

Feb. 23, 1971

D. R. NASH ET AL
METHOD OF AND APPARATUS FOR MANUFACTURING
MINERAL INSULATED ELECTRIC CABLES

3,564,701

Filed Feb. 7, 1969

4 Sheets-Sheet 1

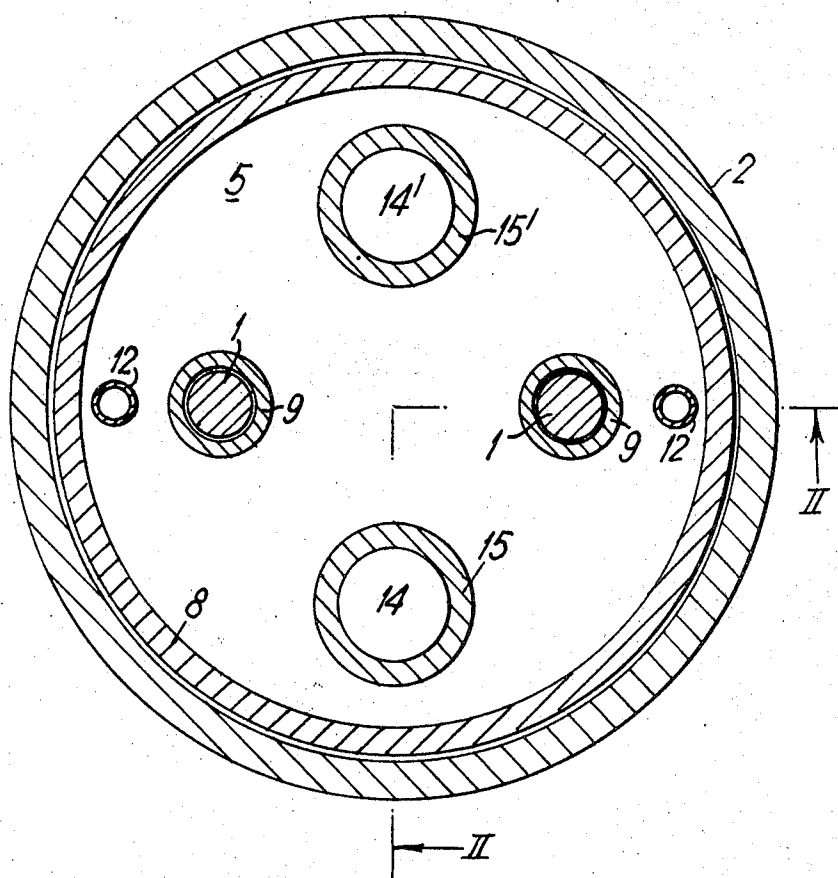


Fig. 1.

Inventor
DEREK RAYMOND NASH
HERMAN RICHARD LORCH
By *Wells Bunker*
Robinson & Wells
Attorney

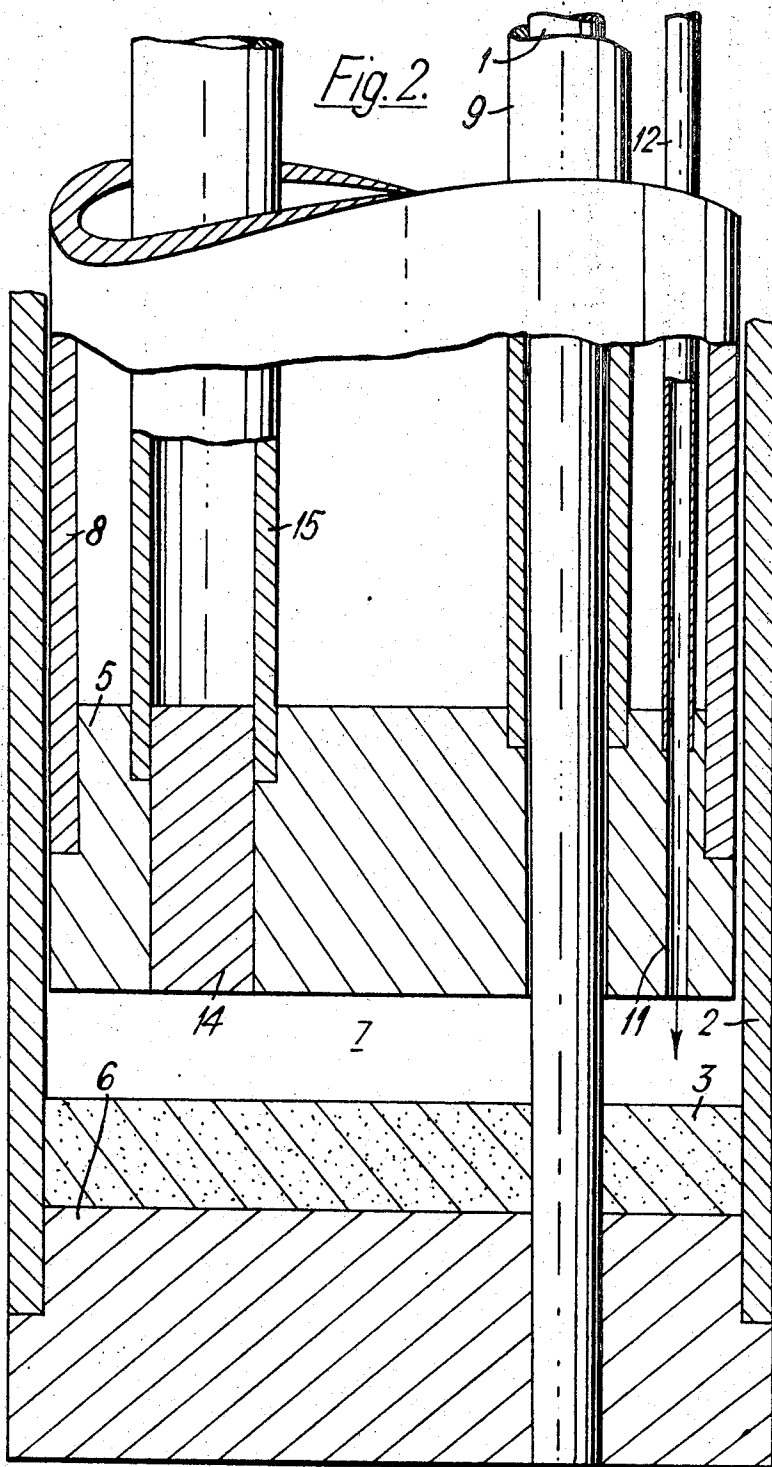
Feb. 23, 1971

D. R. NASH ET AL
METHOD OF AND APPARATUS FOR MANUFACTURING
MINERAL INSULATED ELECTRIC CABLES

3,564,701

Filed Feb. 7, 1969

4 Sheets-Sheet 2



Inventor

DEREK RAYMOND NASH
HERMAN RICHARD LORCH

By *W. H. Bunker*

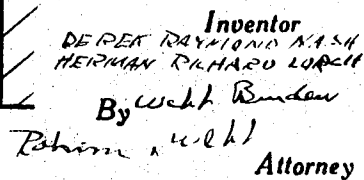
Robert, Webb

Attorney

Filed Feb. 7, 1969

3,564,701

4 Sheets-Sheet 5



Feb. 23, 1971

D. R. NASH ETAL
METHOD OF AND APPARATUS FOR MANUFACTURING
MINERAL INSULATED ELECTRIC CABLES

3,564,701

Filed Feb. 7, 1969

4 Sheets-Sheet 4

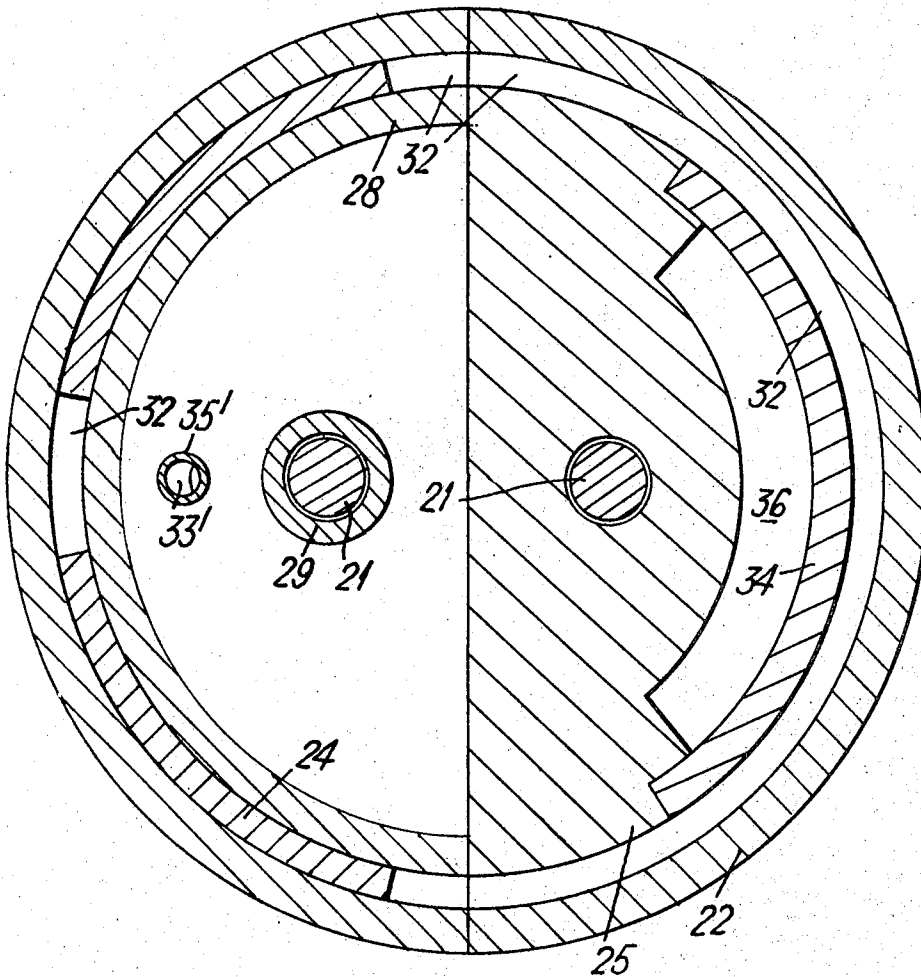


Fig. 4.

Inventor
DEREK RAYMOND NASH
HERMAN RICHARD FORCH
By *W. L. Bunker*
Robinson, W. L. Bunker, Attorney,

1

3,564,701

METHOD OF AND APPARATUS FOR MANUFACTURING MINERAL INSULATED ELECTRIC CABLES

Derek Raymond Nash, Appleton, and Hermann Richard Lorch, Southport, England, assignors to British Insulated Callender's Cables Limited, London, England
Filed Feb. 7, 1969, Ser. No. 864,229

Claims priority, application Great Britain, Feb. 7, 1968, 6,008/68

Int. Cl. B23p 19/00; H05k 13/00; H01b 13/00
U.S. Cl. 29—429 19 Claims

ABSTRACT OF THE DISCLOSURE

In the manufacture of mineral insulated electric cables air is evacuated from the space between a conductor guide and the closed lower end of the sheath tube through a filter in the conductor guide. After mineral insulating powder has been introduced into the evacuated space through a passage bounded at least partially by the guide, air entrained in the powder is evacuated through the filter to cause or assist the powder to form a densely-compact mass. A space is formed between the conductor guide and the compacted powder by relative movement between the sheath tube and guide, further powder is introduced into the evacuated space, and the sequence of operating steps repeated as necessary.

This invention relates to mineral insulated electric cables, that is to say to cables of the kind in which the dielectric consists of compacted mineral insulating powder contained in the space between the cable conductor or conductors and a metal sheath. The invention is concerned with a method of and apparatus for manufacturing a product which will generally be a workpiece from which the cable in its final form may be produced by conventional methods. For convenience, wherever the context permits, such a product will hereinafter be referred to as a mineral insulated cable.

The present invention is particularly concerned with the process of mineral insulated cable manufacture in which a metal tube (the "sheath" tube) supported substantially vertically and closed at its lower end contains at least one conductor which is a sliding fit in, and is positively appropriately relatively spaced from the sheath tube by, a conductor guide that is itself a sliding fit in the tube. Mineral insulating powder is fed through a passage or passages in the conductor guide or between it and the wall of the tube into a space between the conductor guide and the closed lower end of the sheath tube or the upper surface of a mass of powder previously fed and compacted therein.

It is an object of the present invention to provide, in the manufacture of mineral insulated electric cables, an improved method of and apparatus for effecting or assisting compaction of the mineral insulating powder.

According to the invention air is evacuated from the space between the conductor guide and the closed lower end of the sheath tube through a filter incorporated in the conductor guide, mineral insulating powder is introduced into the evacuated space through the passage or passages in the conductor guide or between it and the wall of the tube, the air entrained in the powder is evacuated through the filter to cause or assist the powder to form a densely-compact mass, relative movement is effected between the sheath tube and the conductor guide to form a space between the conductor guide and the surface of the compacted mass of powder, powder is introduced into the evacuated space through the passage or passages and the sequence of operating steps is repeated as necessary.

2

Preferably to ensure that the filter is clear after the mineral insulating powder has been introduced into the evacuated space, a pulse of compressed gas is injected through the filter into the evacuated space to clear the filter, this injected gas being subsequently evacuated through the filter with the air entrained in the powder.

Compaction of the powder by evacuating the air entrained therein permits the use of finely divided or light powders which, though they may be preferred for use in subsequent operations in the manufacture of a mineral insulated cable, hitherto could not be satisfactorily used in the conventional method of ramming the powder owing to the tendency of these powders to form aerosols and blow back past the ram during its compression stroke. Such finely divided or light powders frequently exhibit poor flow properties in a mass and consequently a finely divided or light powder is preferably introduced through the passage or passages into the space beneath the conductor guide in a "fluidised" state.

By way of example it is mentioned that a typical insulating powder normally used in the conventional method of ramming the powder would have a sieve analysis that approximates to:

Mesh number (B.S. 410)	Percent retained in sieve
60 (250 $\mu\text{m.}$)	0
72 (210 $\mu\text{m.}$)	16
100 (150 $\mu\text{m.}$)	37
150 (105 $\mu\text{m.}$)	21
200 (75 $\mu\text{m.}$)	13
300 (53 $\mu\text{m.}$)	7

The balance of powder, 6%, would pass through the 300 mesh sieve.

The present invention permits, for example, the use of a finely divided or light mineral insulating powder that would make a 100% pass through a 350 mesh sieve (45 $\mu\text{m.}$).

If desired the steps of evacuating the space beneath the conductor guide and introducing the powder through the passage or passages into a space beneath the guide may be effected concurrently.

Preferably the space between the conductor guide and the closed lower end of the sheath tube or the surface of the compacted powder contained therein should be such that a convenient amount of powder can be introduced into the space in the course of any one sequence of operating steps. This space is preferably obtained by raising the conductor guide relative to the sheath tube a predetermined distance in each sequence of operating steps. A distance lying in the approximate range 5 to 10 inches is preferred but the guide may be raised a greater distance provided that the distance is not so great that the conductor or conductors is or are no longer positively maintained at the desired spacing from the wall of the sheath tube. In addition to effecting compaction of the powder by evacuation of the air in the space beneath the conductor guide and entrained in the powder, compaction of the powder may also be effected by using the conductor guide as a ram for tamping each increment of powder. In this latter case the conductor guide may be reciprocated relative to the sheath tube by driving the reciprocating guide through a yielding friction coupling, the arrangement being such that when further downward movement of the guide is prevented by the compacted mass of powder, the friction coupling slips by a distance equal to the height of the last increment of compacted powder. The next upward stroke of the guide then provides a predetermined height of space beneath the conductor guide for the subsequent introduction of powder.

Where, as is preferred, it is required to raise the conductor guide step-by-step whilst the sheath tube is main-

3

tained stationary, the friction coupling will preferably grip a tube upstanding from the conductor guide. Where, on the other hand, it is required to lower the sheath tube step-by-step whilst the conductor guide is maintained stationary, or is reciprocated about a fixed point, the friction coupling may grip the sheath tube.

The invention also includes apparatus for manufacturing mineral insulated cable by the aforesaid method, which apparatus comprises a conductor guide in which the conductor or conductors are a sliding fit, for maintaining the conductor or conductors positively appropriately relatively spaced from the sheath tube, formed with one or more passages in it and/or between it and the wall of the tube for introduction of insulating powder into a space beneath the guide, which guide is a sliding fit in the tube, the guide and/or tube being axially movable the one relative to the other, a filter incorporated in the conductor guide, and valve means for selectively connecting the filter to a vacuum pump or to a source of compressed gas.

Preferably a pipe extends from the upper surface of the filter to a two-way valve, one port of which is for connection to the vacuum pump and the other port of which is for connection to the source of compressed gas, preferably compressed air. The filter is preferably made of a sintered ceramic material or a sintered metal.

The conductor guide is preferably attached to the lower end of a support member, usually a tube (the "guide" tube), by which the conductor guide may be adjustably positioned with respect to the sheath tube. The guide tube is preferably a sliding fit in the sheath tube. The or each passage in the conductor guide for introduction of powder into a space beneath the conductor guide preferably has a powder supply tube which is connected to the conductor guide and which extends along the length of the sheath tube. If desired the conductor or each of the conductors may be surrounded by a separate tube (the "shroud" tube) which at its lower end is connected to the conductor guide and which isolates the conductor from the other tubes carried by the guide. In the latter case it is possible to dispense with the pipe extending from the upper surface of the filter and to connect the guide tube, via the two-way valve, to the vacuum pump and the source of compressed air.

The invention will be further illustrated, by way of example, by descriptions, with reference to the accompanying drawings, of two forms of apparatus for filling the sheath tube of a mineral insulated cable with a finely divided mineral insulating powder and for effecting compaction of the powder therein and of our preferred method of manufacturing mineral insulated cable using the aforesaid apparatus. In the drawings:

FIG. 1 is an end view, partly in section and partly in elevation, of the first form of apparatus,

FIG. 2 is a sectional side elevation taken on the line II—II in FIG. 1,

FIG. 3 is a side view, partly in section and partly in elevation, of the second form of apparatus, and

FIG. 4 is a sectional end view taken on the line IV—IV in FIG. 3.

The cable to be manufactured by the first form of apparatus shown in FIGS. 1 and 2 is twin conductor cable comprising two conductors 1 which are separated from each other and from a sheath tube 2 by compacted mineral insulating powder 3. The conductors 1, in the form of lengths of wire, each pass downwards through a conductor guide 5, which is a substantially air-tight sliding fit in the sheath tube 2, into the space 7 between the conductor guide and the closed lower end 6 of the sheath tube.

The conductor guide 5 has upstanding from its upper surface a guide tube 8 which is itself a sliding fit in the sheath tube 2 and which protrudes beyond the open upper end of the sheath tube. Each conductor 1 is enclosed in a separate shroud tube 9 which, at its lower end,

4

is attached to the conductor guide 5 and which also protrudes beyond the upper open end of the sheath tube 2. The conductor guide 5 is formed with passages 11 through which powder can be introduced into the space 7 beneath the conductor guide and each passage has upstanding therefrom a powder-supply tube 12 which protrudes from the guide tube 8 and is connected, via a valve (not shown), to a source of mineral insulating powder maintained in the fluidised state.

Embedded in and extending throughout the axial length of the conductor guide 5 are two separate bodies 14, 14' of filter material which are located on diametrically opposite sides of the two conductors 1. To the upper surface of each filter 14, 14' so formed is connected a separate pipe 15, 15' which extends upwardly within the guide tube 8 and is connected via a two-way valve (not shown) to a vacuum pump and to a source of compressed air, the pump and source of compressed air being common to both filters.

In operation, the conductor guide 5 is spaced a predetermined distance from the closed lower end 6 of the sheath tube 2. The pipe 15 extending from the filter 14 is connected to the vacuum pump by suitable adjustment of the two-way valve associated with the filter, and air is extracted from the space 7 between the conductor guide and the closed lower end of the sheath tube through filter 14 until the space is evacuated. Finely divided mineral insulating powder 3 in a fluidised state is then introduced via the powder supply tubes 12 and passages 11 in the conductor guide 5 into the evacuated space 7 until a desired amount of powder has been admitted. If desired these two operating steps may be carried out concurrently. The two-way valve associated with filter 14 is then adjusted to close the port to the vacuum pump and open the port to the source of compressed air and a pulse of compressed air is blown through filter 14 into the space 7 to clear any "clogging" or "blinding" of the filter that may have occurred. The two-way valve associated with filter 14 is then adjusted to its neutral position and the two-way valve associated with the filter 14', is suitably adjusted to cause the vacuum pump to evacuate through filter 14' the air entrained in the powder 3 and during this operation the powder settles into a compact mass. Suction of air through filter 14' is continued until the space 7 remaining after compaction of the powder 3 has been evacuated.

The conductor guide 5 is now raised a predetermined distance until a space 7 of the required depth is provided between the conductor guide and the surface of the compacted mass of powder 3. The required quantity of finely divided powder 3 in a fluidised state is next introduced into the evacuated space 7, the two-way valve associated with filter 14' is adjusted to close the port to the vacuum pump and open the port to the source of compressed air and a pulse of compressed air is blown through filter 14' into the space 7 to clear the filter. The two-way valve associated with filter 14' is adjusted to the neutral position and the two-way valve associated with filter 14 is now adjusted to bring the vacuum pump into operation and air entrained in the powder 3 is evacuated through filter 14 to cause the powder to settle into a compact mass on top of the previously formed compact mass. Step-by-step filling of the sheath tube 2 is continued in a sequence of operating steps in which the two filters 14 and 14' are cleared and used alternately. After the sheath tube 2 is filled with compacted powder 3 the cable so formed is reduced in diameter and the powder further compacted by subsequent drawing operations and the cable is annealed as necessary in accordance with normal practice.

It will be appreciated that the surface area at the ends of each of the filters 14, 14' will govern the speed at which air can be evacuated from a space 7 beneath the conductor guide 5 and that this in turn will govern the overall speed of filling the sheath tube 2. The surface area at the ends of the conductor guide 5 available for

5

the provision of filters 14, 14' will be determined by the bore of the sheath tube, the number and diameter of the conductors 1 and the number of powder supply passages 11 in the conductor guide and, for a sheath tube of relatively small diameter having two or more conductors, the area available in a conductor guide having only one powder filling passage may be so small as to make filling of the sheath tube a slow process.

With a view to increasing the surface area of conductor guide available for the provision of filters, in the second form of apparatus shown in FIGS. 3 and 4 a conductor guide 25 through which two conductors 21 of a twin conductor cable pass is of such a diameter as to be spaced from the internal surface of a sheath tube 22 by four circumferentially spaced ribs 24 which are carried by a guide tube 28 upstanding from the upper surface of the conductor guide and which are a sliding fit in the sheath tube. The arcuate-shaped flutes 32 between the ribs 24 constitute the powder-supply passages and are connected, via a valve (not shown), to a source of mineral insulating powder maintained in the fluidised state.

As in the first form of apparatus each conductor 21 is enclosed in a separate shroud tube 29 which, at its lower end, is attached to the conductor guide 25 and which, together with the guide tube 28, protrudes beyond the upper open end of the sheath tube 22. The conductor guide 25 is formed with two diametrically-opposed passages 33, 33', each of which extends from the upper surface of the guide to an arcuate-shaped recess 36, 36' in the side face of the guide, and upstanding from each passage is a separate pipe 35, 35'. The recesses 36, 36' are closed by separate arcuate-shaped bodies 34, 34' of filter material, each of which is embedded in the side face of the conductor guide 25 and extends throughout the arcuate and axial lengths of the recess. Each pipe 35, 35' is connected via a two-way valve (not shown) to a vacuum pump and to a source of compressed air, the pump and source of compressed air being common to both filters so formed.

The second form of apparatus is operated in a similar manner to that described with reference to the first form of apparatus shown in FIGS. 1 and 2.

What we claim as our invention is:

1. In the process of manufacturing a mineral insulated cable in which a metal sheath tube supported substantially vertically and closed at its lower end contains at least one conductor which is a sliding fit in, and is positively appropriately relatively spaced from the sheath tube by, a conductor guide that is itself a sliding fit in the tube and in which mineral insulating powder is fed through at least one passage bounded at least partially by the conductor guide into a space beneath the conductor guide, a method of compacting the mineral insulating powder which comprises:

- (a) evacuating air from the space beneath the conductor guide through a filter incorporated in the conductor guide;
- (b) introducing mineral insulating powder into the evacuated space through the passage;
- (c) evacuating air entrained in the powder through the filter to cause the powder to form a densely-compact mass;
- (d) effecting relative movement between the sheath tube and the conductor guide to form a space between the conductor guide and the surface of the compacted mass of powder;
- (e) introducing powder into the evacuated space through the passage; and
- (f) repeating the sequence of operating steps as necessary.

2. A method as claimed in claim 1, wherein after the mineral insulating powder has been introduced into the evacuated space a pulse of compressed gas is injected through the filter into the evacuated space to clear the filter, the injected gas being subsequently evacuated

6

through the filter with the air entrained in the powder.

3. A method as claimed in claim 1, wherein two filters are incorporated in the conductor guide and during the sequence of operating steps the two filters are cleared and used alternately.

4. A method as claimed in claim 1, wherein in each sequence of operating steps the steps of evacuating the space beneath the conductor guide and introducing the powder through the passage are effected concurrently.

5. A method as claimed in claim 1, wherein in each sequence of operating steps the space beneath the conductor guide is obtained by raising the conductor guide relative to the sheath tube a predetermined distance.

6. A method as claimed in claim 1, wherein the powder is a finely divided powder and is introduced through the passage into the space beneath the conductor guide in a "fluidised" state.

7. In the process of manufacturing a mineral insulated cable in which a metal sheath tube supported substantially vertically and closed at its lower end contains at least one conductor which is a sliding fit in, and is positively appropriately relatively spaced from the sheath tube by, a conductor guide that is itself a sliding fit in the tube and in which mineral insulating powder is fed through at least one passage bounded at least partially by the conductor guide into a space beneath the conductor guide, a method of compacting the mineral insulating powder which comprises:

- (a) evacuating air from the space beneath the conductor guide through a filter incorporated in the conductor guide;
- (b) introducing mineral insulating powder into the evacuated space through the passage;
- (c) evacuating air entrained in the powder through the filter and tamping the mass of powder by means of the conductor guide to cause the powder to form a densely-compact mass;
- (d) effecting relative movement between the sheath tube and the conductor guide to form a space between the conductor guide and the surface of the compacted mass of powder;
- (e) introducing powder into the evacuated space through the passage; and
- (f) repeating the sequence of operating steps as necessary.

8. For use in the process of manufacturing a mineral insulated cable in which a metal sheath tube supported substantially vertically and closed at its lower end contains at least one conductor which is a sliding fit in, and is positively appropriately relatively spaced from the sheath tube by, a conductor guide, apparatus comprising a conductor guide that is a sliding fit in the tube and bounds at least partially at least one passage for introduction of insulating powder into a space beneath the guide, the guide and tube being so arranged that one is axially movable relative to the other, a filter incorporated in the conductor guide, and valve means for connecting the filter to a vacuum pump.

9. Apparatus as claimed in claim 8, wherein the filter comprises a body of filter material embedded in and extending throughout the axial length of the conductor guide.

10. Apparatus as claimed in claim 8, wherein at least a lower part of the conductor guide is spaced from the internal surface of the sheath tube, the guide has a passage extending from the peripheral surface of the lower part of the guide to the upper surface of the guide, and the filter comprises a body of filter material located in the said passage.

11. Apparatus as claimed in claim 8, wherein the valve means is adapted to connect selectively the filter to a vacuum pump or to a source of compressed gas.

12. Apparatus as claimed in claim 11, wherein a pipe extends from the upper surface of the filter to a two-way valve.

7

13. Apparatus as claimed in claim 8, wherein two separate filters are incorporated in the conductor guide.

14. Apparatus as claimed in claim 8, wherein the filter is of a sintered ceramic material.

15. Apparatus as claimed in claim 8, wherein the filter is of a sintered metal.

16. Apparatus as claimed in claim 8, wherein the passage for introduction of insulating powder is wholly bounded by the conductor guide.

17. Apparatus as claimed in claim 8, wherein the conductor guide is attached to the lower end of a guide tube and is connected to drive means by which the conductor guide can be adjustably positioned with respect to the sheath tube.

18. Apparatus as claimed in claim 8, wherein the passage in the conductor guide for introduction of powder into a space beneath the guide has a powder supply tube which is connected to the conductor guide and which extends along the sheath tube.

8

19. Apparatus as claimed in claim 8, wherein each of a plurality of conductors is surrounded by a separate shroud tube which at its lower end is connected to the conductor guide and which isolates the conductor from the other tubes carried by the guide.

References Cited

UNITED STATES PATENTS

2,202,575	5/1940	Deroche	29—203X
2,973,572	3/1961	Oakley	29—203
3,430,330	3/1969	Garner	29—429
3,452,434	7/1969	Wagele	29—624
3,474,518	10/1969	Strandell	29—429

15 THOMAS H. EAGER, Primary Examiner

U.S. Cl. X.R.

29—203, 624