July 30, 1940. F. E. D'HUMY ET AL 2,209,327

COMMUNICATION SYSTEM

Filed Aug. 13, 1936

2 Sheets-Sheet 1

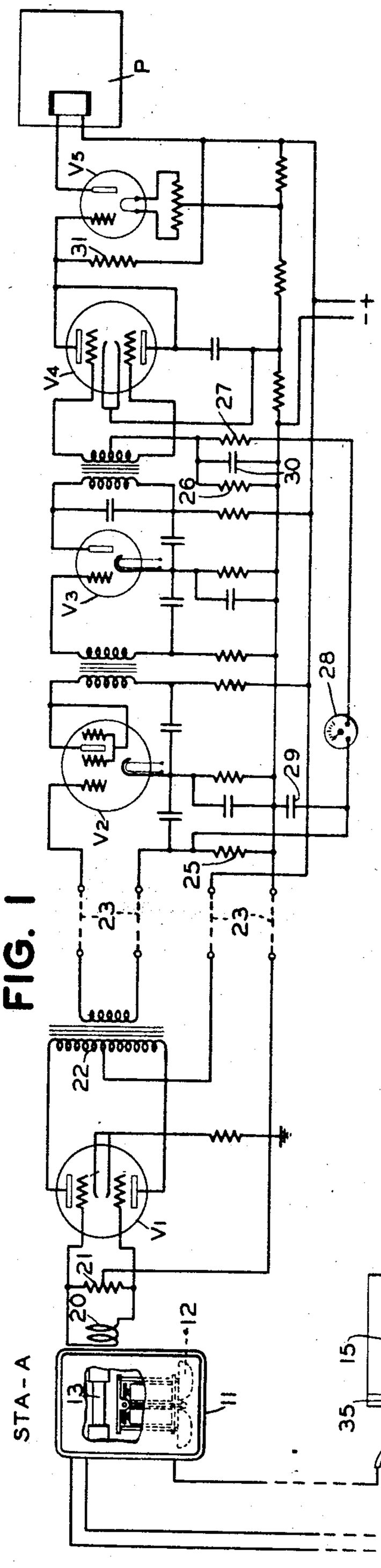

FIG. 1

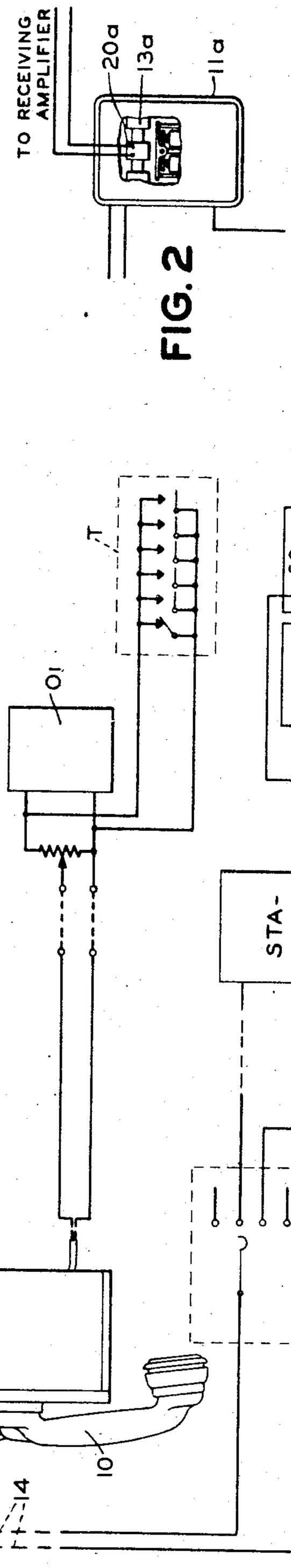

FIG. 2

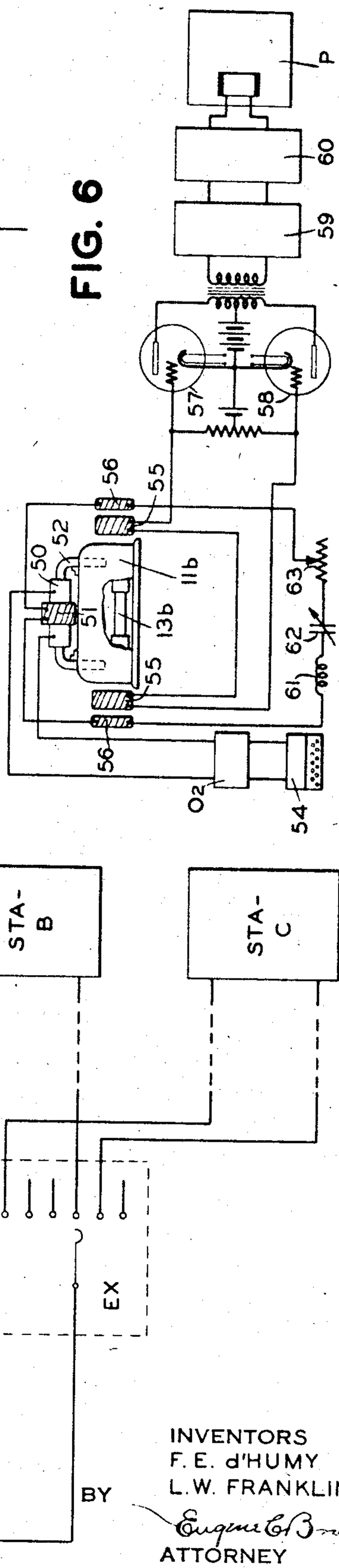

FIG. 6

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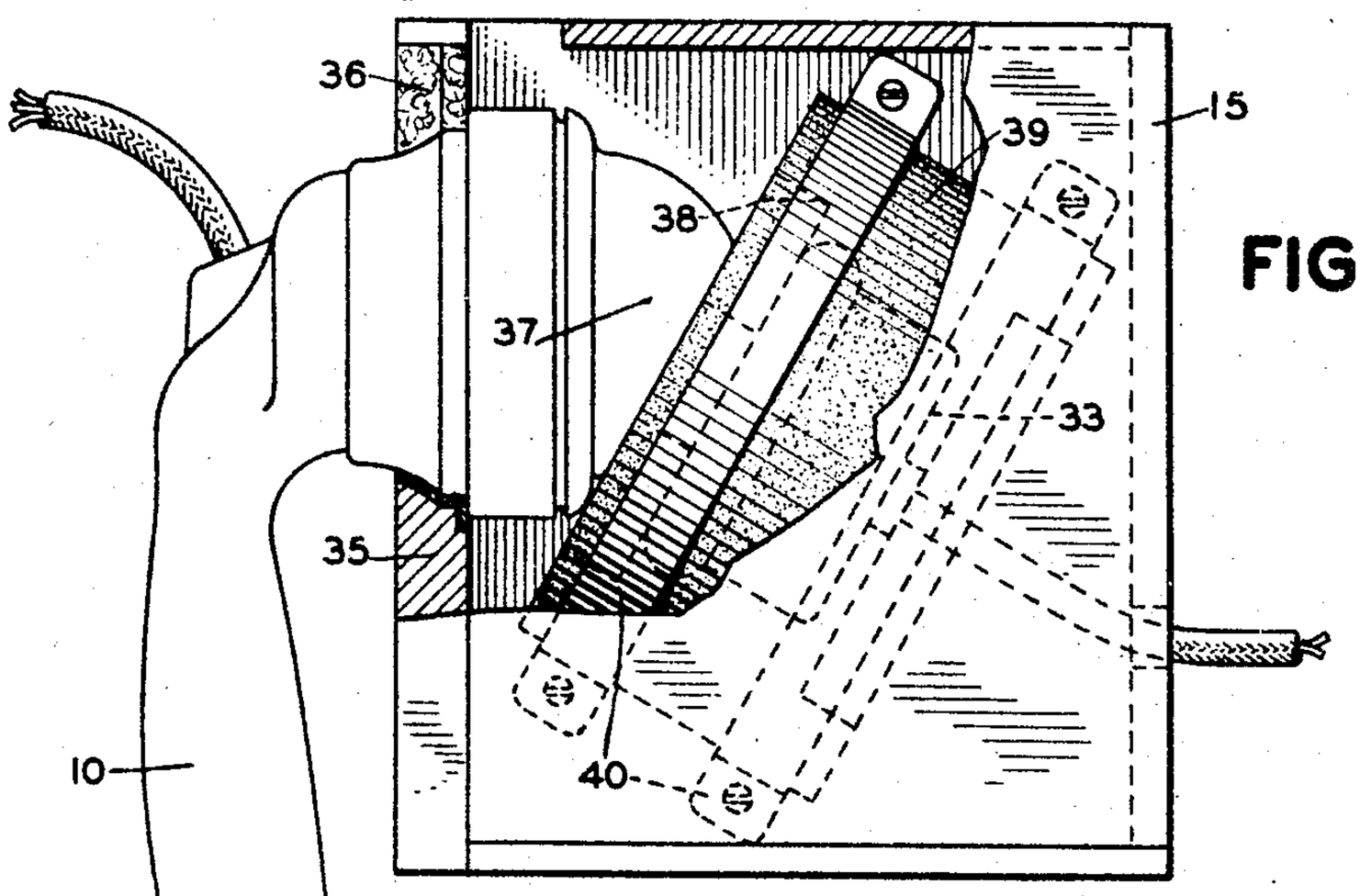


FIG. 3

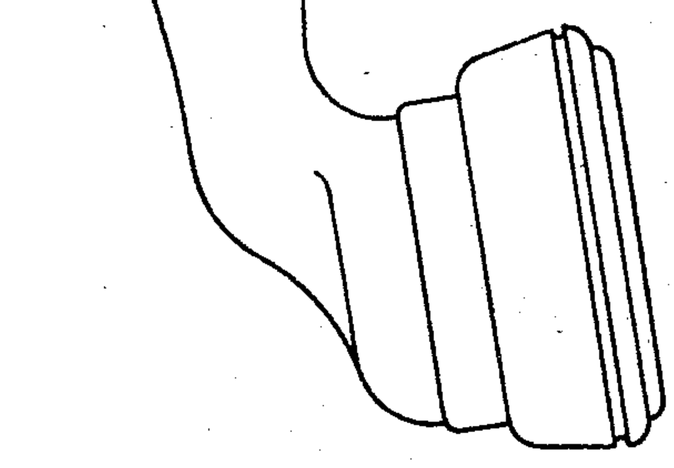
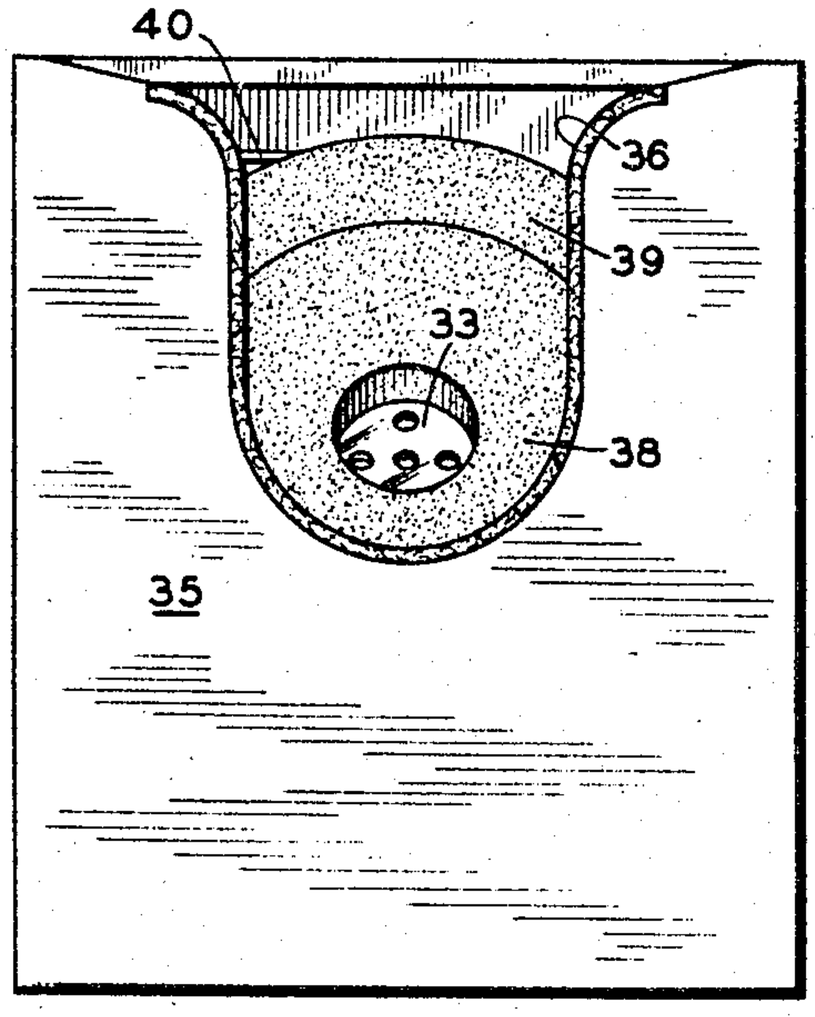
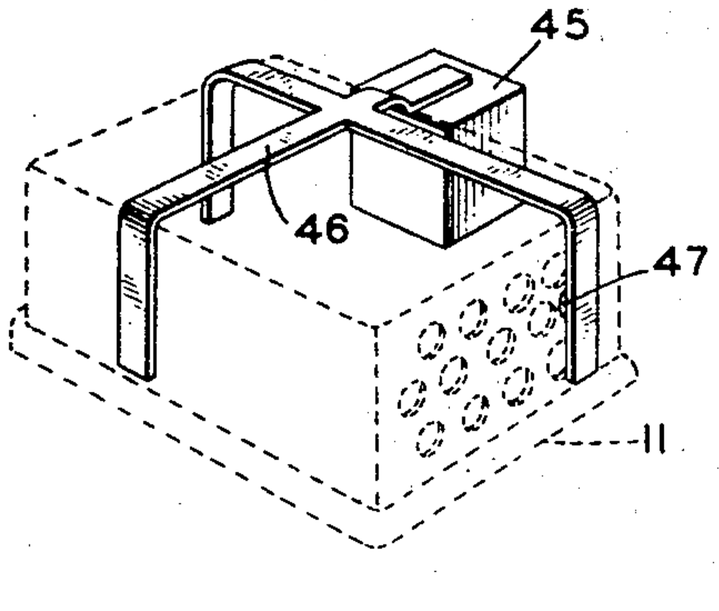


FIG. 5

FIG. 4





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UNITED STATES PATENT OFFICE

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COMMUNICATION SYSTEM

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Application August 13, 1936, Serial No. 95,912

3 Claims. (Cl. 179—4)

This invention relates to communication systems and more particularly to combined telephone-telegraph systems in which the circuits of the telephone system may be utilized for telegraphic communication between telephone subscribers.

In systems of this kind, as it is advantageous to avoid any modification of the telephone circuit or apparatus, it has been proposed to arrange the telegraph transmitting and receiving apparatus in sound-transferring relation to the telephone transmitter and receiver of the substation set in such a manner that the telegraph signals are impressed upon and picked up from the telephone equipment in the same way as the sound variations or speech during the normal use of the telephone. This arrangement involved a sound reproducer, controlled by the telegraph transmitter, coupled to the telephone transmitter and a microphone coupled to the telephone receiver for detecting the received signals which are then amplified and impressed upon the receiving printer. It has been found that this system, though operative, has certain disadvantages which are overcome by the present invention.

For example, the ordinary telephone receiver varies widely in its response to different frequencies and it is necessary to employ a sensitive microphone in connection with the receiver in order to operate on weak signals. On the other hand, any microphone of sufficient sensitivity overloads easily and distorts the signals. On outgoing signals, the sidetone in the telephone receiver is utilized to operate the local printer to make a home copy of the message being transmitted. This involves the further difficulty that when outgoing signals of large amplitude are required to operate the distant printer, the local microphone is overloaded so that different adjustments of the receiving equipment are required during transmitting and receiving. Thus a poor telephone connection, over which however it is possible to converse, is sometimes not operable for two-way telegraph communication.

One object of the present invention is to overcome these limitations of the prior systems.

Another object of the invention is to provide a combined telephone-telegraph system in which the operating limits of the telegraph equipment are such that telegraph communication may be carried on over any circuit over which it is possible to converse, without adjustment of the amplifier or other telegraph apparatus when a change is made from sending to receiving or vice versa.

Another object of the invention is to eliminate the microphone from a system of the character referred to above, and thus avoid the distortion of signals in both the telephone receiver and microphone.

In the prior systems, during transmission of signals the signalling impulses were repeated by four diaphragms, i. e., that of the reproducer associated with the tone generator, of the telephone transmitter, of the telephone receiver and of the microphone. The inertia of these diaphragms, particularly of the receiver and microphone, produced tailing of the signals which are initially square-topped current impulses. Although this distortion could be corrected to a large extent by properly designed circuits, the correction of the wave form involves difficulties which it is desirable to avoid.

A further object of the invention is to provide a system of the character described in which the diaphragm distortion of the receiver and microphone, and if desired of the transmitter and reproducer also, is entirely eliminated.

A further object of the invention is to provide an improved method and means of inductively coupling the telegraph apparatus to the telephone system.

A still further object of the invention is to provide an improved acoustic coupling unit for impressing tone signals on a telephone transmitter.

For a better understanding of the invention both as to its organization and method of operation, reference should be had to the accompanying drawings illustrating preferred embodiments thereof and in which:

Fig. 1 is a circuit diagram of a combined telephone-telegraph system according to the invention;

Fig. 2 shows a modification of a part of the system shown in Fig. 1;

Figs. 3 and 4 are detail views of the acoustic coupling unit shown in Fig. 1;

Fig. 5 is a view in perspective showing the coupling coil and preamplifier mounted on a bell box; and

Fig. 6 is a circuit diagram of a modified system.

Referring to Fig. 1 of the drawings, the invention is illustrated in connection with station A of a telephone system, said station comprising the usual substation set including a handset 10 and a bell box 11 containing a ringer 12 and induction coil 13. Station A may be connected

through its line circuit 14 and a telephone exchange, represented diagrammatically at EX, to other subscribers' stations B and C provided with telephone and telegraph apparatus similar to that shown at station A. The purpose of the system embodying the invention is to provide communication facilities between telephone subscribers supplementing that afforded by the telephones but utilizing the telephone lines and exchange equipment.

In the embodiment of the invention shown, a telegraph transmitter T, for example a start-stop keyboard or tape transmitter, is arranged to key the output of a low frequency oscillator O1, for example of 750 cycles, to produce audible-tone, permutation code signals to be transmitted over the telephone circuit to a subscriber connected to station A through the telephone exchange EX. The tone signals are impressed upon the transmitter of the handset 10 through an acoustic coupling unit 15 shown in detail in Figs. 3 and 4. It will be apparent that the tone signals may be produced by any suitable signalling equipment, such as a facsimile transmitter or telautograph transmitter, and utilized to operate an appropriate facsimile recorder or telautograph receiver at the receiving station. The term "telegraph" is therefore intended to cover other signalling equipment than that shown by way of example in the drawings.

The tone signals are transmitted over the line 14 to the receiving station where the signals are picked up by a coil corresponding to the coil 20 in mutual inductive relation to the induction coil 13 or equivalent element of the substation set at the receiving station. The coil 20 may be inside or outside of the bell box and is preferably constructed with a great many turns, for example several thousand turns, and with as large an area as practicable. The coil is preferably center-tapped or connected to a tapped resistor 21, as indicated. The signalling impulses induced in the coil 20 are amplified by a preamplifier tube V1 having the input circuit thereof arranged in push-pull relation to minimize distortion or interference produced by insufficiently filtered power supply and capacity pickup from the telephone box to the pickup coil of disturbances which may be picked up by the telephone circuit, etc. The coil 20 may be disposed in any position where current is induced therein by the signalling currents traversing the induction coil 13, although obviously the coupling between said coils is a maximum when the coil 20 is located adjacent one end of the core of the induction coil 13, as shown.

The preamplifier is preferably shielded and mounted close to the coil 20 to minimize extraneous pickup, and the output transformer 22 thereof connected through a cable 23 to an amplifier and inverter unit consisting of amplifier tubes V2 and V3, connected in cascade, an amplifier-rectifier tube V4 and an inverter tube V5. The amplifier unit is a conventional low-frequency amplifier, except as noted hereinafter, and need not be described in detail. The tube V2 is preferably a variable-mu tube, such as the type "35" tube with the screen grid and plate strapped together. The amplifier gain is controlled by biasing the control electrode of tube V2 partly in accordance with the grid current of said tube and partly in accordance with the grid current of tube V4, by the arrangement of resistors 25, 26 and 27 which may be 0.1 megohm each. The resistor 25 is disposed in the grid return circuit of tube V2, the resistor 26 in the grid return circuit of tube V4 and the resistor 27 between the grid terminals of both of the other resistors.

With this arrangement it will be apparent that on signals of intermediate amplitude, the bias of the control grid of tube V2 is determined partly by the grid current of tube V2 but principally by the larger grid current of tube V4, and the gain in the amplifier is less with strong signals than when weak signals are impressed upon the tube V2. On the other hand, for stronger signals the gain in both tubes and particularly in the tube V2 is still further reduced by the increased negative bias on the control electrode of tube V2 so that the rectified output of tube V4 is substantially constant over a wide range of amplitude of received signals. The usual automatic volume control circuit in radio frequency amplifier and detector systems utilizes a common bias resistor in the grid return circuits of the detector or rectifier and of the preceding amplifier. The arrangement shown has the advantage over such systems that upon receipt of strong signals, the large bias voltage produced by the grid current of the amplifier V2 does not block the tube V4 since the resistors 25, 26 and 27 are so arranged that the grid bias of tube V4 resulting from the grid current of tube V2 is only a fraction of that upon the control grid of tube V2. Thus the amplifier is not rendered inoperative by the reception of abnormally strong signals and the system is operative over a wider range of signal variation, and may be made sensitive to weak signals without blocking a stage of the amplifier when strong signals are received. Obviously, the resistance of resistors 25, 26 and 27 may be varied to a considerable extent without affecting the operation of the amplifier and the values given are merely illustrative. A milliammeter 28 in series with the resistor 27 provides an indication of the strength of the received signals.

In accordance with a further feature of the invention, the amplification or gain control is given a time constant approximately equal to or faster than the signal frequency but less than the carrier frequency or the frequency of the audible tone generated by the oscillator O1. Thus for a tone frequency of 750 cycles per second, condensers 29 and 30 of 0.1 mf. capacity may be connected in parallel relation to the resistors 25 and 26, respectively, giving the gain control a time constant of about 1/40 of a second; i. e., the condenser 29 or 30 is charged to approximately two-thirds of its final potential in one-fortieth of a second. It will be apparent that for the assumed value of carrier frequency, the gain control will not affect the carrier wave but will be operative to reduce the peaks of large signal impulses. This feature, disclosed and claimed broadly in our copending application, Ser. No. 52,408, filed November 30, 1935, is novel inasmuch as the ordinary gain control as applied to a radio receiver is given a time constant considerably less than the audio component of the carrier in order to avoid distortion of the speech currents.

As shown, the tube V4 is arranged for full-wave rectification and the rectified output currents or signals are impressed upon the grid of the inverter tube V5. The method of keying the oscillator O1 shown in Fig. 1 produces inverted signals, since normally a rest signal corresponds to current flowing in the line circuit, and the tube V5 reinverts the code signals before the same are impressed upon the operating magnet

of the receiving printer P. The tube V5 is normally conductive by reason of the connection of the control electrode thereof through a resistor 31 to a point of positive potential with respect to the cathode. The resistor 31 is also in series relation with the anodes of the tube V4 whereby when signals are impressed upon the latter, the current flow through the resistor 31 causes the control electrode of the tube V5 to become more negative and interrupts the flow of current to the printer magnet for the duration of each signal. Thus the spacing signals, corresponding to tone signals received over the line, are converted into no-current signals to control the printer P in the usual manner.

Since each of the stations A, B, C, etc. is equipped with telegraph sending and receiving apparatus similar to that shown in connection with station A, it will be apparent that two-way telegraph communication may be carried on between any two stations interconnected through the telephone system. The printer P also responds to the local transmitter T by reason of the sidetone in the telephone set so that a home record is made of a message being transmitted. The pickup coil 20 may be inductively coupled in various ways to the induction coil 13 or other element of the substation traversed by the signalling currents. Thus as shown in Fig. 2, one or more coils 20*a* may be wound directly upon the induction coil 13*a*. The coil 20*a* corresponding to the coil 20 of Fig. 1, may be a single-turn coil or strap coupled to the amplifier through a step-up transformer, and as will be apparent to those skilled in the art, various other equivalent means may be employed to detect the tone signals transmitted through the line circuits of the telephone system or if desired, to impress the tone signals from the transmitter upon the line circuits.

As pointed out above, after two subscribers have been interconnected through the telephone exchange, the handsets 10 of the respective subscribers are placed in the acoustic coupling units 15 for telegraphic communication. Figs. 3 and 4 show the detailed construction of one form of coupling unit that may be employed consisting of a hollow box or casing having a front wall 35 provided with an aperture which may be lined with rubber or felt 36 and adapted to embrace the transmitter of the handset when the same is laid in the casing. The casing contains a reproducer 33 which is preferably acoustically shielded and arranged in sound transferring relation to the transmitter of the handset 10 by the act of hanging the handset on the casing. When the handset is hung or suspended on the coupling unit in the position shown in Fig. 3, the hood 37 of the transmitter abuts against a disc 38 of sponge rubber or other sound absorbing material. The disc 38 is arranged to shield the front end of a cylinder or block 39 of sponge rubber or other sound absorbing material attached to the wall of the casing 15 by the clamps 40. As shown in Fig. 4, the diaphragm of the reproducer 33 is exposed through an aperture in the disc 38 in order to permit acoustic coupling between the reproducer 33 and the transmitter of the handset 10 while shielding the transmitter against external noises. When the telegraph equipment is not in use, the handset 10 may be readily withdrawn from the acoustic coupling unit 15 and used in the regular way for telephone communication.

As shown in Fig. 5, a casing 45 containing the coil 20, the tube V1 and the output transformer 22, may be carried by a frame 46 adapted to embrace the sides of the bell box. The frame 46 may include opposite legs one of which is provided with a projecting lug 47 adapted to be received by apertures in the side walls of the bell box so that the preamplifier may be readily attached to and detached from the bell box. In the embodiment shown, when the casing 45 is mounted on the bell box, the coil 20 is located adjacent one side of the box opposite the end of the core of the induction coil.

Instead of utilizing the transmitter of the handset to impress the tone signals upon the telephone line, inductive coupling of the oscillator to the induction coil of the bell box may be employed.

Thus, as shown in Fig. 6, a transmitting coil 50 may be arranged in mutual inductive relation to the induction coil 13*b* corresponding to the induction coil 13 of Fig. 1. The coil 50, and also an auxiliary coil 51, are mounted upon a magnetizable core member 52 secured in any desired manner to the cover of the bell box 11*b*. By way of example, the core member 52 is shown as U-shaped with the projecting pole pieces thereof extending through apertures in the cover into the proximity of the core of the induction coil. Obviously where sufficient power is available, the core member may be arranged entirely outside of the box, i. e., with the pole pieces of the core engaging the outside of the box so that coupling of the telegraph equipment to the telephone line may be effected without any alteration of the substation set. However, the efficiency of the inductive coupling is greatly increased by the arrangement shown which does not hamper ready access to the interior of the bell box or involve any physical connection to the telephone apparatus except the cover of the bell box.

The transmitting coil 50 is connected to an oscillator O2 controlled by a keyboard 54 whereby audible-tone printer signals may be impressed upon the line through the induction coil 13*b*. Incoming signals from a remote substation connected to the line circuit are picked up by the coils 55 at opposite ends of the core of the induction coil 13*b*, said coils being connected in series relation across the input circuit of the preamplifier tubes 57 and 58 arranged in push-pull relation. The output of the preamplifier tubes 57 and 58 is connected to an amplifier 59 and a rectifying and inverting unit 60 which may be similar to corresponding elements of the system shown in Fig. 1, so that further description thereof is not required.

In order to neutralize or partly neutralize the inductive coupling between the coils 50 and 55, auxiliary coils 56 inductively related to the receiving coils 55 are provided. The coils 56 are connected in series with each other and with the coil 51, and are so wound that the voltage induced in the receiving coils 55 thereby is opposite to that induced in the latter by the transmitting coil 50. The circuit of the coils 56 may include inductance 61, capacity 62 and/or resistance 63 to facilitate the proper adjustment of the magnitude and phase of the neutralizing currents whereby the coupling between the coil 50 and receiving coils 55 may be completely neutralized or, if desired, neutralized to such an extent that the local receiving equipment will receive signals of about the same amplitude from the keyboard 54 as from the distant keyboard to make a home

copy of each message transmitted from keyboard 54.

The coils 55 and 56 are mounted in any suitable manner in substantially fixed relation to the induction coil 13b or the bell box itself, either inside or outside of the box. Thus the relation between the receiving coils 55 and the induction coil 13b and transmitting coil 50 remains substantially fixed when the cover of the bell box is in its normally closed position and the elements of the neutralizing circuit require no readjustment during the use of the apparatus.

The embodiments of the invention which have been shown and described in detail are merely illustrative of certain features thereof and various modifications of these embodiments may be made without departing from the scope of the invention as defined in the appended claims. Obviously, the telephone system may include a radio communication link or channel or the tone signals may be transmitted from a radio transmitting station adjacent the telegraph transmitter to a radio receiving station provided with a printer. No claim is made herein to the gain control features disclosed, these features being claimed in our Patent No. 2,186,896, granted January 9, 1940.

We claim:

1. In a communication system, telephone substations, each comprising a transmitter and a receiver, circuits connecting said substations, means including said telephone trasmitter at one of the substations for impressing permutation code signalling impulses of audible frequency upon one of said circuits and telegraphic recording means including inductive means for detecting said signalling impulses at said one of the substations.

2. In a communication system, telephone substations, each comprising a transmitter, a receiver and an induction coil, a communication channel connecting said substations, means including a telephone transmitter at one of said substations for impressing permutation code telegraph signals on said channel and telegraphic recording means inductively related to the induction coil at said one of said substations for detecting signals impressed on said channel.

3. In a combined telephone-telegraph system, a plurality of substations each provided with a telephone transmitter and receiver and with printing telegraph transmitting and receiving apparatus, communication channels interconnecting said substations, means associated with the printing telegraph transmitting apparatus at each substation for generating audible code signals in accordance with the operation of the printing telegraph transmitting apparatus and for impressing the same upon the telephone transmitter at the adjacent substation, and means at each substation for inductively detecting the printer code signals impressed on the system and for operating the printing telegraph receiving apparatus at each substation in accordance with the received signals.

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