

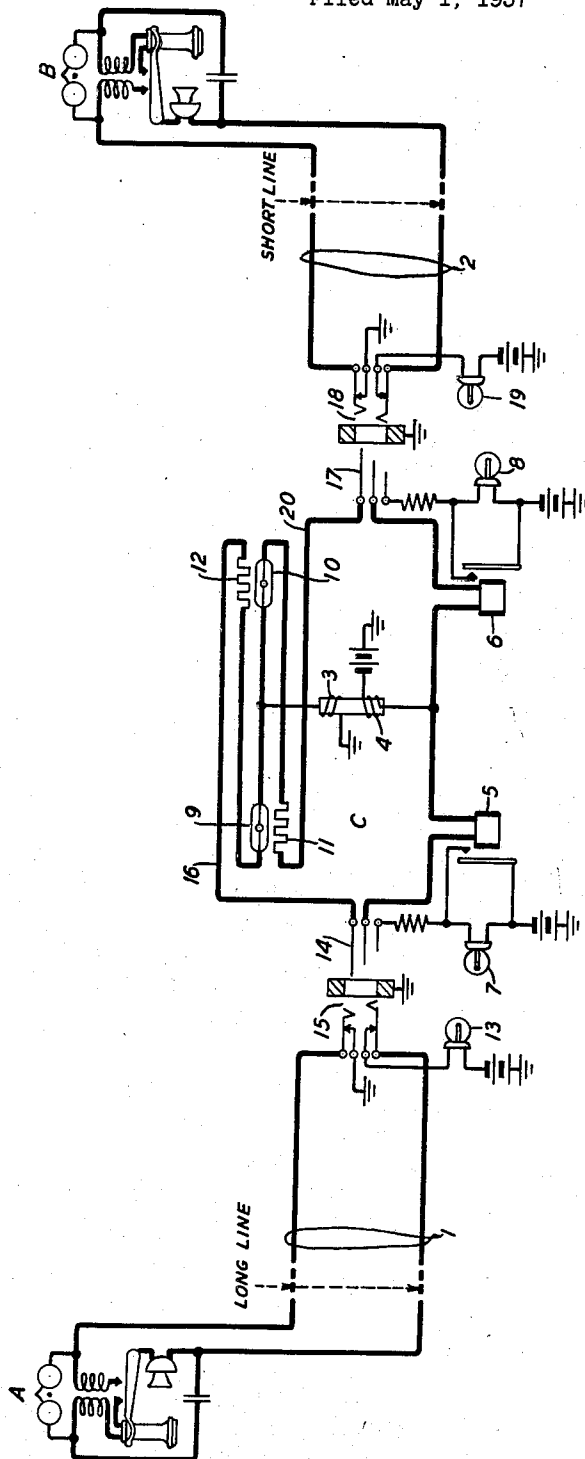
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TRANSMISSION SYSTEM

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TRANSMISSION SYSTEM

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This invention relates to telephone systems, and its objects are to improve the transmission characteristics of the conversational connections, to adjust automatically the impedance of the connecting circuits according to the character of the connected lines, and to secure other improvements in the operation of such systems.

Difficulties have been experienced heretofore with the transmission characteristics of operators' cord circuits of certain types when used for interconnecting subscribers' lines or other telephone circuits having widely varying resistance values. For example, if the operator's cord circuit is one of the type in which talking current is supplied to the calling and called lines through the windings of impedance coils connected to the tip and ring conductors of the cord, and if the calling and called lines differ widely in their resistance values, the result is that the total resistance of the current supply circuit for one line is greater than that for the other line. Consequently one line obtains more current for transmission purposes than the other, the connection is unbalanced, and best transmission results cannot be expected.

According to the present invention these difficulties are overcome by equipping the operator's cord circuit with variable-resistance elements so arranged that their resistance values are automatically adjusted in accordance with the resistances of the two subscribers' lines interconnected by the cord circuit. More specifically two variable-resistance elements are connected in the talking conductors of the cord on opposite sides of the current supply bridge, and these resistance elements are equipped with heating coils, the heating coil of each resistor being connected in the talking conductor on the opposite side of the current supply bridge. With this arrangement the amount of current flowing through the heating winding associated with the resistor in the answering end of the cord depends upon the resistance of the subscriber's line to which the calling end of the cord is connected; similarly the amount of current flowing through the heating coil of the resistor in the calling end of the cord depends upon the resistance of the line to which the answering end of the cord is connected. If, therefore, one line is long and of high resistance and the other line is short and of low resistance, the heating currents flowing through the coils of the two resistors are proportioned in accordance with the resistances of the two lines, and these heating currents change the resistance values of the associated resistance elements to lower the ratio

of the total resistances of the current supply circuits for the connected lines.

The foregoing and other features of the invention will be described more fully in detail in the following specification. The drawing accompanying this specification discloses two subscribers' lines in a telephone system and an operator's cord circuit for interconnecting these lines.

The variable resistors best suited for use in the present system are those having fairly high temperature coefficients of resistance. These resistors when equipped with heating windings vary their resistance in accordance with the temperature to which they are raised by reason of the flow of current through the associated heating windings. Substances such as boron and silver sulphide are particularly suitable. These materials are known to have high negative temperature coefficients of resistance, and resistors made of them may be designed to have high resistances when cold and fairly low resistances when their temperatures are increased by the application of heat. The rate at which the resistance of the elements falls as the temperature increases may be controlled to a considerable extent by the addition of suitable substances in the preparation of the resistance elements. For an understanding of the manner in which resistance elements of this general character are constructed reference may be had to British Patent 472,144, accepted Sept. 17, 1937, and to the copending application of G. L. Pearson, Serial No. 117,527, filed December 24, 1936.

Referring now to the drawing, the operator's cord circuit C which serves to interconnect subscribers' lines, such as lines 1 and 2, is provided with impedance coils 3 and 4 connected to the tip and ring conductors of the cord circuit and constituting a bridge for supplying talking current to the cord and to the connecting lines. The cord C is also equipped with the usual answering and calling supervisory relays 5 and 6, with supervisory lamps 7 and 8, and with the other elements such as listening and ringing keys ordinarily associated with operators' cord circuits but omitted herefrom for the sake of simplicity. Two variable-resistance elements 9 and 10 are connected as shown in the tip conductor of the cord C. The resistance element 9 is provided with a heating coil 11, and the resistance element 10 with a heating coil 12. These coils are wound in any suitable manner in proximity to the resistance elements so that heat produced in the coil is transferred to the element. The resistor 9 is connected in the answering end of the cord circuit, 55

and the resistor 10 is connected on the other side of the battery feed bridge, namely in the calling end of the cord. The heating coils 11 and 12 are oppositely connected; that is, the coil 11 of the unit 9 is connected in the calling end of the cord in series with unit 10, and the coil 12 of unit 10 is connected in the answering cord in series with the unit 9.

The invention will be best understood from a brief description of the manner in which the system operates. For this purpose assume that the subscriber at station A on line 1 wishes to converse with the subscriber at substation B on line 2. Assume further that line 1 is a long line and has consequently a comparatively high resistance, and that line 2 is short and of a comparatively low resistance. When the calling subscriber initiates the call, the line lamp 13 illuminates, and the operator answers by inserting the answering plug 14 in the line jack 15. This disconnects the calling lamp 13 and completes a circuit from battery through the coil 4, supervisory relay 5, ring of the plug 14 and jack 15, thence over the loop of substation A and returning through the tip contacts of the jack and plug over the tip conductor 16 of the cord through the heating winding 12 and the resistance element 9 and impedance coil 3 to the grounded or opposite pole of battery. Relay 5 operates and closes a short circuit around the supervisory lamp 7. The operator makes connection with the calling line by means of the usual listening key (not shown) and obtains the number of the wanted subscriber. She then seizes the calling plug 17 of the cord C and inserts it in the jack 18 of the called line. Thereupon she applies ringing current to signal the called subscriber. When the called party answers, a circuit is completed from battery through the impedance coil 4, supervisory relay 6, ring terminals of the plug 17 and jack 18 over the loop of the called line 2 and returning through the tip terminals of jack 18 and plug 17, tip conductor 20 of the cord circuit, thence through the heating coil 11 and the resistance element 10 and the impedance coil 3 to the grounded pole of battery. Relay 6 closes a shunt around the supervisory lamp 8, and the line lamp 19 of the called line is disconnected by the insertion of the plug 17 in the jack 18.

Because of the different resistances of the lines 1 and 2, the current supply circuits are also of different resistances. In other words the circuit traced from the central office battery over the calling line 1 is of high resistance compared with the circuit from the central office battery over the called line 2, the reason being that line 1 is long and of high resistance whereas line 2 is short and of low resistance. Because of this difference of resistance between the two current supply circuits the current which tends to flow over line 2 is greater than that tending to flow over line 1, but the current flowing over line 2 also flows through the heating coil 11 of element 9, and the current flowing over line 1 flows through the heating coil 12 of element 10. The element 9 therefore receives more heat than element 10 and correspondingly reduces its resistance to a value lower than that of the element 10. The reduction of resistance of element 9 permits more current to flow and this in turn produces more heat for the element 10, but element 10 in thus lowering its resistance permits still more current to flow through the heating coil 11 in turn causing a lowering of the resistance of element 9. As a result of these current and resistance changes a steady state of

current and resistance values is reached in which the resistance of element 9 is lower than that of element 10. Since these elements are of equal or substantially equal resistances when no current is flowing, the effect of their relative change of resistance under current-flow conditions is to bring about a compensation for the difference in the resistances of lines 1 and 2. In other words the difference between the resistance of the circuit that supplies current to line 1 and the resistance of the circuit supplying line 2 becomes less when current is flowing to the lines than it is with no current flowing and also less than it would be if the compensating resistances 9 and 10 were omitted. Stated another way, the automatic change of resistance of elements 9 and 10 upon closure of the current feed circuits is such that the ratio of the resistance of one circuit to the resistance of the other circuit is made nearer to unity than it would be if the resistance units were not present. And, since the resistances of the two current supply circuits are made more nearly equal, the values of the currents flowing in these circuits are also more nearly equal, and a better balance is thereby secured.

After the conversation has been completed the operator removes the cord circuit, and the current supply circuits are interrupted, permitting the resistance elements 9 and 10 to assume their normal resistance values.

While the invention has been disclosed in connection with a manual telephone system in which an operator's cord circuit is used for interconnecting subscribers' lines, it is obvious that it is equally applicable to automatic systems and to other types of communicating systems. Moreover, the particular type of resistance element employed in carrying out this invention is not limited to those specifically disclosed and described herein.

What is claimed is:

1. The combination in a communication system of a pair of lines having different resistance values, a connecting circuit for interconnecting said lines for communication, separate current-supply circuits for said lines, each supply circuit including the corresponding line and conductors of said connecting circuit, and a variable-resistance element in one of said supply circuits responsive to the current flowing in the other supply circuit to compensate for the difference in the resistances of said lines.
2. The combination in a communication system of a pair of lines having different resistance values, a cord circuit for interconnecting said lines, supply circuits for said lines, each including the conductors of the corresponding line and conductors of said cord circuit, variable-resistance elements in said cord circuit for reducing the difference between the resistances of said supply circuits, and means depending upon the resistances of said lines for controlling the temperature of the resistance elements to vary the resistances of said elements.
3. In a communication system, subscribers' lines of different resistances, a connecting circuit for interconnecting any two of said lines for conversation, current-supply circuits for said lines, each supply circuit including the conductors of the corresponding line and conductors of said connecting circuit, variable-resistance elements connected in both of said supply circuits, and individual heat coils for said elements connected in said supply circuits and energized by the currents therein to vary the resistances of said ele-

ments in accordance with the resistances of said lines.

4. In a communication system, two lines of different impedances, a connecting circuit for interconnecting said lines, said connecting circuit having two branches of normally equal impedances, a source for supplying current over both said branches to the respective interconnected lines, and means in one of said branches responsive to the flow of current in the other branch for rendering the impedances of said branches unequal to compensate for the difference in the impedances of said lines.

5. In a communication system, lines of unequal resistance, a cord for interconnecting said lines, said cord having an answering branch for connection to one line and a calling branch for connection to the other line, a first variable-resistance element in said answering branch, a second variable-resistance element in said calling branch, a source for feeding current over the answering branch of said cord to one line and over the calling branch to the other line, and a heat coil for the first element in said calling branch and a heat coil for said second element in said answering branch energized by the currents from said source to change the resistances of the corresponding elements.

6. The combination in a communication system

of a pair of lines having different resistance values, a connecting circuit for interconnecting said lines for communication, a first supply circuit for supplying current to one of said lines, a second supply circuit for supplying current to the other of said lines, variable-resistance elements, one in each of said supply circuits, and means in the first supply circuit for varying the resistance of the element in said second supply circuit and means in the second supply circuit for varying the resistance of the element in the first supply circuit, to compensate for the difference in the resistances of said lines.

7. The combination in a communication system of a first line and a second line, a first supply circuit for supplying current to the first line and a second supply circuit for supplying current to the second line, variable-resistance elements, one in each of said supply circuits, means in the first supply circuit for varying the resistance of the element in said second circuit in accordance with the intensity of current flowing in said first line, and means in said second supply circuit for varying the resistance of the element in said first circuit in accordance with the intensity of current flowing in said second line, the variation in said resistance elements serving to compensate for the difference in the resistances of said lines.

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