April 9, 1963 P. S. DOKUCHITZ ETAL 3,084,415

METHOD OF MAKING ELECTRICAL CONDENSERS

Filed Jan. 30, 1959

Fig. 1

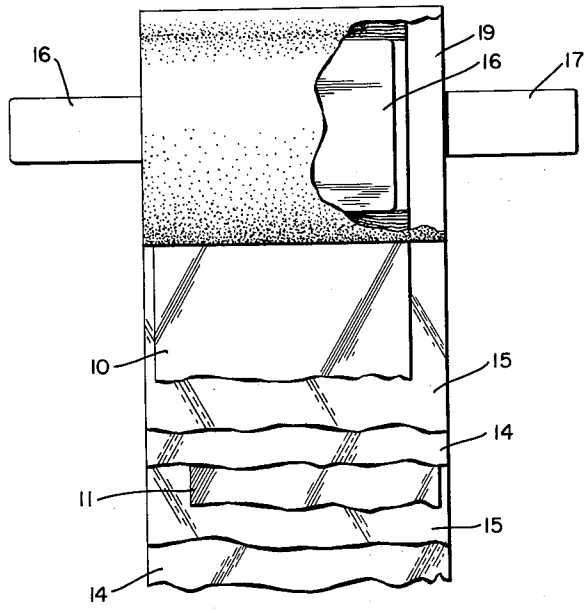


Fig. 2

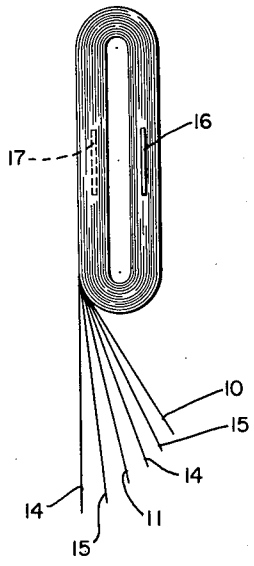
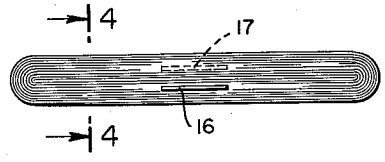


Fig. 3



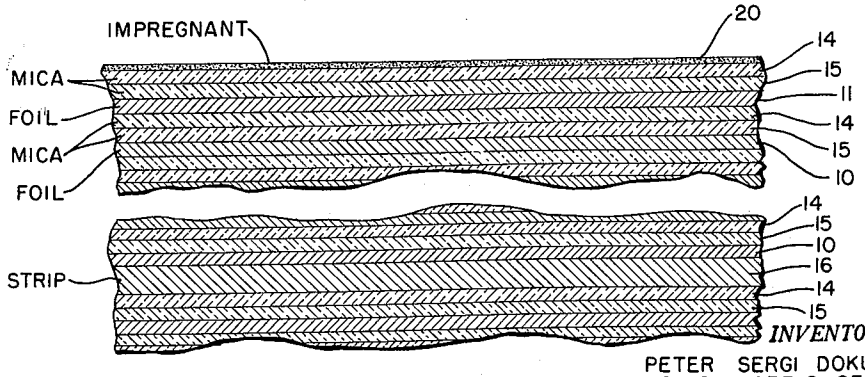


Fig. 4

INVENTORS

PETER SERGI DOKUCHITZ

LOUIS HARRIS SEGALL

BY Bauer and Seymour

ATTORNEYS

United States Patent Office

3,084,415

Patented Apr. 9, 1963

3,084,415

METHOD OF MAKING ELECTRICAL CONDENSERS

Peter S. Dokuchitz, Unadilla, and Louis H. Segall, Sidney, N.Y., assignors to The Bendix Corporation, a corporation of Delaware

Filed Jan. 30, 1959, Ser. No. 790,128
4 Claims. (Cl. 29—25.42)

This invention relates to electrical apparatus and more particularly to electrical condensers or capacitors, and to methods for fabricating the same.

One of the objects of the present invention is to provide an electrical condenser of novel construction which has better physical and electrical characteristics and properties than condensers heretofore made of the same or generally similar materials.

Another object of the present invention is to provides a novel condenser which successfully operates for long periods without deterioration at temperatures on the order of 600° F.

Still another object is the provision of a novel condenser which successfully withstands hard usage in either ground or airborne applications without substantial alteration of its electrical characteristics.

Another object is to provide a novel, high quality condenser having the above properties which may be made at relatively low cost.

The above and further objects and novel features of the invention will more fully appear from the following detailed description when the same is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for the purpose of illustration only and are not intended as a definition of the limits of the invention.

In the drawings, wherein like reference characters refer to like parts throughout the several views,

FIG. 1 is a side view of a partially wound condenser;

FIG. 2 is an end view illustrating a condenser or capacitor in the process of being wound;

FIG. 3 is an end view of one form of finished condenser embodying and made in accordance with the present invention; and

FIG. 4 is a fragmentary view on a greatly enlarged scale of a section of the condenser of FIG. 3, the section being taken generally along line 4 in FIG. 3.

The condenser of the present invention represents an improvement over that disclosed in Ruscito applications Serial No. 248,698, filed September 28, 1951, now Patent No. 2,951,002, and Serial No. 741,709, filed June 4, 1958, now Patent No. 3,026,457. The condenser of the present invention, which is made in generally the same manner as that described and claimed in the above Ruscito applications, is particularly adapted for applications wherein during use it may be subjected to a wide range of temperature ranging, for example, from —67° F. to +600° F. Temperatures of such range may be encountered in equipment employed in the Arctic wherein the condenser is closely associated with a rocket, ram jet or jet engine. It is important that such condensers suffer no ill effects or marked changes in capacity as their temperature is changed within the operational range and even though they are subject to marked mechanical shocks as by reason of acceleration, a landing of an aircraft, and the like.

The so-called condenser or capacitor discharge type of ignition system for combustion engines has come into quite common use in recent years, particularly on rocket, jet or gas turbine engines for aircraft and missiles where a high energy spark is required. In these systems a condenser is repeatedly charged and discharged to create the necessary ignition sparks having high energy. Accordingly, the condenser is an essential part of such ignition systems, and failure thereof is likely to result in failure of the engine and consequent loss of life or severe injury to personnel and destruction of valuable aircraft or other property. It is therefore an important object of this invention to improve this essential element of present-day ignition systems by making the same more efficient and more durable, particularly as regards its resistance to deterioration under conditions imposing wide variations in operating temperature.

The embodiment of the invention illustrated in the drawings and hereafter described in detail, by way of example only, is a condenser having a capacity of .14 UF. and adapted for use as a storage condenser in an engine ignition system. The conductive plates of the condenser are constituted by two strips 10 and 11 of thin metal foil. Aluminum foil having a thickness of about .00025" has been found satisfactory in one commercial embodiment. These strips are preferably of equal width and are spirally wound directly over each other but separated and insulated from each other by two layers 14 and 15 of suitable insulating material. In the preferred embodiment of the present invention layers 14 and 15 are made of "Samica," which is a reconstituted mica made by the Samica Company. Each insulating sheet 14 and 15 is, in the described embodiment, about .0013" thick and sufficiently wide to extend about .062" beyond each side edge of the foil sheets 10 and 11. The foil sheets are preferably longitudinally offset about a half inch so that the adjacent ends thereof will be staggered in a like amount. The foil sheets are, of course, insulated from each other throughout the condenser by insulating layers 14 and 15, and a few of the outermost turns of the condenser are preferably free of foil.

Terminals 16 and 17 preferably extend from laterally opposed halves and opposed ends of the condenser. Said terminals may consist of thin strips of metal, preferably silver, one in good electrical contact with one foil plate 10 and the other in good electrical contact with foil plate 11. The terminal strips may be loosely inserted in the position shown when the condenser has been approximately half wound. When the condenser has been impregnated and compressed in the novel manner hereinafter described, the terminals will make excellent contact with the foil layers and be well secured in position without the use of solder or the like. The wound layers of foil and insulating sheets are impregnated and retained in a substantially flat or out-of-round shape by a special insulating compound which is applied in a manner which is to be hereinafter described. The layers of foil and insulating sheets are tightly compressed to a flat shape (FIG. 3) with the compound filling the pores and interstices in the interposed Samica layers, thereby improving the insulating properties thereof. The Samica layers are not stressed by the action of the impregnating compound and the strength and density thereof are rendered substantially greater by compression than they were before fabrication of the condenser.

The condenser described above is preferably fabricated by the following method. The foil layers 10 and 11 and the Samica layers 14 and 15 are tightly wound on a flat, highly polished mandrel 19, as illustrated in FIG. 1. To facilitate removal of the mandrel after the winding of the condenser, the edges of the mandrel may be very slightly tapered, such as to the extent of about .001" per inch of length. When winding the two layers of foil and two interposed layers of insulating strip so that there is a layer of insulation between the foil strips on all points, care should be taken to avoid any wrinkles. When about half the length of the paper and foil strips have been wound,

the terminal strips 16 and 17 are inserted in the positions illustrated. These leads or terminals should be smooth and free of any particles which might rupture the insulating layers 14 and 15 or foil strips under compression. The winding should be carried out in a room free from dust or similar particles of foreign matter in the air. When the desired number of turns has been wound, the foil layers are cut with the adjacent ends thereof staggered about a half inch or more and at least the outside Samica layer is wound completely to cover the outside foil and secured with an adhesive tape to prevent unwinding of the turns of the condenser during further fabrication.

The condenser is now slipped off the mandrel, so that when the sides of the condenser are lightly pressed toward each other to close the opening left by the mandrel, the layers of foil and Samica will assume a loosely wound condition. Preferably a number of such wound condensers are positioned in a stacking fixture with smooth spacing plates coated, for example, with polytetrafluoroethylene resin between successive condensers, each separate plate being large enough to protrude beyond the condensers on all four sides. The plates should be clean and free from nicks, mars, or other contamination and made of a metal to which the impregnating compound will not adhere. The thus loosely stacked or supported condensers are dried in a convection oven or the like at about 350° F. for at least 12 hours. Upon removal of the condensers from the oven, they are immediately placed in an impregnating tank (which is then empty of impregnant) and baked at 0.5 inch of mercury absolute pressure maximum until the condensers reach a temperature of 280° F.±10° F. The minimum elapsed time of such latter baking under vacuum should be 8 hours, and the vacuum should be uninterrupted. After the above described second baking in a vacuum, the condensers, still maintained in the specified vacuum, are cooled below 100° F. The condensers are now ready for impregnation.

The impregnating compound which is preferably employed in accordance with the present invention, is a low viscosity solventless silcone resin in which there is incorporated a small but effective amount of a catalyst which speeds up the polymerization of the resin. In the preferred embodiment of the invention, the silicone resin is one having the following characteristics:

Unpolymerized:

1. Color	Light straw.
2. Viscosity @ 77° F	50–150 cps.
3. Specific gravity	1.11±0.1.
4. Silicone resin content	100%.

(Viscosity measured with a Brookfield Viscosimeter using spindle number 1 and speed 10.)

Polymerized:

1. Power factor at 250° F	Less than 1.0%.
2. Dielectric constant at 250° F	2.5 minimum.

Such resin may be that sold by the Dow Corning Company as resin "R7521." The catalyst employed in accordance with the invention is preferably dicumyl peroxide, the preferred impregnant consisting of the silicone resin and the catalyst, there being 0.75 part by weight of such catalyst to 100 parts by weight of the silicone resin.

After the catalyst has been mixed with the silicone resin, and while the condensers which have been baked as above described are maintained under vacuum, the impregnating tank is gradually filled with the above described catalyzed impregnating resin. During such impregnating step, the pressure in the impregnating tank must not exceed one half inch of mercury absolute pressure throughout the intake of the impregnating compound, and the compound must be maintained at 80°–100° F. during the process. After the impregnating tank has been filled with the compound to a height sufficient completely to cover all the condensers, the tank is allowed to remain under the stated vacuum for 1 hour. The vacuum is then reduced slowly to room pressure, and the condensers are allowed to soak for 60 minutes. The tank is then very slowly subjected to 50–60 p.s.i. air pressure, such pressure being maintained on the tank for 45 minutes. The pressure is then reduced slowly to atmospheric pressure, following which the impregnating tank is evacuated to ¼ inch of mercury absolute pressure maximum, such vacuum being held for 20 minutes.

The vacuum is now reduced slowly to room pressure, after which 50–60 p.s.i. air pressure is applied to the chamber, the chamber being held under such pressure for 20 minutes minimum. The pressure in the tank is now reduced slowly to room pressure. The impregnated condensers are now removed from the tank, are drained for 10 minutes, and are installed in a pressing fixture.

The impregnated condensers, preferably stacked in multiple, are subjected to a spring pressure which is increased from 0 to 500 pounds over a period of 7 minutes, the pressure being maintained at 500 pounds for an additional 5 minutes at the end of such initial period of increasing pressure. The pressing fixture is then locked so as to maintain the 500 pound pressure on the condenser. The fixture is then turned on its side for 10 minutes to allow the impregnating compound to drain from the edges of the condensers.

After this, the thus held and compressed stack of condensers is transferred to an oven and is first baked at 400° F.±10° F. for 4–6 hours. Following such initial baking, the condensers are baked again at 450° F.±10° F. for 6–8 hours. The stack of condensers, still held in the fixture under 500 pounds pressure, is replaced in the oven and is given three additional successive bakings as follows:

(1) Bake at 500° F.±10° F. for 4–8 hours.
(2) Bake at 550° F.±10° F. for 4–8 hours.
(3) Bake at 600° F.±10° F. for 15–18 hours.

Following the above baking No. 3, the stack of condensers is removed from the oven and allowed to cool to room temperature. After this, the condensers are removed from the stacking and pressing fixture, care being taken not to injure the condensers as they are thus removed and separated.

Following such separation of the condensers and cleaning of the exposed ends of terminals 16, 17 as with a suitable solvent, the condensers are individually tested for capacity, power factor, breakdown voltage, and insulation resistance. The condensers as thus fabricated will normally have a thin layer of cured impregnant 20 on their outer surfaces, thus tending to waterproof them. For best results, however, the condensers should be housed in a moisture-tight casing or coating both during storage and use.

There is thus provided a novelly constructed electrical condenser or capacitor in the form of a solid and dense mass which is entirely free of internal voids or air pockets and wherein the layers are free of detrimental internal stresses. Said condenser is capable of withstanding higher temperatures and higher voltages than heretofore known condensers of comparable size and weight and has higher insulation resistance than any previously known condenser of comparable capacity. In comparison to known structures, said condenser permits less electrical losses, possesses a better power factor and has less corona. The invention also comprehends a novel method for making condensers to endow them with the above advantages. Condensers made in accordance with said method are extremely reliable and will function efficiently and effectively for longer periods of time under severe operating conditions than known types of condensers adapted for the same purposes and uses. Said condensers are phyically durable as well as electrically superior.

Although only a limited number of embodiments of or variations in the condenser and method comprehended by the invention have been illustrated in the drawings and described in the foregoing specification, it is to be expressly understood that the invention is not so limited. Thus,

for example, the Samica insulating sheets may be replaced by sheets of other high temperature-resistant sheet material having suitable properties, such as glass paper of which that sold as "Tissuglas" by American Machine and Foundry Company is typical. The catalyst employed may be benzoyl peroxide, or other suitable organic peroxide, and the amount of catalyst employed, per 100 parts by weight of solventless silicone resin, that is, of dicumyl peroxide, benzoyl peroxide, or other suitable organic peroxide, may range from 0.1 to 2.0 parts of catalyst. The amount of catalyst employed depends generally upon the speed with which is is desired that polymerization of the resin shall proceed. Various other changes and modifications which do not depart from the spirit and scope of the invention will now be apparent to those skilled in the art.

What is claimed is:

1. The method of making an electrical condenser which includes the following steps in the order named: winding two layers of sheet metal with at least one layer of sheet insulation therebetween, impregnating said condenser under vacuum with a flowable insulating compound composed essentially of silicone resin while the layers are loosely wound, subjecting the opposed sides only of said condenser to pressure between substantially flat surfaces which are movable toward each other by said pressure while the compound is flowable and without restriction other than the condenser itself, said pressure being sufficient and being so applied as fully to compress and flatten the condenser to expel excess compound and press adjacent layers into close engagement, and baking the condenser in order at least partially to cure the compound while maintaining the condenser under substantial pressure.

2. The method as defined in claim 1 wherein the baking of the condenser is such as to complete the curing of the compound, the baking being carried out in a cycle wherein the temperature is progressively increased throughout a substantial portion of the cycle.

3. The method as defined in claim 2 wherein in the complete curing cycle the temperature of the condenser is raised from an initial temperature of about 400° F. to a terminal temperature of about 600° F.

4. The method of making an electrical condenser which includes the following steps in the order named: winding two layers of sheet metal with at least one layer of sheet insulation therebetween, impregnating said condenser with a flowable insulating compound composed essentially of silicone resin while the layers are loosely wound, subjecting the opposed sides only of said condenser to pressure while the compound is flowable and without restriction other than the condenser itself, said pressure being sufficient and being so applied as fully to compress and flatten the condenser to expel excess compound and press adjacent layers into close engagement, and baking the condenser in order at least partially to cure the compound while maintaining the condenser under substantial pressure.

References Cited in the file of this patent

UNITED STATES PATENTS

2,665,400	Walker	Jan. 5, 1954
2,819,492	Cummin	Jan. 14, 1958
2,890,396	Hutzler	June 9, 1959
2,948,838	Obenhaus	Aug. 9, 1960

FOREIGN PATENTS

596,311	Great Britain	Jan. 1, 1948