Jan. 5, 1932. R. D. DUNCAN, JR 1,839,301

POLYPHASE FILTER CIRCUITS

Filed May 7, 1927 2 Sheets-Sheet 1

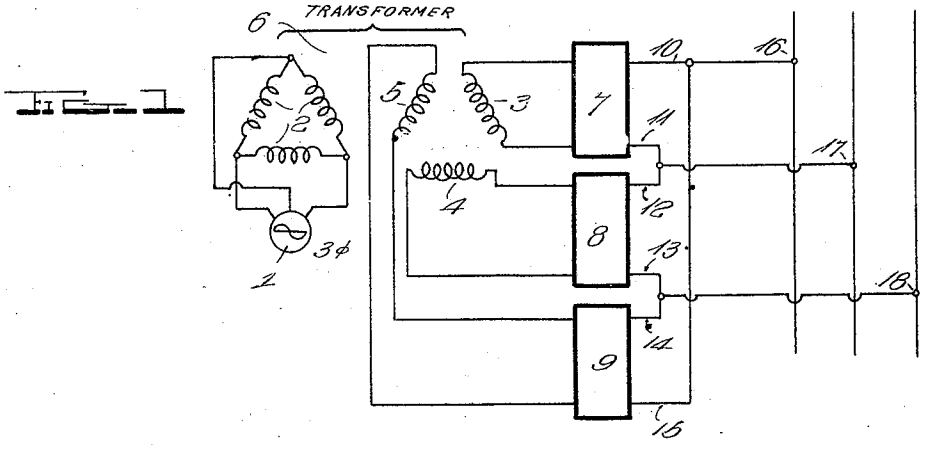


FIG. 1

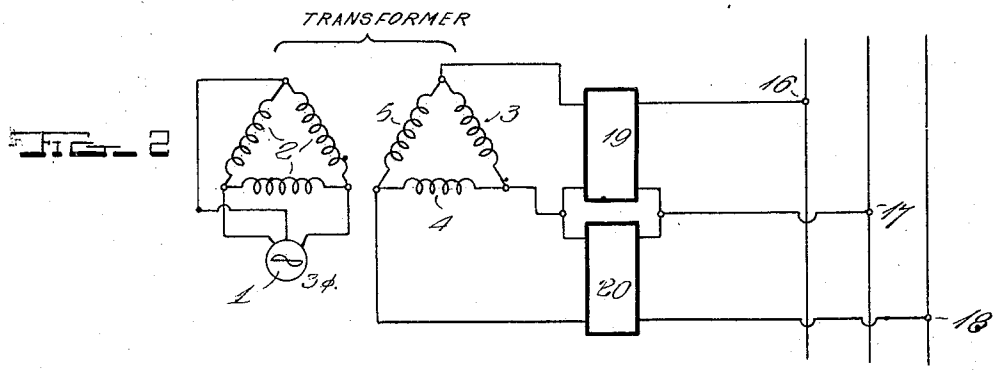


FIG. 2

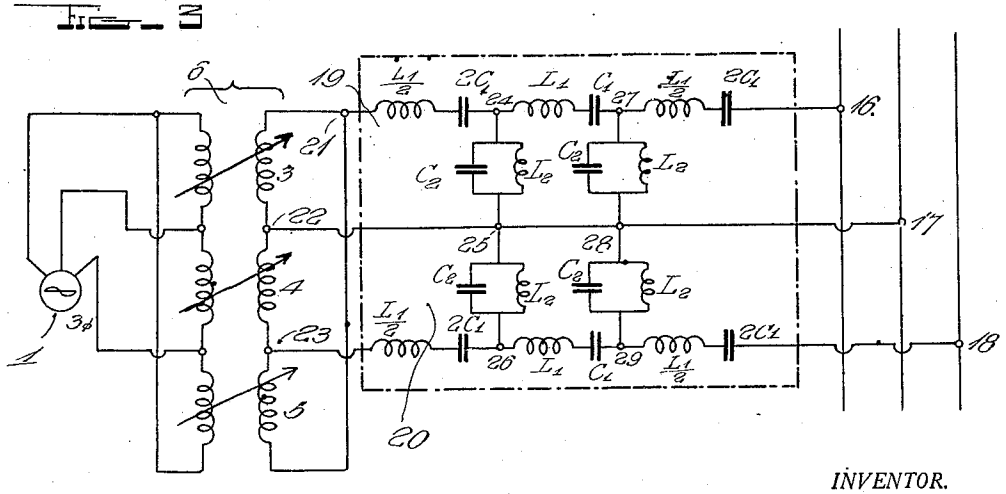


FIG. 3

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FIG. 4

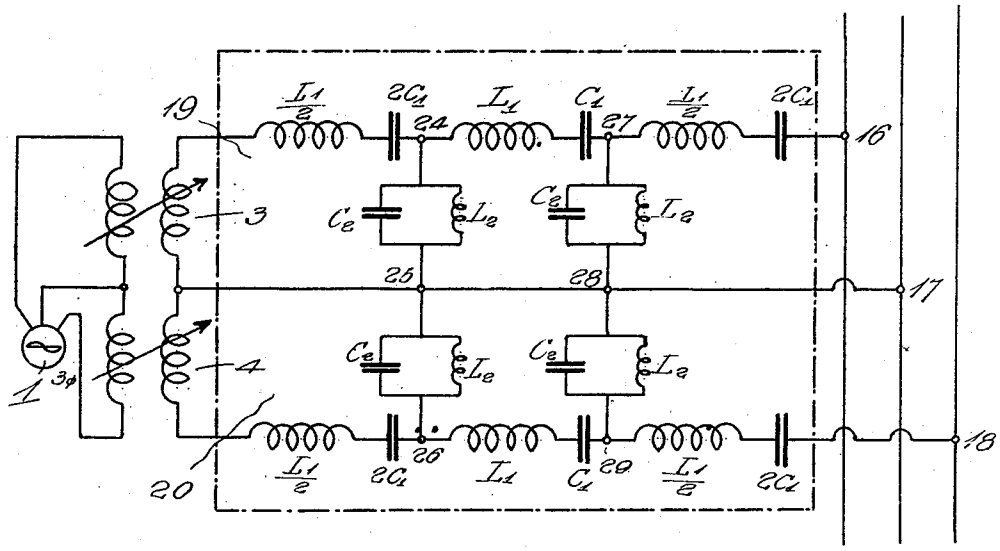
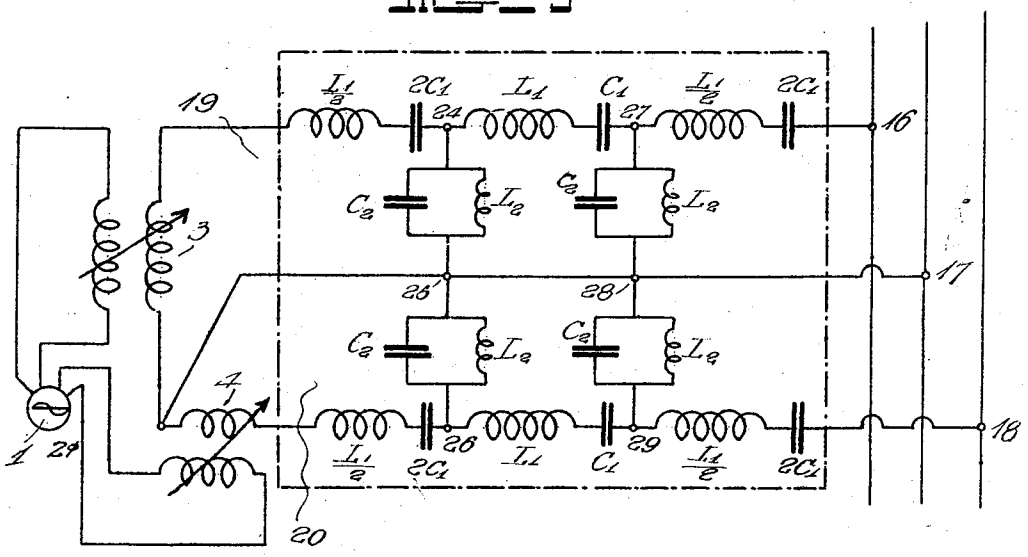


FIG. 5



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Patented Jan. 5, 1932 1,839,301

UNITED STATES PATENT OFFICE

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POLYPHASE FILTER CIRCUIT

Application filed May 7, 1927. Serial No. 189,692.

My invention relates broadly to wired radio broadcasting systems and more particularly to polyphase high frequency systems of wired radio broadcasting.

One of the objects of my invention is to provide a filter circuit arrangement for the polyphase currents which are superimposed on a wire net work for the broadcasting of signaling energy.

Another object of my invention is to provide a three phase filter system or wired radio broadcasting circuits.

I have described my invention in the following specification by reference to the accompanying drawings in which:

Figure 1 shows a typical circuit arrangement for a polyphase wired radio transmission system in which the circuits of my invention are employed;

Fig. 2 shows a modified arrangement of polyphase transmission circuits;

Fig. 3 illustrates the application of the polyphase filter circuit of my invention to a polyphase transmission system;

Fig. 4 shows the connection of a polyphase filter system according to my invention in an open delta circuit and

Fig. 5 shows a three wire two phase system employing the filter circuits of my invention.

A band frequency filter consists of a succession of inductive and capacity elements so interconnected that when interposed between a source of alternating current and the load in which energy is to be expended, it will highly attenuate currents of certain frequencies but will pass with practically zero attenuation currents of other frequencies.

The use of filters in the fields of telephony and telegraphy is well established; this is also true to a limited extent for the case of high frequency in both space and wired radio where single phase alternating currents are dealt with. However, in wired radio broadcasting, or in general where polyphase high frequency currents are employed the use of filters presents a number of new problems. My present invention discloses different circuit arrangement which incorporate new and advantageous features, for the solution of such problems.

There are a large number of different types of filter circuits having different attenuation characteristics. They are all characterized however by the common feature that regardless of the type of filter there are four terminals, two input and two output.

The design of filters to meet specified attenuating and load conditions is complicated and it will suffice to here record that three of the fundamental elements entering the design are, the "cut off" frequencies, the degree of cut off, and the impedance termination of the filter. In general the inductive elements of the filter increase in size in direct proportion, and the capacitative elements decrease in size in inverse proportion to the magnitude of the resistance component of the load impedance which terminates the filter, viz., which is connected between the output terminals 16—17 of Fig. 1.

A load circuit of high resistance will thus require a filter having a high ratio of inductance to capacity; while a load circuit of low resistance will require a filter having a low ratio of inductance to capacity.

Referring to the polyphase circuit shown in Fig. 1 wherein a three phase high frequency current generator 1, the energy thereof being modulated or unmodulated as the case may be, is connected with Δ connected primary windings 2 of transformer 6. The secondary windings 3, 4, 5, of transformer 6 each have two terminals extending therefrom which connect respectively to filters 7, 8, 9, the latter indicated here in blank but having the usual four terminals heretofore mentioned. The filters may be of any selected type. The output leads 10—11, 12—13, 14—15, respectively of filters 7, 8, 9, are shown connected in Δ to the three phase electric power transmission system 16, 17, 18. Viewing the three phase transmission system from the points 16—17, 17—18, and 18—16, the circuits may possess different input resistive properties, effective at high frequency. The filters 7, 8, 9, will therefore be designed accordingly and while having the same cut off frequencies will have different ratios of inductance to capacity. That is, three complete filters are required.

Experiment has shown that in a large number of cases the high frequency input resistance of one phase of a polyphase system is considerably higher than the input resistance of the other phases, which may be of the same order of magnitude. This feature permits of a great simplification in filter construction with a resulting reduction in cost. This is made clear by reference to Figs. 3 and 4, wherein it is assumed that the input resistance of phase 16—18, is high compared to those of phases 16—17, and 17—18. It will be noted that only two filters are employed instead of three as in Fig. 1.

Referring particularly to Fig. 3, the input terminals of filter 19 are shown at 21, 22; the input terminals of filter 20 are 22, 23; the input terminals of combined filter 19—20 are 23—21. Considering first the series connected elements, the ratio of inductance to capacity of the first and last meshes of both filters 19 and 20 is

$$\frac{L_1}{2}\Big/2C_1=\frac{L_1}{4C_1}.$$

For the combined filter 19—20, this ratio is

$$\left(\frac{L_1}{2}+\frac{L_1}{2}\right)\Big/\frac{2C_1\times 2C_1}{4C_1}=\frac{L_1}{C_1}$$

is four times that of the other two filters. For the intermediate mesh, the ratio for filters 19 and 20 is

$$\frac{L_1}{C_1}$$

and for the combined filter 19—20 is

$$\frac{2L_1}{\frac{1}{2}C_1}=4\frac{L_1}{C_1}$$

or again four times that of the other two filters. Considering the parallel connected elements of the filter between points 24—25, 25—26, and 27—28, 28—29 the ratio of inductance to capacity effective is

$$\frac{L_2}{C_2}.$$

Between points 24—26 and 27—29, however, the ratio of inductance to capacity is

$$2L_2\Big/\frac{C_2}{2}=4\frac{L_2}{C_2}$$

or as before, four times the first ratio.

For the purpose of illustration it has been assumed that the input resistance of phase 16—18 is higher than of the other two phases. Thus with the filter connection of Fig. 3, the composite filter has a high ratio of inductance to capacity and operates into the high resistance load. The simplified connection of the filter is shown in outline in Fig. 2.

In Fig. 4 is shown the same filter as in Fig. 3 but with open Δ connected input transformers, an arrangement which has proven extraordinarily effective in practice. In fact, the filter arrangement of Figs. 2, 3, 4 may properly be called an open Δ filter as in Figs. 2 and 3 which have closed Δ input transformers, the presence of secondary 5 in no way affects the design or construction of the filter.

In Fig. 5, is shown the same type of filter operating from a three wire two phase transformer. Here the change in ratio of inductance to capacity is not so important as very rarely is there any load connected to phases 16—18, only the two phases 16—17, and 17—18 being employed. However, it is not intended to restrict the scope of the invention to three phase systems.

The polyphase filter system of my invention has been found to be very practical in operation in polyphase systems of wired radio broadcasting.

While I have described my invention in certain preferred embodiments, and have illustrated its use with only one type of filter, I desire that it be understood that modifications may be made, other types of uniform or composite filters may be employed, and that no limitations upon my invention are intended other than are imposed by the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. In a wired radio broadcasting system the combination of a source of three phase high frequency current, a three phase electric power transmission system, a plurality of filter circuits having common elements interposed in series between said source of three phase high frequency current and said three phase electric power transmission system, each of said plurality of filter circuits being associated with different phases of said power transmission system and shunt connected filter circuits including parallel related inductance and capacity elements disposed in each phase, the ratio of inductance to capacity of both the series and shunt connected branches of one of said filter circuits having a larger value than the ratio inductance to capacity of the remaining of said plurality of filter circuits.

2. In a wired radio broadcasting system the combination of a source of polyphase high frequency current, a polyphase electric power transmission system, a plurality of filter circuits having common elements interposed in series between said source of polyphase high frequency current and said polyphase electric power transmission system, each of said plurality of filter circuits being associated with a different phase of said power transmission system and parallel connected branch impedance circuits disposed in parallel in each phase, the ratio of inductance to capacity of both the series and parallel con-

nected branches of one of said filter circuits having a larger value than the ratio inductance to capacity of the remaining of said plurality of filter circuits.

3. In a wired radio broadcasting system comprising a source of three phase high frequency current, a three phase electric power transmission system, a filter circuits interposed between said source of three phase high frequency current and said three phase electric power transmission system, said filter circuit having three input and three output terminals and comprising independent series and parallel connected composite impedance elements, said filter circuit being so constructed that when viewed from one pair of said three terminals it will have a higher ratio of inductance to capacity elements than when viewed from the two remaining pairs of said terminals.

4. In a wired radio broadcasting system a source of polyphase signaling current having at least three output terminals, an electric power transmission system having at least three conductors, in which the impedance at signaling frequencies between a first and second of said conductors is substantially greater than between either of those conductors and a third conductor, and a filter system connecting said source to said line comprising three series paths, two of which include lumped impedance elements and connect to said first and second conductors respectively and the third of which is of negligible impedance and connects to said third conductor.

5. A system as described in claim 4, further characterized in that shunt impedance elements are connected in said filter system between said first and third paths, but not between said first and second paths.

In testimony whereof I affix my signature.

ROBERT D. DUNCAN, JR.