Jan. 22, 1957 B. M. SOSIN 2,779,000

HIGH FREQUENCY FILTER, COMBINER AND LIKE ARRANGEMENTS

Filed Jan. 24, 1952 2 Sheets-Sheet 1

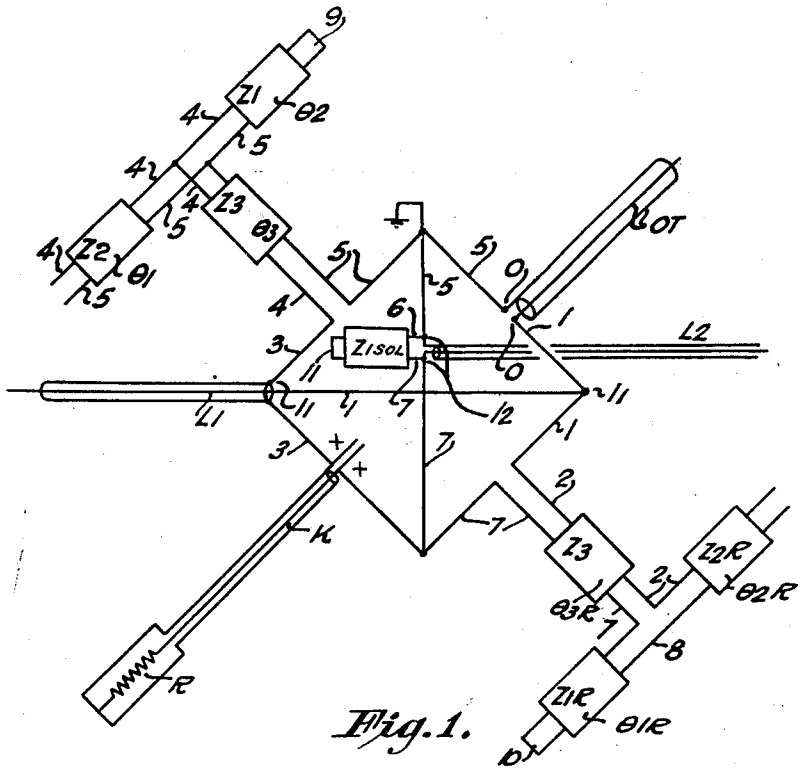


Fig. 1.

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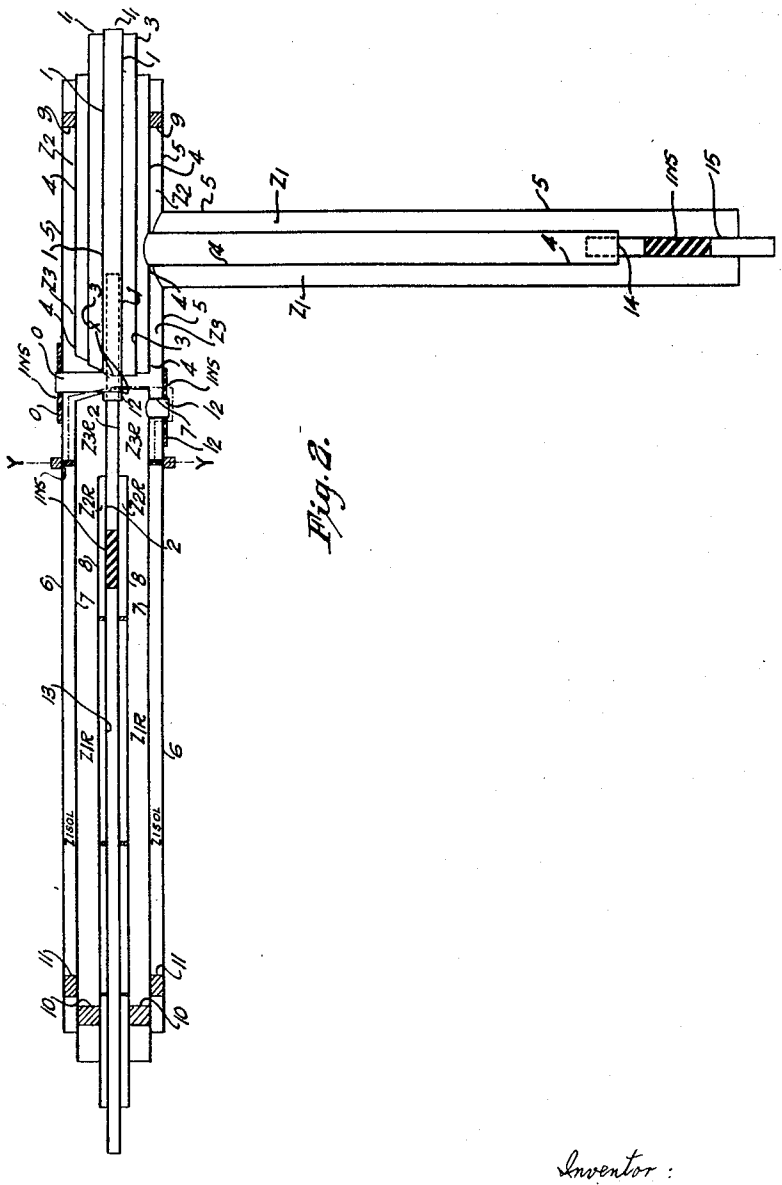


Fig. 2.

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HIGH FREQUENCY FILTER, COMBINER AND LIKE ARRANGEMENTS

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Claims priority, application Great Britain February 2, 1951

4 Claims. (Cl. 333—6)

This invention relates to high frequency filter, combiner and like arrangements and more particularly to such arrangements of the bridge type. As will be seen later the invention may be applied to filters having two pairs of external connection points, one for input and the other for output or to combiners having three pairs of external connection points of which two may be for different inputs and the third for a common output or two may be for different outputs and the third for a single input.

According to this invention a filter, combiner or like circuit arrangement for use on high frequencies comprises a four arm bridge circuit with a T-connected stub in each of two opposite arms, one pair of external connection points in one of the remaining arms, connection points for the connection of a balancing impedance in the other remaining arm and another pair of external connection points in one diagonal, the connections of the bridge and the impedances of the stubs being constituted by distributed reactances and resistance presented by a concentric tubular conductor structure.

In embodiments with three pairs of external connection points the third pair, together with an associated isolating stub, is provided in the second diagonal of the bridge.

An important, though by no means the only application of the invention is to short wave video and sound modulated signal systems.

The invention is illustrated in the accompanying drawings in which Fig. 1 is a circuit representation of one embodiment and Fig. 2 a schematic representation showing the circuit of Fig. 1 actually embodied in a tubular conductor structure. In order adequately to co-relate these two figures corresponding reference numerals are applied to corresponding parts of the conductor representations and corresponding reference letters indicate the various impedances.

Referring to Fig. 1 the bridge circuit therein shown comprises four arms of which the opposite arms containing the conductor lengths **3, 5** and **1, 7** respectively include T connected stubs. One of these stubs consists of an impedance Z_3 and the impedances Z_1, Z_2 (in the "cross bar" of the T) these impedances being of electrical lengths θ_3, θ_1 and θ_2 respectively. In the figure Z_1 is shown open circuited at its far end and Z_2 short circuited at its far end. Z_1 may however be short circuit ended. In the former case (Z_1 open) θ_1 is made slightly less than a quarter of a wave length long at the operating frequency or slightly less than an odd multiple thereof: in the latter case θ_1 is made slightly less than a half wave length long at the operating frequency or slightly less than an integral multiple thereof. In either case θ_2 is made short and θ_3 may be any length.

The T connected stub in the opposite arm arranged to have an input impedance which is the reciprocal of that of the above described T connected stub and consists of impedances Z_{3R}, Z_{1R}, and Z_{2R} of lengths θ_{3R}, θ_{1R} and θ_{2R} respectively. The term "reciprocal" is used herein

in its mathematical sense as explained for example in the text by Guillemin on "The Mathematics of Circuit Analysis" (Massachusetts Institute of Technology, John Wiley & Son, Inc, New York). Corresponding to Z_2 being short circuit ended, Z_{2R} is open circuit ended. Z_{1R} may be short circuit ended in which case θ_{1R} is made slightly less than a quarter of a wave length at the operating frequency, or slightly less than an odd multiple of a quarter wave length long. Z_{1R} may however be open circuit ended in which case θ_{1R} is made slightly less than a half wave length long or slightly less than an integral multiple of a half wave length long. In either case θ_{2R} is made short and θ_{3R} may be any length.

The third arm of the bridge, containing conductor lengths **1** and **5** contains the output connection terminals **0**, the output circuit being represented (in Fig. 1 but not in Fig. 2) as an output tubular line OT leading, for example to a transmitting aerial (not shown). The corner of the bridge between this arm and the arm containing the stub Z_3, Z_1, Z_2 is earthed.

The fourth arm of the bridge contains connection points XX between which a balancing resistance R may be connected through a matched cable K. The cable and resistance are represented in Fig. 1 but not in Fig. 2 where only the points XX are indicated. The cable may, however, be accommodated between the tubes **3** and **4** in Fig. 2 or on the outside of the tube **7**.

One pair of input connection points is constituted by the ends of one diagonal of the bridge and in Fig. 1 an input line L_1 which may carry, for example a video modulated high frequency wave or other wide band input, is indicated. A second pair of input connection points is constituted by the ends 1_2 of the other diagonal and again in Fig. 1 an input line L_2, which may carry, for example, a sound modulated or other narrow band input adjacent the wide band input in frequency, is indicated. Across these terminals 1_2 is connected an isolating stub (marked Z_{ISOL}) short circuited at its far end by a connection **11** and which should be a quarter of a wave length at the operating frequency or an odd multiple thereof, long.

By suitable choice of the lengths θ_3 and θ_{3R} the narrow band frequency can be either below or above the wide band frequency. Also, in some cases the narrow and wide band inputs may be interchanged.

Fig. 2, which will be found largely self-explanatory from the correspondence of numeral and letter references with those of Fig. 1 shows the way in which the circuit of Fig. 1 is embodied in a structure composed entirely of concentric tubes and supporting and spacing insulators INS. All the parts of Figs. 1 and 2 are identified by similar references and the impedances Z_1, Z_2, etc. are marked in Fig. 2 as well as in Fig. 1. There are two T connected stubs electrically in Fig. 2, one is the stub consisting of the impedances Z_1, Z_2 and Z_3 and the other is the stub consisting of the reciprocal impedances Z_{1R}, Z_{2R} and Z_{3R}. All these impedance references will be found in the appropriate places in Fig. 2. While the T connected stubs do not have the appearance of the T connected stubs from the mechanical point of view in Fig. 2, they are there, nevertheless, as electrical stubs and, indeed, much of the ingenuity and value of this invention are to be found in the way in which the complex circuit of Fig. 1 has been mechanically embodied in the convenient structure of Fig. 2. As will be seen the terminals 1_2 are concentric as are the terminals 1_1 and **0**, the outer terminals of 1_2 and **0** being constituted in each case by the periphery of a hole in the appropriate tube. The parts **9, 10** and **11** (Fig. 2) are short circuiting rings provided for adjustment purposes and are slidable as to position, the construction at **10** allowing the tube **7** to be slide endwise to adjust the value of Z_{3R} while a sliding joint at **12** and a push rod **13** enable adjustment of the length of Z_{3R}

to be effected. A sliding joint at 14 and a push rod 15 provide for adjustment of the length of Z_1 for operation on any working frequency. The lengths in question are not particularly critical, the important thing being that they must not be quarter wave lengths or half wave lengths (as the case may be) at any working frequency applied thereto. It will be noted that in cases where there is more than one frequency the said frequencies are closely adjacent. The structure is split, i. e. mechanically dividable along the line Y—Y (where face flanges are indicated) so that the parts to the left of the chain line can be removed to allow those to the right of it to be adjusted.

Where two inputs are not required, i. e. in the case of a filter, the input terminals 1_2 may be dispensed with, in which case, if the outermost tube 6 is omitted and the tubes 5 and 7 connected together, the arrangement becomes a switching type filter of narrow pass band or narrow stop band characteristics (depending upon the length chosen for θ_3 and θ_{3R}) i. e. a filter which switches from output to balancing resistance and thus appears always matched at the input. Alternatively, the same results can be achieved by dispensing with terminals 1_1 and connecting the tubes 1 and 3.

Again by dispensing with terminals 1_2 and connecting tubes 5 and 7 as before, but using the terminals 0 as input terminals and the terminals 1_1 as output terminals the filter may be used as a stop or trap filter eliminating a desired wide or narrow signal band—e. g. video or sound signals from a partially mixed output—in dependence upon the lengths chosen for θ_3 and θ_{3R}. Such an arrangement may be made of quite small dimensions. Similar results can be achieved by dispensing with terminals 1_1, connecting the tubes 1 and 3 and using 1_2 as output terminals and 0 as input terminals.

The invention provides important practical advantages which are extremely difficult if not impossible to achieve with known arrangements. There are no condensers or other lumped impedances to produce large voltage differences and insulation difficulties; adjustment is easily effected, mostly from outside the structure thus allowing final and accurate trimming to be effected while a measuring signal, or actual useful power is present; the corners of the bridge are brought virtually to the same point physically—this fact enables an actual embodiment to accord closely with theoretical design data; the balancing resistance is connected by a matched transmission line (the cable) and is thus effectively at the central junction, so that the actual resistance can be outside the structure; the T-connected stubs give high efficiency and low losses without having to be physically large; the reciprocal arms of the bridge can be made reciprocal to a high degree of accuracy because the lower ends of the "stems" of the T's are brought to the central junction and adjustment to virtually exact reciprocal values is comparatively easy; in the case of a combiner for wide and narrow band inputs either can be of the higher frequency, as may be desired; the parts of the stubs where losses occur are constituted by identical tubes so that the stub impedances remain closely reciprocal even at resonance, where resistance is the governing factor; and the construction allows of forced cooling e. g. forced air or water cooling if required.

I claim:

1. A high frequency filter, combiner or like circuit arrangement comprising a four arm bridge circuit including concentric tubular conductor structures with a T-connected stub in each of two opposite arms, one pair of external connection points in one of the remaining arms, connection points for the connection of a balancing impedance in the other remaining arm and a second pair of external connection points in one diagonal, the arms of the bridge circuit being constituted by the impedance of the stubs and resistance presented by the concentric tubular conductor structures in which one of the T-connected stubs has an input impedance which is the reciprocal of that of the other, said other stub comprising three impedances (Z_1, Z_2, and Z_3) of which Z_1 and Z_2 are in the "cross bar" of the T, the concentric tubular conductor structure constituting impedance Z_1 being open circuited at its far end and the concentric tubular conductor structure constituting impedance Z_2 being short circuited at its far end, Z_1 constituting an impedance equivalent to a circuit having an electrical length slightly less than an odd number, including one, of quarter wave lengths long at the operating frequency and Z_2 constituting an impedance equivalent to a circuit having an electrical length which is short in relation to the wave length of the operating frequency.

2. A high frequency filter, combiner or like circuit arrangement comprising a four arm bridge circuit including concentric tubular conductor structures with a T-connected stub in each of two opposite arms, one pair of external connection points in one of the remaining arms, connection points for the connection of a balancing impedance in the other remaining arm and a second pair of external connection points in one diagonal, the arms of the bridge circuit being constituted by the impedances of the stubs and resistance presented by the concentric tubular conductor structures in which one of the T-connected stubs has an input impedance which is the reciprocal of that of the other, said other stub comprising three impedances (Z_1, Z_2, and Z_3) of which Z_1 and Z_2 are in the "cross bar" of the T, the concentric tubular conductor structure constituting impedance Z_1 being short circuited at its far end and the concentric tubular conductor structure constituting impedance Z_2 being short circuited at its far end, Z_1 constituting an impedance equivalent to a circuit having an electrical length slightly less than a whole number, including one, of half wave lengths long at the operating frequency and Z_2 constituting an impedance equivalent to a circuit having an electrical length which is short in relation to the wave length.

3. A high frequency filter, combiner or like circuit structure composed entirely of concentric tubes and supporting and spacing insulators, said structure embodying a four arm bridge circuit including concentric tubular conductor structures with a T-connected stub in each of two opposite arms, one pair of external connection points in one of the remaining arms, connection points for the connection of a balancing impedance in the other remaining arm and a second pair of external connection points in one diagonal, the arms of the bridge circuit being constituted by the impedances of the stubs and resistance presented by the concentric tubular conductor structures, in which one of the T-connected stubs has an input impedance which is the reciprocal of that of the other, said other stub comprising three impedances (Z_1, Z_2, and Z_3) of which Z_1 and Z_2 are in the "cross bar" of the T, the concentric tubular conductor structure constituting impedance Z_1 being open circuited at its far end and the concentric tubular conductor structure constituting impedance Z_2 being short circuited at its far end, Z_1 constituting an impedance equivalent to a circuit having an electrical length slightly less than an odd number, including one, of quarter wave lengths long at the operating frequency and Z_2 constituting an impedance equivalent to a circuit having an electrical length which is short in relation to the wave length of the operating frequency.

4. A high frequency filter, combiner or like circuit structure composed entirely of concentric tubes and supporting and spacing insulators, said structure embodying a four arm bridge circuit including concentric tubular conductor structures with a T-connected stub in each of two opposite arms, one pair of external connection points in one of the remaining arms, connection points for the connection of a balancing impedance in the other remaining arm and a second pair of external connection points in one diagonal, the arms of the bridge circuit

being constituted by the impedances of the stubs and resistance presented by the concentric tubular conductor structures, in which one of the T-connected stubs has an input impedance which is the reciprocal of that of the other, said other stub comprising three impedances (Z_1, Z_2, and Z_3) of which Z_1 and Z_2 are in the "cross bar" of the T, the concentric tubular conductor structure constituting impedance Z_1 being short circuited at its far end and the concentric tubular conductor structure constituting impedance Z_2 being short circuited at its far end, Z_1 constituting an impedance equivalent to a circuit having an electrical length slightly less than a whole

number, including one, of half wave lengths long at the operating frequency and Z_2 constituting an impedance equivalent to a circuit having an electrical length which is short in relation to the wave length of the operating frequency.

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