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## TELEPHONE SYSTEM

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My invention relates to a method of and apparatus for easy and rapid testing of the receiving and transmitting efficiency of the receiver and the microphone, respectively, of subscriber's stations in ordinary service on a telephone system.

It is known that the above test is now usually carried out by means of a conversation between a tester at the station under test and the operator at the test desk of the exchange, during which conversation the operator at the test desk judges the efficiency of the microphone of the station under test and the tester at this station judges the reception of his own receiver.

It is however obvious that, in the first place, this method is slow and costly, requiring the services of two testers, and in the second place, the results of the test are comparatively uncertain, they being influenced by the subjective judgment of two persons.

More exact methods of testing the efficiency of transmission and reception have indeed been proposed, consisting in comparing the station under test with standard instruments, or else through the use of complex arrangements, partly installed in the exchange and partly to be carried to the subscriber's station to be tested; these methods have however the dual defect of requiring the services of two testers and the transport to the station to be tested of comparatively heavy and bulky apparatus. Moreover the tests take an excessively long time.

According to my invention, a rapid test of the receiving and transmitting efficiency of a subscriber's station in ordinary service on a telephone system is obtained by installing in the exchange an apparatus capable of registering, and afterwards reproducing, sounds (which will be hereinafter called, for the sake of brevity, "phone-repeater"), in which apparatus are permanently recorded one or more typical phrases, obtained by means of a standard microphone under predetermined conditions of transmission, and on which apparatus are recorded, at the moment of the test, a phrase or suitable sounds, transmitted by the tester through the microphone of the station under test, the installation of the "phone-repeater" apparatus and its connection the exchange being so made that the tester at the station under test, after having transmitted from the station itself the phrase, or the sounds, desired, can receive from the "phone-repeater" in immediate succession the typical phrase or phrases recorded on it per-

manently, and the phrase or sounds he has himself transmitted.

This arrangement besides realizing, in comparison with the current method as at present in use, a saving in the staff employed, since the test is made, both for the microphone and for the receiver, by the single tester at the station under test, and besides making it possible to carry out the test quickly, further allows of obtaining more reliable results. In fact, as regards the effect of the subjective judgment of the tester, it will be remarked that according to my invention it is only the tester at the station under test who hears his own voice, reproduced by the "phone-repeater", besides the typical phrase recorded on the repeater itself, and thus judges directly, and alone, of the efficiency of the telephone set he is testing.

My invention further provides an arrangement whereby the test of the efficiency of subscriber's stations is made under substantially identical conditions, irrespective of the distance between the station under test and the exchange, and that is, independently of the different attenuations due to the line, the differences of attenuation being compensated for by the automatic insertion in the circuit of additional attenuations.

My invention will be hereinafter described in detail as applied to an automatic telephone exchange; the description refers to the annexed drawing, in which are schematically represented the phone-repeater apparatus, the auxiliary devices and the connections contemplated by the invention.

The particular phone-repeater apparatus illustrated and described substantially comprises a drum carrying a ribbon of magnetic material wound spirally on it and capable of receiving a magnetic record made by an electro-magnet (recording magnet) as well as a second electro-magnet destined to detect the variations in the magnetization of the ribbon, giving rise to induced currents in its windings (reproducing or reading magnet) and a third electro-magnet, strongly excited by a constant current, capable of cancelling the previous record (cancelling magnet). Apparatus of this type are, of themselves, already known; it also should be stated here that there may be similarly employed for the purposes of my invention, without going beyond the scope of the same, other similar types of apparatus, also known, for example, with a magnetic wire instead of a ribbon, or with a ribbon wound on bobbins, etc., as are used, for

instance, for sound recording for wireless transmission, or for other similar purposes.

Referring to the drawing, a frame which comprises two uprights 1 and 2 carries a drum 3, mounted on a spindle in such a manner as to be capable of rotating, and upon which is wound a ribbon 4 of magnetic material; 5 is the recording magnet, 6 the reproducing magnet and 7 the cancelling magnet. The connections of these magnets are shown respectively by the figures 8, 9, 10, which are repeated in other parts of the drawing where such connections are continued. The drum 3 is set rotating through an electro-magnet 11, when this is excited, because it lifts and causes to engage with a bevel wheel 12, mounted on the spindle of the drum 3, a bevel wheel 13 mounted to slide on a driving spindle 14; at the same time as the magnet 11 is excited, another electro-magnet 15 in parallel with it is also excited, and this lifts an armature 16 shaped like a ratchet pawl which, when lowered, engages with the teeth of the wheel 12, preventing the drum 3 from rotating. The spindle 14 is kept in motion, through worm and worm-wheel gearing 17, by an electric motor 18 fed by the current from an ordinary distributing main 19, and which is set in motion when the relay N, as will be described later, comes into action.

In those installations in which, accordingly to the number of subscribers connected to the exchange, it is desirable to install several phone-repeaters, a single frame may carry preferably several drums (for example, up to three) which will have a common mechanical drive by means of a single spindle 14 and a motor 18.

The magnets 5, 6 and 7 are carried by an arm fixed to a carriage 20 sliding along guide rods 21 and 22, parallel to the axis of the drum. The pole pieces of the magnets engage in a helical groove in the drum, in which is wound a ribbon of magnetic material 4, in such a manner that the drum, rotating, draws the carriage 20 along parallel with its axis, whilst the magnets 5, 6 and 7 travel over the whole length of the ribbon. The direction of rotation of the drum is such that the carriage moves in the direction, in the figure, from left to right.

The rod 21 on which the carriage 20 slides is round, so that the carriage can revolve around it; on the rod 22 the carriage however simply rests through a roller (not seen in the figure) carried on a rocking arm pivoted to the carriage, which is caused to rock through the action of an electro-magnet 23 when the latter is energized. This arm, when operated, reacting on the carriage 20, lifts it up, thus lifting the magnets 5, 6 and 7 clear of the spiral groove; when the electro-magnet 23 is de-energized, the carriage comes down again by virtue of its own weight, and the magnets take up their working positions again.

A counterweight 24 acts on the carriage 20, bringing it back towards the left as soon as, upon the carriage being lifted, the magnets 5, 6 and 7 are disengaged from the spiral groove. A cylinder 25 serves as a guide for the counterweight 24 and at the same time constitutes, with the counterweight itself, an adjustable air brake, which moderates the traverse of the carriage.

The carriage 20 is fitted with a projecting arm 26 which acts, when the carriage is at the left end of its traverse, on contacts 27, 28, 29 thus closing or opening circuits which shall be hereinafter described; the carriage is also provided

with a projecting arm 31 which acts, when the carriage is at the right end of its traverse, on a contact 32. The arm 31 also bears a contact 33 which can slide along a spring contact 34 or make a short contact with a spring contact 35, these spring contacts being slidably secured on a rod 36 of insulating material, at suitably chosen points. The contact 33 is grounded through the carriage 20, slide rods 21 and 22 and the frame of the apparatus, generally, which is grounded. The positive pole of the battery which feeds the apparatus is also grounded; the negative pole of the same is indicated throughout in the drawing by the numeral 30. The contact 33 thus grounds, during the traverse of the carriage 20, the spring contact 34 for a period of time and the spring contact 35 for an instant.

The apparatus comprises a system of relays and magnets the operation of which shall be particularly described later on, as well as a key K and a vacuum tube amplifier 37.

A subscriber's station whatever, in ordinary service on a telephone system, as has been indicated in the drawing by the numeral 38, is connected to the phone-repeater through the line 39, over selectors 40, 41, 42 and 43. In the drawing, the dotted line a, b circumscribes the telephone set, line and selectors which make part of the ordinary installation of the telephone system.

The selectors 42, which can be seized over the preceding group selectors 41, have as a rule many levels connected to the following selectors 43; the first level is connected to the following selectors directly, while the second level is connected to said selectors over an attenuator 44, the third level is connected to said selectors over an attenuator 45, and so on as the case may be. In the case represented in the drawing, three levels of the selectors 42 are connected to selectors 43, say one directly and two over attenuators of different values.

The operation of the apparatus is as follows.

The tester at the subscriber's station 38 dials a number of two or three digits, thus seizing, in the usual way, the selectors 42; through a successive digit he seizes one of the selectors 43 either directly or at will, according to the figure of this last digit, over an attenuator, 44 or 45, of more or less value.

The seized selector 43 rotates until it seizes a phone-repeater which is free. The seizing operation is as follows. Each selector 43 is fitted with a test and busy relay T<sub>1</sub>, or T<sub>2</sub> or T<sub>3</sub>; when the selector (for instance the uppermost one in the drawing) finds a phone-repeater which is free, the following circuit is connected up: earth, T<sub>1</sub>, relay C, battery 30. T<sub>1</sub> and C are operated. T<sub>1</sub> short-circuits, through its contact 46, a portion of its own winding, so that another selector 43 may not afterwards seize the same relay C, inasmuch as it is shunted by the reduced resistance of the preceding relay T<sub>1</sub>. Simultaneously C operates its contacts 47, 48 and 49 whereby:

1. Through the contact 47 it grounds the filament of the amplifier 37; through the contact 48 it closes the circuit of a tone 50 which is sent over the resting contacts 51 and 52 of relay V to the tester, to inform him that he is connected to the phone-repeater.

2. Through the contact 49 it grounds the relay H, over the resting contact 53 of relay G. A magnet N which is branched in parallel with this second circuit then energizes and operates its

contacts 54 and 55, through which current from the distributing main 19 is fed to the motor 18. The latter starts, thus driving the shaft 14 and continues to rotate until any of the phone-repeaters in the plant is busy.

The relay H holds operated also through grounds it finds at the contact 56 of relay Z and at the contact 28, over its own contact 57 operated. The relay H, through its lower contact 58, grounds the relay G, thus energizing it, and grounds through the contact 59 the lamp L<sub>o</sub>, which lights, and the relay L<sub>rm</sub>. The relay G on being operated changes its contact 53, thus holding operated over the ground contact of relay C, while rendering the relay H independent of the operation from C.

The relay L<sub>rm</sub> is a mechanically slow operated relay which after a period of time pulls up and grounds over its own contact 61 the magnets 11 and 15, the lamp L<sub>a</sub> and the relay V. The lamp L<sub>a</sub>, as well as the already mentioned one L<sub>o</sub> and the lamp L<sub>i</sub> give the maintenance staff in the exchange opportune signals. The relay V on being operated removes the tone 50 from the line of the calling station 38, which is instead extended to the resting contacts 62 and 63 of relay B<sub>2</sub> which are connected to the anode circuit of the amplifier 37; the tester at the telephone 38 is then ready to listen to the transmission from the phone-repeater.

The ribbon 4 has been previously prepared, as will be hereinafter explained, so that it carries recorded on a portion of it, starting from the left end, one or a plurality of standard phrases, or a series of logatoms. There may be recorded for instance two successive phrases suitably chosen. The length and position of the spring 34 and the position of spring 35 depend upon the extension of said phrases, as will be clear from the following explanations.

At the beginning of the operation the carriage 20 is at the left end of its traverse. Upon rotation of the drum 3, the reproducing magnet 6, under the influence of the state of magnetization of the ribbon 4, will give rise to a telephonic current which will be directed toward the station 38 under test over the circuit: wires 9, resting contacts 64 and 65 of relay B<sub>1</sub>, grid transformer 66, potentiometer 67, grid of amplifier 37, anode transformer 68, resting contacts 62 and 63 of relay B, shunt over one winding of attenuator 69, over the resting contact 70 of relay R, contacts 51 and 52 of relay V operated, selectors 43, 42, 41, 40 and line 39. The tester at the station 38 will then receive the first standard phrase recorded on the ribbon 4.

At the end of this phrase, the contact 33 reaches the spring contact 34, the position of which has been correspondingly adjusted on the insulating bar 36, thus grounding the circuit: spring 34, contact 71 of relay X at rest, relay R, battery 30. The relay R pulls up and, by removing the short circuit over its contact 70, while extending the circuit over its contact 72, connects up the attenuator 69 between the anode transformer 68 and the selector 43, in such a way that the tester at the station 38 now receives with a corresponding attenuation the second standard phrase recorded on the ribbon 4. The intensity of this transmission will be so chosen, through a corresponding choice of the value of the attenuator 69, that it will be satisfactorily received only with a receiving telephone in normal conditions, while it would not be perceived or would

be only in objectionable way with a telephone in deficient conditions.

As the traverse of carriage 20 continues, the contact 33 grounds the spring 35, thus completing the circuit: ground, contact 33, spring 35, contact 73 at rest of relay X, relay A, battery 30. The relay A pulls up and holds operated also after the contact 33 clears the spring 35, through an auxiliary ground he receives over its own contact 74, operated and the contact 29.

Moreover, the contact 75 of A grounds the signalling lamp L<sub>i</sub> as well as the relays B<sub>1</sub> and B<sub>2</sub>, over the circuit: ground, contacts of key K, at rest, relays B<sub>1</sub> and B<sub>2</sub> in parallel, battery 30.

The relays B<sub>1</sub> and B<sub>2</sub> on being operated effect the following operations, viz.:

B<sub>1</sub> grounds through its contact 76 the relay E which operates and in turn diverts over the contact 77 the grid of the amplifier from the potentiometer 67 to the potentiometer 78; this is intended to obtain a different degree of amplification as is necessary for recording on the ribbon 4 in comparison with that which is necessary for the reproduction. Further, over the other contacts 64 and 65, operated, the grid transformer 66 is extended to the line coming from the telephone 38, whilst the wires 9 coming from the reproducing magnet 6 are disconnected.

B<sub>2</sub> extends through the contacts 62 and 63, operated, the anode transformer 68 to the wires 8 which lead to the recording magnet 5. A battery 79, variable resistance 80 and condenser 81 are connected up on one of said wires 8.

Thus the tester at the station 38 by transmitting through his microphone a phrase or logatoms records these sounds on the ribbon 4. At the end of the traverse of carriage 20 towards the right, the arm 31 closes for an instant the contact 32 which grounds the relay P<sub>2</sub>; the latter effects the following operations, viz.:

By opening its contact 82, it removes the ground from lamp L<sub>a</sub> and relay V, which latter falls back thus causing the tone 50 again to be sent to the tester: the tester is so informed that the phone-repeater has reached the end of its traverse. The relay P<sub>2</sub> further grounds, over its contact 83, operated, the magnet 23 which acting upon the support of the carriage on the guide bar 22, as has been already mentioned, causes the carriage to rock thus disengaging the magnets 5, 6 and 7 from the helical groove in the drum 3, whereby, through the effect of the counter-weight 24, the carriage quickly returns towards the left. During this traverse, however, the contact 33 does not touch the springs 35 or 34, on account of the carriage being lifted or swung through an angle around the guide bar 21. Through the contact 84 the relay P<sub>2</sub> gives its own winding a holding ground, over the contact 29, so that it holds operated even when on beginning of the return traverse of the carriage the contact 32 again opens.

At the end of the traverse towards the left, the arm 26 opens the contacts 28 and 29 and closes the contact 27. The contact 29, on opening, removes the ground from relay P<sub>2</sub>, which falls back.

At the same time the relay A, upon falling to it the holding ground over the contact 29 falls back; further P<sub>2</sub>, on falling back removes the ground from the magnet 23 and allows of the carriage to take its normal, lowered position, so that the magnets 5, 6 and 7 again rest on the ribbon 4. The rocking movement of the carriage also disengages the arm 26 from the contacts 27, 75

28 and 29, thus the latter are allowed to take up again their positions of rest.

On falling back, the relay A removes the ground from the lamp  $L_1$  and the relay  $B_1$  and  $B_2$ : the initial conditions are then restored and the circuits are ready for the reproduction of the phrases recorded on the drum and the reception thereof by the station 38. Meanwhile, through the operation of the contact 27 the relay X is energized over the circuit: earth, contact 27, relay X, battery.

The relay X operates and closes its contact 84 through which it then holds operated over the contact 59 of relay H, giving it an earth, and completes through its contact 73 a circuit for the operation of the relay Z, extending to the contact 35, whilst cutting off the relay A. Further, by opening the contact 71 it disconnects the circuit for the operation of the relay R, coming from the contact 34, so that when the contact 33 will touch the contact 34, R will not be operated.

The tester at the station 38 hears therefore both the standard phrases recorded on the drum without any difference in the attenuation. The contact 33 reaches then the spring contact 35 thus grounding the relay Z which pulls up, over the circuit: earth, contact 33, contact 35, contact 73 diverted to right hand, relay Z, battery 30. Z holds operated, also after the contact 33 clears the contact 35, over the circuit; earth at contact 28, contact 85 of relay Z itself, operated, relay Z, battery 30. Further the relay Z closes over its own contact 86 and the connections 10 the circuit of the cancelling magnet 7 in such a manner that at the beginning of the portion of the ribbon 4 on which the sounds transmitted by the tester are recorded these sounds are immediately cancelled by the magnet 7 after they have been detected by the magnet 6.

During the whole traverse of the carriage 20 the tester then listens to the standard phrases and the phrase or other sounds he has himself transmitted, consecutively.

At the end of the traverse towards the right, the contact 32 is again closed thus energizing as has already been described the magnet 23 which causes the carriage 20 to rock upwards and to travel back towards the left. At the end of this return traverse, again the contacts 28 and 29 are opened and the contact 27 is closed. The contact 29, on opening, removes the ground from the relay  $P_2$  which falls back; the contact 28, on opening, removes the ground from the relay H which now falls back inasmuch as the other ground, from the contact 56 of relay Z, which is now operated, is missing.

Upon falling back of the relay H successively fall back the relays  $L_1$ , M, D and N and the magnet 11 is deenergized, unless another call is being extended from another station, in which case the relay N which is common to the several phone-repeaters in the plant will hold operated. Further falls back the relay V while the relays  $T_1$  and C hold operated as long as the station under test holds the line, that is until the tester does not hang up; at this time G also falls back and the amplifier extinguishes.

In case the tester would hang up before the carriage 20 has travelled back to its position of rest, first fall back  $T_1$  and C, whilst G holds operated over the contact 58 of relay H; upon falling back of H then G falls back too.

The key K is intended for allowing the recording of the standard phrases or the cancellation thereof. On raising the key K, ground is given

to relays H and Z; thus the phone-repeater is set rotating and since Z is operated the record on the ribbon 4 is wholly cancelled. On throwing the key K, instead, ground is given to relays  $B_1$  and  $B_2$ , thus energizing the recording magnet 5 starting from the beginning of the traverse of the carriage 20 in such a manner as to allow of standard phrases being recorded on the first portion of the ribbon.

The arrangement for inserting between selectors 42 and 43 attenuators (44, 45) of different values, at will, is intended to allow, as has already been mentioned, to carry out efficiency tests on subscribers' stations, substantially under equal conditions irrespective of the location of the station in the telephone network, that is independently of the greater or less attenuation of the line connecting the station to the exchange.

To this end, the telephone network will be considered as divided in a number of zones, within each of which the average attenuation of the subscribers' lines may be considered as practically constant, and an additional attenuation of more or less value, according to the zone within which the station under test is located, will be inserted in the circuit during the test operation, to compensate for the change in the average attenuation of the line connecting the station to the exchange.

In the particular case as illustrated on the drawing, there has been considered a network divided in three zones, of minimum, medium and maximum attenuation, respectively; accordingly there has been provided the possibility of inserting between selectors 42 and 43 a maximum additional attenuation 45, or a medium additional attenuation 44, or no attenuation, respectively.

In multi-exchange systems, if a phone-repeater is installed only in the main exchange, the subscribers' stations connected to the satellite exchanges shall be considered as if they were located in a zone having an average attenuation corresponding to the attenuation of the line connecting each station to its satellite exchange plus the attenuation of the junction to the main exchange. Alternatively, a phone-repeater may be installed in each satellite exchange.

I claim:

1. An apparatus for testing the receiving and transmitting efficiency of the receiver and the microphone, respectively of subscribers' stations in ordinary service on a telephone system through speaking and listening from the station itself, which comprises an apparatus adapted to be connected to the subscriber's station through the usual telephone central office, and which comprises an automatic recording and receiving apparatus, arranged to reproduce, for transmission to the subscriber's station, sounds or words from a permanent record, record sounds or words from a subscriber's station and reproduce these sounds or words for transmission back to the subscriber's station, and means to automatically cancel words or sounds recorded by the operator after such words or sounds have been reproduced.

2. An apparatus for testing the receiving and transmitting efficiency of the receiver and the microphone, respectively, of subscribers' stations in ordinary service on a telephone system through speaking and listening from the station itself, which comprises an apparatus adapted to be connected to the subscriber's station through the usual telephone central office, and which comprises an automatic recording and receiving apparatus, arranged to reproduce, for transmission to the subscriber's station, sounds or words from

a permanent record, record sounds or words from a subscriber's station, and reproduce these sounds or words for transmission back to the subscriber's station, and a plurality of attenuations of different sizes adapted to be placed in the line at the central office, which attenuations compensate for the length of line between the subscriber's telephone and the central station.

3. An apparatus for testing the receiving and transmitting efficiency of the receiver and the microphone, respectively, of subscribers' stations in ordinary service on a telephone system through speaking and listening from the station itself which comprises an apparatus adapted to be connected to the subscriber's station through the usual telephone central office, and which comprises an automatic recording and receiving apparatus, arranged to reproduce, for transmission to the subscriber's station, sounds or words from a permanent record, record sounds or words from a subscriber's station and reproduce these sounds or words for transmission back to the subscriber's station, automatic means for making particular connections, a plurality of which connections terminate at the recording and reproducing apparatus, and a plurality of attenuations of different sizes to compensate for differences in the length of line from the subscriber's telephone to the said apparatus, each of said attenuations being inserted in a different connection so that the amount of attenuation in the line may be controlled by the selection of the connection to be used.

4. A method for easy and rapid testing of the receiving and transmitting efficiency of the receiver and the microphone, respectively, of subscribers' stations in ordinary service on a telephone system through speaking and listening from the station itself, comprising installing in the exchange a recording and repeating apparatus (phone-repeater), permanently recording

on said apparatus words or sounds, providing said apparatus with connections, mobile contacts and relays to allow an operator at any of the subscribers' stations in the system to extend a call to the recording apparatus, listen to the words or sounds permanently recorded on it, record on the same words or sounds transmitted through the subscriber's microphone, and then listen again to the permanently recorded words or sounds and the words or sounds previously transmitted by himself in immediate succession, and inserting in the connections between the subscriber's station and the recording apparatus additional attenuations of more or less value to compensate for the different attenuation of each subscriber's line.

5. A method for easy and rapid testing of the receiving and transmitting efficiency of the receiver and the microphone, respectively, of subscribers' stations in ordinary service on a telephone system through speaking and listening from the station itself, comprising installing in the exchange a recording and repeating apparatus (phone-repeater), permanently recording on said apparatus two successive series of words or sounds, providing means whereby said series of words or sounds are reproduced with different intensity, and providing said apparatus with connections, mobile contacts and relays to allow an operator at any of the subscribers' stations in the system to extend a call to the recording apparatus, listen to the two series of words or sounds permanently recorded on it and reproduced with different intensity, record on the apparatus words or sounds transmitted through the subscriber's microphone, and then listen again to the permanently recorded words or sounds and the words or sounds previously transmitted by himself in immediate succession.

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