

Oct. 26, 1943.

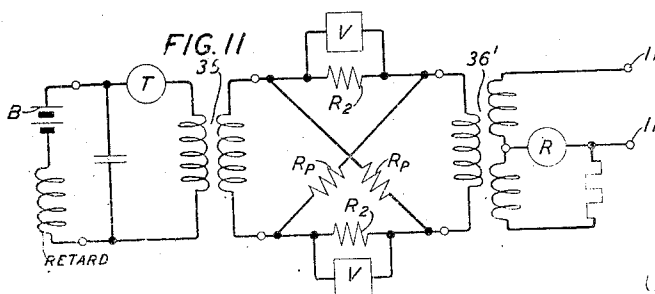
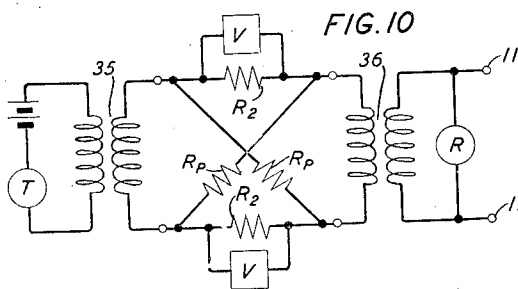
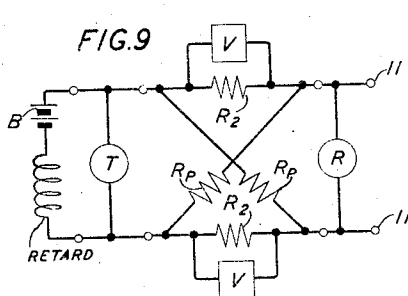
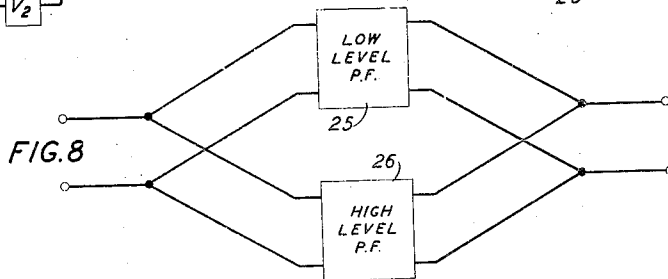
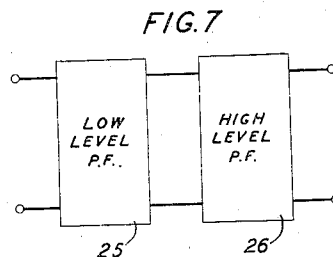
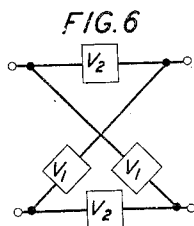
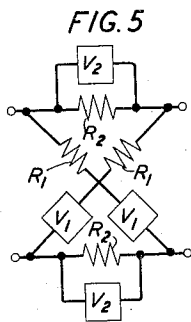
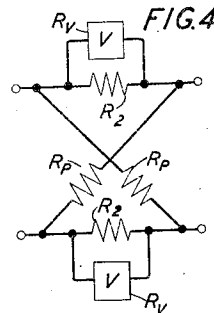
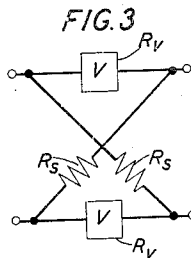
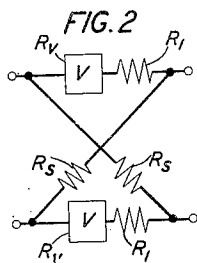
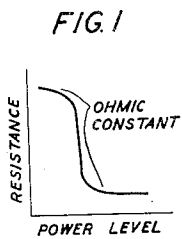
K. S. JOHNSON

2,332,643

TELEPHONE SET CIRCUIT

Original Filed June 10, 1939

2 Sheets-Sheet 1



INVENTOR
K.S. JOHNSON

BY

Robert J. Bluskey
ATTORNEY

Oct. 26, 1943.

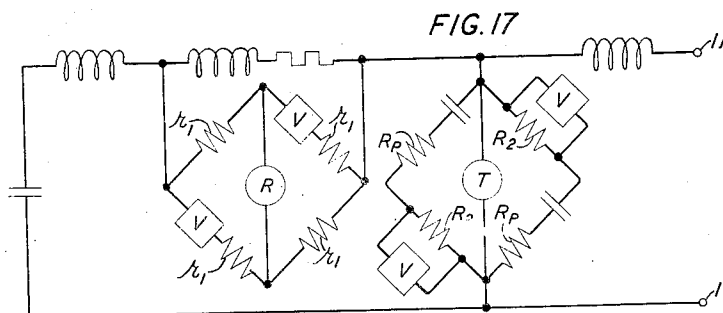
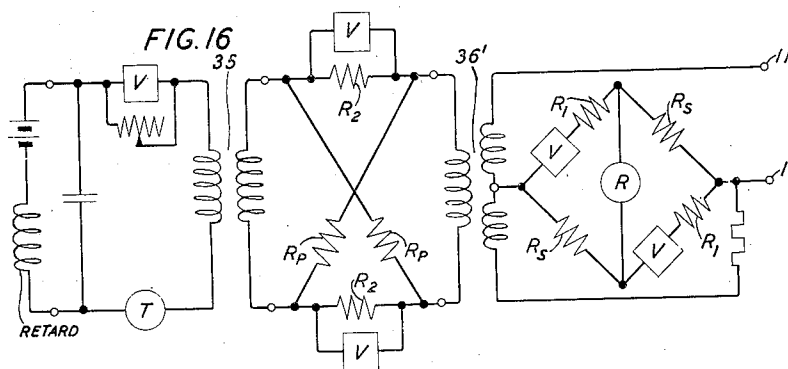
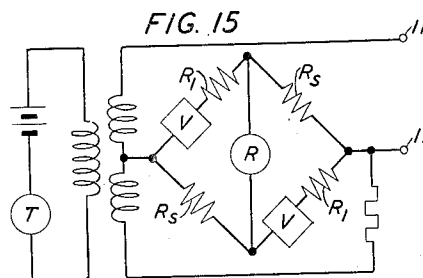
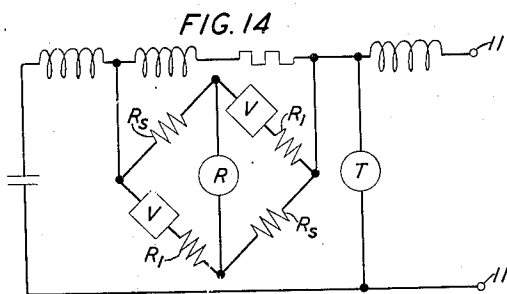
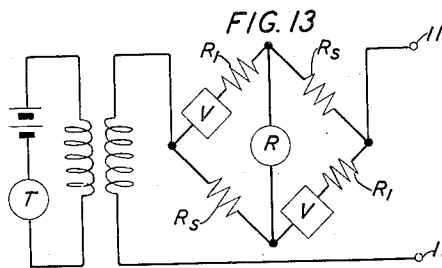
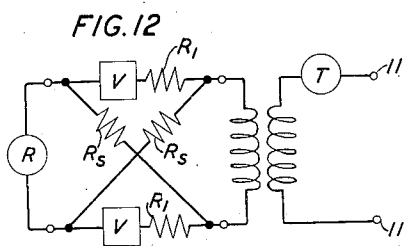
K. S. JOHNSON

2,332,643

TELEPHONE SET CIRCUIT

Original Filed June 10, 1939

2 Sheets-Sheet 2.



INVENTOR
K.S. JOHNSON

BY

Robert J. Fluskey
ATTORNEY

UNITED STATES PATENT OFFICE

2,332,643

TELEPHONE SET CIRCUIT

Kenneth S. Johnson, South Orange, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Original application June 10, 1939, Serial No. 278,411. Divided and this application March 12, 1942, Serial No. 434,372

19 Claims. (Cl. 179—81)

This application is a division of my copending application Serial No. 278,411, filed June 10, 1939, for Telephone circuits, which matured into Patent No. 2,287,998 on June 30, 1942.

The above-identified application discloses a number of telephone set circuits incorporating temperature, current or voltage controlled or dependent, variable resistance elements, materials or devices. With specific reference to Figs. 1 to 41 of the parent application, one or two of such elements or devices are associated with the transmitting and/or receiving circuit of the telephone set circuits there shown, the transmitting or the receiving circuit being effectively disabled or enabled for a given temperature, voltage or current condition of the variable resistance device.

Figs. 42 to 58 of the parent application, and that portion of the specification of the latter descriptive of such figures, are directed to electric wave energy level or intensity filters or networks and their inclusion in telephone set circuits. Such filters or networks minimize or prevent side tone in the receiver of the set circuit during transmitting out of the set circuit, and minimize or prevent interfering currents in the receiver during the listening period, that is, while audio frequency currents are being received at the set circuit, such interfering currents having their possible origin in room noises or other sounds effective on the diaphragm of the transmitter of the set circuit.

The electric energy or level filter or network comprises a plurality of linear and non-linear resistance devices or elements so arranged that the filter or network is balanced with respect to low level or low intensity electric energy and unbalanced with respect to relatively high level or high intensity electric energy, or balanced with respect to high level or high intensity electric energy and unbalanced with respect to relatively low level or low intensity electric energy. By appropriately connecting such networks in a telephone set circuit and in appropriate relation to the telephone receiver and telephone transmitter thereof, the transmitter may be effectively disabled during receiving at the set circuit, that is, during the listening period thereat, or the receiver may be effectively disabled during transmitting out of the set circuit, that is, during the talking period, both the enabling of the transmitter and the disabling of the receiver being under control of the transmitting circuit.

The non-linear resistance device or element of the network is one of the type or of a material

having a rapid and sharp change in resistance from a high to a low value, or vice versa, when a critical current therethrough is realized, or when a given current is maintained sufficiently long to change the temperature of the element by a predetermined amount at which altered temperature the element undergoes a rapid and sharp change in resistance. This element may be a unit comprising a mixture of carborundum, clay and graphite, such as is disclosed in K. B. McEachron Patent 1,822,742, issued September 8, 1931, and known commercially as "Thyrite"; or a unit comprising a copper-oxide rectifier unit; or a unit of a semiconductor, such as boron, silver sulphide, uranium oxide, or the like. Devices such as gas-filled tubes and photoconductive cells will also give, when shunted by a finite resistance, essentially the characteristic of such a unit.

A more complete understanding of the invention will be obtained from the detailed description that follows, taken in conjunction with the appended drawings wherein:

Fig. 1 shows a typical resistance-power level characteristic curve for a variable resistance element or device such as has been referred to hereinabove;

Figs. 2 to 6 show networks embodying variable resistance elements and linear resistances, that constitute low level or high level pass filter sections;

Figs. 7 and 8 show how a low level and a high level pass filter section of the type shown in Figs. 2 to 6 may be connected to provide a band-pass level filter and a band level elimination filter, respectively;

Fig. 9 shows a telephone set circuit embodying a high level pass filter, such as that of Fig. 4, isolating the transmitter from the receiver so that low level room noises are not transmitted to the receiver but the high level voice currents pass to the line terminals of the circuit;

Fig. 10 shows a local battery telephone set circuit embodying a filter of the type shown in Fig. 4 and coupled to the transmitter and receiver through transformers;

Fig. 11 shows a common battery anti-side tone telephone set circuit embodying a filter of the type shown in Fig. 4;

Fig. 12 shows a telephone set circuit in which the receiver is isolated from the transmitter and the line terminals by a low level pass filter of the type shown in Fig. 2;

Fig. 13 shows a local battery telephone set circuit with the receiver in one diagonal of a level

pass filter balanced for high levels or intensities but unbalanced for low levels or intensities;

Fig. 14 shows a common battery anti-side tone telephone set circuit embodying the low level pass filter of Figs. 12 and 13;

Fig. 15 shows a local battery anti-side tone telephone set circuit embodying the low level filter of Figs. 12 to 14;

Fig. 16 shows an operator's telephone set circuit in which features of Figs. 11 and 15 are embodied; and

Fig. 17 shows a common battery telephone set circuit embodying a low level pass filter associated with the receiver and a high level pass filter associated with the transmitter.

The resistance characteristic of units or devices such as have been referred to is that of a relatively high constant or ohmic type of resistance at all low electric inputs. This resistance rapidly decreases as the electrical input is increased until at relatively high inputs the resistance has become an extremely low constant or ohmic type of resistance. This type of characteristic is illustrated in Fig. 1. The unit or device may be incorporated in what may be called a level or intensity filter, in contrast to the usual wave or frequency filter. In such a level or intensity filter, the unit or device, designated as V, V₁, or V₂, in Figs. 2 to 6 and Figs. 9 to 17, balances a bridge network at either high or low intensities or levels of electrical input, and will produce, therefore, infinite attenuation at all frequencies under these conditions. On the other hand, at the inverse intensities or levels (low or high) the level filters will produce negligibly small attenuation at all frequencies. Some simple types of intensity filter sections are shown in Figs. 2 to 6. Referring to Fig. 2, let it be assumed that at low input levels or intensities, $R_v + R_1 = R_s$, where R_v is the resistance of element V, and R_1 and R_s are the resistances of substantially linear current-resistance characteristic resistance elements. The bridge network will be balanced and the filter section will give infinite attenuation for all of the low intensity levels at which R_v has the value that will satisfy the above relation. At high levels, however, R_v rapidly approaches a low resistance, as indicated in Fig. 1, and the resultant attenuation of the section will be greatly reduced. The minimum attenuation would occur for these high levels if R_1 had originally been made equal to zero, in which case the value of the minimum attenuation would be determined simply by the ratio of R_s to the low constant ohmic resistance of R_v . This structure, then, when operating as described, may be called a high level pass filter. Its maximum discrimination would be that existing in the limiting case referred to above, i. e., when $R_1 = 0$. In this case, the high level filter section would reduce to the form shown in Fig. 3. The same physical structures as are shown in Figs. 2 and 3 obviously can be made to provide a low level pass filter section by selection of constants so that the bridge or lattice is balanced at the high constant ohmic resistance value of the elements V.

The same general approach applies to the level filter section shown in Fig. 4. As in the case of Fig. 2, this lattice network can be balanced at either high or low levels, resulting in either a low level or a high level pass filter section, as desired. If maximum discrimination is wanted, the resistance R_2 would be omitted, and the structure would reduce essentially to that shown

in Fig. 3. The practical choice between the filter sections of Figs. 2 and 4 depends in part upon the relative resistances of the elements V and the desired characteristic impedance of the filter section. The characteristic impedance of that shown in Fig. 2 is

$$\sqrt{R_s(R_1 + R_v)}$$

and that of Fig. 4 is

$$\sqrt{R_v R_2 / (R_v + R_2)}$$

where R_v and R_2 represent the resistances of the linear resistance-current elements of the network. Even though the elements V do not have identically the same resistances, the section will still have its two image impedances equal to each other.

The lattice section of Fig. 5 may be proportioned so as to be balanced at either the high or low levels at which the elements V₁ and V₂ are ohmic, but, in general, the balanced condition would not exist at intermediate intensities. The amount of this attenuation at intermediate levels depends upon the relations between R_1 , R_{v1} , R_2 and R_{v2} , where R_{v1} and R_{v2} are the resistances of elements V₁ and V₂. If R_1 is made equal to zero and R_2 is made infinite, the structure of Fig. 5 would reduce to that of Fig. 6. This structure may be readily proportioned to have a constant—either finite or infinite—attenuation at all levels or intensities with a constant but relatively high characteristic impedance at low intensities, and a low but constant characteristic impedance at high intensities or levels.

In the same way that a section of a low and a high-pass wave or frequency filter can be put in tandem to produce a band-pass wave or frequency filter, a section of a low level pass filter may be put in series or in tandem with a high level pass filter to produce a band level pass filter. Such an arrangement is shown in schematic in Fig. 7, in which section 25 has high attenuation for high levels, and section 26 is balanced or has high attenuation for low levels. Only energy lying between the two level cut-offs will be transmitted through the entire structure with small attenuation, and all other levels will be effectually attenuated. A band level pass filter can be constructed using two or more sections in tandem, each having the same general configuration, but one of the sections being balanced so that it has a low level cut-off and the other section being balanced for a high level cut-off. By proper selection of the cut-off points a level band of preassigned width is obtainable.

In the same way, and analogous to the practice of wave or frequency filters, the low and the high level pass sections described may be put in parallel to give a structure that is essentially a band level elimination filter. These might be sections of the types shown in Figs. 2, 4 and 5, and might comprise two or more sections of the same general configuration. An illustration of such a band level elimination filter is shown in schematic in Fig. 8.

The low level and high level filters described hereinabove may be used advantageously in place of the simple series or shunt connected variable resistance elements of Figs. 1 to 41 of the parent application, Serial No. 278,411. This fact is due primarily to the possibility of producing, in effect, infinite attenuation at either high or low electrical energy levels.

In Fig. 9 there is shown a elementary substitution in which marked discrimination can be ob-

tained between the low intensity electrical energy levels produced by room and the like noises and the high intensity electrical energy levels produced when the transmitter is actuated by the voice. The transmitter T is isolated from the receiver R and line, which latter would be connected with the set circuit line terminals 11, by a high level pass filter of the type shown in Fig. 4. The filter section is balanced for low values of alternating current electromotive force encountered when the circuit is in the normal or receiving, i. e., listening, condition, thus, in effect disabling the transmitter with respect to room and the like noises. The value of R_2 should be slightly greater than R_1 . When the transmitter is talked into, however, the alternating current electromotive force generated breaks down the resistance of the elements V to such an extent that the bridge reduces essentially to the two shunt resistances R_1 acting in parallel across the transmitter T. A more elaborate form of the circuit of Fig. 9 is shown in Fig. 10 wherein the level pass filter section is coupled by an induction coil or transformer 35 to the local circuit for the transmitter and coupled by an induction coil or transformer 36 to the line terminals 11 across which the receiver is connected. This circuit operates in the same manner as that of Fig. 9. In Fig. 11, the circuit arrangement is substantially the same as that of Fig. 10 except that a common battery source B of talking current is indicated, and a Campbell-type anti-side tone circuit arrangement is included using a three-winding transformer 36'.

In Fig. 12 there is shown an elementary substation circuit in which the receiver is isolated from the transmitter and line by a low level pass filter of the type shown in Fig. 2. The value of R_1 is slightly lower than that of R_2 . In other words, this filter section is balanced for large or high level electromotive forces at its terminals. That is, for the large electromotive forces generated when the transmitter is talked into, the resistances of the elements V are substantially zero, and the bridge is proportioned to be balanced under such conditions, resulting in an efficient anti-side tone performance that is independent of the line impedance and providing a type of anti-side tone circuit effective as a result of the intensity of speech rather than as a result of a Wheatstone bridge type of balance. For low level electrical energy, however, such as would be represented by voice or signal energy incoming to the substation circuit the filter section is unbalanced, and the receiving efficiency is not appreciably impaired by the presence of the filter section.

In the local battery substation circuit of Fig. 13, the receiver R is connected to the rest of the circuit by a filter section similar to that of Fig. 12. As in the latter figure, the filter section is balanced for the relatively high intensities or levels occurring while the transmitter is being talked into, but is unbalanced for and readily passes the relatively weak intensities or levels of the incoming voice or signal currents during the listening condition of the circuit.

In Fig. 14, there is shown a common battery substation circuit employing the anti-side tone arrangement of the Gooderham Patent 1,901,958, issued March 21, 1933, and, in addition, the low level pass filter section of Figs. 12 and 13. This circuit is doubly anti-side tone in that it has the usual Wheatstone bridge type of balance, tending to give anti-side tone, coupled with a level filter. If, on transmitting, there is a large un-

balance between the telephone line and the substation network, resulting in large voltages being impressed across the terminals of the filter section, the latter will be effectively balanced to any such high voltages and greatly attenuate them before they can be effective on the receiver. On the other hand, during receiving, the section is unbalanced and the circuit acts essentially as if the filter section were not present.

The substation circuit of Fig. 15 is a local battery arrangement embodying the filter section arrangement of Figs. 12, 13 and 14. The circuit is also doubly anti-side tone in that it is balanced for high potentials across the terminals of the level filter section, and in that the circuit embodies the Campbell-type anti-side tone arrangement employing a network to balance the line.

The circuit of Fig. 16 represents an operator's set circuit in which the features of Fig. 40 of the parent application and Figs. 11 and 15 of this application have been incorporated. In other words, there is first a variable resistance element V in series with the transmitter so that the transmitting circuit will effectively discriminate against weak sounds, such as room noises. Secondly, the transmitter branch is effectively isolated, during the receiving or the listening condition, by a high level pass filter section, i. e., a network that is balanced for low values of electromotive force impressed on its terminals, transformer-coupled to the transmitter-branch and to the receiving circuit. Thirdly, the receiver is effectively isolated from the transmitting circuit by a low level filter that is balanced for large electromotive forces across its terminals. In addition, the circuit includes the balancing network anti-side tone arrangement of the Campbell Patent 1,254,472, issued January 22, 1918.

Fig. 17 shows a common battery substation circuit incorporating the feature of a low level pass filter section associated with the receiver R and effectively balanced for high values of electromotive force, and the feature of a high level pass filter associated with its transmitter T and effectively balanced for low values of electromotive force.

In practice, telephone set circuits usually include parts that, for a complete understanding of this invention, it has not been necessary to show in the circuit arrangements of the drawings, for example: a switchhook and switching springs, or other switching means; signaling or ringer means; a calling device or dial, when the circuit is to be used in an automatic telephone system. These may be supplied, of course, in accordance with the telephone practice with reference to telephone set circuits.

What is claimed is:

1. A telephone set circuit comprising a transmitting circuit including a transmitter, a receiving circuit including a receiver, and a Wheatstone bridge arrangement of linear and non-linear resistance elements with said receiver connected across one diagonal of said bridge arrangement.
2. A telephone set circuit comprising line terminals, a transmitting circuit connected to said terminals and including a transmitter, a receiving circuit connected to said terminals and including a receiver, and means comprising a network of linear and non-linear resistances for preventing current generated in said transmitter by sources other than the user of the set from being reproduced in said receiver.
3. A telephone set circuit comprising a transmitting circuit including a transmitter, a receiving

4. A telephone set circuit comprising a transmitting circuit including a transmitter, a receiving circuit including a receiver, and Wheatstone bridge arrangements of linear and non-linear resistance elements with said receiver connected across one diagonal of one bridge arrangement and said transmitter connected across one diagonal of another bridge arrangement, said receiver bridge arrangement being balanced with respect to high level electric energy and unbalanced with respect to low level electric energy, and said transmitter bridge arrangement being balanced with respect to low level electric energy and unbalanced with respect to high level electric energy.

6. A telephone set circuit comprising a transmitting circuit including a transmitter, a receiving circuit including a receiver, an electrical energy level filter for preventing interfering currents originating in said transmitting circuit from having access to said receiving circuit during the listening period, and a second electrical energy level filter for preventing voice currents generated in the transmitting circuit during the talking period from being reproduced in said receiver.

8. A telephone set circuit comprising a transmitting circuit including a transmitter, a receiving circuit including a receiver, an electrical energy level filter for preventing interfering currents originating in said transmitting circuit from having access to said receiving circuit during the listening period, and a second electrical energy level filter for preventing voice currents generated in the transmitting circuit during the talking period from being reproduced in said receiver, each of said filters comprising a bridge arrangement of linear and non-linear resistance elements, the transmitter being connected across one diagonal of said first-mentioned filter bridge arrangement and the receiver being connected across one diagonal of said second filter bridge arrangement.

listening period, and a second electrical energy level filter for preventing voice currents generated in the transmitting circuit during the talking period from being reproduced in said receiver, said first-mentioned filter comprising a bridge arrangement of linear and non-linear resistance elements balanced with respect to low level electric energy and unbalanced with respect to high level electric energy, and said second filter comprising a bridge arrangement of linear and non-linear resistance elements balanced with respect to high level electric energy and unbalanced with respect to low level electric energy.

11. A telephone set circuit comprising a transmitting circuit including a transmitter, a receiving circuit including a receiver, and an electrical energy level filter for preventing voice currents generated in the transmitting circuit during the talking period from being reproduced in said receiver.

13. A telephone set circuit comprising a transmitting circuit including a transmitter, a receiving circuit including a receiver, and an electrical energy level filter for preventing voice currents generated in the transmitting circuit during talking into the transmitter from being reproduced in said receiver, said filter comprising a bridge arrangement of linear and non-linear resistance elements balanced with respect to high level electric energy and unbalanced with respect to low level electric energy, the receiver being connected across one diagonal of the bridge.

15. A telephone set circuit comprising a transmitting circuit including a telephone transmitter and a bridge arrangement of linear and non-

linear resistance elements balanced with respect to low level electric energy and unbalanced with respect to high level electric energy.

16. A telephone set circuit comprising an audio frequency transmission circuit including an audio frequency transducer and a bridge arrangement of linear and non-linear resistance elements balanced with respect to one level of electric energy and unbalanced with respect to a substantially different level of electric energy.

17. A telephone set circuit comprising a bridge arrangement of linear and non-linear resistance elements, each arm of one pair of oppositely disposed arms of said bridge containing linear resistance only and each arm of the other oppositely disposed pair of arms of said bridge containing a non-linear resistance element, a telephone receiver connected between one pair of junctions of said bridge arms, and an electric energy circuit for said receiver connected to the other pair of junctions of said bridge arms.

18. A telephone set circuit comprising a bridge arrangement of linear and non-linear resistances, each arm of one pair of oppositely disposed arms

of said bridge containing linear resistance only and each arm of the other pair of oppositely disposed arms of said bridge containing a non-linear resistance element, a transmitter connected between one pair of junctions of said bridge arms, and a speech current transmission circuit connected to the other pair of junctions of said bridge arms.

19. A telephone set circuit comprising line terminals, a multiwinding induction coil the windings of which are connected in series circuit between said line terminals, a network including a telephone receiver connected in shunt with one of said windings, said network being balanced with respect to high level electric energy and unbalanced with respect to low level electric energy, and a second network including a telephone transmitter connected in a series circuit across said line terminals with a second of said windings, said second network being balanced with respect to low level electric energy and unbalanced with respect to high level electric energy.

KENNETH S. JOHNSON.