assembly 28 includes a check valve 30, which allows a substantially unobstructed passage of fluid 26 from the second chamber 24 into the first chamber 22. A spring-loaded valve 32, which forms part of the assembly 28, is so designed as to admit fluid from the first chamber 22 to the second chamber 24 whenever the fluid pressure in the first chamber exceeds a predetermined value.

The valve 32 is so designed that its opening pressure corresponds to a required maximum compressive loading which the apparatus 10 is required to support. A commercially available valve assembly sold under the HAWE trade mark (model number SVC56E, type G04-219) accommodates the valves 30 and 32 in a common housing, and has been used in a prototype apparatus according to the present invention. The performance of this apparatus is described more fully below with reference to Figures 6A to 6C.

When the apparatus 10 is in an extended condition, as shown in Figure 1, the plunger 14 is generally remote from the plate 20, and the bulk of the hydraulic fluid 26 resides in the first chamber 22. The chamber 24 generally contains the residue of the fluid 26 and a small amount of air in the freeboard space above it.

On application of a compressive force, indicated by the arrow 34 in Figure 1, the plunger 14 is urged towards the partitioning plate 20, thereby gradually increasing the fluid pressure in the chamber 22. Since the fluid 26 is substantially incompressible, the threshold pressure value for opening the valve 32 is generally reached after a relatively small downward displacement of the plunger 14.
Whenever the predetermined threshold pressure is exceeded, a small amount of fluid 26 passes from the chamber 22 through the valve 32 and into the chamber 24, as indicated by the arrows 36 in Figure 1. This generally relieves the excess pressure in the chamber 22 and re-establishes a new position for the plunger 14 while maintaining a substantially constant fluid pressure in the chamber 22.

In use, the plunger 14 travels downwardly towards the partitioning plate 20 for as long as the compressive force indicated by the arrow 34 subsists. On release of this compressive force, the plunger 14 may be withdrawn manually as indicated by the arrow 38 in Figure 2. The fluid pressure in the chamber 22 is thereby reduced below that in the chamber 24, thereby causing hydraulic fluid 26 to pass through the check valve 30 and issue back into the first chamber 22, as illustrated by the arrows 40.

Figures 3 and 4 of the accompanying drawings illustrate a further preferred apparatus according to the invention, which is generally designated by reference numeral 100. The apparatus 100 again includes a tubular body portion 112 within which a plunger 114 of circular cross section is slideably displaceable along a common longitudinal axis 116. The plunger 114 is equipped with a pair of axially spaced sealing rings 118, which bear slidingly against the inner walls of the body portion 112 in order to maintain a continuous seal between the body portion and the plunger.

The plunger 114 defines an internal, coaxial bore 119 which accommodates a piston 121 which is axially displaceable along the bore. A sealing ring 123 is held captive by the piston and bears against the inner walls of the bore 121 in order to maintain a continuous fluid-tight seal between the piston and the plunger 114.

A circular partitioning plate 120 is located towards the end of the plunger 114 which is located within the body portion 112, and separates a first chamber 122 bounded by the body portion and the partitioning plate from a second chamber 124 extending along the bore 121 between the plate 120 and the piston 121. The apparatus 100 is charged with a substantially incompressible hydraulic fluid, generally denoted by reference numeral 126, which resides in the chambers 122 and 124 and is reversibly transferable between them in the manner described below.

A valve assembly 128 which includes a check valve 130 and a controlled release valve 132 corresponding respectively to the valves 30 and 32 of the apparatus 10, is supported on the plate 120, and projects into the chamber 124.
In use the apparatus 100 is set in an extended condition shown in Figure 3 in which the bulk of the fluid 126 is located in the first chamber 122 and the piston 121 is as close as possible to the partitioning plate 120. When a compressive load, indicated by arrow 134 in Figure 3, is applied to the plunger 114, the fluid pressure in the chamber 122 increases fairly rapidly by reason of the incompressible nature of the fluid 126. The valve 132 opens as soon as the fluid pressure in the chamber 122 exceeds a threshold value, which corresponds to the load-bearing duty of the apparatus 100.

The valve 132 remains open for as long as the excess pressure conditions subsist, and fluid passes from the first chamber 122 into the second chamber 124, as indicated by the arrows 136. This in turn causes the piston 121 to rise, as indicated by the arrow 137 in Figure 3.

The fluid pressure in the chamber 124 is generally kept close to atmospheric pressure by providing a lateral air vent (not shown), which links the space inside the bore 119 above the piston 121 with the external environment of the apparatus 100.

The apparatus 100 may be re-used by releasing the downward load on the plunger 114 thereby allowing the plunger to be withdrawn from the body portion 112, as indicated by the arrow 138 in Figure 4. The fluid pressure in the chamber 122 hence drops below that in the chamber 124, causing the check valve 130 to open and thereby admitting the fluid 126 back into the chamber 122, as indicated by the arrows 140 in Figure 4.

At the same time, the piston 121 returns towards the partitioning plate 120 as indicated by arrow 141 in Figure 4.

Figure 5 shows a yieldable roof support 150 for use in underground mining operations. The roof support 150 incorporates the apparatus 100. The roof support 150 has a mechanical adjusting means 152 interposed between the apparatus 100 and a tubular support member 154 all arranged in coaxial relationship with each other.

The adjusting means 152 includes a pair of shanks 156 and 158 having opposite-handed thread formations, the shanks 156 and 158 projecting in opposing directions from a cylindrical body 160 to which they are respectively connected.

The body has at least one transverse passage 162 into which a rod (not shown) is insertable for rotating the adjusting means 152 about the axis 116.
The shanks 156 and 158 respectively engage complementary female thread formations defined by a pair of end caps 164 and 166, which are respectively secured to the plunger 114 and the tubular support member 154 as shown in Figure 5. The moving components of the mechanical adjusting means 152 are protected by a tubular shield 168, which overlaps and extends from the plunger 114 to the tubular support member 154. The apparatus 100 is separately and independently protected against the ingress of dust and moisture, which commonly occur in underground mine workings, by means of a sealing ring 142 (see Figures 3 and 4). The apparatus 10 is conveniently equipped with a corresponding, similar sealing ring 42.

The apparatus 100 and the support member 154 shown in Figure 5 are respectively equipped with frustro-conical rock engagement means 170 and 172 respectively. In use, the roof support 150 is prepared for installation by bringing the apparatus 100 to its fully extended state, as illustrated in Figure 3. At the same time the adjusting means 152 is operated to bring the apparatus 100 and the tubular support member 154 as closely as possible towards each other by rotating the adjusting means 152 in the appropriate direction.

The roof support 150 is then positioned at a desired location with the lower rock engagement means 170 resting on a footwall of an underground mine working. The rock engagement means 172 is brought into contact with an opposing hanging wall by rotating the adjusting means 152. The roof support 150 is then pre-loaded by further rotating the adjusting means 152 until the apparatus 100 is subjected to a compressive load at which the fluid pressure in the chamber 124 approaches the opening pressure of the controlled release valve 132.

The roof support 150 operates substantially in the manner described above with reference to Figure 3, until the plunger 114 approaches its lowermost position. The roof support 150 is then released by operating the adjusting means 152 in order to remove compressive load on the apparatus 100, thereby allowing the roof support to be removed and re-installed in a new desired location.

Figures 6 A to C illustrate the operation of a prototype roof support, similar to the one shown in Figure 5, which incorporates an apparatus corresponding to the apparatus 10 shown in Figures 1 and 2. The curves shown in the drawings were obtained on a test-bench by applying a comparatively slow compression for the first seven minutes, and then increasing the rate of compression for the next 2.5 minutes, as illustrated in Figure 6C.
The prototype unit was designed for a load of 20 tonnes, and sustained this load after an initial displacement of approximately 15 millimetres. This initial compression is probably attributable to small amounts of air being retained in the chambers 22 and 24 during the assembly of the apparatus 10. The presence of this air probably also accounts for the apparent instability of the curves shown in Figures 6A and 6B under full-load conditions. This instability is not considered material since the apparatus succeeded in maintaining the required loading of 20 tonnes until a final convergence of approximately 150 millimetres was reached. Substantially similar results were obtained in successive load tests after the apparatus had been restored to its initial condition by simple manipulation.

Mine roof supports incorporating the illustrated apparatus according to the present invention have the general advantage that they do not require an external hydraulic fluid supply for pre-loading purposes. Moreover they do not require any coarse pre-loading means associated with mechanical roof supports, usually in the form of a pin which is insertable in axially spaced, transverse passages passing through a telescopically extendible support member.

Roof supports according to the present invention are likely to be able to withstand blasting conditions, where hydraulic roof supports have generally been found suitable while purely mechanical roof supports have tended to fail. The present roof supports do not, however, have the associated disadvantages of hydraulic fluid spillage associated with known hydraulic roof supports.

It will be evident to a skilled reader that the preferred apparatus described above lends itself to a variety of adaptations and modifications without departing from the essential elements set out under the summary of the invention. The scope of the present invention should accordingly not be construed as being limited in any way by the features of the preferred apparatus.
The claims defining the invention are as follows:

1. A re-usable apparatus for yieldably supporting an overhead load, which includes
   - a base portion and a plunger which are displaceable in relation to each other along a common axis;
   - a first chamber bounded at least partially by the base portion and/or the plunger;
   - a second chamber separated from the first chamber; and
   - first and second valves respectively interconnecting the first and second chambers with each other, the first valve being so designed as to admit fluid from the first chamber to the second chamber whenever the fluid pressure in the first chamber exceeds a predetermined value when the base portion and the plunger are subjected to an axial, compressive load, while the second valve is so designed as to allow the transfer of fluid from the second chamber to the first chamber when the base portion and plunger are drawn apart from each other.

2. A re-usable apparatus as claimed in claim 1, wherein the base portion and the plunger are slideably displaceable in sealing relationship with each other.

3. A re-usable apparatus as claimed in claim 1, wherein the base portion includes a tubular sleeve and the plunger is of circular cross section, thereby rendering the apparatus telescopically extendible and retractable.

4. A re-usable apparatus as claimed in claim 1, wherein the second chamber has a fixed volume while the first chamber, being partially bounded by the plunger, has a variable volume.

5. A re-usable apparatus as claimed in claim 1, wherein the volumes of both the first and second chambers are variable, the first chamber being bounded by the base portion and the plunger, while the second chamber is partially bounded by an inner bore defined by the plunger, and partially by a piston which is slideably displaceable within this bore.
6. A re-usable apparatus as claimed in claim 1, comprising, in addition, a tubular support member of which one end is adapted to engage with a hanging wall of an underground mine working; and mechanical adjusting means interposed between the other end of the tubular support and the plunger.

7. A re-usable apparatus as claimed in claim 6, wherein the adjusting means comprises:

- a pair of end caps;
- a cylindrical body;
- and a pair of shanks having opposite-handed thread formations, the shanks projecting in opposite directions from the cylindrical body, one end of each of the shanks being connected to the cylindrical body, the opposite end of each of the shanks respectively engaging a complementary female thread formation in one of the pair of end caps, the end caps being respectively secured to the plunger and to the tubular support member.

8. A roof support comprising a re-usable apparatus as claimed in claim 1.

9. A roof support comprising:

- a tubular support member of which one end is adapted to engage with a hanging wall of an underground mine working;
- a re-usable apparatus which includes:
  - a base portion and a plunger which are displaceable in relation to each other along a common axis;
  - a first chamber bounded at least partially by the base portion and/or the plunger;
  - a second chamber separated from the first chamber; and
first and second valves respectively interconnecting the first and second chambers with each other, the first valve being so designed as to admit fluid from the first chamber to the second chamber whenever the fluid pressure in the first chamber exceeds a predetermined value when the base portion and the plunger are subjected to an axial, compressive load, while the second valve is so designed as to allow the transfer of fluid from the second chamber to the first chamber when the base portion and plunger are drawn apart from each other; and

- mechanical adjusting means interposed between the other end of the tubular support and the plunger, the base portion being adapted to engage with the footwall of the underground working.

10. A roof support as claimed in claim 9, wherein the adjusting means comprises:

- a pair of end caps;

- a cylindrical body;

- and a pair of shanks having opposite-handed thread formations, the shanks projecting in opposite directions from the cylindrical body, one end of each of the shanks being connected to the cylindrical body, the opposite end of each of the shanks respectively engaging a complementary female thread formation in one of the pair of end caps, the end caps being respectively secured to the plunger and to the tubular support member.

11. A method of yieldably supporting an overhead load in repetitive cycles, which includes the steps of

- locating a substantially incompressible fluid in a first chamber located between a base portion and a plunger which are displaceable in relation to each other along a common axis;

- allowing the fluid from the first chamber to be urged into a second chamber at a predetermined axial load; and

- returning the fluid from the second chamber to the first chamber by axially drawing the base portion and the plunger away from each other.
DATED this TWENTY-SEVENTH day of JANUARY 1995
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Load Versus Displacement

Displacement Versus Time