

July 29, 1947.

S. RUBEN

2,424,904

PROCESS FOR THE TREATMENT OF REGENERATED SHEET CELLULOSE

TO IMPROVE ITS DIELECTRIC PROPERTIES

Filed Oct. 5, 1940

5 Sheets-Sheet 1

Fig. 1

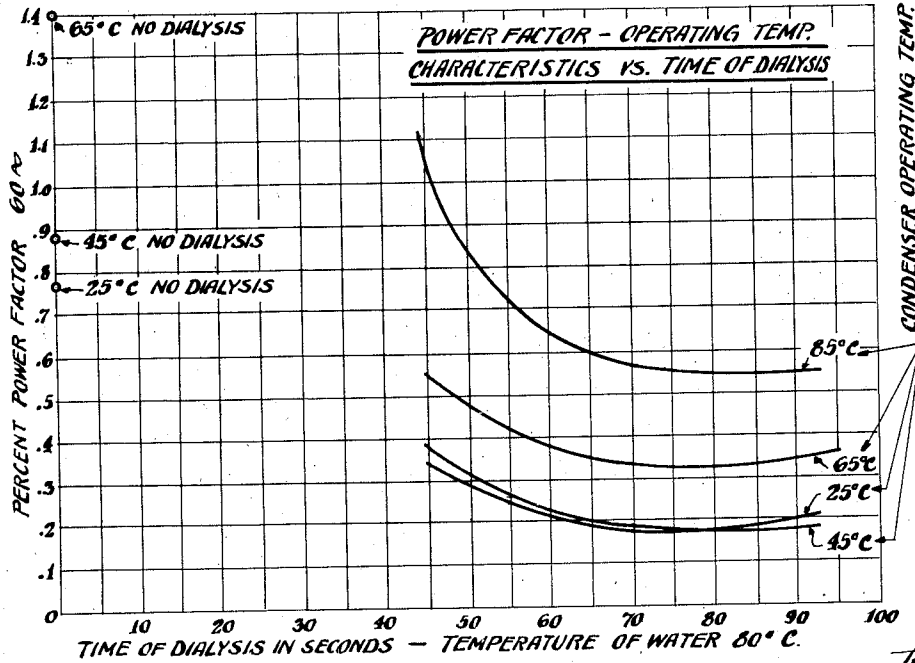
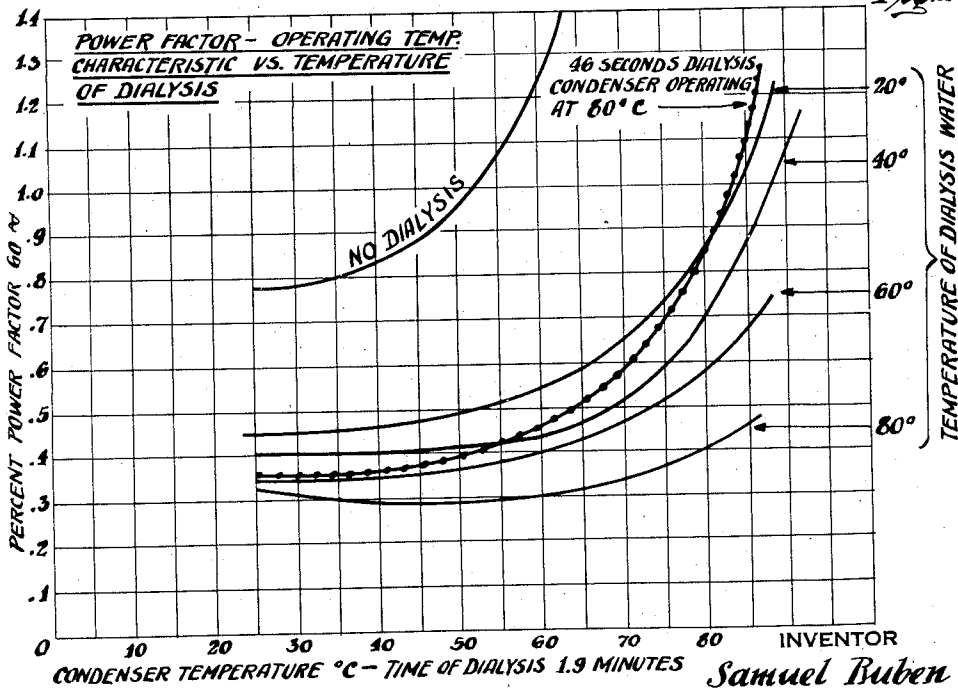


Fig. 2



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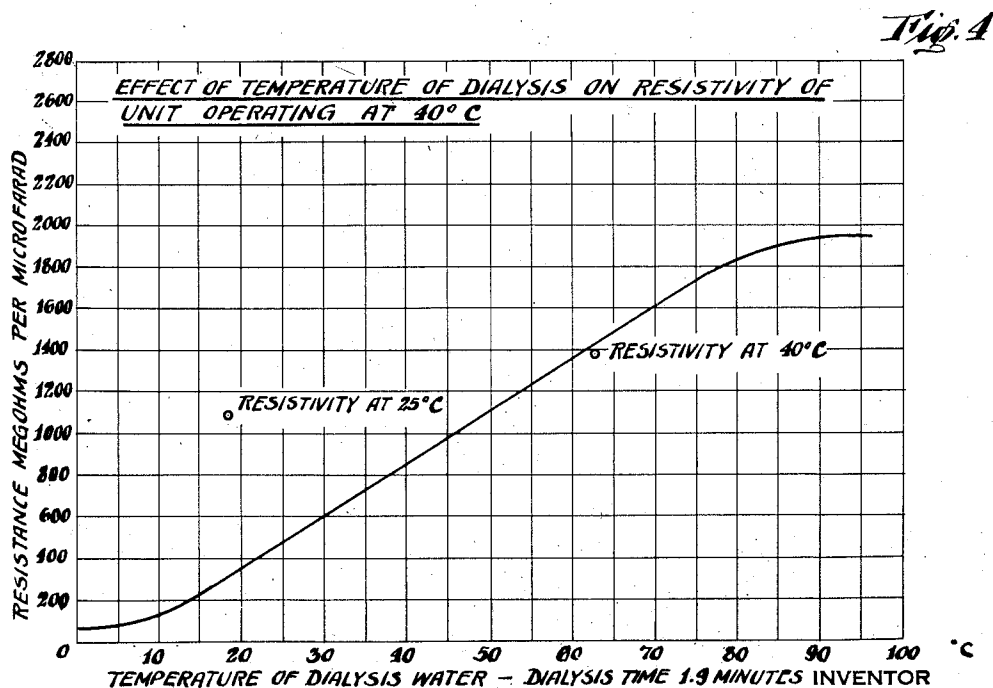
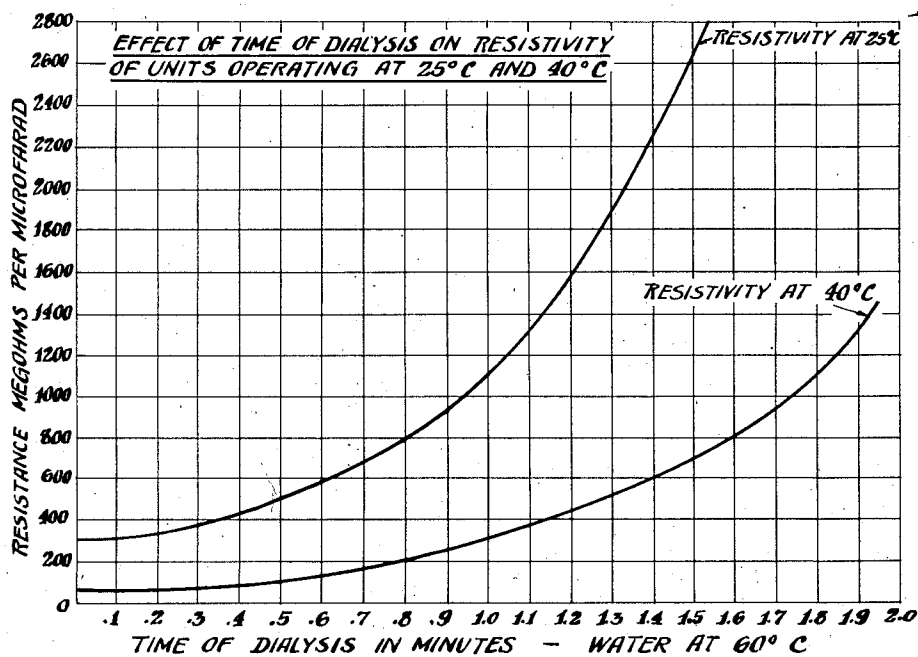
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5 Sheets-Sheet 2



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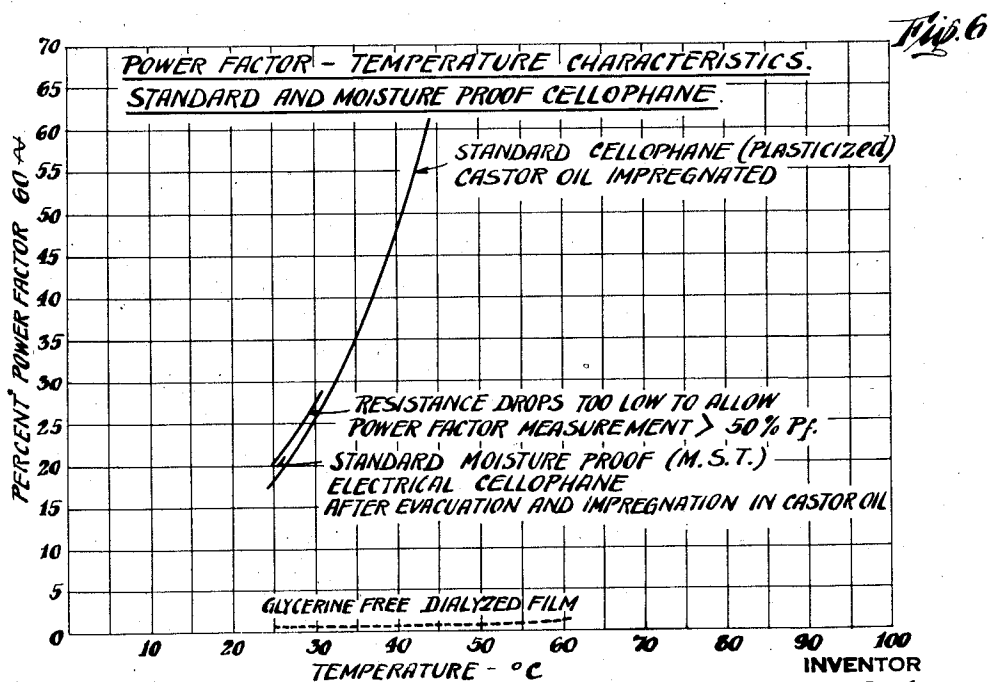
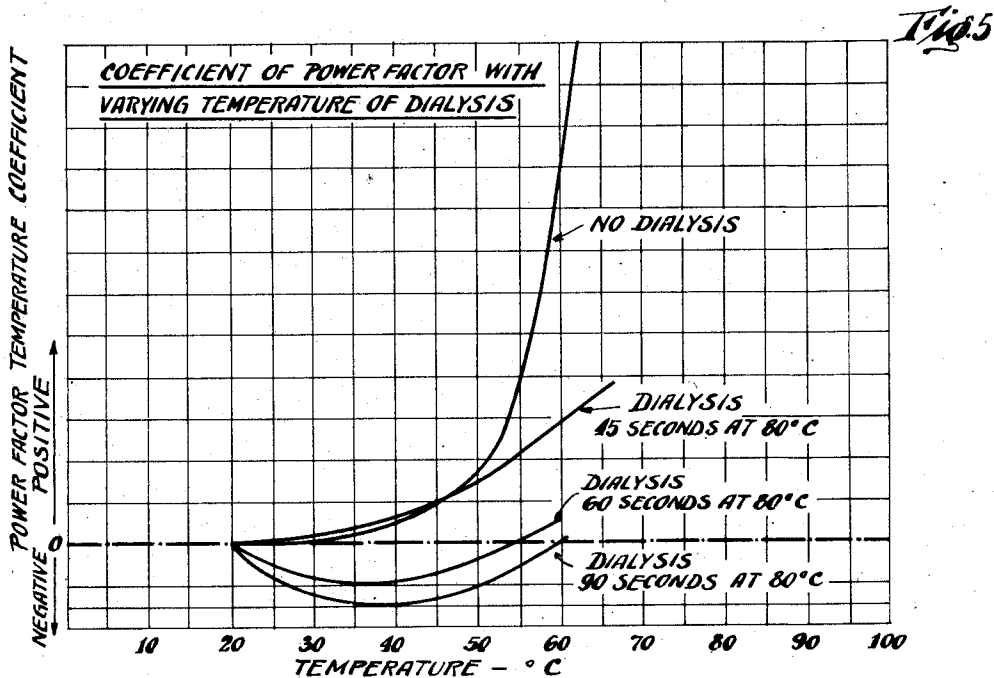
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5 Sheets-Sheet 3



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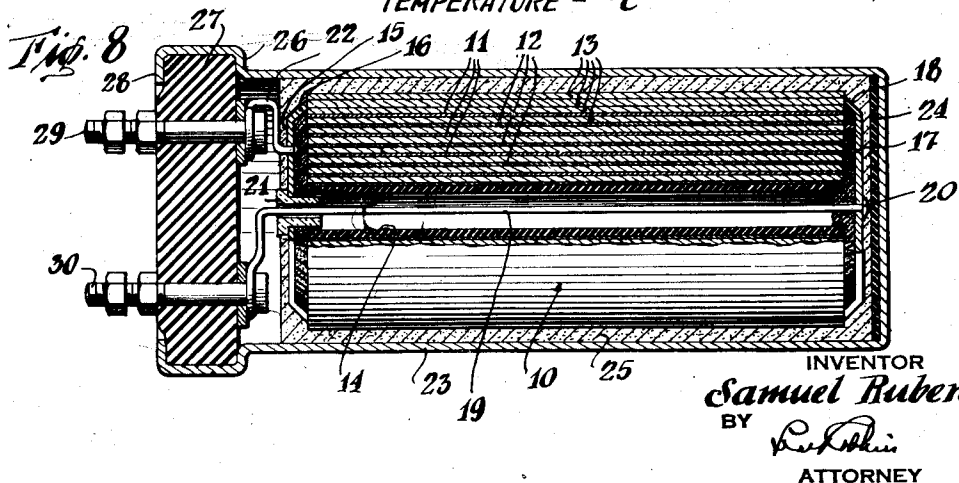
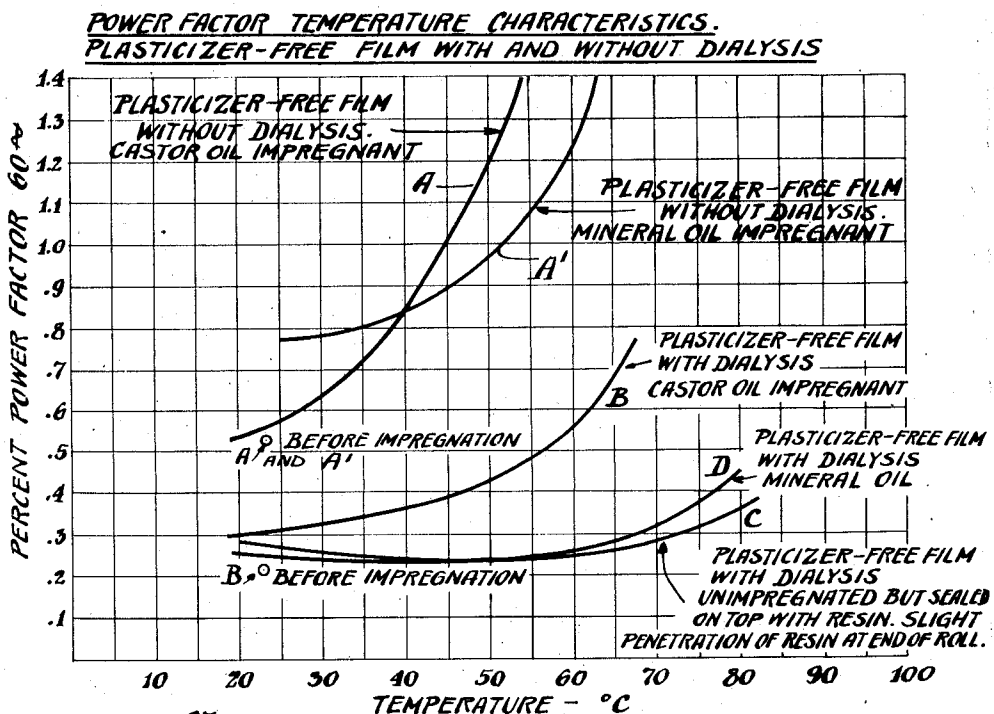
PROCESS FOR THE TREATMENT OF REGENERATED SHEET CELLULOSE

TO IMPROVE ITS DIELECTRIC PROPERTIES

Filed Oct. 5, 1940

5 Sheets-Sheet 4

Fig. 7



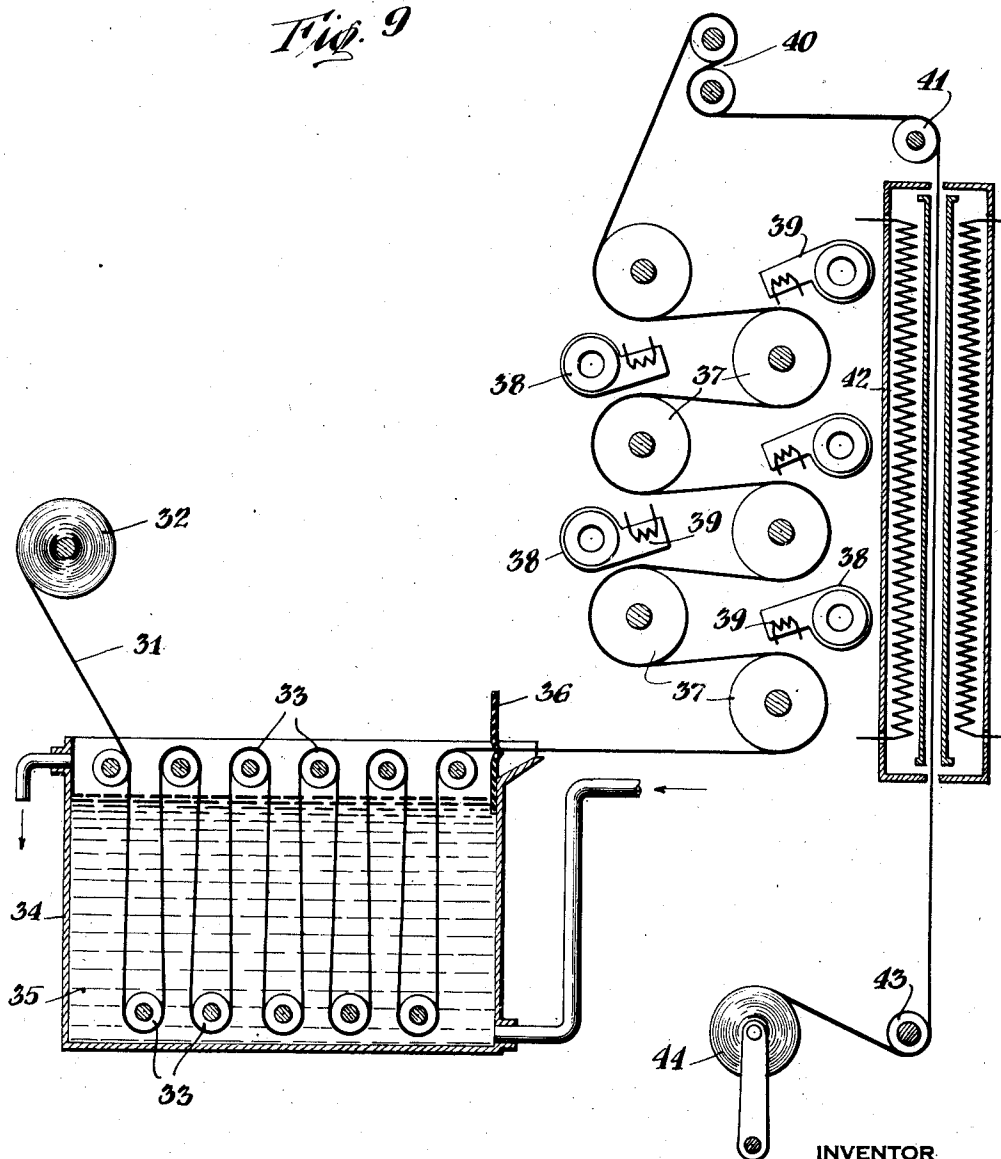
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Filed Oct. 5, 1940

2,424,904

5 Sheets-Sheet 5

Fig. 9



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UNITED STATES PATENT OFFICE

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PROCESS FOR THE TREATMENT OF REGENERATED SHEET CELLULOSE TO IMPROVE ITS DIELECTRIC PROPERTIES

Samuel Ruben, New Rochelle, N. Y.

Application October 5, 1940, Serial No. 359,884

8 Claims. (Cl. 18—48)

1

This invention relates to a process of making dielectric material of regenerated sheet cellulose for use in condensers. This application is a continuation-in-part of my copending applications, Serial No. 256,668, filed February 16, 1939, and Serial No. 288,944, filed August 8, 1939, respectively.

The invention has for its object generally the provision of a process for the treatment of regenerated sheet cellulose to permit its commercial utilization as a dielectric spacer in electrostatic condensers.

A particular object is to provide a method for controlling or eliminating the factors which have up to now prevented the use of regenerated sheet cellulose in electrostatic condensers; specifically, to provide a method for limiting the high power factor-temperature coefficient of regenerated sheet cellulose.

Another object is to provide a conditioning process for regenerated sheet cellulose, free of plasticizers, whereby electrically harmful impurities are removed, so that greatly improved operating characteristics result, such as increased resistance per unit of capacitance and higher break-down voltage, with elimination of a tendency toward a runaway increase in power factor with rise in temperature.

Other objects will be apparent as the disclosure proceeds and from the drawings in which

Figs. 1 to 7 are charts or graphs showing the improved electrical characteristics of condensers employing a sheet dielectric processed in accordance with the invention, compared with similar condensers employing unprocessed sheet dielectrics,

Fig. 8 is a view, mainly in vertical section, showing a roll-type capacitor or electrostatic condenser employing the sheet dielectric of the present invention;

Fig. 9 is a view illustrating the production of sheet dielectric material of regenerated cellulose in accordance with the invention, and shows in part schematically the steps practiced and the type of apparatus employed.

Although regenerated sheet cellulose has been produced for a great many years and although it has been mentioned in the art for more than ten years that Cellophane is adapted for use as a dielectric spacer for electrostatic condensers and the like, no such condensers have been or are made commercially utilizing this material.

A small amount of regenerated cellulose film has been used for wire insulation and cable wrapping but the amount used is almost insignificant

2

compared with the amount of paper and cotton used for this purpose. In alternating current electrostatic condensers of the wound foil type, paper is used exclusively. The opinion has been and is widely published that no cellulose material approaches paper in desirable electrical characteristics.

One of the chief objections to the use of regenerated sheet cellulose in the electrical insulating field is based on the poor electrical performance characteristics of the material as commercially produced. Regenerated sheet cellulose, such as is known to the trade as "cellophane," has been tried and failed as a dielectric spacer in electrostatic condensers because of the relatively high power factor, high coefficient of power factor with temperature, relatively low resistivity and relatively low alternating current breakdown voltage which it possesses. For instance, impregnated wound foil capacitors made with spacers of regular 1.32 mil thick commercial plasticized "cellophane" had a power factor of 36% at 20° C., a resistivity of only 70,000 ohms per microfarad and a breakdown voltage of approximately 200 volts A. C., these values being obtained after evacuation of the rolled condenser unit at 130° C. for ten hours, prior to impregnation in purified castor oil for ten hours at 90° C. (This breakdown is not a puncture value but a runaway characteristic due to cumulative electrolytic conduction caused by the negative temperature coefficient of resistance of electrolytic conductors.) As continuous operating A. C. condensers with power factors greater than 2% at 20° C. are commercially not practicable, it will be seen that such a unit would be of little or no value.

If the glycerine plasticizer be omitted in the manufacture of "cellophane," there is some improvement in initial characteristics, the resistance being increased to about 100 megohms per microfarad and the power factor being reduced to about 0.8% after evacuation and after the free spaces between the foils and film have been impregnated with a dielectric, such as mineral oil. However, the glycerine-free film, if operated on alternating current, soon fails, due to a very rapid rise in power factor with internal loss heating effect and an equally rapid drop in resistivity to excessively low values. The plasticizer-free film also has a definite electrolytic runaway characteristic, the power factor and electrolytic leakage effect increasing with time and temperature.

The lowest power factors for dried glycerine-free regenerated sheet cellulose reported in the literature (Stoops, Journal of American Chemical

Society, 56, 1480 (1934)); (Kohman, Industrial and Engineering Chemistry, vol. 31, No. 7, July 1939), are from 0.9 to 1%, under favorable test conditions. In the processed regenerated sheet film of this invention, the power factor will always be substantially lower than 0.09% and usually approaches a value close to .2% after final treatment.

So-called "moisture-proof" "cellophane," and so-called electrical grade "cellophane," which are commercial plasticized "cellophane" films with a coating of wax and lacquer, are also unsuitable as dielectric spacer material. Their power factor, though somewhat lower than regular commercial "cellophane" is unusually high, varying from 1.8% to 20% prior to evacuation and impregnation of the condenser and rising as high as 56% after evacuation and impregnation. These excessively high power factors after evacuating are due to the melting of the wax coating and penetration by the plasticizer into and through the coating.

The process at present used in the manufacture of regenerated sheet cellulose film is substantially that described in the article by Dr. William L. Hyden of du Pont Cellophane Co. appearing in May 1929 issue of "Industrial and Engineering Chemistry." In the process of making film as described in the article, certain basic steps are employed, namely: Dissolving cellulose in caustic soda to form the sodium cellulose compound; reacting the latter with carbon disulphide to form sodium cellulose xanthate; and then dissolving the xanthate compound in caustic soda to form viscose, which is fed through a restricted orifice onto receivers that enter when thus coated an acidic solution, such as sodium or ammonium acid sulphate solution. Upon contact with the acidic solution the coating is substantially instantaneously congealed into a tenuous film. Thereafter the film is given a rapid water wash and finally a plasticizing treatment in aqueous glycerine solution. Moisture-proof or electrical grade film is produced by adding a wax-lacquer coating.

In an endeavor to secure regenerated cellulose film suitable as a dielectric spacer for electrostatic condensers, I have obtained from the du Pont Cellophane Company, film containing no glycerine or other plasticizer, and which has been washed in distilled water instead of the usual water employed in the washing tanks. However, such film, as well as plasticizer-free film secured from the other United States supplier, the Sylvania Industrial Company, exhibited the characteristics of having a runaway increase in power factor with temperature rise especially when employed as a dielectric spacer in electrostatic condensers used in alternative current circuits. Furthermore, the material possessed low resistivity.

I have discovered that these undesirable characteristics are caused by minute amounts of trapped compounds not heretofore removed from the film and apparently, as far as the art shows, not known to have been contained in the film and not recognized as electrically harmful.

I believe that as a result of the sudden congelation of the cellulose when exposed to the acidic sulphate solution during the course of its manufacture, that there is locked within the interior of the film a minute quantity of reaction compounds. The final washing given to the film during its manufacture serves mainly to remove the salts and products of cellulose regeneration from the surface. These very small quantities of ionizable materials, which remain locked in the

film do not affect the film in commercial use, and have hence been either not recognized or deemed negligible.

However, these minute impurities which are ionizable in nature and which I believe to be alkaline cellulose or salt compounds, fundamentally affect the suitability of the film as a dielectric and prevent it from acting as a homogeneous cellulose sheet. At elevated temperatures, due to water of crystallization contained in these compounds and which is not detached during the condenser evacuation process because it would require a temperature greater than the decomposition temperature of the cellulose to release it, these impurities become more active. They give rise to localized centers of low resistance, therefore field localization, and in view of the negative resistance temperature co-efficient of ionic conduction, the effect is progressive. These undesired electrical characteristics are most evident when the film is serving as a dielectric in apparatus to which alternating current is continuously applied. In such case, a runaway or progressively increasing power factor is evidenced with a rise in temperature caused by the losses inherent to any dielectric and dependent upon the degree of polarizability.

I have found that by removing these internally locked electrically harmful compounds, that the runaway power factor characteristic is eliminated or controlled and that the power factor does not rise over the maximum normal range of operation of the condenser. These residual compounds, I have ascertained, are water soluble and may be removed by dialysis. Immersion of the film in pure heated water for a suitable time, after it has been originally dried, will induce a dialysis that effectually and completely removes the electrically harmful substances. This is strikingly evidenced by the results obtained with capacitors employing dialyzed film. For instance, regenerated cellulose sheet, completely dialyzed and having a thickness of .88 mil, when built into a capacitor will have a resistance of 2000 megohms per microfarad instead of 146 megohms obtained with undialyzed film built into a similar unit; the power factor after dehydration in a vacuum at 130° C. for ten hours and before impregnation will be .19% instead of .55% at 20° C.

A capacitor employing a dielectric separator of dialyzed film after impregnation with heavy mineral oil, will have a power factor at 23° C. of .3% and at 75° C. of .33%, whereas a condenser made with similar undialyzed film will have a power factor of .8% at 23° C. and 1.7% at 75° C.

For a given water temperature, the time required for effecting a satisfactory dialyzing of the regenerated sheet cellulose to remove the soluble compounds depends on the thickness of the film. A sufficient time is required at a temperature adequate to allow dissolving and migration of the impurities through the cell membranes. The most important factor is the temperature of the water. The water should be as pure as possible.

By using heated pure water, the film is freed from the undesired compounds at a greatly accelerated rate, due to increase in solubility of and increase in mobility of the ionizable impurities, and more pronounced swelling of the cells, which facilitates migration through the cell membranes of the entrapped salts. In water maintained at room temperature or lower, such as is used in the commercial production of film, complete dialysis of the impurities does not take

place, regardless of the length of time of immersion, and the maximum reduction in power factor and increase in resistance is not obtained. I have found, in order to remove the undesired compounds, that it is highly desirable, if not necessary, that the dialysis water be hot and that the hotter the water, the more expeditious the removal of the compounds. A temperature of 40° C. or greater is apparently needed for the production of reasonably good film, the range of 50° C. to 100° C. being generally required and the preferred temperature being greater than 80° C.

The period of dialysis may also be shortened by applying an electrical potential difference across the film and its dialyzing bath. By making the film the anode in an electrical circuit when dialyzing out the ionizable compounds, rapid removal of the latter takes place. The use of an impressed potential difference also permits the conjoint use of a convenient colorimetric indicator to determine when the dialysis is sufficiently completed. This may be achieved while the wet film in the bath is connected to the positive terminal of a source of potential and the negative electrode to the water, by adding phenolphthalein to the water. When a sufficient dialysis has taken place, the added indicator will show that the film has reached a point where the submerged negative electrode no longer gives an alkaline ion reaction.

In general, to effect a proper dialysis, the film should remain in the water for a period long enough to remove the undesired soluble ionizable compounds. Accordingly, a relatively long bath may be employed, or a shorter one in which the film is run through several passes in the water, for example, in a plurality of up and down passes.

After the film has passed through the dialyzing bath, whereby the harmful compounds are removed, the excess water is taken off the film and the latter fed on to a series of staggered drying rolls, which are preferably of aluminum or other non-film-adhering material and provided with adjacently located hot-air blowers. Such blowers may employ any convenient air heating means, for example, electric heating coils, and are preferably arranged to blow heated air at high velocity onto the film while passing over the rolls, whereby drying is effected on a flat surface.

It is important, in the treatment of regenerated sheet cellulose, as here proposed, to dry the film on a non-adhering, smooth plane or cylindrical surface. This is desirable on account of the relatively large amount of shrinkage that occurs in the film during such drying step. The film when in wet or swollen condition adheres tenaciously to other types of surfaces on drying so that it is very difficult to separate it from such surface when dried. This causes distortion of the surface, which is readily noticeable when the film is rolled up because of the tension existing in the center of the film on the adherent ends (which dry first due to freer exposure to the air). This disadvantage I have avoided by drying the film while in continuous motion in a plurality of stages while passing over surfaces of the character indicated.

After the film has been dried on the hot-air swept rollers, it may, if desired, be passed through an oven to remove by baking any residual moisture and effect a further drying and shrinking of the film. This pre-shrinking is sometimes desirable if the film is to be used as a separator in wound foil electrostatic condensers. The pre-

shrunk film will not shrink materially during evacuation of the condenser and hence will not cause wrinkles which would shorten the condenser life by forming high pressure local areas and localizing the electric field, inducing breakdown at relatively low voltages. Wrinkles do not present a real problem with paper, which is soft and pliable, but regenerated sheet cellulose, when adequately dehydrated is hard and somewhat inflexible so that the wrinkles cause cracks which lower the voltage breakdown value of the condenser. After the final baking, the film may be fed to a slitting machine and cut into desired widths.

Referring now to Fig. 9, a sheet of plasticized or unplasticized film shown at 31, and indicated as being unwound from a roll 32, passes by way of a guide roller into a tank 34 containing pure running water 35. Here it is preferably passed up and down through the water several times over a series of smooth aluminum rollers 33. The water employed is preferably heated to a relatively high temperature, for example, 90° C. The passing film is immersed in this manner for a period of about one minute whereby the ionizable compounds and any hygroscopic plasticizer that may be present are effectively removed by dissolution and dialysis. When plasticized film is used the period of immersion should be about ten per cent longer than for the glycerine-free film. As the film emerges from the bath the excess water is wiper off by spreader blades 36, and then fed over a series of staggered smooth-surfaced aluminum rollers 37. Adjacent each of two or more of such rollers is a high velocity air blower 38, each containing a heating element 39. These blowers emit streams of heated air which are applied on opposite sides of the film while passing over the rollers. The film thus dried is then passed by way of pressure rolls 40 and guide roll 41 into a baking oven 42, which may be electrically heated and maintained at a suitable high temperature, for example, 200° C. if the speed of film travel is approximately twenty feet a minute. After passing through the oven the film is fed by way of roller 43 onto roll 44.

When film which has been thus dialyzed is to be used as a dielectric separator without further evacuation, or as insulating tape or sheet, it is advantageously fed, after the baking step and prior to assembly, into a bath composed of a 15% solution of polystyrene in xylol containing 40% ethyl chloro benzene. The resulting coating on the processed film, unlike polystyrene, imparts no brittleness. The film in consequence remains flexible, adherent, moisture-proof, of low electrical loss, and possesses good mechanical structure.

The cut or stripped dialyzed film when baked is ready to be assembled as the dielectric element of electrical apparatus. For electrostatic condensers, such stripped sheet material may be further cut into pieces and placed between the plate electrodes, or it may be wound as a continuous web between ribbons of foil-like electrodes. Roll type electrostatic condensers are produced in this manner; an example of such a condenser being shown in Fig. 8, in which the condenser section 10 comprises a pair of metal foil electrodes 11 and 12, preferably .0003" aluminum wound together with a pair of treated regenerated sheet cellulose dielectric spacers 13, .0004" thick, dialyzed and conditioned before winding in the manner hereinabove described. The foils are offset so that foil 12 projects beyond the sheet cellulose dielectric spacers at the top of the roll and

terminates short of the dielectric spacers at the bottom and foil 11 projects at the bottom and is overlapped by the cellulose sheets at the top. The foils and sheet cellulose are wound around hollow mandrel 14 and several turns of the dielectric spacers are wound around the outside of the condenser section to afford extra insulation from the metal can 23. Connections with the offset electrodes are made by means of rectangular bronze spring plates 15 and 17, having bent down contacting portions 16 and 18 respectively, the edges of which make contact with electrode foils 12 and 11. Plate 17 has attached thereto wire terminals 19, soldered to the plate at 20, the wire being pulled up through mandrel 14. Plate 15 has a central aperture into which is inserted ceramic member 21 through which passes wire terminal 19. A terminal for electrode 12 is provided by soldering a wire 22 to plate 15. After the condenser has been thus assembled it is heated to a temperature of 130° C. in a vacuum of at least 0.1 mm. Hg for four hours and thereafter for a like period of time is immersed in mineral oil maintained at a temperature of 130° C. Thereafter, the oil bath is allowed to cool to room temperature, the condenser sections being then withdrawn and the excess oil allowed to drain off. An examination of the section shows that a thin film of oil has been absorbed onto the surface of the dielectric cellulose sheet, although it does not permeate the sheet. The impregnated condenser section is then placed in the metal container 23 about one-fourth of which has been filled with a mixture of 70% coumaroneindene resin-30% mineral oil. The container is heated to a temperature of 130° C. at which point the resin-oil is almost fluid. As the condenser section is placed in the container from which it is insulated at the bottom by fibre washer 24, the resin-oil mixture is forced up along the sides and top of the section so as to form a complete tenacious waterproof seal over the entire section. As the mixture is solid or immobile at normal operating temperatures, I am thus able to obtain the advantages of an oil seal within the wound unit, at the same time providing a dry solid waterproof seal outside the active unit, thereby avoiding problems present with a fluid sealing means.

Container 23 has a Bakelite top 27 which rests on shoulder 26, the can being spun over against the top at 28. Inside terminal wires 19 and 22 are fastened to outside terminal members 30 and 29 respectively, which protrude into the can through top 27.

The graphs in Figures 1 to 7 inclusive, illustrate the character of dielectric properties imparted to regenerated cellulose film by dialysis as practiced in the invention unless otherwise described. The starting material which was subjected to dialysis treatment to give the graphs is that sold by the du Pont Co. in the current year and in the immediately preceding years as plasticizer-free or "deglycerinated" film. As a matter of fact, in respect to the material tested, extra precautions were taken by the du Pont Co. to provide the purest type of film possible and in most cases the film was apparently thoroughly washed to free it from surface salts, etc. In all cases, and unless otherwise specifically mentioned, the graphs have been taken from the performance of wound foil condensers of approximately 3.0 mfd., wound with .0003" aluminum foil and .00088 film, the condenser subsequent to winding and evacu-

ation being impregnated with dielectric mineral oil.

In Fig. 1 is shown the power-factor operating temperature characteristics of condensers operating at temperatures of 25° C., 45° C., 65° C., and 85° C. as affected by the time of dialysis of the film in water heated to a temperature of 80° C. Also shown are the power factors of condensers of identical construction employing undialysed film and operated at temperatures of 25° C., 45° C., and 65° C.

In Fig. 2 is shown the effect on the power factor of condensers operating at various temperatures as affected by dialysis bath temperatures of 20°, 40°, 60°, and 80° C.; also shown is the power factor curve for a similar condenser, the film of which has not been subjected to dialysis. For purposes of comparison a curve has also been drawn showing the power factor of a condenser in which the film has been subjected to a dialysis treatment for 46 seconds in water at 80° C. The results indicated by these curves would not be obtained if the process merely involved surface washing.

In Fig. 3 is illustrated the variation in leakage or resistance per mfd. in a completed condenser at operating temperatures of 250° C. and 40° C. as determined by the variation in time of dialysis in water heated to 60° C.

Fig. 4 depicts the effect of temperatures of the dialysis bath upon the leakage or the resistivity of the film treated. This curve indicates that only with baths at relatively high temperatures are the film-locked ionic components that cause electrolytic conduction in the film sufficiently driven out for optimum operating conditions. The resistivity measurements are taken at condenser operating temperature of 40° C. and for basis of comparison the resistivity at 25° C. is indicated on the graph.

Fig. 5 illustrates the elimination of the positive coefficient of power factor within normal operating range due to elimination of the film-locked impurities and distinctly shows how the sign of the coefficient within this range is actually changed to a negative one, allowing reduced losses instead of a progressive runaway characteristic. This characteristic, as pointed out, has been the limiting factor for regenerated sheet cellulose and the cause of self-destruction on alternating currents of condensers employing dielectric spacers of regenerated sheet cellulose. It will be seen that with a normal operating temperature rise of 20° C., the power factors of condensers in which the film has been subjected to a dialysis treatment of 60 seconds or 90 seconds at 80° C., have almost continuously dropped; that the power factor of a condenser employing film dialysed for 60 seconds at 80° C., has not risen above the starting point with a temperature increase of 35° C.; that a condenser employing a dielectric film subjected to dialysis treatment for 90 seconds at 80° C. does not show a rise past initial power factor with an operating temperature rise of 40° C.; whereas condensers employing similar film not subjected to dialysis, show a continuously rising and runaway power factor characteristic.

Fig. 6 illustrates the runaway power factor-temperature characteristics of castor oil impregnated wound foil condensers employing dielectric spacer elements of standard and moisture proof "cellophane," each of which materials contains a glycerine plasticizer. Also shown for purposes

of comparison is a curve giving the power factor-temperature characteristic of castor oil impregnated condensers of similar construction employing glycerine-free dialysed film.

In Fig. 7 curve A illustrates the power factor-temperature characteristics of a plasticizer-free "cellophane" spacer condenser impregnated with castor oil and curve A' illustrates the power factor-temperature characteristics of a plasticizer-free "cellophane" spacer condenser impregnated with mineral oil. These may be compared with curve B which illustrates the power factor-temperature characteristics of a condenser employing a dielectric of dialyzed plasticizer-free film and impregnated with castor oil; with curve D which illustrates the power factor-temperature characteristics of a condenser employing a dielectric of dialyzed plasticizer-free film and impregnated with mineral oil; and with curve C which illustrates the power factor-temperature characteristics of a condenser employing a dielectric of dialyzed plasticizer-free film and unimpregnated, the condenser being sealed on top with resin. Also indicated are power factors before impregnation.

The graphs show that it is possible to commercially utilize regenerated cellulose film for the manufacture of electrostatic condensers by controlling or eliminating the factor which has restricted its use. This limiting factor has been the high power factor temperature coefficient which was the basic cause of condenser destruction on alternating current. The curves show that within the normal maximum operating range, as between 20° C. and 60° C. that this positive coefficient cannot only be reduced, but eliminated and changed in sign to a negative value. Heretofore there has been no indication or recognition of the possibility that the sign or direction of the power factor coefficient could be reversed within a practical range. It has apparently been taken for granted that this rising power factor character with increase in temperature is one definitely associated with cellulose bodies. By the teachings of this invention, it is shown that this power factor can be reduced from initial values to values lower than 0.2% during operation of the condenser.

It has also been shown that the mere elimination of the plasticizer does not eliminate the progressively destructive factor; for instance, it is shown that plasticizer-free film, washed and dried by the du Pont Co., has a coefficient for a 40° C. operating range of over 1% per degree rise.

It can also be observed from the curves that prolonged dialysis in a dialysing bath maintained at higher than room temperatures is necessary in order to bring about the maximum improvement with reduction or elimination of the positive power factor coefficient within normal operating limits. It can also be noted from the curves that film properly treated possesses characteristics identical with pure linen paper thus indicating true cellulose characteristics freed from secondary ionic effects due to internally locked ionically conductive salts. The nature of the interlocked impurities is apparently such that cold water does not provide adequately rapid solubility to bring about complete migration through the cell membrane of the undesired ionic constituents even though the treatment is maintained for a long period of time. In order to bring about the necessary migration of ionizable impurities through and from the film, adequate water temperature and sufficient time is required. It might well be

that this time and temperature are not commercially practicable in the primary production of cellulose film because the gelatinous character of the film as it is being produced at high speed and relatively low water temperature necessitates tremendous speeds in the travel of the film through the washing tanks.

The term "dialysis" is used to describe applicant's process because it is recognized that with the pellicular structure of regenerated cellulose, the only way that impurities locked in the cells can be eliminated is by migration through the membrane structure. Dialysis of the impurities is not effected by mere surface washing of the film and is only accomplished when adequate time and temperature are employed. The term "dialyzed" is used to define film which has been subjected to the dialysis process herein defined.

In general, it may be noted that the factors which have heretofore commercially prevented the use of regenerated cellulose as a capacitor dielectric element have been described, their effect graphically illustrated and specific directions for their elimination have been given.

The expression "substantial removal of soluble impurities" used in the claims means removal to an extent whereby the dried film when used as a spacer in a condenser as described shows no substantial rise in power factor and preferably exhibits a negative temperature power factor coefficient from about 20° to 50° C. when subjected to commercial 60 cycle A. C. voltage.

What is claimed is:

1. The process of producing regenerated sheet cellulose film for use as a dielectric in electrical apparatus which comprises immersing regenerated sheet cellulose in water at a temperature above about 40° C. for at least in the order of one minute.
2. The process of producing regenerated sheet cellulose film for use as a dielectric in electrical apparatus which comprises immersing regenerated sheet cellulose in water at a temperature between approximately 40° C. and 100° C. for at least one minute.
3. The process of reducing the power factor and increasing the resistance of regenerated cellulose film for a dielectric spacer element for capacitors and the like, which comprises the steps of dialyzing said film to remove soluble impurities by passing said film through a bath of water maintained at a temperature above 40° C. for a period at least in the order of one minute, then drying the film while in motion.
4. The process of producing a dielectric sheet from a regenerated cellulose film which comprises the steps of dialyzing said film to remove soluble impurities in a bath of water at a temperature of between 50° C. and 100° C. for a period of time at least in the order of one minute, then drying and baking the same, whereby the dried product in a condenser exhibits a negative temperature power factor coefficient from about 20° C. to 50° C. when subjected to commercial 60 cycle A. C. voltage.
5. The process of producing regenerated sheet cellulose film for use as a dielectric in electrical apparatus which comprises immersing regenerated sheet cellulose in water at a temperature between 80 and 100° C. for a period at least in the order of 45 seconds.
6. The process of reducing the power factor and increasing the resistance of regenerated cellulose film for a dielectric spacer element for capacitors and the like, which comprises the steps

of dialyzing said film to remove soluble impurities by passing said film through a bath of water maintained at a temperature between 80° C. and 100° C. for a period at least in the order of 45 seconds, then drying the film while in motion.

7. The process of producing a dielectric sheet from a regenerated cellulose film which comprises the steps of dialyzing said film to remove soluble impurities in a bath of water at a temperature of between 80° C. and 100° C. for a period of time at least in the order of one minute, then drying and baking the same, whereby the dried product in a condenser exhibits a negative temperature power factor coefficient from about 20° C. to 50° C. when subjected to commercial 60 cycle A. C. voltage.

8. The method of treating regenerated cellulose sheet for improving its electrical characteristics as a dielectric spacer for electrostatic condensers and the like, which comprises, immersing said sheet in water at a temperature above about 40° C. for at least 45 seconds, maintaining a co-relation between the temperature of the water and the time of immersion of the sheet to effect substantial removal of soluble impurities from the latter, and thereafter drying said sheet.

SAMUEL RUBEN.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

	Number	Name	Date
	1,989,046	Robinson	Jan. 22, 1935
	2,042,588	Charch	June 2, 1936
10	1,968,883	Geer	Aug. 7, 1934
	257,607	Parkes	May 9, 1882
	2,205,449	Wiley	June 25, 1940
	2,206,850	Parsons	July 2, 1940
	1,980,413	Lewis	Nov. 13, 1934
15	1,728,471	Bratring	Sept. 17, 1929
	981,368	Brandenberger	Jan. 10, 1911
	1,601,289	Brandenberger	Sept. 28, 1926

FOREIGN PATENTS

	Number	Country	Date
20	631,797	France	Sept. 20, 1927
	670,747	France	Aug. 24, 1929

OTHER REFERENCES

- 25 Heyden Industrial & Engineering Chemistry, vol. 21, No. 5 (May 1929), passages 405-410.
Article by Stoops in Journal of the American Chemical Society, 1934, vol. 56, pages 1480-1483.