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INDICATING AND MEASURING CIRCUITS

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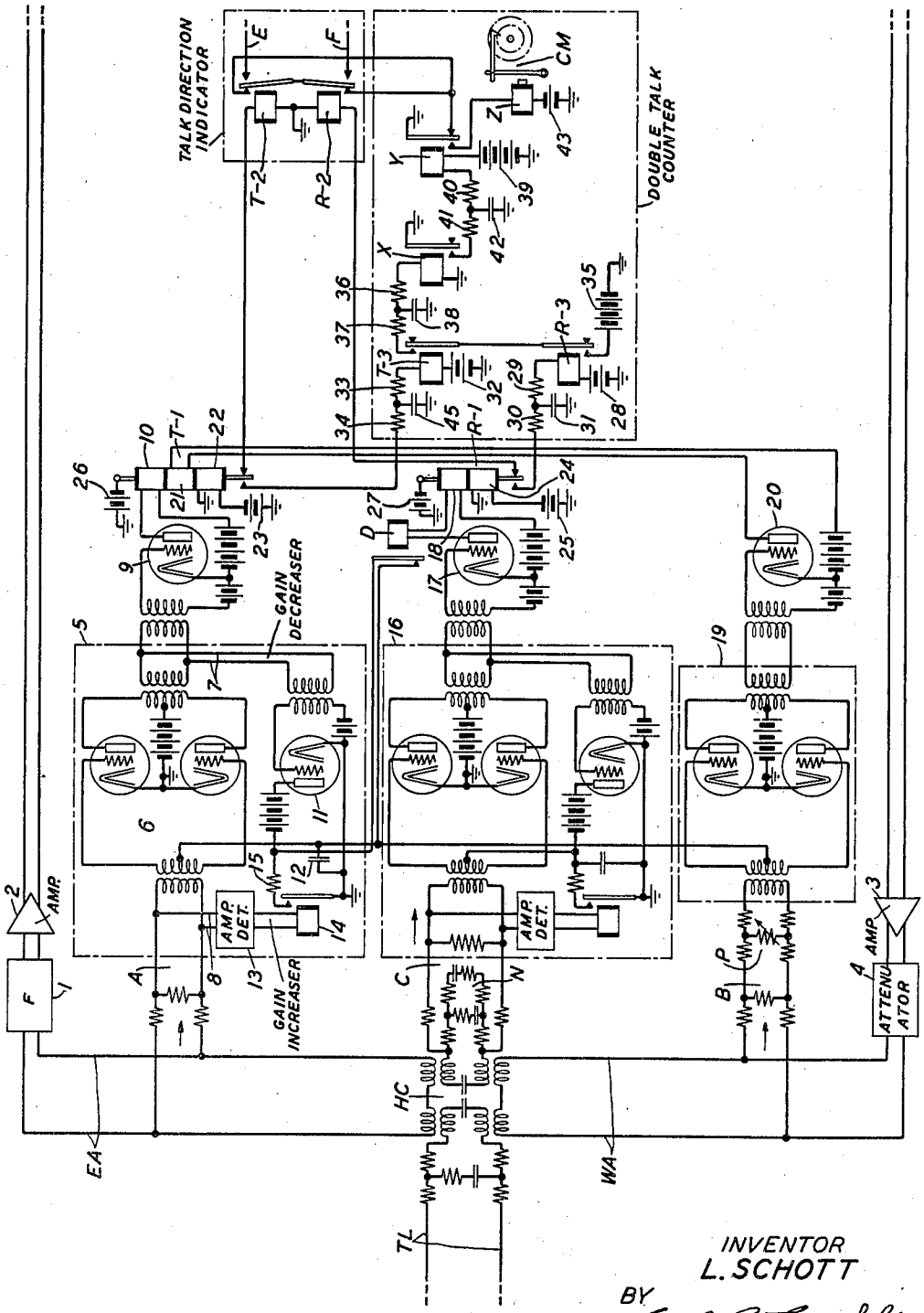

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INDICATING AND MEASURING CIRCUITS

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The invention relates to indicating and measuring circuits and particularly to such circuits used in connection with two-way telephone systems for observing and recording data on their operation under service conditions.

To obtain proper operation of two-way telephone systems employing, at least over a part of the system, oppositely directed one-way paths for repeating the telephone signals in opposite directions, it has been found desirable in the past to utilize in connection therewith signal-controlled switching apparatus operating to effectively disable the signaling path for one direction while signal transmission is taking place over the signaling path in the opposite direction, in order to suppress echoes, prevent singing, and to minimize so-called double talking. The type and design of the switching apparatus and its adjustment is determined by the constants of the telephone circuits with which it is used and the variable service conditions encountered, such as circuit noise, static, etc.

An object of the invention is to determine quickly and accurately the talking conditions in such systems as a measure of the efficiency of the switching apparatus.

This object is attained in accordance with the invention by an automatic device which, when connected to the telephone system under test will operate to indicate (1) when the subscribers are talking; (2) which subscriber is talking; (3) when both subscribers are talking at the same time (double talking) and the number of times this occurs in a given interval, and (4) the number of circuit reversals in a given time.

Other objects and features of the invention will be brought out in the following detailed description thereof when read in connection with the accompanying drawing, the single figure of which shows schematically a portion of a four-wire telephone circuit and associated therewith a service observation circuit embodying the invention.

The drawing shows schematically the west end of a known four-wire telephone circuit comprising the one-way transmission circuit EA including near its input the filter 1 and the one-way amplifying device 2, for repeating telephone signals in the direction from west to east, and the one-way circuit WA including near its output the one-way amplifying device 3 and the attenuation pad 4, for repeating telephone signals in the direction from east to west, the input of the circuit EA and the output of the circuit WA being coupled by means of the hybrid coil HC and the associated balancing network N in conjugate relation with each other and in energy transmitting relation with the two-way telephone line TL in well-known manner.

The remaining apparatus and circuits in the drawing make up the service observation circuit of the invention. As shown, it includes the three branch switching circuits A, B and C having their inputs respectively connected through high impedance resistance bridges across the input of the circuit EA, the output of the circuit WA and the network side of the hybrid coil HC.

Branch circuit A includes a voice-operated gain adjusting device (vogad) of known type, shown within the dot-dash box 5, comprising an amplifier 6 used as a vario-repeater consisting of two three-electrode amplifying tubes connected in push-pull, circuits for automatically controlling the gain of said amplifier to compensate for variation in the amplitude lead of impressed waves comprising the "gain decreaser" circuit 7 and the "gain increaser" circuit 8, the three-electrode vacuum tube detector 9 having its input connected across the output of amplifier 6, and the operating winding 10 of the electromagnet relay T–1, connected in the plate-cathode circuit of detector tube 9.

The "gain decreaser" circuit 7 comprises the three-electrode vacuum tube detector 11 having its input connected across the output of amplifier 6, and the regulating condenser 12 in the common portion of the control grid-cathode circuits of the two push-pull tubes in amplifier 6. The tube 11 is arranged to operate in response to an increase in the output level of amplifier 6 above a certain desired value to charge the condenser 12, so as to cause the gain of the amplifier 6 to be decreased in proportion to the increase in the output level of amplifier 6 over the desired value. The "gain increaser" circuit 8 comprises an amplifier-detector 13 having its input connected across the input of amplifier 6, and the electromagnet relay 14 in the output of device 13, operating in response to an increase in the level of the waves in the input of amplifier 6 above a certain minimum value to short-circuit the condenser 12 through the large resistance 13 so that the condenser will be slowly discharged thereby increasing the gain of amplifier 6. As the gain increaser circuit tends to discharge the condenser 12 and the gain decreaser circuit tends to charge that condenser, the net effect is to produce a varying charge thereon which will be proportional to the amplitude level of the waves applied to the input of the amplifier 6 and such as to maintain the output level of the amplifier at a substantially

constant value. By proper choice of the constants of the vogad 5, this value is made such that when outgoing speech is applied from the circuit EA to the branch circuit A and is amplified and detected therein, the detected current in winding 10 of relay T–1 will be such as to cause positive operation of that relay.

The branch circuit C comprises a voice-operated gain adjusting device (vogad) 16 including a vario-amplifier and associated gain decreaser and gain increaser circuits, similar to the device 5 in the branch circuit A, a three-electrode vacuum tube detector 17 having its input connected to the output of the vogad 16, and the winding of the disabler relay D and an operating winding 18 of the relay R–1 connected in series in the anode-cathode circuit of detector tube 17.

The branch circuit B connected across the output of the circuit WA comprises in order, the attenuation pad P, the vario-amplifier 19 comprising two three-electrode vacuum tubes connected in push-pull, the three-electrode vacuum tube detector 20 having its input connected to the output of amplifier 19, and the winding 21 of the relay T–1, poled so as to oppose the operating winding 10 thereof, connected in the cathode-anode circuit of the detector tube 20. Condenser 12 controlling the gain of the vario-amplifier 6 in circuit A is also connected in the common portion of the control grid-cathode circuits of the tubes in the vario-amplifier 19 of circuit B, so that the gain of the latter amplifier is varied in accordance with the condenser charge by the gain increased and gain decreaser circuits associated with the amplifier 6 under control of the outgoing speech signals in path EA.

In addition to the opposing windings 10 and 21, the relay T–1 has a biasing winding 22 supplied with biasing current from the battery 23, which is poled so as to oppose winding 10 and thus assists winding 21 to hold the armature of relay T–1 on its right-hand contact, as indicated, when winding 21 is energized. The relay R–1 in addition to the operating winding 18 has a biasing winding 24 supplied with biasing current from the battery 25 in such manner as to hold the armature of the relay R–1 normally on its right-hand contact.

The "talk direction indicator" of the circuit of the invention shown within the dot-dash box so labeled, includes the relays T–2 and R–2, and the normally unoperated external circuits indicated by the lines E and F, respectively, controlled thereby, which may be lamp circuits or any other type of indicator, recorder, or alarm circuit. The winding of the relay T–2 is supplied with energizing current from battery 26 through the normally closed armature and right-hand contact of relay T–1, so that it is normally operated to hold its armature on its left-hand contact. The winding of the relay R–2 is supplied with energizing current from battery 27 through the normally closed armature and right-hand contact of relay R–1, so that it is normally operated to hold its armature on its left-hand contact.

The "double talk counter" of the circuit of the invention shown within the dot-dash box so labeled, includes the control relays T–3 and R–3, the chain of counting relays X, Y and Z, and the counter mechanism CM shown diagrammatically, which may be of any type suitable for progressively recording the number of times the relay Z is operated in a given time interval. The other elements of the talk direction indicator, the double talk counter and the associated circuits, shown in the drawing will be referred to in the following complete description of operation of the circuit of the invention.

It will be first assumed that speech current from a telephone subscriber associated with the east end (not shown) of the four-wire circuit are being received at the west terminal over the circuit WA, and at that time no speech currents from the west subscriber associated with the telephone line TL are being received in the input of the circuit EA.

A portion of east's speech currents in the output of the attenuator 4 in the path WA is diverted into the branch circuit B and the remaining portion is divided in the hybrid coil HC between the telephone line TL, and the network side of the hybrid coil HC where a portion passes into branch circuit C. Of course, if any unbalance exists between line TL and network N, a small portion of east's speech currents may reach line EA, as an echo. The portion of east's speech energy transmitted into the circuit C will be amplified by the amplifier in the vogad 16 therein, the speech energy in the input and output of the amplifier through the associated gain decreaser and gain increaser circuits operating to adjust the gain of the vogad 16 so that the level of the waves in the output thereof impressed on the input of the detector 17 is of a desired constant value, in the manner which has been described above. The detected waves in the output of detector 17 will be supplied as energizing current to the winding of the disabler relay D and the operating winding 18 of the relay R–1 in series.

The disabler relay D will then operate to open its normally closed armature and contact to break the normal connection between the gain control condenser 12 associated with amplifier 6 of vogad 5, plate-cathode circuit of tube 11 and its associated gain decreaser (output circuit of tube 11) and gain increaser (13, 14, 15) circuits, thereby preventing any change in the gain of amplifier 6 and of the vario-amplifier in circuit B, under control of the waves reaching circuit EA from WA by way of reflections from unbalances between line TL and network N.

The energization of winding 18 of relay R–1 will overcome the bias on that relay through winding 24, and relay R–1 will operate to shift its armature from the right-hand contact to the left-hand contact.

The energy due to east's incoming speech entering the branch circuits B and A respectively bridged across circuits WA and EA will be amplified by the amplifiers therein to an amount depending on the gain setting previously provided by the associated automatic volume control circuits, which gain will depend, of course, on the strength of the outgoing speech (from the west talker) only, and will be detected by the detectors 20 and 9 in the respective branch circuits respectively causing energizing current to be supplied to the opposing windings 21 and 10 of relay T–1. Actual operation of the relay T–1 on the incoming speech is prevented, however, because the energizing current supplied to the winding 21 by the branch circuit B is slightly stronger than the energizing current supplied to the winding 10 from the branch circuit A so that the armature of the relay T–1 is maintained on the right-hand contact of the relay as in the normal condition of the circuit when neither subscriber is talking.

The A branch circuit is less sensitive to incoming speech because of the loss encountered between the receiving and transmitting sides of the hybrid coil HC. The minimum difference between the A and B circuit sensitivity is set as small as possible by suitable selection of the value of the resistance pad P in the input of the circuit B for two reasons: (1) when the gain is high in the amplifier 6 in circuit A, the loss provided by the pad P in the circuit B helps to prevent any unnecessary overloading of the following amplifier-detector in the latter circuit; and (2) as will be pointed out below, the pad P provides a generally satisfactory operate margin for the relay T–1 in favor of the outgoing or transmitted speech acting in the branch circuit A.

Relay T–1 being in the normal condition shown, the relay T–2 controlled thereby will be maintained energized so that its armature will be held on the left-hand contact as shown. Relay R–1, however, being operated to the left-hand contact, the normal energizing circuit for relay R–2 from battery 27 through the armature and right-hand contact of relay R–1 will be broken, and the relay R–2 will release so that its armature will fall back to the right-hand contact applying ground through the armature and normally closed right-hand contact of relay Y to operate the external circuit F to indicate to the observer that the east subscriber is talking. Similarly, the armature of the relay T–2 being in its normal condition on the relay left-hand contact, ground is not applied to the external circuit E so that it is in the unoperated condition, which indicates to the observer that the west subscriber is not talking.

When the armature of relay R–1 reaches its left-hand contact, the winding of relay R–3 is energized by current from batteries 27 and 28 in series flowing through that winding, the series resistances 29 and 30 and the closed armature and left-hand contact of relay R–1. This will have no effect on the operation of the counting relays X, Y and Z in the double talk counter circuit, for the first relay in that chain, relay X remains deenergized because its energizing circuit is broken at the left-hand contact of the relay T–3 because of the deenergized condition of the latter relay due to the fact that the control relay therefor, T–1, is unoperated.

When the east subscriber ceases talking, the removal of energizing current from the winding 18 of relay R–1 will cause that relay to release to shift its armature from the left-hand to the right-hand contact thereby causing the relay R–2 to again return to the operated condition due to the resupply of energizing current to its winding from battery 27. This will again remove ground from the external circuit F indicating to the observer that the east subscriber is no longer talking.

Relay R–3 will remain operated for a short time interval after the relay R–1 has released to break the connection of its winding through the latter's left-hand contact to battery 27, while condenser 31 which was discharged to nearly the potential of battery 27 (which is negative with respect to ground) when relay R–1 operated, charges up to the potential of battery 28 (which is positive with respect to ground) through the winding of relay R–3 and resistance 29 in series.

Now let it be assumed that speech currents from the west subscriber are being received at the west terminal of the four-wire circuit over the telephone line TL, and at that time no speech currents from the east subscriber are present in the output of the circuit WA of the four-wire circuit.

The speech energy from the west subscriber will be divided in the hybrid coil HC, half passing into the upper circuit EA toward the branch circuit A, and half passing into the lower circuit WA toward the branch circuit B. The portions of west's speech energy diverted into the two branch circuits A and B will be amplified by the amplifier and detected by the detector in the respective circuits causing energizing current to be supplied respectively to the opposing windings 10 and 21 of relay T–1. Because of the effects of the attenuation pad P in the branch circuit B, the energizing current supplied to winding 10 of relay T–1 from circuit A will be sufficiently stronger than the energizing current supplied to the winding 21 from the branch circuit B, so that relay T–1 will operate to shift its armature from the right-hand to the left-hand contact. If the hybrid coil HC is in normal balance the portion of the west subscriber's speech energy which may enter the branch circuit C bridged across the net side of hybrid coil HC will not be sufficient to cause operations in vogad 16 or in relay R–1.

As soon as the armature of relay T–1 leaves its right-hand contact, the source of energizing current 26 will be disconnected from the winding of relay T–2 and that relay will release shifting its armature from the left-hand to the right-hand contact thereby applying ground to the external circuit E indicating that the west subscriber is talking. Relay R–1 being unoperated, the relay R–2 will remain operated and ground will be removed from external circuit F, indicating to the observer that the east subscriber is not talking.

When the armature of relay T–1 reaches the left-hand contact, energizing current will be supplied from batteries 26 and 32 through the series resistances 33 and 34 to the winding of relay T–3 causing the operation of that relay to close its armature and left-hand contact. This will not result in the operation of counting relays X, Y and Z as the energizing circuit for the first relay in the chain, relay X, from battery 35 will still be broken at the left-hand contact of the unoperated relay R–3 because of the non-operated condition of the control relay R–1.

Now, let it be assumed that both the east and west subscribers are talking simultaneously, that is, there is double-talking. Then, both the relay T–1 and the relay R–1 will become operated in response to the energy entering the branch circuits A and C, respectively, causing the relays T–2 and R–2 controlled by the first-mentioned relays, respectively, to release, so that the armature of each is on the right-hand contact of the relay. This will cause ground to be applied to both external circuits E and F so that there will be no indication of which talking direction exists. Instead, the "double talk counter" circuit will be operated in the manner which will be described and will remain so operated until the double talking stops and the circuit is again operating normally.

In the "double talk counter" circuit, the relay T–3 will be operated by the current from batteries 26 and 32 in series transmitted through the winding of relay T–3, the series resistances 33 and 34 and the closed armature and left-hand contact of the operated relay T–1. Also, the relay R–3 will be operated by the current from batteries 27

and 28 in series passing through the relay winding, series resistances 29 and 30 and the closed left-hand contact and armature of relay R–1 due to the operation of the latter relay.

With both relays T–3 and R–3 operated, the winding of relay X is energized by current from battery 35 through the closed armature and left-hand contact of relay R–3 and the closed armature and left-hand contact of relay T–3 in series, the series resistances 37 and 36, and the winding of relay X to ground. The condenser 38, normally discharged through the winding of relay X and resistance 36, becomes charged by battery 35 through resistance 37 before relay X is actually operated.

After a short delay due to the effect of the associated condenser-resistance arrangement, relay X will operate to close its armature and left-hand contact completing an energizing circuit for the winding of relay Y from battery 39, the relay winding, series resistances 40 and 41 and closed left-hand contact and armature of relay X, and simultaneously causing the condenser 42, normally charged from battery 39 through the winding of relay Y and resistance 40, to be discharged to ground. Relay Y will then operate to close its armature and left-hand contact completing an energizing circuit for the winding of relay Z from battery 43. Relay Z will then operate to operate the counter 44.

If, then, the west subscriber or the east subscriber, stops talking, the relay T–1, or relay R–1, will release, respectively breaking the energizing circuit for relay T–3 from battery 26, or for relay R–3 from battery 27. The latter relays, however, will not immediately release. Relay T–3 would be maintained operated for a short hangover period while condenser 45 was being charged up from battery 32 through the winding of relay T–3 and resistance 33, and relay R–3 would be maintained operated for a corresponding time interval while condenser 31 was being charged to the potential of battery 26 through the winding of relay R–3 and resistance 29. Shortly following the release of either relay T–3 or R–3, relay X will also release. Release of relay Y is delay for a short period after the release of the preceding relay X while the condenser 42 is being charged up from battery 39 through resistance 40 and the relay winding. The slow release of relay Y obtained in the manner pointed out is provided to insure that one case of double talking, during which the R and T relays might chatter or operate and release several times, will not be counted more than once. Relay Z will release immediately when relay Y releases, releasing the counter CM. Each complete operation of both relays X and Y, which by proper design of the relay circuits may be made to occur only when "double talking" persists for the selected time interval, will thus be registered by the counter.

In some cases, as when the gain is high in the transmitting vogad 5 in branch circuit A and the incoming received speech volume is also high, the current in winding 21 of the relay T–1 received from the B branch circuit may be strong enough to prevent positive operation of the T–1 relay through its winding 10, when double talking occurs. The armature of the relay T–1 would then chatter, operating and releasing generally quite rapidly as the combination of transmitted and received speech energies acting in the B branch circuit varied. To take care of conditions like this when chattering occurs, the short "slow release" periods of the relays R–3 and T–3 and the "slow operate" action of relay X have been provided under control of their respective associated resistance-condenser arrangements. Thus, if the relays R–3 and T–3 are operated at any time so that their operated periods overlap long enough to exceed the slow-operate time of relay X, a "double talk" situation may be assumed. Under normal operation of the circuit, when relays R–1, R–2 and T–1, T–2 are alternating in their actions with the east and west subscribers' speech, respectively, the operated periods of relays R–3 and T–3 do not overlap appreciably.

Thus, it is seen that the counter-mechanism CM, which may be of any suitable type, will give an accurate indication of the number of "double talks" occurring in a given time interval and the "talk direction indicator" comprising the relays T–2 and R–2 in combination with the external circuits E and F, respectively, will give an indication of which subscriber is talking. The number of times the external circuits E and F are made operative in a given period of time will indicate the number of separate flows of speech from the respective talkers. By other simple means, such as a non-biased polarized relay connected to operate and remain in one position when the ground pulses are applied from E and then to reverse its position when the ground pulses are applied from F, a count indication may be obtained of the number of telephone circuit reversals.

Various modifications of the circuits illustrated and described which are within the spirit and scope of the invention will be apparent to persons skilled in the art; for example, as a means of effectively preventing false operation of the C branch circuit on outgoing speech, that circuit may be connected across the circuit WA in front of the one-way amplifying device 3 instead of being bridged across the network side of the hybrid coil HC as shown; other forms of vogads known in the prior art may be employed in connection with the circuits A, B and C in place of the particular ones illustrated; and the number of counting relays and associated circuits used in the "double talk counter" may be varied if desired to change the "double talking" test period if the talking conditions warrant it. In addition to merely counting the number of times the direction relays operate, suitable clock mechanisms could be provided to measure the durations of the various relay actions.

What is claimed is:

1. In combination with a two-way signaling system comprising at least over a portion of its length oppositely directed one-way paths for repeating signals in opposite directions, means for automatically indicating operating conditions in said system comprising means for effectively balancing the transmissions in the oppositely directed paths at one point in said system against each other, indicating means responsive in one manner to substantially stronger transmission in one of said paths than in the other and responsive in another manner to substantially stronger transmission in said other path than in said one path, and other indicating means operating whenever transmissions of substantially equal strength are simultaneously present in said one and said other path for a given time interval.

2. In combination with a two-way signaling system including a four-wire circuit, means for automatically indicating operating conditions in said system comprising means near one terminal of said circuit for effectively balancing the trans-

mission in the outgoing side thereof against that in the incoming side, indicating means controlled by said balancing means responsive in one manner to substantially stronger transmission in said outgoing side than in said incoming side, and in another manner to substantially stronger transmission in said incoming side than in said outgoing side and other means for indicating whenever transmission of substantially equal value is present in both sides of said circuit for a given time interval, and the number of times that condition exists during a predetermined time period.

3. The combination of claim 2, in which said balancing means comprises two control circuits respectively connected to said outgoing and incoming side of said four-wire circuit, an electromagnetic relay having two opposing windings respectively energized in response to the transmission impressed on a different one of said control circuits, said control circuits and relay winding being such that said relay will be operated in one direction in response to signal transmission in said outgoing side only and in the opposite direction for signal transmission in said incoming side only, the operation of said relay in said one direction controlling the first indicating means in said one manner and the operation in said opposite direction controlling it in said other manner, and said other indicating means comprising a third control circuit responsive to signal transmission in said incoming side and relay means jointly controlled by the first relay and said third control circuit when both are operated simultaneously for said given time interval and a counter controlled by said relay means for counting the number of simultaneous operations.

4. The combination of claim 2 in which said balancing means comprising two amplifier-detectors respectively controlled by the transmission in said outgoing side and in said incoming side of said four-wire circuit, an electromagnetic relay having two opposing windings respectively energized by the detected current from a different one of said amplifier-detectors, and means for controlling the sensitivities of said amplifier-detectors so that said relay will be operated in one direction when transmitted signals are present in said outgoing side and only dissipated energy of said signals in the incoming side and in the opposite direction when signals are present in said incoming side and only dissipated energy of said signals in said outgoing side, the first indicating means being responsive in said one manner to operation of said relay in said one direction, and in said other manner to operation of said relay in said other direction, and said other indicating means comprises a third amplifier-detector responsive only to signal transmission in said incoming side, relay means jointly controlled by said third amplifier-detector and said relay and completely operated thereby when signal transmission exists simultaneously in said outgoing side and in said incoming side for said given time interval, and mechanism controlled by each complete operation of said relay means to count the number and duration of the complete operations in said predetermined time period.

5. A circuit for observing talking conditions in a four-wire telephone circuit, comprising means for balancing the transmission at corresponding points in the two sides of said four-wire circuit against each other, and automatic means controlled by said balancing means for indicating at any instant the direction of signal transmission in said circuit, and the number of times telephone transmission occurs in both sides of said circuit for a given time interval.

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