Sept. 15, 1931. R. E. MARBURY 1,823,368

FUSED SECTIONALIZED CONDENSER

Original Filed June 16, 1926 2 Sheets-Sheet 1

Fig. 1

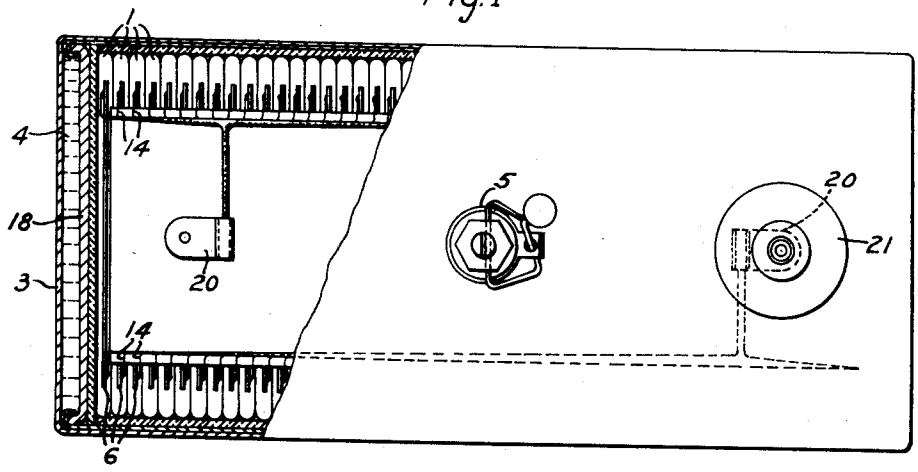
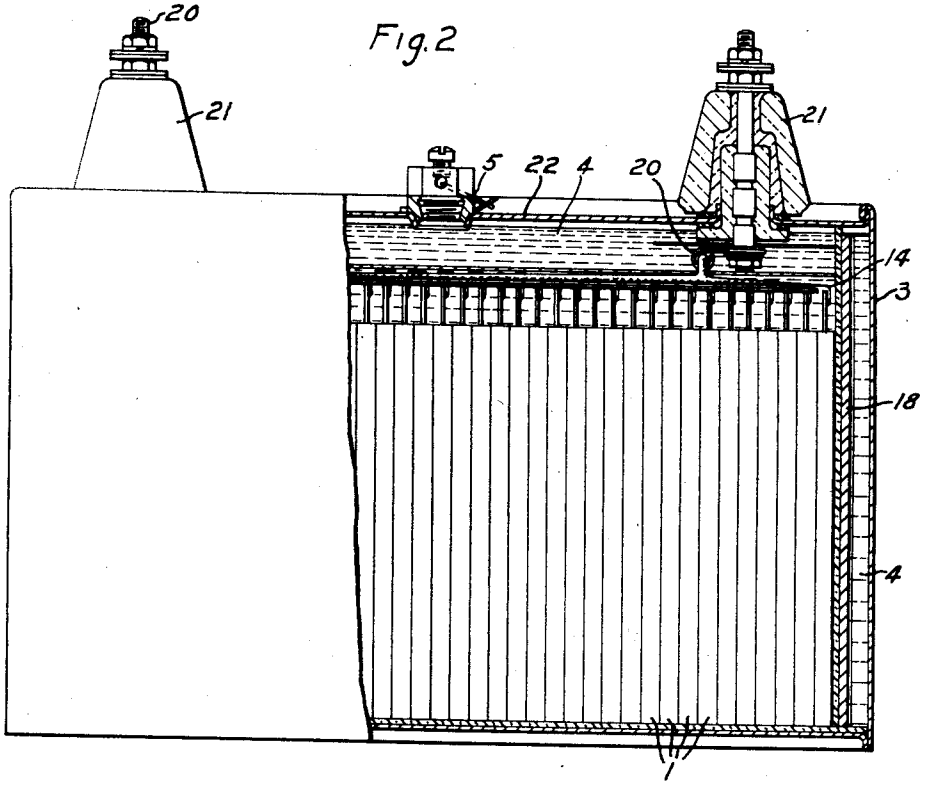


Fig. 2



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Fig. 3

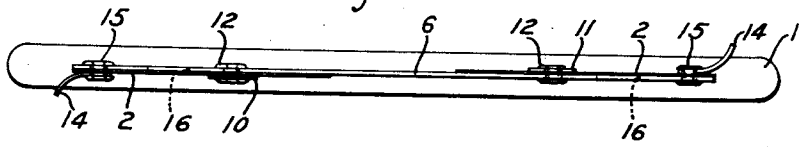
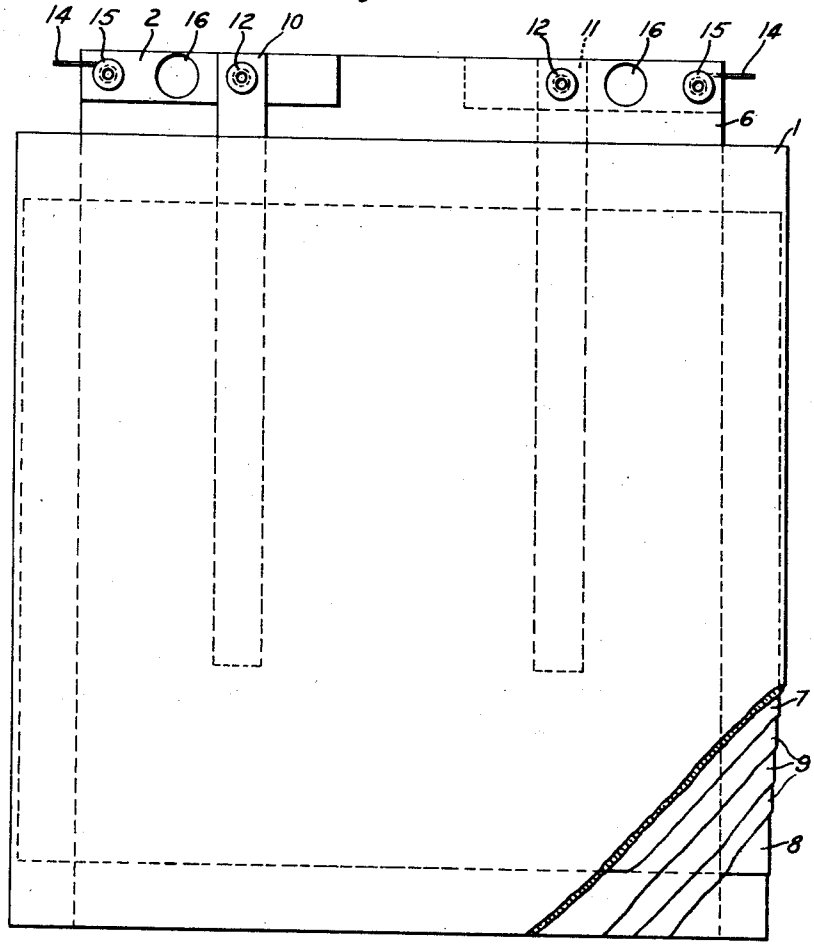


Fig. 4



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1,823,368

UNITED STATES PATENT OFFICE

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FUSED SECTIONALIZED CONDENSER

Application filed June 16, 1926, Serial No. 116,273. Renewed February 3, 1931.

My invention relates to electrostatic condensers and methods of making the same, and it has particular relation to paper condensers of the oil-impregnated type.

A more particular object of my invention is to provide a construction and a method of manufacture of the condenser, whereby the labor of reclaiming the good material out of defective condenser units is reduced to a minimum, and yet, at the same time, the amount of material wasted in the process of manufacture is also very much reduced, as compared to any constructions and processes of manufacture heretofore known and practiced.

With the foregoing and other objects in view, my invention consists in the details and methods of construction hereinafter described and claimed, with reference to the accompanying drawings, wherein

Fig. 1 is a plan view of a 2½ k. v. a., 220 volt condenser embodying my invention,

Fig. 2 is a side elevation thereof,

Fig. 3 is a top plan view of a single section of the condenser shown in Figs. 1 and 2, and

Fig. 4 is a side elevation of the section shown in Fig. 3.

A condenser constructed in accordance with my invention comprises a large number of relatively small units or sections 1 which are assembled, with individual fuses 2, within a single enclosing tank 3, wherein the whole assembly is vacuum-treated and impregnated with oil 4 through a suitable opening 5 in the top of the tank.

In the process of manufacture, the individual sections are wound, in a well known manner, on a mandrel 6 of fish paper or other insulating material, two aluminum foils 7 and 8 being utilized for this purpose, and separated by three sheets 9 of paper of .0004 inches thickness each. During the winding process, two terminal strips 10 and 11 are inserted into the wound structure in contact with the two foils 7 and 8, respectively.

The fuses 2, previously mentioned, are cemented to the top end of the mandrel 6, which extends beyond the wound structure of foil and paper. A convenient method of cementing the fuse material 2 is to first apply a coating of shellac to the mandrel and then apply the fuse material itself, which is composed of extremely thin tin foil. The terminal strips 10 and 11 are held in place and electrically connected to the tin foil fuses 2 by means of eyelets 12 which are clamped, in each instance, through the mandrel, the fuse and the terminal strip. In the form of my invention shown in Figs. 3 and 4, two fuses are shown for each condenser section, but it is obvious that only one fuse may be employed, without departing from the essential features of my invention.

Two terminal leads 14 of flexible wire are provided for each of the condenser sections, the same being secured to the ends of the respective fuse foils 2 by means of additional eyelets 15 which clamp the lead wires 14 in place against the fuses. After the fuse foils have been cemented in place, holes 16 may be punched through both the mandrel and the fuses in order to reduce the cross-sectional areas of the fuses to any desired extent, thereby avoiding the necessity of handling fuse strips of extremely narrow width, as well as thickness, during the assembly.

It has heretofore been customary to prepare condensers in sectional form, but not in such small sections that each section is of a very small capacity as compared to the capacity of the whole, so that one or more sections might be disconnected without greatly changing the rating of the condenser, as is the case in my present invention.

It has also been, to some extent, the practice to subject the individual condenser sections to certain tests, immediately after their assembly as individual condenser sections, said tests being for the purpose of detecting outstanding faults, as where the two leads or terminal strips have been connected to the same sheet of foil, or where the foil has been wound in such manner as to project out at the end, or where the paper has been damaged. Such tests cannot be very severe because the water has not been taken out of the insulation and the losses are very high. Furthermore, the break-down voltage of the unimpregnated paper dielectric is very much lower than in the final treated and impregnated condenser.

For the reasons just mentioned, my condenser sections 1 are tested, in dry form, immediately after the winding of the same, thereby culling out a certain amount of defective material.

The individual sections 1 are then assembled in the container 3, being held in position by means of clamping plates 18.

The number of sections in each assembly is somewhat larger than the number that is required to provide the rated capacity of the condenser. The extra condenser sections are necessary because of the impossibility of testing the dry condenser sections under actual working conditions and because of failures which may be produced by a mechanical movement or shifting of the layers of paper during the handling and compressing operations incident to the assembly of the sections in the container 3.

The respective leads 14 of the sections are connected together to two condenser terminals 20 which are suitably mounted in insulating bushings 21, extending through the top 22 of the condenser tank 3. The tank is then carefully soldered all around in order to make the same vacuum and oil-tight.

The finished condenser is then given an impregnation treatment, which usually includes 100 hours' treatment under vacuum before admitting the impregnating fluid 4, which is a high grade of oil, preferably one which is fluid at all operating temperatures. When the treatment just described is completed, the tank is closed by means of the sealing plug 5 and the condenser is given its final test at a voltage higher than its rated voltage, whereby some of the condenser sections which may have defects are caused to fail, thereby blowing their individual fuses and disconnecting the same from the assembly, as provided for in the extra sections included in the unit.

The savings effected by my construction and method of manufacture will best be understood by a comparison of the hereinabove-described structure and operation with the constructions and methods of assembly heretofore practiced in the manufacture of 2300-volt condensers, and by a consideration of some of the problems encountered in the design of electrostatic condensers.

The making of a 5 k. v. a., 220 volt unit was an extremely difficult problem because of the extremely small number of layers of paper in each dielectric and because of the extremely large area of dielectric which is required. It is not possible to obtain paper having fewer than about 40 conducting particles per square foot. The conducting particles just mentioned are of microscopic dimensions and are caused by carbon and metallic dust in the air, the wearing of the calenders, and other causes. Efforts have been made, in cooperation with paper manufacturers, to eliminate the conducting particles, but so far, no practical solution has been obtained. In addition to the conducting particles, most paper contains a certain number of perforations. In fact, the paper must have a certain number of extremely fine perforations in order to render it impregnable, but some of the perforations are larger than others. As thinner and thinner material is used, the problem of holes in the paper becomes still greater.

Heretofore 2300-volt condensers have been constructed utilizing 10 sheets of 1.15-mil paper. Thus, each dielectric was composed of ten sheets of paper, and the probability of obtaining an alinement of holes or conducting particles through all ten sheets of paper was quite remote. A 5 k. v. a., 2300-volt condenser contained 38,000 square inches of dielectric, each dielectric being ten sheets thick.

A 5 k. v. a., 220-volt condenser, according to my present invention, contains dielectrics comprising only 3 sheets of 0.4-mil paper, and the condenser contains 432,000 square inches of dielectric, the dielectric being three sheets thick. By reason of the smaller number of sheets in each dielectric, and the smaller thickness of each sheet, a far larger percentage of failures should be expected than were obtained in the 2300-volt condenser.

The 2300-volt condenser, with the most careful construction, involves a loss of 6% of the final condenser units, even after the defective material had been culled out as well as was possible in the sectional construction before the final assembly. Six failures out of every 100 condensers of 2300-volt rating would mean six failures out of every 3,800,000 square inches of dielectric, or one short-circuit in about 600,000 square inches of dielectric. In making 100 condensers of the 220-volt rating, there would be 43,200,000 square inches of dielectric, and 72 defects would be expected out of 100 condensers, or 72% scrap, even if it be assumed that the percentage of defective material would be no higher than in the 2300-volt unit. As a matter of fact, however, the number of alinements of defects in the paper, per unit area, would be very much greater in the 220-volt unit than in the 2300-volt unit, and hence, if the same methods of construction were utilized in both, every one of the 220-volt condensers would fail. Consequently, it has been impractical to build 5 k. v. a., 220-volt condensers heretofore.

The actual labor of building a 2300-volt condenser of the old type was also much larger than is involved in the construction of the condenser constituting the subject-matter of my present invention. The 2300-volt unit was made in six sections, and while a wound construction of the individual sections would have been preferred, it was neces-

sary to resort to a stacked construction involving the piling up of many sheets of superposed foils and dielectrics, in order that when a defective section was discovered, the good material might be reclaimed, in order to eliminate the enormous waste which would otherwise be involved.

The procedure just described involved extensive restacking operations, and even with all this care, six out of every 100 condensers which I manufactured contained flaws. Furthermore, the utilization of a stacked construction necessitated soldering the alternate sheets of foil, which projected at opposite sides of the condenser section, and as no kind of soldering flux could be utilized without harming the paper, it was necessary to utilize lead foil with a stacked construction in the 2300-volt unit.

It will be clear, from the foregoing, that even though a sectional construction was utilized for 220-volt condensers and even though the sections were sub-divided into as small units as possible, and each unit was tested as well as was possible in the dry state, before assembling the sections into their final structure, there would be at least one or two failures in each one of the condensers, after finishing the compressing, evacuating, and impregnating processes, to say nothing of the large restacking cost. These failures are unavoidable by reason of alinement of defects in paper and the law of probabilities, whereby it was certain that some failure would be encountered throughout the enormous area of dielectric which was required in the condenser.

The occurrence of faults in the final assembly could theoretically be avoided by pressing each of the condenser sections in a tank of its own, impregnating the same under the final pressure at which it would always operate, and testing each section so constructed, before assembling it in the final condenser bank. Such method, in fact, is the method heretofore employed for building up a condenser bank of large rating from small complete sections which are merely connected together in parallel to a common bus, a fuse or other protective device being sometimes provided for each unit. The sections, however, had all been tested at a voltage higher than their rated voltage, and the fuses were not expected to blow, in normal service, during a reasonable life of the apparatus.

The cost of a 5 k. v. a., or even a 2 k. v. a., assembly of small, complete 220-volt condenser units, each unit having a small rating such as 1/8 k. v. a. or 1/25 k. v. a., would be quite prohibitive, as compared to the cost of a condenser constructed in accordance with my invention. The principal reason for the very high cost of the bank of small condenser units is the cost of impregnation. Insulation, if worked at 200 to 225 volts per mil in order to keep the size and cost of the condenser unit within reason, must be of the oil-impregnated type. Each impregnating process requires about 100 hours, thereby imposing a certain fixed charge for each condenser, regardless of the size of the unit. In addition, each unit must be provided with a container which is oil-tight and vacuum tight. Obviously, the cost of such a container for a small fractional k. v. a. condenser would be a very large proportion of the total cost of the condenser.

According to my invention, the necessity for individual impregnating treatments and individual tanks for the several sections is avoided, thus making possible a much more elaborate evacuating, impregnating and tank-soldering treatment. If, according to the law of averages, two failures were expected for each complete condenser, each condenser would contain two more sections than are really required, and two of the sections would be disconnected, by their fuses, upon the final test of the unit, at a suitable over-voltage, before the shipment of the condenser.

If desired, three or four additional units may be provided in each casing, and the final test voltage, which is applied before shipment, may be gradually increased to even higher values, until a sufficient number of sections fail to bring down the rating to the required value, thereby producing a very superior product by virtue of the higher standard test.

It will be understood that the individual fuses of the sections are not expected to blow during normal service, at the rated voltage of the condenser, but are merely placed inside the tank for the purpose of avoiding the scrapping of every condenser which is manufactured. It will be observed that instead of having a 6% scrap of the final product, we have no scrap whatever in the final product, the only scrap being the normal scrap on the wound sections.

The problem of providing a fuse which would operate under oil was a very difficult one. A fine filament could be utilized, such as are used in lamps, but such filaments would be extremely costly to handle and would be subject to a large amount of breaking, both in assembly and as a result of their mechanical weakness and their inability to withstand the jars incident to the shipment of the apparatus. If a foil is utilized for the fuse, it must be of extreme thinness, such as one-quarter of a mil, and even then, it would have to be cut after assembly, because of the impossibility of handling such narrow strips as would be required.

Moreover, the cooling effect of the oil, in contact with both sides of the fuse strip, has a very great effect upon the magnitude of the current necessary to fuse a strip of any

given cross-sectional area. In view of the foregoing difficulties, it will be perceived that one of the important problems to be solved in the construction of my new condenser was the provision of a fuse which is strong mechanically, is inexpensive to handle and assemble, and is capable of blowing at a current which is sufficiently low not to damage the entire condenser unit, even in spite of the cooling effect of the oil.

While I have described my invention with particular reference to a 220-volt condenser, it is obvious that the same constructions and methods of manufacture are applicable to condensers of all voltage ratings.

I claim as my invention:

1. A fused, sectionalized, impregnated electrostatic condenser comprising a plurality of sections, an individual fuse for each section, an impregnating fluid surrounding said fuses and said sections, and a single container permanently containing said impregnating fluid and the entire assembly of condenser sections with their individual fuses, the number of sections being somewhat larger than the number of operative sections finally desired to obtain the rated capacity, a relatively small number of sections being broken down and their fuses blown prior to the actual use of the device, the remaining condenser sections being operable, at the rated voltage of the condenser, without blowing their fuses.

2. A fused sectionalized, impregnated electrostatic condenser comprising a large number of relatively small sections, each section being of a very small capacity as compared to the capacity of the whole, an individual fuse for each section, an impregnating fluid surrounding said fuses and said sections, and a single container permanently containing said impregnating fluid and the entire assembly of condenser sections with their individual fuses, the number of sections being somewhat larger than the number of operative sections finally desired to obtain the rated capacity, a relatively small number of sections being broken down and their fuses blown prior to the actual use of the device, the remaining condenser sections being operable, at the rated voltage of the condenser, without blowing their fuses.

3. A fused, sectionalized, impregnated electrostatic condenser comprising a plurality of conducting sheets separated by a dielectric comprising a relatively small number of layers of impregnable insulating material of very large area, said conducting sheets and dielectric being subdivided into a large number of relatively small sections, each section being wound upon an insulating mandrel having an end extending beyond the wound material, a fuse connected to the extending end of each mandrel, a terminal strip secured to said extending end for making connection with one of the alternate conducting sheets wound on each mandrel, a terminal lead connected to the aforesaid terminal strip of each section, in series with said fuse, a terminal strip and a terminal lead for the other of the alternate conducting sheets wound on each mandrel, a single body of impregnating material for the entire assembly of condenser sections with their individual fuses and terminal leads, and a single permanent container therefor, the number of sections being somewhat larger than the number of operative sections finally desired to obtain the rated capacity, a relatively small number of sections being broken down and their fuses blown prior to the actual use of the device, the remaining condenser sections being operable, at the rated voltage of the condenser, without blowing their fuses.

4. An electrostatic condenser element comprising an insulating mandrel, a pair of alternate conducting sheets separated by sheet dielectric material wound thereon, said mandrel having an end extending beyond the wound material, a fuse supported by the extending end of each mandrel, a terminal strip secured to said extending end for making connection with one of the alternate conducting sheets, a terminal lead connected to said mandrel and to said terminal strip in series with said fuse, a terminal strip and a terminal lead for the other of said alternate conducting sheets, a container for the whole assembly, and an impregnating material covering said condenser element and fuse in said container.

5. A condenser comprising an insulating support, a plurality of condenser plates mounted on said support, a terminal secured to said insulating support and connected to one of said condenser plates, a second terminal secured to said insulating support, and a fuse strip cemented to said insulating support and connecting the said terminals.

6. A condenser comprising an insulating support, a plurality of condenser plates mounted on said support, a terminal secured to said insulating support and connected to one of said condenser plates, a second terminal secured to said insulating support, a fuse strip cemented to said insulating support and connecting said terminals, a container for the whole assembly, and an impregnating material in said container.

7. The method of making an electrostatic condenser which comprises assembling small section, testing the same to eliminate certain defective sections and assembling a plurality of such tested sections, with an individual fuse for each section, in a single container, treating and impregnating said sections in said container and finally testing the completed unit at a voltage sufficiently high to

cause the rupture of one or more of the individual fuses.

8. A fused, sectionalized, impregnated electrostatic condenser comprising a plurality of sections, an individual fuse for each section, an impregnating fluid surrounding said fuses and said sections, and a single container permanently containing said impregnating fluid and the entire assembly of condenser sections with their individual fuses, the number of sections being somewhat larger than the number of operative sections finally desired to obtain the rated capacity, characterized by the fact that, upon a failure of a relatively small number of sections, the remaining sections provide an operating capacity which does not vary materially from the rating desired.

In testimony whereof, I have hereunto subscribed my name this 4th day of June, 1926.

RALPH E. MARBURY.