July 22, 1924. 1,502,343

B. MACPHERSON

PROCESS AND APPARATUS FOR MAKING ELECTRICAL CONDENSERS

Filed May 26, 1920 7 Sheets-Sheet 1

Fig. 1.

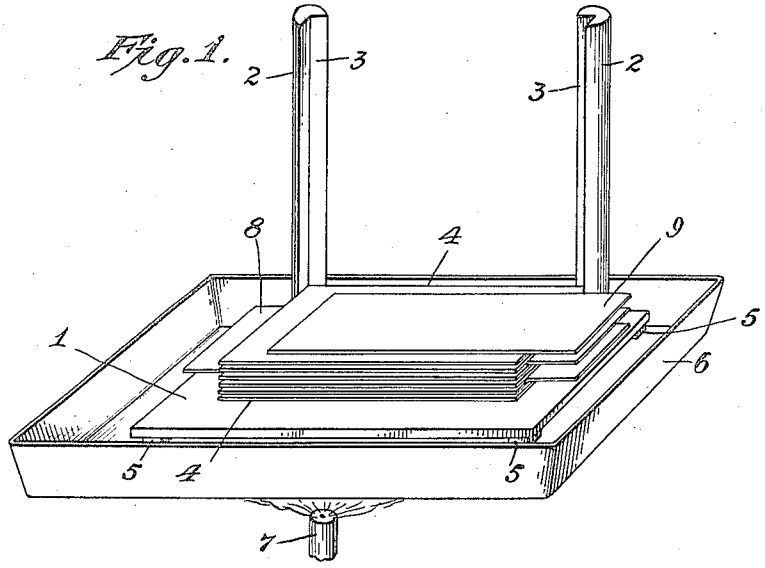
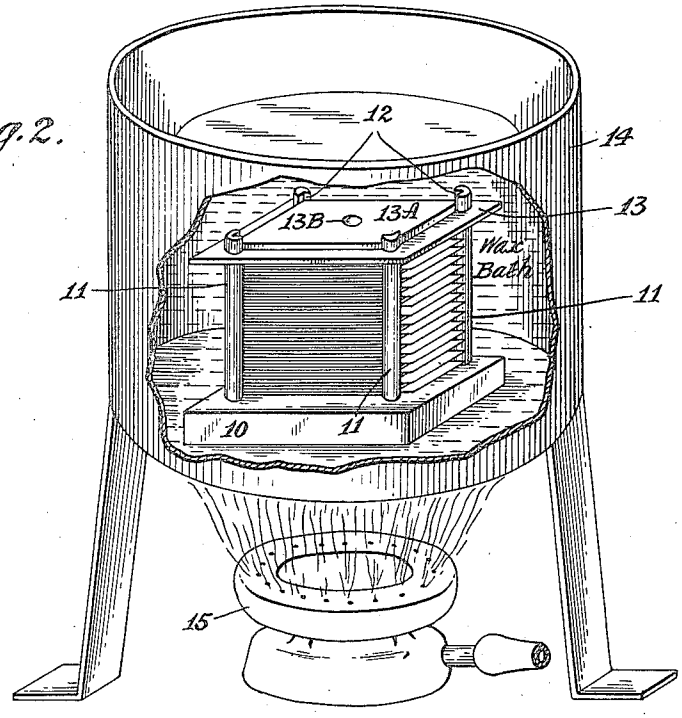


Fig. 2.



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Fig. 3.

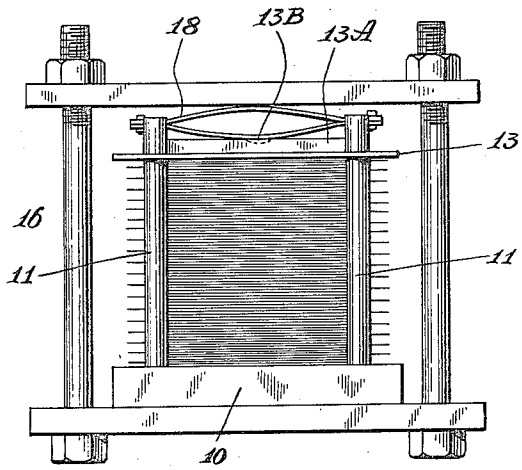
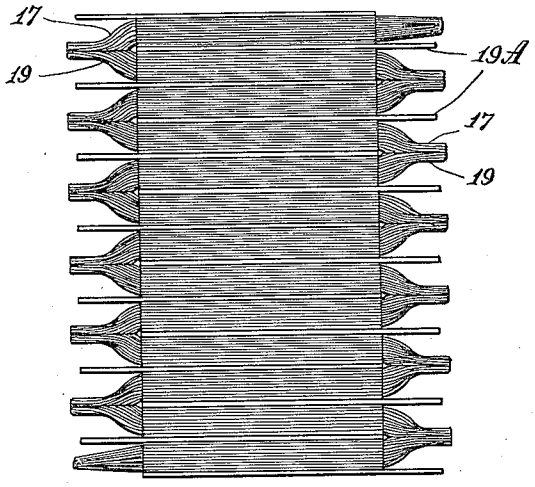


Fig. 4.



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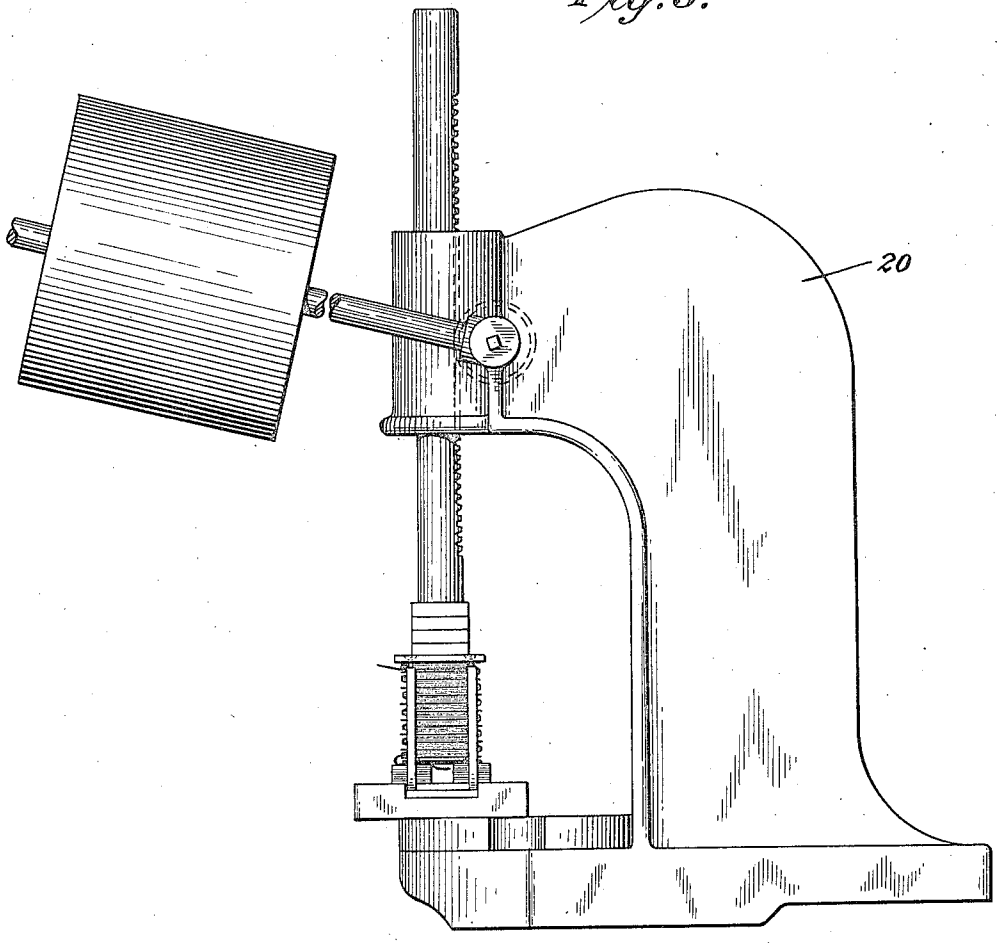
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PROCESS AND APPARATUS FOR MAKING ELECTRICAL CONDENSERS

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Fig. 5.



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Fig. 7.

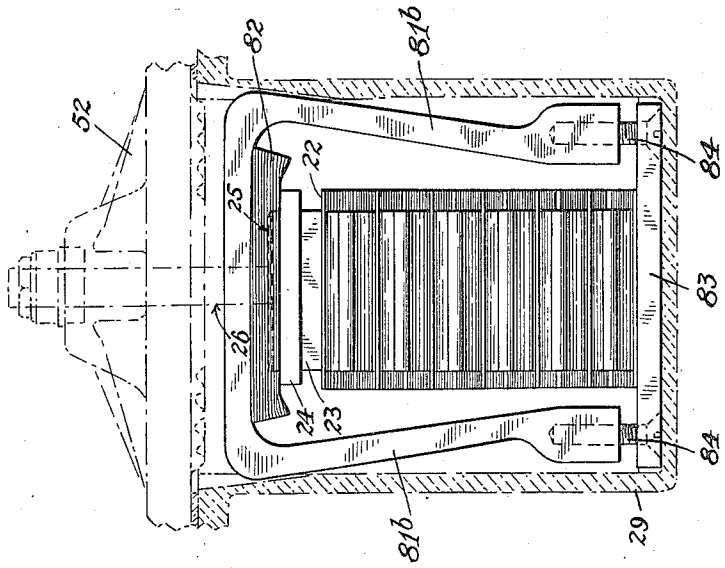
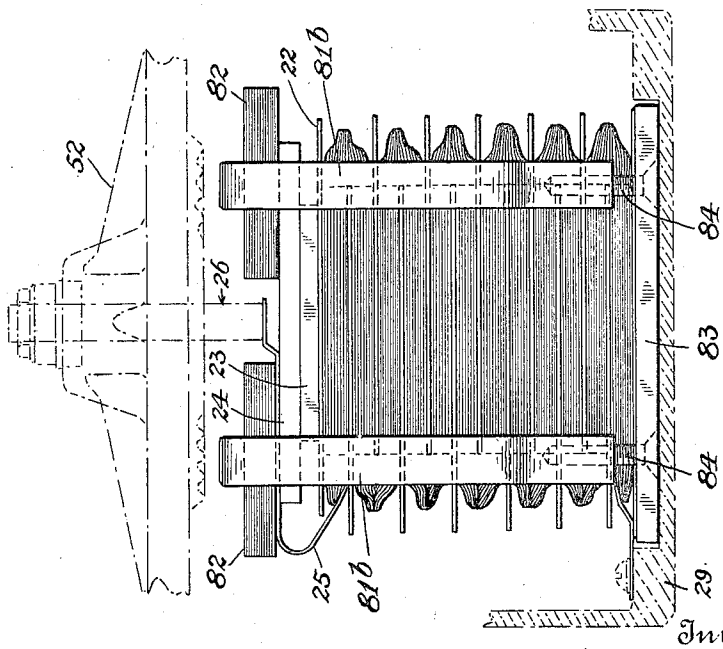


Fig. 6.



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Fig. 8.

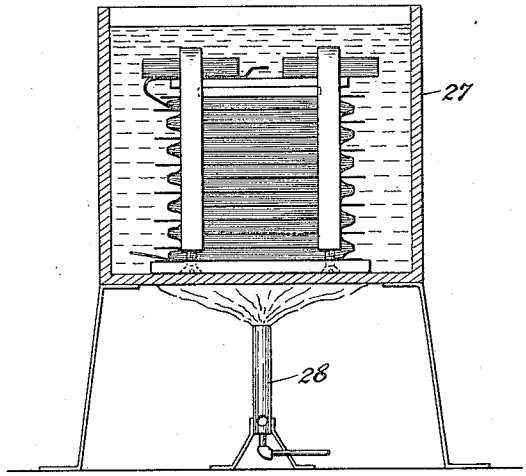
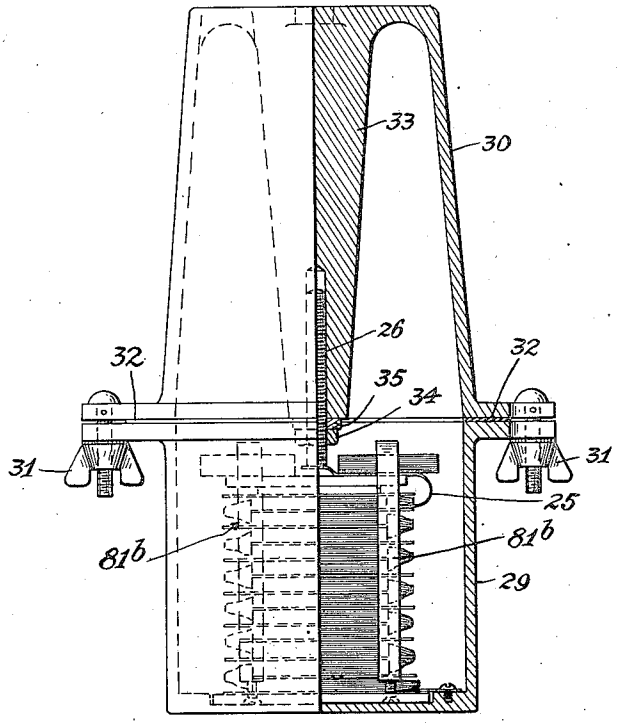


Fig. 9.



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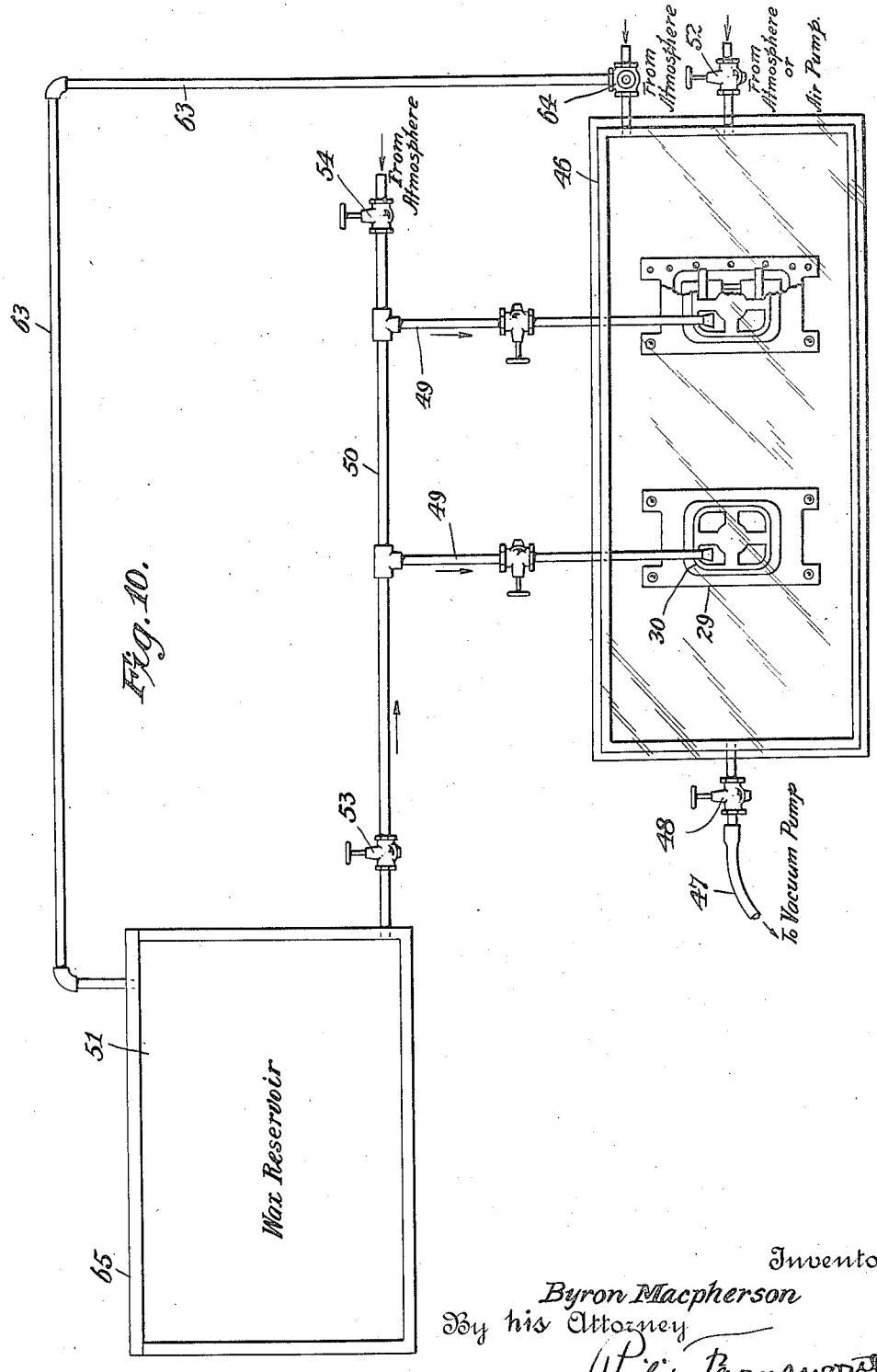


Fig. 10.

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PROCESS AND APPARATUS FOR MAKING ELECTRICAL CONDENSERS

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Fig. 11

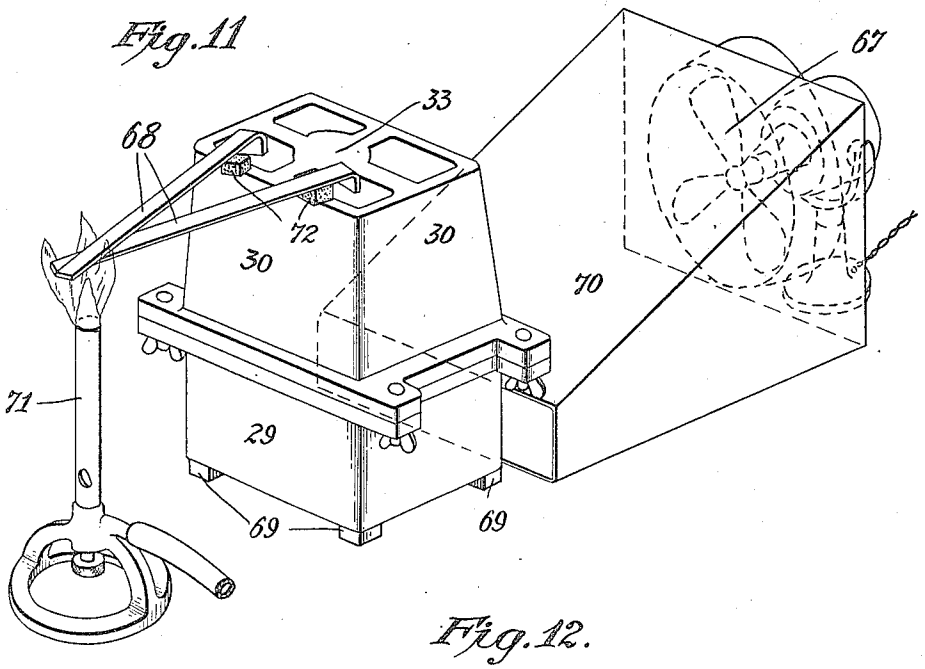
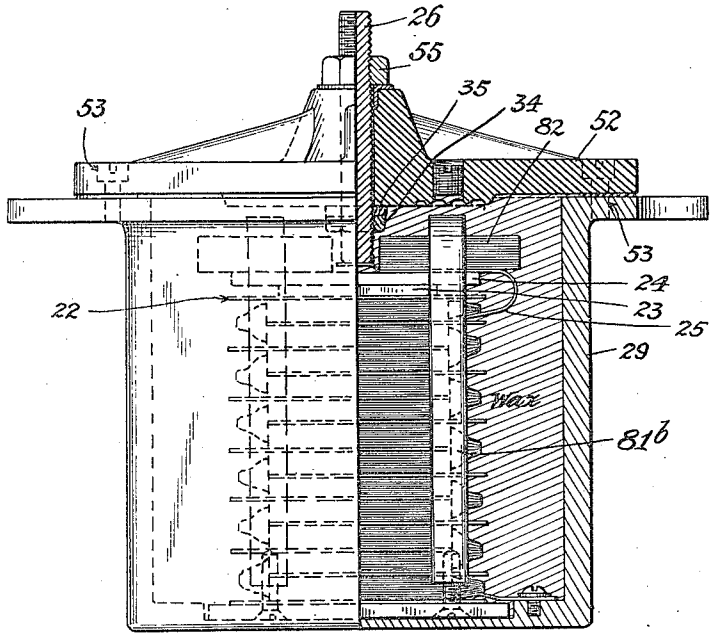


Fig. 12.



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Patented July 22, 1924. 1,502,343

UNITED STATES PATENT OFFICE.

BYRON MACPHERSON, OF ROXBURY, MASSACHUSETTS, ASSIGNOR TO WIRELESS SPECIALTY APPARATUS COMPANY, OF BOSTON, MASSACHUSETTS, A CORPORATION OF NEW YORK.

PROCESS AND APPARATUS FOR MAKING ELECTRICAL CONDENSERS.

Application filed May 26, 1920. Serial No. 384,501.

To all whom it may concern:

Be it known that I, BYRON MACPHERSON, a citizen of the United States of America, and a resident of Roxbury, in the county of Suffolk and State of Massachusetts, have invented certain new and useful Improvements in Processes and Apparatus for Making Electrical Condensers, the principles of which are set forth in the following specification and accompanying drawings, which disclose the form of the invention which I now consider to be the best of the various forms in which the principles of the invention may be embodied.

This invention relates to improvements in and relating to electrical condensers of the sheet type and more particularly of the type wherein mica is used for the dielectric sheets.

The object of the invention is to obtain an improved condenser of the sheet type which comprises a stack consisting of sheets of mica and metal foil in permanently intimate contact with one another, the interior of the stack between the sheets being freed as nearly as possible of air, moisture and all materials other than the mica and foil sheets themselves, the mica and foil sheets having nothing whatsoever between them when the object of the invention is completely attained. The foils adapted for my processes are preferably soft and non-resilient so that as the result of the execution of the process they are in intimate contact with the mica sheets, their surfaces inside the stack of sheets being freed of air, moisture and wax and sealed from the outside atmosphere. Therefore I prefer lead foil (sometimes known as "tin-foil" in the trade), although not only may there be used soft metal foils as of lead, tin and copper alloys thin enough to be sufficiently non-resilient, but the foils themselves may have some degree of resilience although that is not so desirable. Owing to the soft, inert or non-resilient character of such foil sheets, they exert no tendency to force the sheets apart after they have been compressed together, and the resultant condensers will consist of mica and foil sheets compressed into persistently intimate contact with each other without any substantial intervention of wax which has existed between the sheets during the execution of the process of construction as an agent for washing out air and moisture from between the sheets. The condenser is permanently compressed mechanically to maintain the above condition, and to the same end is permanently embedded in a mass of suitable paraffin; the condenser prior to such embedding being subjected to the highest practicable compression, so that the treatment during manufacture and the permanent compressing and embedding serve respectively to eliminate from and prevent re-entry into the interior of the stack, of materials foreign to the mica and foil sheets.

The invention consists in certain of the processes described herein and in certain combinations of such processes, and in the apparatus employed in and for the processes.

Of the drawings:

Fig. 1 is a perspective of the apparatus employed in temporarily coating the sheets with paraffin and in building such sheets into a material-stack;

Fig. 2 is an elevation of the apparatus employed in treating the built material-stack in a pre-heating bath of paraffin;

Fig. 3 is an elevation of a form of apparatus which may be employed in highly compressing the built material-stack as it is taken from the bath of Fig. 2, when hot and while cooling;

Fig. 4 is an elevation of the assembly into a condenser stack or condenser, of portions of the previous material-stack which have been separated or divided therefrom, or made separately, the sections in this assembly being electrically separated from one another but electrically connected in series with one another;

Fig. 5 is an elevation of the apparatus employed in compressing the assembled condenser at certain stages of the process;

Fig. 6 is an elevation (partly in section) of permanent small clamps which are placed as shown on the condenser stack and adapted to be received and retained with the condenser in the permanent condenser casing as indicated in Fig. 6; Fig. 7 being a side view of the same;

Fig. 8 is an elevation (partly in section) of the apparatus in which the assembled condenser (compressed in its permanent

small clamp) is subjected to a pre-heating bath in a temporary container, as in Fig. 2 save that now the permanent clamp is applied;

Fig. 9 is an elevation (partly in section) of the apparatus in which the permanently compressed condenser stack is placed, the lower part of this apparatus (29) constituting the final casing for the condenser (see Fig. 6), and the upper part comprising a temporary head used in embedding the condenser in paraffin in the lower part 29 or condenser casing.

Fig. 10 is a diagrammatic plan of apparatus employed in filling in the embedding paraffin around the condenser in its casing;

Fig. 11 is a perspective of apparatus employed ancillary to that of Fig. 9, and after the operations with Fig. 10, for the purpose of cooling the embedding paraffin; and

Fig. 12 is an elevation (partly in section) of the condenser completely embedded in its casing and provided with a cover over the embedment and casing.

The processes hereof are more particularly adapted for use under conditions where it is important that there shall be minimum electrical losses in the condenser in service, such as in radio telegraph transmitters, power lines, laboratory standards and the like. The condenser stack in any case may be employed as a unit in any desired way, or it may be constructed so as to be divided in sections which in service may be grouped in any desired relation of series, parallel or series-parallel of the sections; or the condenser may be constructed into sections permanently connected in series, as in a radio telegraph transmitting use where the condenser not only may be constructed with sections insulated from one another in well-known ways, but the sections may be connected permanently in series in well-known ways.

In the processes, a suitable wax is employed, first during the construction of the stack of mica and foil sheets, and later for the permanent embedding of the eventual condenser stack. While any kind of wax or similar material may be employed for these purposes, nevertheless paraffin wax is very highly preferably as being specially adapted to the processes and product hereof. Also a small percentage (say five per cent more or less) of carnauba wax, or waxes possessing similar properties, is mixed with the paraffin for use in the operations with Figs. 8 and 9. The addition of the carnauba wax raises the melting point of the mixture and when cooled provides a harder material for the condenser embedment. This specification of wax refers to that to be used in all the steps of the processes. Wherever reference is made hereinafter to paraffin, it is to be understood as preferably including the above small percentage of carnauba wax save in the operations of Figs. 1 and 2. The paraffin used in all the processes hereof is preferably previously freed from moisture as by heating it from 100° centigrade to 180° C., whether or not the liquid paraffin is used in the processes at such temperature in any given instance.

As the first process or step in the processes, all the sheets, of both mica and foil, are coated with the paraffin, which serves later to wash out air and moisture from the sheets after their assembly into a stack, later steps or processes being employed for the purpose of squeezing out this paraffin from between the sheets to the greatest possible extent with the view of producing a condenser stack consisting only of the sheets of mica and foil, freed so far as possible from all the paraffin which has been temporarily employed for the purpose of washing out air and moisture from the interior of the stack between the sheets. This coating may be effected by treating the loosely-assembled sheets to a bath of hot paraffin; but the greatly-preferred process is that of separately coating each sheet with the paraffin, this being done preferably while the process of building up the material-stack out of the separate sheets is being effected. This preference is due to the fact that the sheets when wet with the paraffin and when the stack is temporarily cooled are much more conveniently held together and handled at this stage of the manufacture than when the sheets are not coated. At this stage, the stack is called the material-stack, because it constitutes the material out of which the eventual condenser stack (or simply "condenser") is to be made as by the selection of a sufficient length or lengths of the material-stack which has or have an electrical capacity suitable for the desired condenser.

Fig. 1, in perspective, shows the apparatus employed in coating the mica and foil sheets with paraffin and in building the sheets into the material-stack. The building stand consists of a horizontal metal plate 1; also two vertical posts 2 which are cut away at right angles at 3 to correspond with the corners of the mica sheets 4 so as to aline and guide the mica sheets during the operation of building the material-stack. The building stand is also provided with corner legs 5 on its base plate 1 so that, when the building stand is inserted in the waxing tray 6, the paraffin therein may circulate freely around base plate 1. Tray 6 is filled with molten paraffin so as to permit the latter to heat base plate 1 during the operation of building. The temperature of this paraffin during the coating and building operation is about 70° C., i. e., not very hot but about the temperature which the oper-

ator's fingers will conveniently stand. The paraffin is kept at this temperature by the flame of a very small Bunsen burner 7.

As each sheet of mica or foil respectively is about to be placed first on top of base plate 1 and then on top of one another alternately, the operator dips each such sheet in the paraffin in tray 6 and then places it on the growing stack (Fig. 1). As the operator puts each foil sheet in place, she can and should observe whether any air bubble is entrained in the paraffin (due possibly to incomplete dipping), and if there be, or preferably in every case, she smooths down (squeegees) each foil to squeeze out the air. Likewise, in putting each dipped mica sheet in place, she presses it down on the coated foil sheet beneath it, for the same purpose of squeezing out air. Thus the material-stack is built up of alternated sheets of mica and foil, while the successive foil sheets are placed so as to extend respectively at opposite ends of the stack. The portions of the successive foil sheets which overlap one another (with intervening mica sheets) in the interior of the stack constitute the active area of the condenser sheets in the operation of the apparatus. During this building operation, the stack is kept warm, i. e., both by the warm liquid paraffin coatings on the respective sheets and by the heat conducted from the warm paraffin in tray 6 by the metal base 1 and metal posts 2 which are in contact with the stack. This maintenance of warming during building assists in keeping down unnecessary thickness of the paraffin coatings between sheets (due to the increasing tendency of the growing stack to squeeze out excess paraffin by gravity) and also assists in avoiding the entrapping of air in the stack at this stage (due to the tendency to greater intimacy of contact between the sheets and the consequent tendency to cause the liquid paraffin to wash out air and moisture from between the sheets rather than to permit entrance or entrapping between the sheets). If the material-stack during the building operation becomes insufficiently warm, or if it hardens as appears to the operator's eye, she may spoon up the paraffin from tray 6 and pour it over the material-stack from time to time.

In case the eventual condenser is to consist of a number of sections connected in series, temporary separators of metal or any other convenient material may be inserted as the building operation proceeds, as a convenient method of separating and marking or indicating the sections in the material-stack, particularly if during the building operation pains are taken to insure that each section has the same electrical capacity, as by the use of mica sheets of uniform thickness and by counting the sheets added above each separating marker so that the portions of the stack between the markers will have uniform capacity. The above applies also to any case where a proper portion of the total material-stack is selected for the final condenser, whether a series-sectional condenser or otherwise.

After the material-stack is built as high as permitted by the building stand of Fig. 1, the stack is allowed to cool therein sufficiently to permit convenient handling without impairing the unitary character of the stack consisting of the sheets temporarily held in alinement by the cooled and hardened paraffin layers between the sheets. After cooling to such extent, the stack is transferred to the so-called pressing frame shown in Fig. 2, although the compressing function of the frame is not exercised until after a pre-heating bath later to be described. This frame consists of a substantial metal base 10 with four upright metal posts 11 at the corners thereof, each post being provided with right angle cut-away portions 12 like the cut-away portions 3 of the posts 2 of the building frame of Fig. 1. In the case of this pressing frame all four corners of the mica sheets are thus alined in the stack. When the material-stack is inserted down between said posts in this pressing frame, the foil sheets project out at both ends of the stack between the vertical posts 11, but the mica sheets are alined by such posts as stated. After the material-stack is inserted in this pressing frame, a compression plate 13, having four holes alined with posts 11, is slipped down over said posts and upon the top of the stack.

The next step (Fig. 2) consists in subjecting the material-stack in its pressing frame (but not yet highly compressed) to a heating bath of hot molten paraffin in a temporary container 14, preliminary to a compressing operation. In this pre-heating step, the paraffin coatings on the surfaces of the sheets which yet remain as thin layers between sheets in the material-stack, are completely liquefied. This heating bath is maintained for approximately twenty minutes, the temperature of the paraffin being maintained at substantially 135° C. by the flame of an ordinary-sized Bunsen burner 15. By the time the material-stack is thoroughly heated by the paraffin, the moisture between the sheets inside the stack, some of which may yet remain, becomes vaporized and escapes from the stack into the bath of paraffin. Such moisture is that which may have been entrapped in the coating paraffin or on the surfaces of the sheets during the dipping and building operation when the paraffin was not at so high a temperature as in this bath, i. e., not sufficiently high to vaporize such moisture.

Upon completion of the heating of the material-stack in the heating bath of Fig. 2,

the stack is subjected to the highest practicable mechanical compression by some such means as that shown in Fig. 3, and while yet in the pressing stand, and while hot so that the paraffin yet in the stack is liquid. This is a very important step in the process. It results in squeezing the thin paraffin layers from out between the sheets and thereby washing out from their surfaces and from the interior of the material-stack most of any remaining air and moisture together with the paraffin as the washing-out agent. As stated, the continued presence of any foreign matter between the sheets, even the paraffin itself, is detrimental in the service of the condenser as being the cause of electrical losses or breakdowns. This step may be effected by applying to the stack and its pressing frame, such a clamp as 16, Fig. 3 (or an ordinary large C-clamp), and screwing the clamp up by hand as tightly as possible, or by employing any other powerful press such as the common arbor press such as that shown in Fig. 5. By highest practicable compression is meant the highest compression which it is practicable to obtain without injuring the soft metal foil sheets at the temperature employed, for this squeezing-out process is most effective when executed forthwith upon the removal of the stack from the paraffin heating bath of Fig. 2, i..e., when the stack is yet very hot and the paraffin quite fluid between the sheets. The pressure usually employed, which is without injury to the foil sheets, is of the order of several hundreds of pounds up to say one thousand pounds per square inch of the active area of the mica sheets, i. e., that area of the mica sheets which lies between the overlapping portions of the foil sheets in the central part of the stack. Before applying the press, it is preferable to place on top of plate 13 another pressing member 13^A which has a central depression 13^B for use in centering the stack in the press. After partial cooling of the stack while yet under the compression of the press, or at intervals before complete cooling (and in the event that no spring as 18 (Fig. 3) is employed in the clamp), the press or clamp should be further tightened to compensate for the shrinkage or contraction during cooling, thereby restoring the initial high compression. In order to maintain the initial compression automatically during contraction, it is desirable at this stage to employ some form of spring clamp as by the interposition of a leaf spring 18 between the clamp and the stack (Fig. 3).

The cooling of the stack under this compression should be complete in order that, after the removal of the clamp 16 from the pressing frame (and the removal of the stack from the pressing frame 10, 11, 13), there will be no reentry into the material-stack of any foreign matter such as air, moisture or liquid paraffin which it has been the object of the process thus far to wash out from the stack. Under proper operation of the process and upon not too early removal of the clamp, the stack will be held in its compressed condition of intimate contact between the sheets by means of the hardened coating of paraffin which envelops the stack and particularly by the hardening of the paraffin which has run in between the portions of the mica sheets which project beyond the foil, all of which may be referred to as the marginal paraffin. In other words, at this stage, after the cooling and upon the removal of the clamp, the material stack is hermetically sealed by said marginal paraffin which serves when cooled and hardened to bind the sheets together and maintain the condition of high compression and intimate association of the sheets which was initiated by the press. The explanation of the maintenance of said condition of intimate contact by the small amount of marginal paraffin lies largely in the fact of the hermetical sealing by such paraffin around the edges of the sheets; for the application of the compression has resulted in a contact of mica and foil sheets which is so close that this contact will tend to be automatically maintained as long as air is excluded from between the sheets, and this exclusion is effectively maintained by the hardened marginal paraffin. Thus the desired condition of the material-stack is fully maintained after the removal of the clamp or press and independently of the degree of success attendant upon the process of obtaining the desired end of squeezing out all the paraffin between the sheets; and no reliance is placed or required to be placed upon any such remaining paraffin for the purpose of holding the material-stack in this condition of permanent intimacy of contact between the sheets.

At this point, selection is made from the material-stack of that portion or those portions which may be desired to constitute the condenser stack or condenser itself. In case temporary markers have been employed, the stack is simply divided at such markers and the desired divided portion is removed for use as the condenser. If no markers have been used, the portion or portions desired are split from the material-stack; but, in effecting this, great care is necessary in order not to disturb the air-tight highly compressed condition of the split-off portion, and this is preferably done with the aid of a thin knife carefully applied to the edge and inserted between adjacent sheets in order to split off the desired portion. If it is desired to produce a sectional condenser, sections of approximately the desired capacity may be split

off from the material-stack, in case temporary markers have not been employed during the building operation. If the condenser is not to be a sectional condenser but is to consist simply of a single section, then such single section, of greater or less length, is split off from the material-stack, or the entire material-stack may be used if of the desired capacity. In case of a sectional condenser, each section has the bunches of foil ends projecting from each end, soldered together to constitute a section-terminal at each end. In Fig. 4 is shown a condenser stack consisting of an assembly of such sections, wherein the foil bunches 17 of each section are electrically connected by soldering to the foil bunches 19 of the adjacent section, and where each section is separated from its adjacent section by sheets of insulation 19[A] which may be of mica and projecting from the unconnected ends of adjacent sections,—all pursuant to long-established practice. From this point on, the stack which is subjected to the processes is the condenser stack as distinguished from the material-stack as existing up to this point.

At this point, if the processes have been carefully followed, the condition of each section of the assembled condenser will be the same as was the condition of the completed material-stack, i. e., the sheets being in intimate contact and sealed and held in such condition so that each section alone might be used as a condenser. The subsequent treatment (but prior to the final embedding operation) now to be described, of the assembled sectional condenser of Fig. 4 is that simply which is desirable to put the assembly into the same condition as is each section, all precedent to the final or embedding operation.

The condenser, now cold at this point, is subjected to the highest practicable compression. This may be effected by a temporary rigid C-clamp or any such clamp as in Fig. 3, or by an arbor press as in Fig. 5. This temporary compression is for the purpose of permitting the measurement of the electrical capacity of the condenser in a condition of compression corresponding generally to its final condition, and if the capacity is not proper, to permit readjustment as by the addition or subtraction of the condenser sheets, the clamp, of course, being removed to permit the latter if shown to be necessary.

After the final capacity of the condenser is thus determined, the condenser is placed in its permanent clamp. See Figs. 6 and 7. An insulator 22 (as a mica sheet) is placed on top of the condenser, on top of 22 is placed a metal plate 23 (as brass), and on top of plate 23 is placed an insulating plate 24 (as of fiber or bakelite). Also the upper copper strip high potential lead 25 has its lower end soldered to the soldered-together bunch of foils extending from the top section of the condenser, and the upper part of lead 25 is bent over the top insulating plate 24 toward the centre of the condenser, and to this end of lead 25 (after the subsequent treatment of the condenser and before its insertion in its permanent casing) is soldered the top stud or high potential terminal 26 of the condenser.

Then in accordance with my process there is applied at this stage to the condenser a permanent clamp such as shown in Figs. 6 and 7, comprising a construction (to be described shortly) small enough to enter into the permanent condenser casing and remain permanently as a portion of the final assembly with the condenser in its casing.

This permanent spring clamp of Fig. 6 is loosely applied to the condenser stack as shown in Fig. 6, and thereupon the cold condenser with this small clamp loosely applied is inserted into a press or clamp 20 of Fig. 5, the condenser being yet cold. (As yet, neither the casing nor cover indicated in Figs. 6 and 7 has been applied to the condenser.) When the clamp 20 is screwed up on the condenser, then the adjusting screws 84 (Fig. 6) of the small clamp are tightened up to maintain such compression, whereupon the condenser may be removed from the large clamp or press 20 and subjected to further treatment.

Referring back to Figs. 6 and 7 for the description of the small permanent spring clamping means, the resilient member is the metal plate 83 on which rests the bottom of the condenser. Two U-shaped metal yokes 81[b] each has its two free ends connected to spring plate 83 by adjustment screws 84. Two insulating blocks 82 (conveniently consisting of stacks of mica sheets) are inserted between the curved upper ends of yokes 81[b] and the top insulating plate 24, which may be of hard fiber and rests on top of the condenser, which top in usual service is the high potential end of the condenser and is by this construction adapted to serve as such high potential end. Upon adjustment of the screws 84, the resilient steel plate 83 is drawn up firmly against the stack, and flexed, and the upper ends of the yokes 81[b] are drawn down firmly upon the insulating blocks 82, thereby establishing a yielding pressure on the stack and maintaining a constant live pressure on its ends irrespective of variations in length thereof due to temperature changes involved in subsequent processes of manufacture and during service. The resilient part 83 may or may not constitute a terminal of the lower end of the stack. As the opposite ends of the stack may have a high difference of potential between them, the insulators 82 and 24 should have sufficient thickness to prevent discharge

between the top of the stack and the upper portions of the metal yokes 81b. The metal parts of the clamp, i. e., the steel U-shaped yokes 81b, the bottom spring plate 83 and the top metal plate 23, are copper plated in order to prevent losses in service by eddy currents in such parts.

After the condenser has been removed from the press 20 (Fig. 5), being thus under the high compression of the small permanent clamp, it (the condenser) is pre-heated, preliminary to a re-compression, by insertion in a hot-paraffin bath in a temporary container 27 (Fig. 8), the condenser not yet having been provided with its final casing or its cover. This bath is at about 135° C. The condenser is maintained therein under the compression of its permanent spring clamp for about twenty minutes, the temperature of the bath being maintained by the flame of a Bunsen burner 28, the effect being to thoroughly heat the condenser and liquefy the marginal paraffin on and about the condenser. While this heating bath is preliminary to a further compression, yet it also serves to drive out of and off from the condenser any air or moisture which may have been introduced into the marginal paraffin since the production of the condenser from the material-stack or since the air and moisture were first previously washed out from the material-stack by the initial compression when hot. If the cold compression just previous to this heating bath be omitted, i. e., if the condenser be subjected to the heating bath without being under substantial compression, then the value might be lost of the advantages of the original hot compression of the material-stack, i. e., the substantial washing out of air and moisture from between the sheets in the interior of the stack.

As the result of the heating bath of Fig. 8, all the marginal paraffin yet remaining in and about the condenser (and at this stage there is very little, if any, paraffin left inside the condenser) is liquefied. The hot stack, yet and always hereafter under compression, is then removed from the heating bath of Fig. 8 and returned while hot to the arbor press of Fig. 5,—or equivalent clamp,—wherein the compression is again applied, but to a degree higher than when the condenser was cold. While under the high compression of the press, the permanent small clamp is further tightened by its screws 84 (Fig. 6) to maintain the compression attained by the large clamp or press, which at this stage was set for about one thousand pounds per square inch of active area of the mica sheets, i. e., that which covers the overlapping portions of the foil sheets in the center of the condenser. Upon the tightening up of the small permanent clamp, the condenser is finally removed from the press of Fig. 5. This operation, which is the final operation on the condenser stack itself, has resulted in yet more nearly, if not completely, squeezing out any paraffin remaining between the sheets in the hot condenser and therefore in washing out any remaining air or moisture vapor within such paraffin.

The condenser stack, thus far not embedded in any large block of paraffin (having only a thin enveloping or marginal sheath as the result of the paraffin baths), but otherwise completed, is next, and preferably while yet warm, inserted in the container for hot paraffin which is to serve to embed the condenser in a large block of paraffin completely filling the permanent condenser casing as shown in Fig. 12. This container may be and preferably is the permanent condenser casing 29 of Figs. 6, 7, 9, 11 and 12 (in fact, the last above preheating bath may have been in this casing). The condenser may be centered in its casing 29 by the engagement of its clamp members 81b (Fig. 7) in the upper internal grooves in the casing, and by the reception of the base-plate 83 of the clamp (Fig. 6) in a depression in the bottom of the casing between two lateral ledges or steps; but the centering may be provided for by the internal projection 33 of head 30 to be described. Preferably at this time, i. e., before the next process of pre-heating to be described, the temporary waxing head 30 (Fig. 9) is secured on top of the open upper end of casing 29, as by screws 31. Fig. 9 is an end view of casing 29 and head 30. As shown in Fig. 9, the bottom of head 30 is open, to communicate with the interior of casing 29, gasket 32 being inserted between the margins of casing and head to permit a tight joint. Thus waxing head 30 has its side walls constituting upward extensions of the side walls of casing 29. In general, the height of temporary head 30 is preferably at least equal to that of casing 29 itself, and it may advantageously be higher as will appear. The view of this head in Fig. 9 is an end view, the top of head 30 being shown in Fig. 10. The head 30 is provided (Fig. 9) with a central tapered pin or projection 33 depending from the top of the head and having a hole drilled in its lower end to receive the threaded condenser terminal 26 to center the latter, so that the condenser is centered in its casing 29 and so that the terminal 26 will in all cases be in the same position in order to extend through a standard final cover 52 (Figs. 6 and 12) to be applied after the completion of the embedding process. (Terminal 26 has been soldered to high potential lead 25 before the condenser has been placed in its casing 29.) For the purpose of keeping the paraffin (with which the apparatus is to filled) away

from the upper part of the condenser terminal 26, a nut 34 is threaded on terminal 26, and a rubber washer 35 is placed between nut 34 and the lower end of tapered projection 33. Of course, nut 34 and washer 35 are put in place on terminal 26 before temporary head 30 is applied to casing 29, the nut 34 being first screwed down into or slightly above its proper position and thereafter the head and its tapered internal projection 33 are placed on top of the casing and on top of the washer 35 respectively. The tapered projection 33, together with the external tapering of the entire head 30, provide an internal space which is tapered annularly, in order the more readily to permit the removal of the head later on from the paraffin which by that time has hardened in said annular space in the head.

Previous to the final embedment, and after the emplacing of temporary head 30 on casing 29, the condenser is subjected to a final pre-heating operation. This pre-heating process may consist in replacing the clamped condenser in the hot paraffin in temporary container 27 of Fig. 8 (in order to restore to the condenser the heat lost while it was undergoing its hot and final compression after its prior removal from the first heating bath of Fig. 8), the bath being maintained hot as before by the burner 28. Or, and preferably, as stated above, the present pre-heating process may consist of a temporary filling of hot paraffin in the casing 29 and head 30 of Fig. 9 after the condenser has been inserted in casing 29 as shown therein; and during this pre-heating an application of heat is made to the exterior of casing 29 as by a Bunsen flame, all whereby the casing 29, condenser and head 30 are thoroughly heated, preliminary to the flowing in of the final embedding paraffin in the casing 29 and head 30 (in the apparatus of Fig. 10 to be described). After the condenser, casing 29 and head 30 are thoroughly heated by said temporary flowing of hot paraffin, and by the application of heat to the exterior, the paraffin is decanted from casing and head. This pre-heating serves to thoroughly heat the condenser itself, thereby liquefying the marginal paraffin. At this stage, however, little or none of the paraffin coatings remain on the sheets inside the condenser, but the sheets are in direct, intimate contact with one another as before on account of the maintenance of the high mechanical compression during the paraffin-heating operation.

The function of the spring clamp, both during the execution of the process and during service, is to yield to varying lengths of the condenser caused by temperature variations, so as to exert uniformly the desired high mechanical compression and to prevent deformation of or injury to the condenser stack.

Then said parts of Fig. 9, with the condenser as always now under the high compression of its permanent spring clamp, are transferred to the apparatus of Fig. 10, wherein, as shown, more than one set of such apparatuses may be placed in tank 46 to undergo treatment in the tank simultaneously for the permanent embedding. Tank 46 is used primarily as a vacuum tank, tube 47 at the left being in communication with a vacuum pump and provided with a valve 48. The insertion of the condensers in this tank should be made immediately upon pouring off the preceding paraffin heating bath and while the stack is yet as hot as possible, and the subjection to the vacuum treatment should also be effected immediately. This vacuum should be a fairly high vacuum of the order of a few millimeters, at preferably not much higher pressure than 3 millimeters. The vacuum treatment need not be applied to the stack for more than a few minutes, because it is most effective while the stack is hot and its marginal wax is liquefied or soft, the object of the vacuum treatment being to remove air and moisture from the liquid or soft marginal wax in preparation for the process next to be effected, of enveloping the stack in hot paraffin for eventual cooling and embedment.

All this time the stack is under the above-described mechanical compression of either the leaf spring 37 of Fig. 3 or the permanent spring clamp of Fig. 6.

While the vacuum is yet applied to the condensers in the tank 46 (Fig. 10), hot paraffin for the permanent embedding is flowed in around the condenser in each casing until not only is the stack completely submerged in the paraffin, but the head 30 also (Fig. 9) on top of the casing above the stack is completely filled with the hot paraffin. The maintenance of the vacuum around the stack until the latter is submerged in the paraffin serves to prevent the entrapping of any air or gaseous vapor in any portions of the final embedding paraffin, which may be so close to the condenser as to cause electrical losses or breakdowns in service due to such air or moisture. While the hot embedding paraffin is being flowed into the exhausted space around the condenser, the air or vapor which may have been in the marginal paraffin of the condenser and which has been removed therefrom by the vacuum and attenuated and distributed through the vacuous space in the tank is prevented by the continuation of the vacuum from being concentrated or entering again into the margin wax. Thus, the inflowing paraffin from pipes 49, branching from pipe 50, connected to paraffin reservoir

51, can, upon entering the condenser casings, merge with the hot marginal condenser paraffin freed of air and moisture, the incoming paraffin having been also freed of air and moisture by heating. In some instances, a satisfactory condenser may be produced without the application of the paraffin in the above precise fashion, but when the best possible condenser is desired these processes of vacuum and filling in embedding paraffin while under vacuum are extremely important.

An equalizer pipe 63 may be connected between the wax reservoir 51 and the tank 46. Its function is to make the gas pressure on wax in reservoir 51 at all times equal to that in tank 46, the reservoir 51 being provided with an air-tight cover 65. Then, regardless of any application of vacuum (or air pressure) to tank 46, the paraffin will flow from reservoir 51 into the condenser casings in vacuum tank 46 under gravitational head only, that is, the head given by the elevation of the reservoir 51 above tank 46. Thus the paraffin may flow by gravity from reservoir 51 to the condenser casings in tank 46, irrespective of the air pressure in the latter. In equalizer pipe 63 there is placed a two-way valve 64 for the purpose of throwing the pipe 63 out of service whenever desired, valve 64 being then turned to open the reservoir 51 to the atmosphere. The other or normal position of valve 64 simply places in communication with one another the air-spaces in reservoir 51 and tank 46. (Pipe 63 need not be used, in which case cover 65 will not be needed.)

At any time after the inflowing paraffin has submerged the condenser in its casing, the vacuum treatment can be terminated by the closing of valve 48 in the tube to the vacuum pump, and by the opening of the bleeder valve 52 in the pipe at the right communicating with the outside air. However, during the paraffin filling, the remanent air or vapor which has come from the stack or incidently from the inflowing paraffin, highly expanded in the vacuous space in tank 46 on account of the greatly reduced pressure on the paraffin due to the vacuum, will have risen up through the hot paraffin in the condenser casing to points at or near its surface, where it may exist in the form of foam or froth just below the surface. Thereupon these bubbles just beneath the surface will break through the surface and disappear in the space in the tank. Therefore, it is preferable not to shut off the main paraffin valve 53 until after this froth has disappeared and, therefore, until after both the casing 29 and the head 30 are completely filled with paraffin substantially freed of air. Preferably also the valve 52 is not open to let the outside air into tank 46 until after said filling has been completed.

After main paraffin valve 53 has been closed, and before bleeder valve 52 is opened, and before paraffin has solidified in pipes 49, valve 54 is opened in pipe 50 (the end of which is open to the atmosphere), in order to cause atmospheric pressure to force paraffin remaining in pipes 49 against the reduced pressure in tank 46, for the purpose of clearing the pipes and preventing their being stopped up by cooled and solidified paraffin. The additional amount of paraffin thus flowed into the condenser casings is small, as the pipes 49 are small.

The filling with paraffin in the above manner substantially eliminates the possibility of any large bubbles of air remaining in the paraffin in casing 29 in the vicinity of the condenser, since the heat, the vacuum and the paraffin in the temporary head 30 above the condenser in its casing (Fig. 9) all co-operate to move any such air or moisture upwardly out of the paraffin in the casing and into the paraffin in the temporary head 30. If thereafter, however, the paraffin in the casing and head is left to cool in an ordinary manner, such cooling due to the shrinkage of the paraffin as its temperature is reduced and as it passes from the liquid to the solid state, will cause cavities or voids to form in the interior of the body of paraffin. Such voids result on such ordinary cooling irrespective of the filling in of the paraffin while the condenser and casing are in vacuo, and such voids may contain gas, possibly under less than atmospheric pressure, or a partial vacuum. Such voids existing in the embedding paraffin in the casing in the vicinity of the condenser are extremely objectionable as being likely to allow brush discharges and increased losses in service.

In an instance where a permanent condenser clamp is not employed, to remain permanently inside the casing 29, the apparatus which is used with the filling operation of Fig. 10 may be an apparatus similar to the apparatus shown in Fig. 3 whereof the temporary spring may act on the condenser during the filling process and the subsequent cooling process. But such a temporary clamping apparatus should be high enough to permit the reception of temporary head 30 on top of casing 29, unless the inverted filling process (to be described) be employed.

The next process is that of cooling the embedding paraffin, which is illustrated in Fig. 11. The function of temporary head 30 is to assist in causing proper cooling and prevent the formation of voids in the embedding paraffin of the casing around the condenser, thereby producing a holosteric embedment. During the process of cooling, the paraffin in the casing and head decreases largely in volume, and this contrac-

tion, in the absence of the high head 30, would result in the formation of cracks and voids in the paraffin in the upper part of the casing in the vicinity of the high potential upper end of the condenser. These voids or cracks are liable to be filled with gases or vapors entrained in the paraffin or with atmosphere drawn in from outside the paraffin. Such cracks or voids in the vicinity of the high potential end of the condenser would be liable in service to result in losses and undue heating. By means of the paraffin in the high head 30, however, there is maintained a substantial head of paraffin which bears down on the surfaces of solidification during cooling, thereby closely following up the shrinkage and at all times and places preventing formation of voids in the paraffin in the casing around the condenser, especially in the vicinity of its upper or high potential end. During the cooling, additional hot paraffin is poured into head 30 to compensate for shrinkage during cooling and solidification and to keep the head full, and this addition of hot paraffin keeps liquefied the paraffin in the upper part of the head. Of course, voids or cracks in the paraffin in the upper part of the head will be formed finally upon solidification of such paraffin, but one object of the temporary head is to provide a sufficient volume of paraffin above the permanent embedding paraffin in the casing so that all cracks or voids which are formed will be formed in the paraffin in the head and not in the permanent paraffin embedment in the casing.

As an example of the general size and proportions of the temporary head 30, it may be stated that for a condenser casing 29 about 3½ inches high and 4½ inches long by three inches wide (internal dimensions) the temporary head 30 may be of the same length and width and of at least the same height; but, as shown in Fig. 9, the head may be of greater height, and may be advantageously even higher and larger than shown. While a much shorter head than here specified will tend to prevent some of the voids in question, yet it is extremely important to employ a head of substantially the height here specified, in order to prevent voids in the paraffin around the upper or high potential end of the condenser.

Preferably, the above cooling process is so conducted as to cause the solidification to proceed from the bottom of the casing upwardly to the top of the temporary head, i. e., causing the cooling to proceed more slowly at upper parts of the paraffin in casing and head, for in this way the functions of the temporary high head are best executed. This cooling from the bottom upwardly may be effected either (1) by abstracting heat from the bottom of the embedding paraffin and without doing anything to the top paraffin, or (2) by applying heat to the top paraffin while permitting the bottom to gradually cool upwardly as by room temperature, or (3) by abstracting heat from the bottom while simultaneously applying heat to the top. Specifically, the latter is preferable for economy of time and in giving better control of the progressive cooling. In practice, the last or preferable manner is effected (Fig. 11) by cooling the bottom by an air blast from fan 67 while heating the top paraffin by means of heated copper strips 68 which extend down into the top of the paraffin in head 30. The casing 29 rests on supports 69 which raise it above a table or bench; and the blast from fan 67 is directed by a sheet metal frame 70 toward the lower part of a side of the casing 29 and the bottom between the supports 69; the upper part of frame 70 serving as a shield to prevent the air blast from contact with the upper part of casing 29 and the head 30. The copper strips 68 have their outer ends brought near together and both are heated in the flame of a Bunsen burner 71, the heat being thence conducted to the other and bent-down ends of the strip which extend down in the paraffin, those ends being separated from the head 30 by heat-insulating members 72 of felt or the like. Additional heat is imparted to the paraffin in head 30 by the hot paraffin which is added thereto from time to time to compensate for the shrinkage of the lower and cooling portions of the paraffin.

In the case of a condenser of any given dimensions to be treated by this process, the head 30, and the heating strips 68 if used, may be designed so that the entire process will be automatic in the sense that there will be no need for the addition of hot paraffin and no need of the operator reducing or discontinuing the heating by means of strips 68. (It may be stated that during the progress of the cooling and before the removal of strips 68, the operator may gradually reduce the heating by reducing the heating flame 71 at the ends of strips 68.) That is, the head 30 will be large enough to contain sufficient paraffin to provide compensation for shrinkage and to preserve a sufficient head of paraffin above the casing to prevent the formation of voids in the hardened paraffin in the top of the casing; and heating strips 68 will project just sufficiently down into the head and not too far down, so that the paraffin in the head will have been lowered below the heating strips at about the time when the paraffin in the casing has been completely solidified; and meanwhile the heating will have been progressively reduced due to the decrease of area of the heating strips in the paraffin in the head by the falling of the paraffin there-

in in compensating for shrinkage. Also, if desired, a single very large or wide head may be employed above a plurality of condensers in their casings.

The above filling and cooling processes respectively may be employed irrespective of the other described features of the processes described.

The above advantages of the embedding and cooling operations may be obtained if desired by providing an opening in the bottom of the casing (as the making a perforation or hole for the screw at the right of Fig. 12) for the inflowing of embedding paraffin, the casing (with its final cover 52 applied and connection 26 or connections made therethrough) being inverted during the filling and cooling operations, and after solidification, the bottom opening closed up as by said screw. By such an operation, one may avoid the use of the temporary head 30 (Fig. 9), for the condenser would be centered in its casing by assembly with the cover of the casing (Fig. 12), the assembled condenser and cover being applied in and to the casing. Thus, with the casing with cover applied (Fig. 12), but inverted during filling under vacuum and solidification, and the high potential terminal-end of the condenser (top Fig. 12) lying in what is temporarily the bottom of the container of liquid paraffin but which is normally and actually the upper part of casing 29, the paraffin begins to cool at the temporary bottom and around the high potential end of the condenser, and the paraffin thereabove bears down on the upwardly extending surfaces of solidification, thereby preventing the formation of voids or cracks near the high potential end; and any cracks or voids in the paraffin near the low potential end of the condenser would be relatively innocuous. Also the paraffin by this method is caused to adhere to the inside surface of the cover 52 of the casing, as the result of being applied thereto when hot and molten.

If desired, an air or gas pressure of substantial amount (say 150 pounds per square inch, as distinguished from atmospheric pressure) may be applied to the top of the embedding paraffin during the cooling process; the apparatus in such case being placed in tank 46 of Fig. 10 and the air pressure applied by means of air valve 52 from a suitable air compressor.

If desired, one or a number of condensers (each in its permanent casing and clamped) may be placed in the bottom of a very large tank filled with molten embedding paraffin to a considerable height so that a large head of molten paraffin is located above the condensers; and then the mass of wax solidified and the various condensers separated from the mass and all the wax removed from each save that inside the casing around the stack. For convenience, such large tank may have its sides detachable to facilitate the removal of the condensers from the mass of hardened wax. This modification obviates the placing of a waxing head on each casing.

After solidification is completed, by any equivalent process of filling and cooling, head 30 (Figs. 11 and 9) is removed from casing 29 and from the paraffin body above the casing, this removal being readily permitted (on account of the tapered internal annular surfaces of the head), upon the application of a gas flame to the outside of the walls of the head. Then, by means of a long knife, the paraffin body above the casing is cut and chipped off and then pared and shaped to a level with the top of the casing. The device is now completed save for the application of a suitable cover 52 (Figs. 6 and 12) of insulating material such as fiber, bakelite or the like. This cover has a central opening for the threaded condenser terminal 26 and a lower recess for the nut 34 and rubber washer 35. When the cover is put in place and secured to casing 29 by screws 53 (Fig. 12), a nut 55 is then threaded on the terminal 26. Terminal 26 is one terminal of the condenser and may be the high potential terminal; and the other or low potential terminal may be the casing 29 when that is of metal, the bottom section of the condenser being electrically connected to the casing as shown in Figs. 6 or 11; the foil ends of the condenser being soldered to a strip lead which is screwed to casing 29 by a screw inside the casing.

In instances where the filling and cooling processes have been operated on the condenser without a permanent small spring clamp on the stack but with a temporary external clamp as in Fig. 3 (as above referred to), the temporary clamp is removed before the removal of temporary head 30 in order to permit such latter removal. Also, in such instances, the condenser may be kept permanently under compression in its casing by any suitable means whereby pressure is exerted by way of the cover. This, however, is undesirable electrically and mechanically; for electrical reasons, the cover in any instance is preferably of insulating material, and there is no insulating material satisfactory for maintaining such high compression as is desirable to be maintained on the condenser hereof.

When a permanent condenser clamp is used, it is not so important that the foil sheets be non-resilient, for such clamp at a sufficiently early stage in the process will serve to maintain the desired intimacy of contact between mica and foil sheets, which prevents entrance of everything foreign between the sheets. And even when a permanent condenser clamp be not used, the foil sheets may have some degree of resili-

ency without resulting in breaking down the hermetical sealing by the marginal paraffin, especially if the stack in the early stages of the process have a sufficient thickness of marginal sheath (laterally with respect to the stack), to prevent expansion of the stack, and this may be obtained if necessary by suitable dipping of the stack in the paraffin bath for the purpose of obtaining such substantial thickness of the marginal paraffin.

Whenever compression or clamps are referred to herein, such compression is to be be understood to be preferably the highest mechanical compression which is practicable to be applied on the soft lead-foil sheets, and this in practice is about 1,000 pounds or more per square inch of the active area of each mica sheet, i. e., that part of the mica sheet which lies between the overlapping foil sheets, this being a pressure which amounts to about a ton or more on the entire end surface of an ordinary condenser 3″ high by 2″ long by 1½″ wide.

When the word paraffin is used in the claims, it is intended as applying to any material which is the substantial equivalent of the paraffin-carnauba mixture preferred herein.

As to the limitation to sheets of mica, it is to be understood that this does not exclude other materials which might be found to be equivalent within the invention, as to the valuable properties of mica for this purpose involving its low dielectric losses, high dielectric strength and its ability to be formed into thin sheets of sufficient mechanical strength for my processes.

I claim:—

1. That improvement in the process of enclosing a sheet condenser in a body of wax which consists in placing it in a receptacle substantially higher than the condenser, filling the receptacle with melted wax to a point substantially above the top of the condenser, supplying heat by means independent of the receptacle to the upper part of said body of wax, and cooling the receptacle to cause the wax to harden gradually from the bottom upwardly.

2. In the art of making mica sheet condensers, the improvement comprising forming a holosteric embedment around the stack of sheets, of an insulating material which shrinks upon solidification at ordinary temperatures, said improvement consisting in surrounding such stack with the insulating material in hot fluid condition to a point substantially above the stack itself, thereby providing a fluid head on the portion of the fluid material which surrounds the stack; causing the sheets of the stack to be held together under high mechanical compression to prevent the fluid surrounding the stack from being forced into it by the fluid head above such surrounding fluid; and, while said fluid head and mechanical compression are maintained, supplying heat to the fluid head and maintaining it in its fluid state until the solidification of the insulating material which surrounds the stack.

3. That improvement in the process of supplying a wax filler to a casing containing a condenser or the like which consists in fitting a hollow extension to the top of the casing, exhausting said casing and extension, filling said casing and extension with melted wax while they are maintained in an exhausted condition and thereby submerging the condenser for a substantial distance below the surface of the wax, utilizing one or more metal strips to conduct heat into the body of the wax in said extension without heating the casing, cooling the casing to harden the wax gradually from the bottom upwardly, continuing the cooling operation until the wax has hardened to a point above the top of the casing, thereafter allowing the wax in said extension to harden, and then removing said extension and cutting off the wax above the top of the casing.

4. The process of solidifying a mass of molten wax-like material which consists in cooling the mass at the bottom and supplying heat directly to the interior of the mass at the top until the lower portion of the mass has solidified.

5. The process of cooling a mass of molten wax-like material surrounding a condenser stack, which consists in cooling the mass at the bottom and supplying heat directly to the interior of the mass at the top until the lower portion of the mass has solidified.

6. In an apparatus for embedding an electrical condenser in its casing, an insulating material which is fluid when hot and put in place and shrinks on solidification at ordinary temperatures, the combination with a casing for the condenser and such surrounding insulating material, of a casing-extension detachably secured to the top of said casing, said casing having a top opening, and said casing-extension having a hollow interior of considerable height above the casing and communicating with the space inside the casing around the condenser therein, said casing extension having a top opening and being tapered from the top outwardly and downwardly toward the walls of the casing.

7. In an apparatus for embedding an electrical condenser in an insulating material which is fluid when hot and put in place and shirks on solidification at ordinary temperatures, the combination with a casing for the condenser and such insulating material, of a casing-extension detachably mounted on the top of said casing, said casing having an open top and communicat-

ing with the interior of the extension, said extension having a hollow interior substantially as high above the casing as the height of the casing itself and having an upper inlet opening.

8. In an apparatus for use in filling a condenser casing with wax-like material, a casing extension adapted to be detachably applied to one end of the condenser casing, and heat conducting means extending from outside into the interior of said casing extension from the outside.

9. In the art of making mica condensers, the improvement comprising forming a holosteric embedment around the stack of condenser sheets, of an insulating material which shrinks upon solidification at ordinary temperatures, said improvement consisting in surounding the stack while standing on one end in a receptacle, with such insulating material in hot fluid condition. and increasing the height of such fluid to a point which is substantially as high above the upper end of the stack as the length of the stack itself, thereby providing a fluid head of the material above the like material around the stack in the receptacle; holding the sheets of the stack together under high mechanical compression while the stack is so surrounded by the fluid material and while such fluid head is maintained, thereby preventing entrance of the fluid into the stack; and maintaining said conditions of the stack and fluid head until the solidification of the fluid around the stack, thereby preventing the formation of cracks or voids in the embedment around the sides of the stack.

10. In the art of making mica condensers, the improvement comprising forming a holosteric embedment around the stack of condenser sheets, of an insulating material which shrinks upon solidification at ordinary temperatures, said improvement consisting of standing the stack on one end on the inside of the bottom of a receptacle which is substantially higher than the stack; surrounding the stack with such insulating material in hot fluid condition up to a point substantially above the upper end of the stack and providing a fluid head of the fluid material above the fluid around the sides of the stack, such head being insufficient to force such fluid material between the sheets of the stack; and then converting the fluid material around the stack into a solid embedment, by supplying heat to the upper portion of the fluid, i. e., the fluid head, until the fluid around the sides of the stack has solidified, and thereby preventing the formation of cracks or voids.

11. In the art of embedding mica condenser stacks in wax-like insulating material, the improvement in producing a holosteric embedment without permitting entrance of the insulating material when fluid between the sheets of the stack, which consists in maintaining a fluid head of the insulating material above a body of similar material around the sides of the stack, during solidification of the insulating material around the stack, and while the sheets of the stack are held together sufficiently closely to prevent entrance between the sheets of the insulating material around the stack prior to solidification thereof.

12. In the art of making electrical condensers which comprise a stack of dielectric and conducting sheets, the improvement in producing a holosteric embedment around such stack, of an insulating material which shrinks upon solidification, said improvement consisting in immersing the stack in a body of such insulating material in hot fluid condition; and, while permitting said fluid body to cool and solidify, preventing the formation, by shrinkage, of cracks or voids therein, by maintaining a fluid head of such insulating material above the fluid body to be solidified, while the sheets of the stack are held close together preventing the fluid head from forcing the fluid insulating material between the sheets.

13. In the art of embedding mica sheet condensers in fluid insulating material which shrinks substantially upon solidification at ordinary temperatures, the improvement which consists in maintaining upon the insulating embedment in hot fluid form around the stack and until its solidification, a sufficient fluid head of similar insulating material to prevent the formation of cracks or voids which tend to form in the embedding material during its solidification; and meanwhile preventing the entrance of the fluid embedding material between the sheets of the stack under pressure of the fluid head by holding the sheets of the stack together.

14. In the art of making mica sheet condensers, the improvement comprising forming a holosteric insulating embedment around the mica condenser stack, which consists in surrounding such stack with hot fluid insulating material which solidifies and shrinks at ordinary temperatures; causing the sheets of such stack to be held together while it is surrounded by the hot fluid material and thereby preventing entrance of the latter between the sheets and into the stack; and, while said surrounding material is solidifying around the stack, maintaining on it a fluid head of similar insulating material of sufficient height to prevent the formation of cracks or voids in the solid embedment around the stack; the sheets of the stack being held together during the progress of solidification, with sufficient closeness to prevent unsolidified surround-

ing material from being forced between said sheets by the pressure of said fluid head.

15. In the art of making mica stack condensers, the improvement in forming a holosteric embedment around the stack, of insulating material which shrinks on solidification at ordinary temperatures, said improvement consisting in maintaining high mechanical compression on the stack, while subjecting it when hot to a vacuum, and while surrounding it with such insulating material in hot fluid condition; and then maintaining a fluid head of similar insulating material on said stack-surrounding material while such compression of the stack is maintained; said fluid head being maintained at sufficient height to prevent the formation of cracks or voids in said surrounding material, and said fluid head being maintained until the solidification of the stack-surrounding material.

In testimony whereof I have signed my name to this specification.

BYRON MACPHERSON.