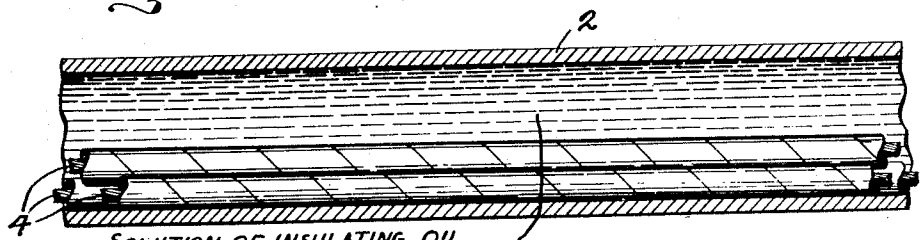
Dec. 30, 1947. C. E. BENNETT 2,433,729

ELECTRIC CABLE

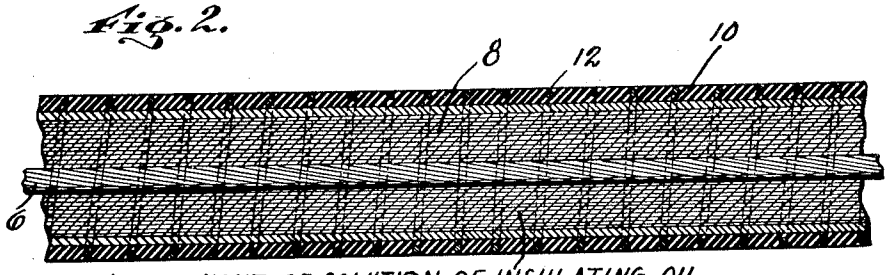
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Fig. 1.



SOLUTION OF INSULATING OIL AND DICHLORO DIFLUOROMETHANE IN LIQUID AND GASEOUS PHASES

Fig. 2.



IMPREGNANT OF SOLUTION OF INSULATING OIL AND DICHLORO DIFLUOROMETHANE IN LIQUID AND GASEOUS PHASES

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2,433,729

UNITED STATES PATENT OFFICE

2,433,729

ELECTRIC CABLE

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3 Claims. (Cl. 174—25)

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This invention relates to an improvement in electric power cables of the type wherein one or more conductors insulated with oil impregnated insulation are enclosed either in a tight fitting sheath or in a pipe line filled with insulating oil.

One object of my invention is to provide a cable such as above mentioned wherein the cable is always under a positive pressure, this pressure increasing with rise in cable temperature, the employment of extraneous pressure supplying means such as pumps and the like, however, being entirely eliminated.

Another object of my invention is to provide a construction wherein this pressure medium also functions to eliminate fire hazard from short circuits or other cause, it being my intention to employ as the major insulating fluid the usual natural oil commonly employed in cable practice. This oil, which is a natural oil, as distinguished from a synthetic, has a rather complex structure and might be said to be made up of a combination of naphthenic, aromatic and paraffinic hydrocarbons, and is quite inflammable.

My invention is realized by incorporating a minimum quantity of dichloro difluoromethane (CCl_2F_2) in a cable so insulated, this material being introduced under temperature and pressure conditions where the same is in the liquid phase. Dichloro difluoromethane is highly miscible in the insulating oil of the cable, and has no corrosive action on lead, steels and copper so that it is admirably suited to my purpose. This material also has a high dielectric strength which makes it very desirable for my purpose, its dielectric strength at 90 pounds pressure being substantially the same as that of nitrogen at 225 pounds pressure.

Dichloro difluoromethane has another characteristic which adapts it to my purpose, in that it is noninflammable when mixed with air, whether it is in the liquid phase or in the gaseous phase.

In the course of my research in connection with the use of dichloro difluoromethane in an electric power cable, I conducted the following tests. Approximately 250 cc. of cable insulating oil as received from the refinery was poured into a metal pan to a depth of about 1'' and surface exposure of 6'' in diameter. The powerful flame of a Bunsen burner was directed onto the surface of the oil for a period of 30 seconds with a rest period of 10 seconds between flame cycles. When the test sample would burn continuously the test was considered complete. The sample burned continuously on the third flame cycle. I then

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made the same test on the same oil containing 10% by weight of dichloro difluoromethane immediately after removal from a pipe where it had been confined under 50 pounds pressure. The oil did not burn continuously until the tenth flame cycle. While this was an excellent showing, I went even further. The same quantity of oil containing dichloro difluoromethane in amount approximating 10% by weight was removed from a pipe where it had been confined under 50 pounds pressure and allowed to stand in the open, exposed to atmospheric pressure at 45° F. for twenty-two hours. This oil would not burn continuously until on the tenth flame cycle.

I am convinced from these tests that the dichloro difluoromethane has a great affinity for the insulating oil, and even when exposed to atmosphere for an appreciable length of time, enough will remain in the oil to impart to the oil the remarkable flame resisting characteristics above noted. It will be appreciated by all those skilled in this field that the 30 second flame cycle is a very severe test, and I am completely satisfied from the results of my tests that the dichloro difluoromethane has a very great affinity for the oil and its displacement can be accomplished only with great difficulty under atmospheric pressure.

I have also conducted chemical stability tests on cable oil as it came from the refinery, to which I added 10% by weight of liquid dichloro difluoromethane. A single conductor cable 1,250,000 C. M., 156 wall paper with usual shielding tape and D armor on the outside was placed in a 6'' steel pipe and filled with the oil containing approximately 10% by weight of liquid dichloro difluoromethane. This was maintained under a pressure of 200 pounds per square inch.

A voltage stress of 152 kv. was applied at night, with no voltage in the day time. After 20 heat cycles (3 weeks testing) where copper temperature was 80° C. and oil temperature in the pipe about 73° C., some oil was removed for spectrophotometric testing. Practically no color change was found, and I conclude that the oil is stable electrically, and hence a cable submerged therein should be stable.

Reverting to the pressure feature of this invention. As above mentioned, it is very desirable to maintain an oil insulated cable under pressure at all times, and for the pressure to build up as the cable temperature rises, without the employment of any pressure means extraneous to the cable. This is precisely what I am able to accomplish by introducing a certain minimum amount of liquid dichloro difluoromethane into a

sealed cable containing the usual insulating oil. Economically my invention is practicable, in that while the cost of dichloro difluoromethane is high as compared with oil, I use as little as 10% by weight of the dichloro difluoromethane so that the total cost per gallon is still so low as to be more than offset by the saving effected in pressure supplying equipment and cost of maintenance and repair of such equipment, all of which I eliminate.

I am aware that attempts have been made prior to my invention to maintain pressure on cables without the necessity of employing pumps and the like, all of which suggestions are entirely different from the present invention, however. Furthermore, so far as I know to the contrary, no one has attempted to eliminate the fire hazard incident to oil insulated cables in the manner herein proposed.

I am familiar with Cooper Patent 2,221,670 which is directed to electrical equipment, even to electric cables. This patent discloses the use of dichloro difluoromethane in X-ray apparatus instead of oil—not with oil—so that the equipment may be operated at higher voltages than with oil. This patent also shows a cable conductor spaced from its sheath by insulators, the space between being filled with dichloro difluoromethane. My invention, obviously, is superior to this idea, in that I am able to keep my costs down by retaining the major portion of the oil customarily employed in cable practice with all its attendant advantages and at the same time eliminate the fire hazard incident to the presence of an inflammable oil.

I am familiar also with patents such as Dunsheath 2,052,922, 2,052,923 and 2,057,562, all of which are directed to cables. In these patents the conductor is insulated with an oil impregnated paper which is so applied as to leave a gas space in the cable for the reception of air under pressure, carbon dioxide, etc. This gas is maintained under pressure. However, in this type of cable the pressure medium is not miscible in the insulating oil of the cable, nor does its presence—it might be air—lend anything to the cable so far as elimination of fire hazard is concerned.

I am aware also that dichloro difluoromethane has been suggested for use in electrical apparatus such as circuit interrupters, as disclosed, for example, in McMahon Patent 2,077,429. The dielectric employed in this patent is a synthetic, such as trichloroethylene, which as distinguished from the natural oil employed in cable practice is non-inflammable. McMahon employs dichloro difluoromethane in his patent as a preservative, his dielectric having a corrosive action on his equipment due to deterioration. Dielectrics other than trichloroethylene are suggested by McMahon, but paraffinic hydrocarbons are specifically excluded because of their inflammable nature, not realizing, as the present invention provides, that the inflammability of such a dielectric can be successfully eliminated or overcome by the addition of liquid dichloro difluoromethane.

Beaver in his Patent 2,067,169 suggests the use of a pressure medium in a cable for maintaining the cable under pressure. As distinguished from my invention, Beaver employs a gas, such as nitrogen or carbon dioxide, and deliberately provides against this gas mixing with the insulating oil by subjecting his insulating paper to special treatment so that no gas will be absorbed.

In British Patent 511,174 the suggestion is made that the cable be filled with an oil which has been degasified and then charged with a gas such as nitrogen, carbon dioxide, helium, etc. The entire idea is to prevent deterioration of the oil of the cable without thought of eliminating fire hazard, and eliminating extraneous pressure means. It is noted in this patent that the cable is maintained under pressure, but obviously not by the presence of the nitrogen, for example, but by some extraneous equipment.

I have deemed it necessary and desirable to make reference to these prior suggestions to emphasize my familiarity with these prior practices and to stress most forcibly the distinctions between my invention and this prior art.

My invention is exceedingly simple in that any cable manufacturer can practice it with existing equipment, to say nothing of the advantages accruing to my invention by reason of the elimination of fire hazard, the fire-extinguishing properties of dichloro difluoromethane equalling that of carbon-tetrachloride, and being more than twice as good as carbon dioxide and more than four times as good as nitrogen—the yardstick of non-inflammability; and accruing to my invention by reason of the elimination of the necessity for extraneous pressure applying equipment.

In the accompanying drawing:

Fig. 1 is a fragmentary view of one embodiment of the invention; while

Fig. 2 is a similar view of another embodiment.

With reference to Fig. 1: **2** designates a pipe line of metal or other suitable material containing paper insulated conductors **4**, and filled with oil and about 10% by weight liquid dichloro difluoromethane, the latter being introduced under 70 pounds pressure at a temperature approximating 70° F. The dichloro difluoromethane is highly miscible in the oil, and sufficient oil and dichloro difluoromethane are introduced initially, the cable being sealed as will be understood to bring the cable pressure up to say 40 pounds per square inch pressure at around 70° F. This will be sufficient to insure that the cable will be under positive pressure even if its temperature drops to 0° F., or even lower, and, as explained above, as the cable temperature rises, the cable pressure will rise also, due to the fact that the dichloro difluoromethane is introduced as a liquid. In the event of a short circuit in the cable, there is no danger of the oil becoming ignited because of the fact that the dichloro difluoromethane is highly miscible with the oil, as above pointed out, and hence is thoroughly dispersed throughout the oil, and because its fire extinguishing characteristics or properties equal that of carbon tetrachloride and are more than four times as good as nitrogen. It will be appreciated, furthermore, that should the pipe line be ruptured from any cause so that the oil and dichloro difluoromethane are released, the latter has such an affinity for the oil, as above pointed out, that even though the mixture under these conditions is exposed to the air, combustion will not ensue.

The cable of Fig. 2 comprises conductor **6**, insulated with paper **8**, and enclosed in lead sheath **10**, which conveniently may be reinforced as shown at **12**. The cable is impregnated and filled with the usual cable oil and 10% by weight of liquid dichloro difluoromethane introduced under about 70 pounds pressure at around 70° F. The amount of oil and dichloro difluoromethane is sufficient to maintain about 40 pounds per square inch gauge pressure on the cable at say 70° F. As pointed out in connection with Fig. 1 such a cable will be maintained under positive pressure

at 0° F. and below, the pressure rising as the cable temperature increases.

This application is a continuation-in-part of abandoned application, Serial No. 426,824, filed January 15, 1942.

What I claim is:

1. An electric power cable comprising in combination a conductor, paper insulation therefor, a sealed impervious enclosure for the paper insulated conductor, and a fixed quantity of a solution of inflammable insulating oil and dichloro difluoromethane, the latter being partly in the liquid phase, impregnating said paper and filling all of the spaces within said enclosure, the proportion of the dichloro difluoromethane to the oil being such that the solution is non-inflammable, the solution maintaining the cable under internal superatmospheric pressure throughout the operating temperature range of the cable.

2. An electric power cable comprising in combination a conductor, paper insulation therefor, a tight fitting sealed impervious enclosure for the paper insulated conductor, and a fixed quantity of a solution of inflammable insulating oil and dichloro difluoromethane, part of the latter always being in the liquid phase, impregnating said paper and filling all of the spaces within said enclosure, the proportion of the dichloro difluoromethane to the oil being about 10% by weight of dichloro difluoromethane to produce a non-inflammable solution, the solution maintaining the cable under internal superatmospheric pressure throughout the operating temperature range of the cable.

3. An electric power cable comprising in combination a conductor, paper insulation therefor, a sealed pipe line loosely enclosing the insulated conductor, and a fixed quantity of a solution of inflammable insulating oil and dichloro difluoromethane, part of the latter always being in the liquid phase, impregnating said paper and filling all of the spaces within the pipe line unoccupied by the conductor and its insulation, the proportion of the dichloro difluoromethane to the oil being such as to produce a non-inflammable solution, the solution maintaining the cable under internal superatmospheric pressure throughout the operating temperature range of the cable.

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