Sept. 22, 1931. W. M. BAILEY 1,824,530

ELECTRICAL CONDENSER

Original Filed May 27, 1924

Fig. 1.

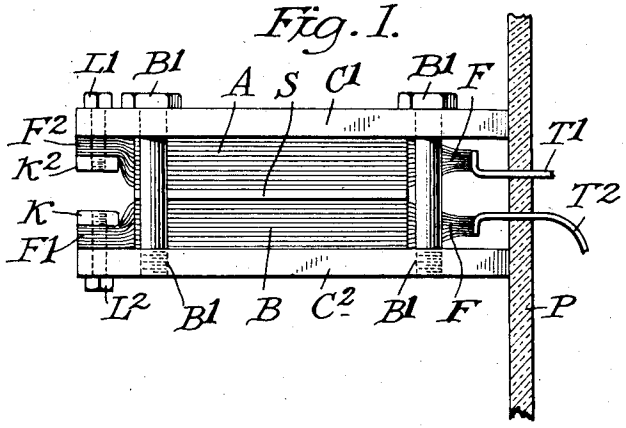
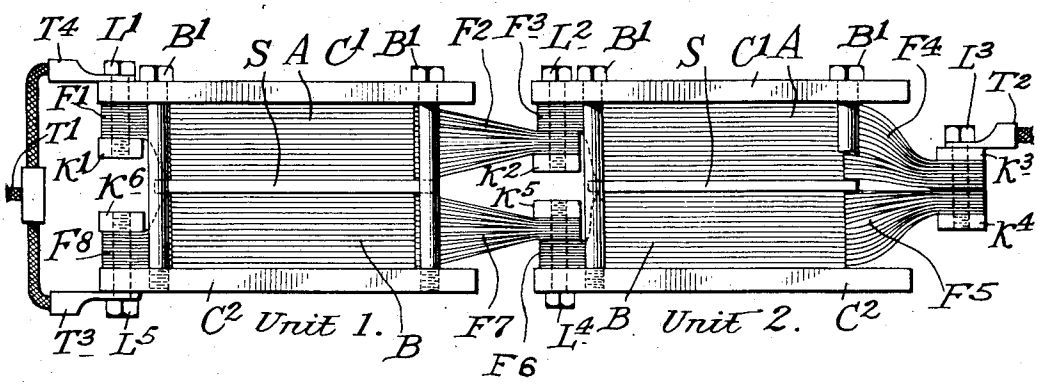


Fig. 2



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Patented Sept. 22, 1931

1,824,530

UNITED STATES PATENT OFFICE

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ELECTRICAL CONDENSER

Original application filed May 27, 1924, Serial No. 716,107. Divided and this application filed March 30, 1926. Serial No. 98,413. Renewed April 6, 1931.

This application is a division of my application Serial No. 716,107, filed May 27, 1924.

This invention relates to improvements in electrical condensers, particularly of the type wherein sheets of dielectric and conducting foils are built up in a stack, the dielectric sheets being preferably at present of mica.

The invention relates more particularly to condensers designed to carry high currents of, say, ten amperes more or less and upwardly to hundreds of amperes; although certain structures embodying the invention are useful also for high potential service whether or not large currents be used. The invention is particularly useful with alternating currents of high amperage and high frequencies such as radio frequencies, as well as for high potentials.

Heretofore in condensers of the foil-stack type, in designing the same for use with currents of more than a few amperes, it has been necessary to increase greatly the number of dielectric sheets, for the sole purpose of preventing serious over-heating of the condenser by such high currents. Inasmuch as good quality dielectric sheets for condenser work, such as good quality of the preferred mica sheets, is very expensive (i. e., many times more expensive than metal), and inasmuch as the amount of mica necessary to prevent over-heating by the high currents increases very rapidly with the amperage employed, the cost in mica for such high current mica-and-foil condensers has been very high heretofore. The reason why the use of a much larger quantity of dielectric sheets resulted in preventing undue heating of the condenser by high currents was the consequent reduction of current per sheet and therefore the reduction of the watt loss per sheet, the total watt loss being distributed throughout the increased number of sheets, thereby providing a larger dissipating surface of the stack, i e., such surfaces comprising the edges of the mica sheets in the stack. In order to maintain the originally desired capacity of the condenser when thus increasing the number of dielectric sheets, it was usually necessary to divide the stack into several serially-connected sections whereby the voltage per section was reduced and whereby also were reduced the losses due to brushing resulting from high voltage. The greater part of the increase in dielectric sheets to prevent over-heating by high currents was due to such series-sectional construction.

The principal and important object of the invention is to reduce the quantity of dielectric, such as mica, in condensers designed for high current duty. Other minor but valuable objects and results will be disclosed in connection with the drawings.

The invention consists, among other things, of a foil-stack condenser construction or its equivalent, wherein the heat developed by the high alternating currents used is so efficiently conducted away from the stack by means to be described as to make it unnecessary to increase the number of dielectric sheets (quantity of mica) for the purpose of causing a lower heat generation per sheet. In a certain sense, the invention involves to a certain extent the substitution of masses of metal constituting heat-absorbing, heat-conducting and heat-dissipating means, in lieu of the addition of much more expensive dielectric sheets.

Of the drawings,

Fig. 1 is a side elevation of an embodiment of the invention, and

Fig. 2 is a side elevation of a modification.

In Fig. 1 is shown a clamped unit of the invention wherein is a stack comprising two electrical sections or units A, B connected in series by the clamping and compressing means, the adjacent faces of these two stack-sections being separated from one another by insulating sheet S. The main body of alternating foils and micas is clamped between metal compression members C1 and C2 by four tension members as corner bolts B1; also projecting foil-bunch F1 (Fig. 1) of the stack-distributed foils is clamped to lower member C2 by auxiliary compression member K1 and two bolts or tension members L2; and projecting foil-bunch F2 is clamped to upper member C1 by auxiliary compression member K2 and two bolts L1. But the two clamped foil-bunches F1, F2 of Fig. 1 and their auxiliary clamps K and bolts L, are lo-

cated at the same side (left) of the unit, there are no insulating bushings between upper clamp member C1 and bolts B1, said bolts B1 acting as electrical connections between C1 and C2 so that the clamping means as a whole seems to electrically connect stack sections A and B together (said sections being separated from one another by insulating sheet S). The two terminals T1, T2 of this two-section clamped unit (soldered to the foil-bunches at the right instead of being connected to the clamping members) both extend from the same side thereof, this clamped unit, if desired, being supported on a rack P, or terminal-board or panel. This provides a strong construction of the terminal connections. The clamped two-section unit of Fig 1 may be pluralized in any desired manner in a stack, if desired. All the clamping members of this unit of Fig. 1, however, are at the same potential, which is that of the midpoint between oppositely-poled terminals T1, T2.

The drawings are diagrammatic in the sense that the stack-sheets are shown as separated for clearness, so that the thickness and external area of each stack are greatly exaggerated.

In Fig. 2, two unit embodiments of the invention, unit 1 and unit 2, are combined end to end in a condenser in a manner as distinguished from assembly face to face in a stack. In Fig. 2, each of the two units 1 and 2 is similar (including insulating separator S) to the two-section stack-clamped unit of Fig. 1.

In the assembly (Fig. 2) of such double section stack in the clamping members, there are three features whereby the two sections A, A of the respective units are connected in series with one another, and the two sections B, B in series with one another, but sections A, A are connected in parallel with sections B, B. First, at the left, circuit terminal T4 is clamped as shown together with foil-bunch F1 and upper stack-clamp C1; and circuit terminal T3 is clamped as shown together with foil-bunch F8 and lower stack-clamp C2. Second, at the right, foil-bunches F4, F5 are clamped together and to a heat-absorbing mass of metal K4, which may be provided with heat-dissipating vanes, fins or the like, not shown. And, third, where the two clamped units are electrically connected together, they are thermally connected by clamping to stack-clamps C1, C2 of unit 2, by the arrangement shown wherein foil-bunches F2 and F3 are clamped together and to stack-clamp C1, and foil-bunches F6, F7 are clamped together and to stack-clamp C2. By this construction, the foil-bunch terminal of one clamped unit is clamped directly to the foil-bunch terminal of an adjacent clamped unit.

In the above-described electrical arrangement of Fig. 2, T1 (at the extreme left) and T2 (at the extreme right) are the circuit terminals of the entire condenser comprising sections A, A, B, B, i. e., clamping units 1 and 2; but, all four stack-sections of the two independently-clamped double-section units 1 and 2 (located alongside one another as in Fig. 2) may be connected successively in series by using terminals T3, T4 at the left of unit 1 as the two circuit terminals (not using T1 or T2 as circuit terminals or the connections shown between terminals T3 and T4) and inserting insulating bushings between clamp C1 and bolts B1, in both units 1 and 2 of Fig. 2.

In general, condensers embodying this invention are designed for moderate to high capacity of each clamped unit, .005 to .2 microfarad being obtained readily. With such range of capacity, almost any relation of capacity, voltage and current may be obtained by employing a plurality of units in various relations of series, parallel, or series-parallel.

The following has been a practical result of placing the distributed projecting foil-bunches in heat-conducting relation with one or more heat-dissipators of the below-specified order of exposed area. It has proven to be practicable to construct foil-stack condensers for high current duty with the same quantity of mica as for low current duty, and this whether the stack have only one or a plurality of sections. That is, by positively removing from the stack, via the foil-bunches and the heat-dissipaters, the heat developed in the stack by the use of high currents, there is obviated all need of increasing the quantity of mica for the purpose of ridding the stack of the heat so developed. And while, with the invention, some mica may be added to assist in removing heat from the stack, the need of the same is removed in proportion to the efficiency of application of this invention. Prior to the use of said invention, the use of high currents required each section of a series-sectional stack to contain additional sheets of mica (more than was needed to obtain a desired capacity), in order to avoid over-heating by such currents, and in order to maintain a given desired capacity for the condenser it was necessary to divide the stack into serially-connected sections (or to increase the number of sections in a stack already comprising several series sections) when the number of sheets of mica in each original section was increased to prevent over-heating. Hence the quantity of mica for a condenser of given capacity was greatly increased, due to the additional sheets in each section and to the additional sheets due to the addition of sections, so that a condenser for high current duty had very much more mica and a longer stack than a condenser for a low current duty but of the same capacity. By this invention, the number of sheets of

mica in a condenser of given capacity can be kept substantially the same (for high or low current duty) whether the stack consists of a single section or of a plurality of sections connected in series. But the length of a stack provided with the invention (whether in a single section or a plurality of sections) is not necessarily less than that of a stack adapted by increase of mica to run without excessive heating under high current duty; because when the metal clamps for the condenser stack units are employed as in the invention, as the heat removing means via the projecting foil bunches, the metal of such clamps occupies more or less the same order of stack-length as when extra micas were employed for heat-distribution being sometimes much greater due to the dissipating vanes. In effect, therefore, the invention involves the substitution of metal for mica, the metal being very much cheaper. Various other advantages of the invention and of its various forms of embodiment have been specified above.

The efficiency of the invention in removing heat from a stack with which currents of very high amperage are employed may be dependent upon the efficiency of dissipation of heat from the metal masses which extract heat from the stack via the bunches of stack-distributed foils. That is, the maintenance of efficiency in continuously maintaining the conduction of heat from the interior of the stack at a desirably low stack-temperature, is dependent upon the continuous maintenance of heat-dissipation from the heat-extracting metal masses.

The following general instructions are given for the guidance of the designer or constructor, relative to this important matter of exposed area of the heat-dissipating means of the invention. This is for condensers of various designs, and condensers for various services as to amperage, frequencies and potential, in which the stack-generated heat may vary within wide limits. This is on the premise that the heat-dissipators are the stack-clamps substantially enclosing the stack and thermally connected via the foils to the dielectric sheets distributed through the stack; and that substantially sole reliance is placed on the exposed surfaces of the clamps for the removal of heat from the stack at the desirable low temperature thereof, it being kept in mind that a higher stack-temperature may be permitted by this invention on account of the permissive and preferred elimination of the previously customary paraffin embedment of the stack for high potential service. It should be noted that as the volume of the stack is increased (mica added for any reason), the exposed areas of heat-dissipation should be increased at a more rapid rate than the increase in external stack area correpsonding to the increased stack volume. The object of the designer of a given condenser for desired conditions of service is to ensure the removal of all stack-generated heat without permitting the temperature of the stack to rise above a given upper limit. Therefore in designing a given condenser to embody the invention for given service, there will be calculated the amount of heat generated in the stack per unit of time, and the definite rate at which heat must be removed from the stack without "blowing" the stack or exceeding the upper limit of stack temperature. Since the invention provides adequate means of removing most rapidly from the interior of the stack, the heat generated therein, provided that after being so removed it is dissipated from the removing means, therefore the designer is concerned only in making sure to provide sufficient exposed area of the heat-dissipator in good thermal connection with the distributed foils. The designer therefore will provide such area sufficient to dissipate the removed heat at the rate at which he has calculated that it will be generated in the stack. And while, in general, such area exposed to the cooling medium will be of substantially a greater general order of magnitude than the exterior area of the stack itself, yet it will vary within wide limits in various designs, on account of the several variables specified hereinbefore, including of course the kind of service and the amperage, frequency and potential to which the condenser is to be subjected. Within such wide limits there is provided a control by the designer of the stack temperature which it may be desired to maintain. The area of the heat-dissipating means which is exposed to the cooling medium and thermally connected to the specified foils is, in any instance, that which causes dissipation of the heat generated inside the stack at the desired low stack-temperature, depending on the nature of the cooling medium, i. e., whether it is still air, a forced draft or a liquid circulation; and, of course, depending on the conditions of service, as to potential, amperage and frequency; this referring to the area of the heat-dissipating projections or fins or vanes, if and when they are employed as they preferably will be, especially when still air is the cooling medium.

I particularly point out and distinctly claim the part, improvement, or combination which I claim as my invention or discovery, as follows:—

1. The improvement in preventing undesirable temperature rise in the interior of a foil-stack electrical condenser, which includes means dividing the stack electrically into two units, each comprising foil-armatures in inductive relation to one another; two terminals insulated from one another; foil-projections from the two stack-units and

electrically connected with said insulated terminals; metal stack-clamping means constituting a unitary electrical conductor and having a substantial area exposed from the stack for heat-dissipation, said clamping means including metal compression members engaging and covering substantially the entire areas of the end faces of the stack, and including metal tension members mechanically and electrically connecting said compression members together; and foil-projections from foils in both stack-units in direct thermal connection with said heat-dissipating clamping means, whereby the metal of said clamping means constitutes the electrical connection of the foil-armatures on one side of said dividing means with the foil-armatures lying on the other side of said dividing means.

2. The improvement in preventing undesirable temperature rise in the interior of a sheet-stack condenser, which includes a plurality of stacks each as follows, i. e., means dividing the stack electrically into two stack-units, none of the armature sheets in one of such units being directly connected with any of the armature sheets of the other unit; stack-clamping means extending over substantially the entire area of the two end faces of the stack and having substantial area exposed from the stack for heat-dissipation; armature-sheet-projections from both sides of each stack-unit, two of such projections being in direct metallic thermal engagement with the heat-dissipating clamping means; such duplicate stacks being located alongside one another; and the two armature-sheet-projections in one of said duplicate stacks not connected to the stack clamping members thereof, being in direct thermal engagement with the two armature-sheet-projections in the next of the duplicate stacks which are in thermal engagement with the clamping means thereof.

3. The improvement in preventing undesirable temperature rise in the interior of a sheet-stack of an electrical condenser, which includes means dividing the stack into two units whose armature sheets are mechanically separate and electrically connected; two terminals insulated from one another, but electrically connected with armature sheets respectively in the two stack-units; integral armature-sheet-projections from armature-sheets in the two stack-units which are in inductive relation with the armature sheets connected to said terminal; metal stack-compressing members respectively in clamping engagement with substantially the entire end-faces of the stack, said compressing members having substantial areas exposed from the stack for heat-dissipation; and metal tension means mechanically and electrically connecting said compression members together and constituting the entire clamping means as an electrically conducting unit; said integral armature-sheet-projections from one of the two stack-units being in direct metallic thermal engagement with one of said heat-dissipating compression members, and said integral armature-sheet projections from the other stack-unit being in direct metallic thermal engagement with the other heat-dissipating compression member; said clamping means, as an electrically conducting unit, constituting the series connection of the armature-sheet on one side of said dividing means, with the armature sheets on the other side of said dividing means.

4. The improvement in preventing undesirable temperature rise in the interior of a sheet-stack of an electrical condenser, which includes means dividing the stack into two units not electrically directly connected with one another by way of their armature sheets; two terminals insulated from one another but electrically connected with armature-sheets respectively in the two stack-units and projecting from the same side of the stack; two bunches of integral armature-sheet-projections extending respectively from armature-sheets in the two stack-units and all extending from the same side of the stack but from a side other than the side at which said terminals are located; metal stack-compressing members respectively in clamping engagement with substantially the entire end-faces of the stack, said compressing members having substantial areas exposed from the stack for heat-dissipation; and metal tension means mechanically and electrically connecting said compression members together and constituting the entire clamping means as an electrically conducting unit; said bunch of integral armature-sheet-projections from one of the two stack-units being in direct metallic thermal engagement with one of said heat-dissipating compression members, and said bunch of integral armature sheet-projections from the other stack-unit being in direct metallic thermal engagement with the other heat-dissipating-compression member; said clamping means, as an electrically conducting unit, constituting a connection between said two stack-units.

5. The improvement in preventing undesirable temperature rise in the interior of a sheet-stack condenser, which includes means dividing the stack electrically into two units, the armature sheets in one unit being mechanically separate from the armatures in the other unit; stack-clamping means including two electrically connected compression members respectively extending over substantially the entire area of the end faces of the stack, and having substantial areas exposed from the stack for heat-dissipation; and armature-sheet-projections from armature sheets in the two stack-units and in direct metallic thermal engagement with said compression members, whereby heat is conducted

via the armature sheet-projections directly to the heat-dissipating clamping means from each stack-unit without passing thru the other stack-unit; said clamping means constituting the electrical connection between the two stack-units.

6. The improvement in preventing undesirable temperature rise in the interior of an electrical condenser stack, which includes means dividing the stack electrically into two units; metal heat-dissipating means having a substantial area exposed from the stack; and armature-projections from both of said stack-units and in direct thermal engagement with said metal heat-dissipating means, said heat-dissipating means connecting the stack-units to one another.

7. The improvement in preventing undesirable temperature rise in the interior of an electrical condenser stack, which includes means dividing the stack electrically into two units; metal stack-clamping means including compression members in clamping engagement with the end faces of the stack, and including metal tension members electrically connecting together the two compression-members, said compression members having substantial heat-dissipating areas exposed from the stack; an armature-projection from one stack-unit and thermally connected with the compression members adjacent the unit; and an armature-projection from the other stack-unit and thermally connected with the compression member adjacent that unit; the stack-clamping means connecting the two stack-units electrically to one another.

8. The improvement in preventing undesirable temperature rise in the interior of an electrical condenser stack, which includes means dividing the stack electrically into two units; metal stack clamping means including compression members in clamping engagement with the end faces of the stack, and including metal tension members thermally connecting the two compression members together, said compression members having substantial heat-dissipating areas exposed from the stack; and armature-projections from both the stack-units and thermally directly engaging a portion of the exposed area of the stack-clamping means whereby the metal thereof connects the two stack-units electrically together.

9. The improvement in preventing undesirable temperature rise in the interior of an electrical condenser stack, which includes means dividing the stack electrically into two units; metal stack-clamping means including compression members in clamping engagement with the end faces of the stack, and including metal tension members thermally connecting the two compression members together, said compression members having substantial heat-dissipating areas exposed from the stack; armature-projections from both the stack-units; and means clamping said armature-projections directly in thermal engagement with a portion of the exposed area of said compression members, whereby said members cooperate with one another in dissipating heat from both stack-units, said stack-units being thermally connected in series with one another by way of said compression members.

10. The improvement in preventing undesirable temperature rise in the interior of an electrical condenser stack, which includes means dividing the stack electrically into two units; metal means clamping the stack, constituting a unitary electrically conducting structure, and having substantial heat-dissipating area exposed from the stack; and armature-projections from both stack-units in direct thermal engagement with a portion of said heat-dissipating area; and terminals insulated from one another and connected to the other armatures of the two stack-units; all whereby the heat-dissipating clamping means constitutes the only electrical connection between armatures on one side of said dividing means and the armatures on the other side of said dividing means.

11. The improvement in preventing undesirable temperature rise in the interior of an electrical condenser stack, which includes means dividing the stack electrically into two units having no direct electrical connection with one another, armature-projections from the respective units being connected respectively to terminals insulated from one another; and metal heat-dissipating means having a substantial area exposed from the stack; the armature-projections from the stack which are in inductive relation to said terminal-connected armatures, having direct thermal engagement with a portion of the exposed surface of said metal heat-dissipating means, whereby the metal of said means constitutes the electrical connection between the armatures on one side of said dividing means with the armatures on the other side of said dividing means.

12. The improvement in preventing undesirable temperature rise in the interior of a foil-armature condenser-stack, which includes means dividing the stack electrically into two units; metal heat-dissipating means having a substantial area exposed from the stack; two terminals insulated from one another; foil-projections from the two stack-units and electrically connected to said insulated terminals; and means clamping in thermal engagement with a portion of the exposed surface of said heat-dissipating means, foil-projections from the foil-armatures of the two stacks which are in inductive relation with said terminal-connected armatures

of the two stack-units; whereby the metal of the heat-dissipating means constitutes the electrical connection of the armatures on one side of said dividing means, with the armatures on the other side of said dividing means.

13. The improvement in preventing undesirable temperature rise in the interior of a condenser-stack, which includes means dividing the stack electrically into two units; metal stack-clamping means having a substantial area exposed from the stack for heat-dissipation; two terminals insulated from one another; armature projections from the stack-units and electrically connected with said insulated terminals; and means clamping in thermal engagement with a portion of the exposed area of said stack-clamping means, the armatures of the two stack-units which are in inductive relation with said terminal-connected armatures of the two stack-units; whereby the metal of the stack-clamping means constitutes the electrical connection of the armatures on one side of said dividing means, with the armatures on the other side of said dividing means.

In testimony whereof I hereunto affix my signature.

WILLIAM M. BAILEY.