

July 16, 1940.

I. E. COLE ET AL
COMMUNICATION SYSTEM

2,207,720

Filed July 19, 1938

7 Sheets-Sheet 1

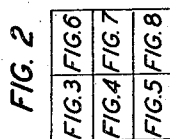
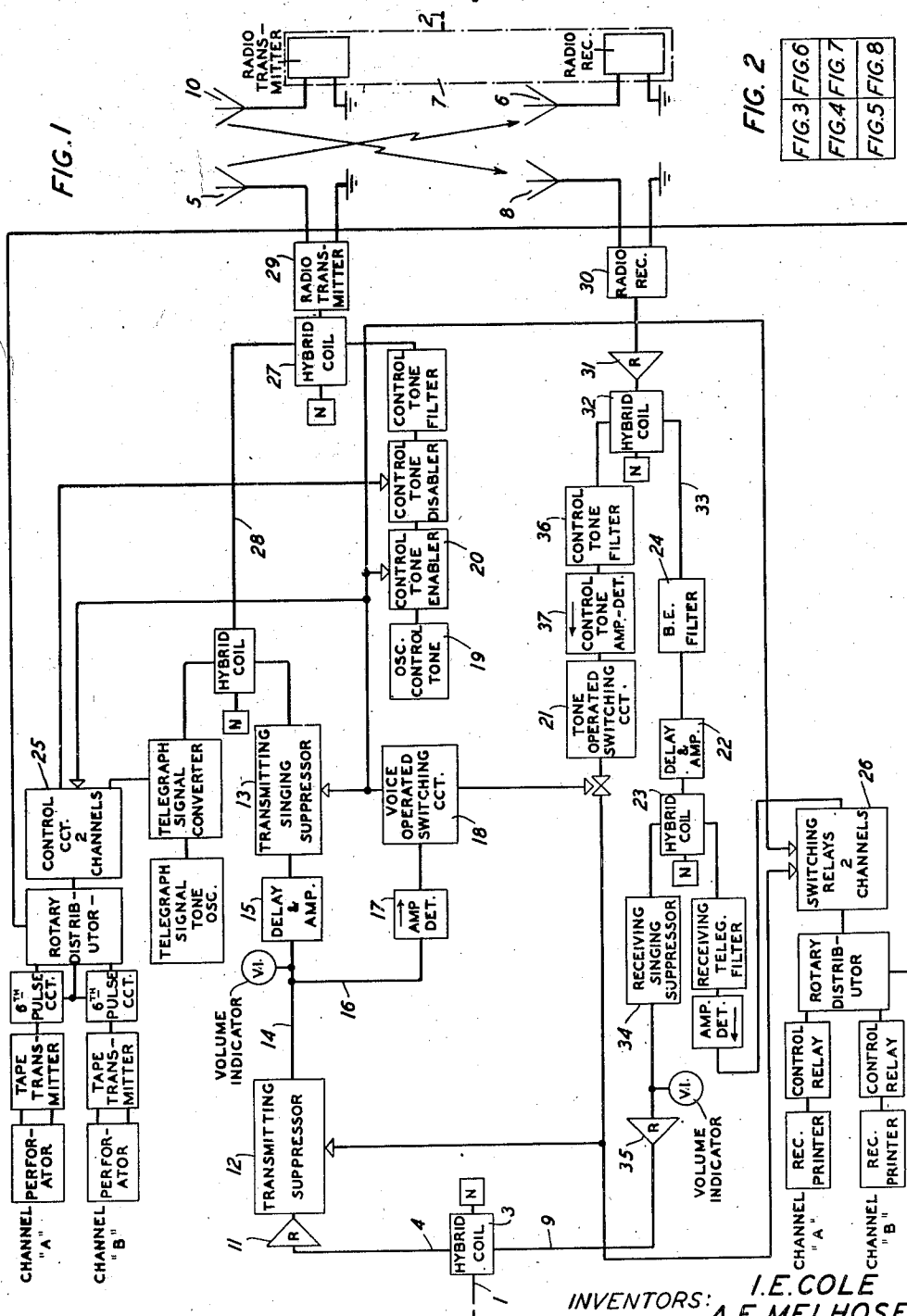


FIG. 3 FIG. 6

FIG. 4 FIG. 7

FIG. 5 FIG. 8

INVENTORS: I.E. COLE
A.E. MELHOSE
BY 

ATTORNEY

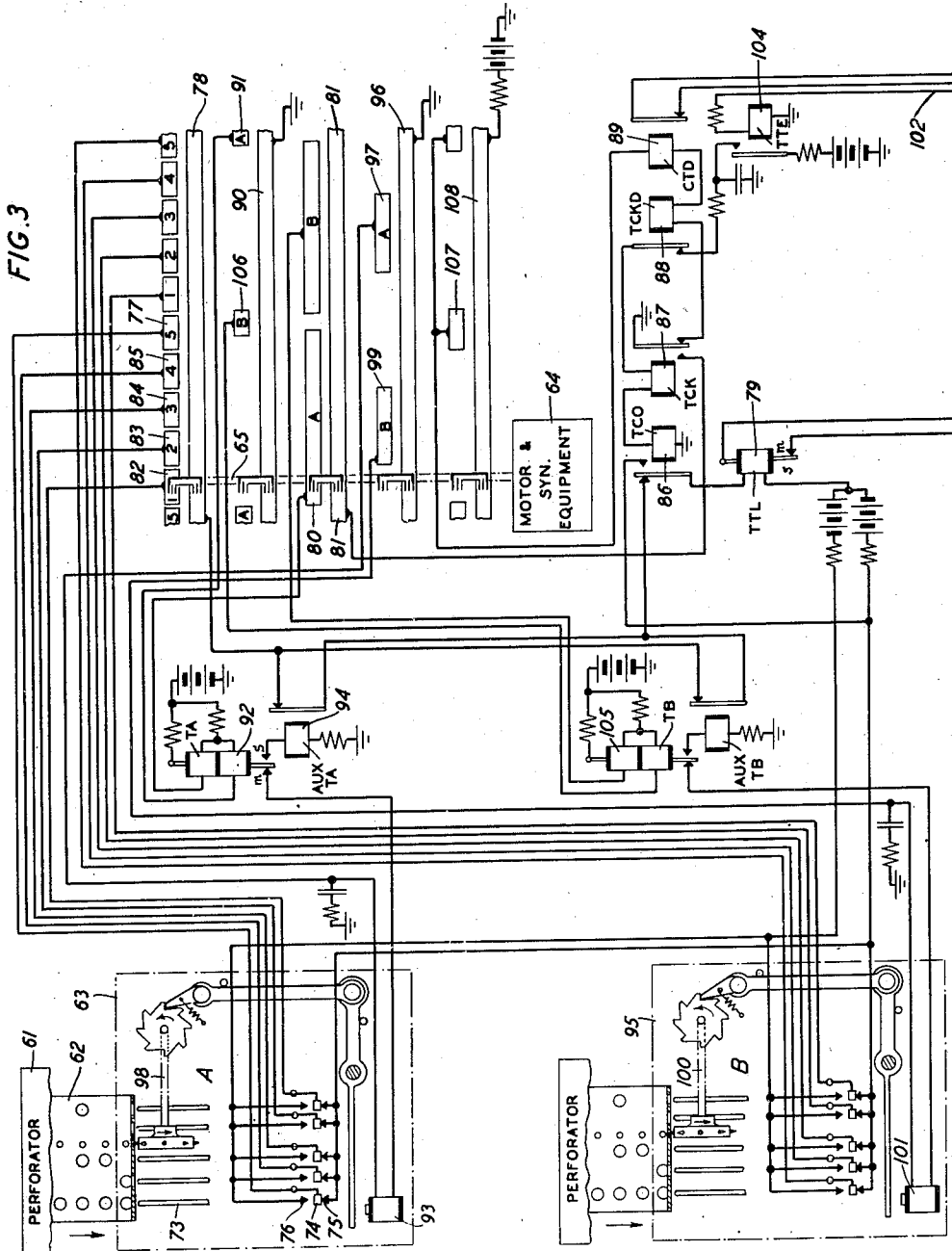
July 16, 1940.

I. E. COLE ET AL
COMMUNICATION SYSTEM

2,207,720

Filed July 19, 1938

7 Sheets-Sheet 2



INVENTORS: I. E. COLE
A. E. MELHOSE
BY *E. W. Adam*
ATTORNEY

July 16, 1940.

I. E. COLE ET AL
COMMUNICATION SYSTEM
Filed July 19, 1938

2,207,720

7 Sheets-Sheet 3

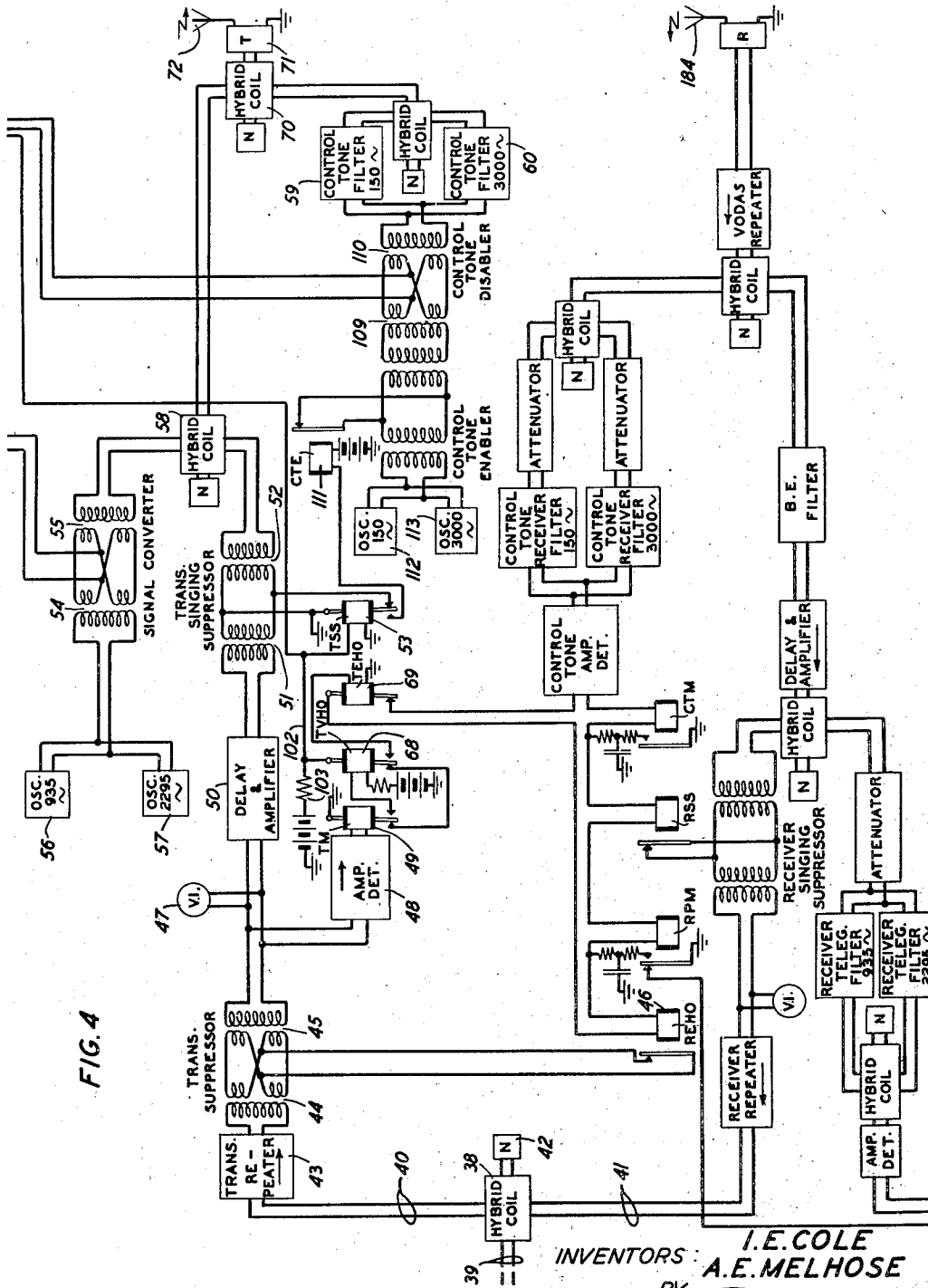


FIG. 4

I. E. COLE
A. E. MELHOSE
BY *E. W. Adams*
ATTORNEY

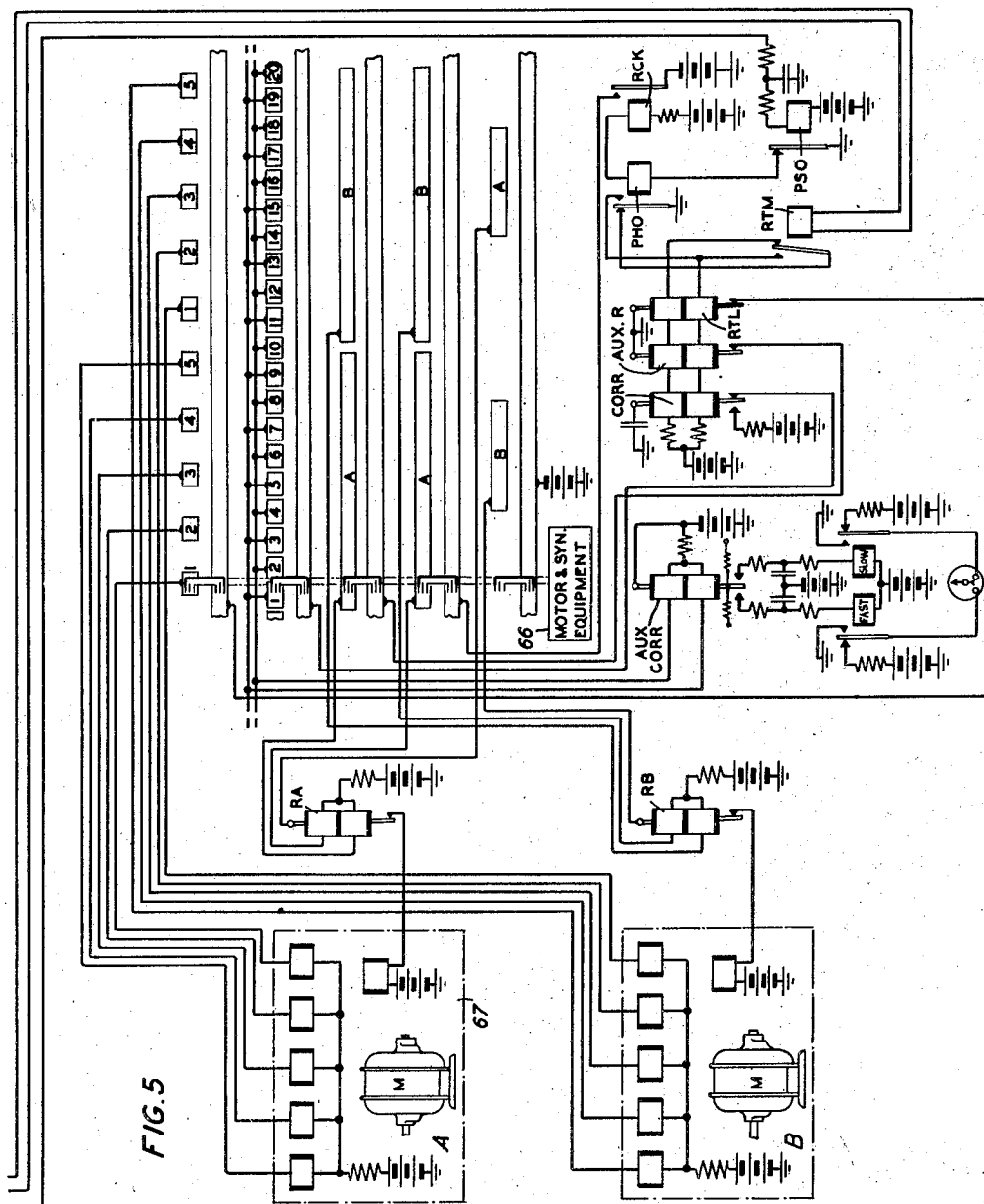
July 16, 1940.

I. E. COLE ET AL
COMMUNICATION SYSTEM

2,207,720

Filed July 19, 1938

7 Sheets-Sheet 4



INVENTORS: I. E. COLE
A. E. MELHOSE
BY *E. W. Adams*
ATTORNEY

July 16, 1940.

I. E. COLE ET AL
COMMUNICATION SYSTEM

2,207,720

Filed July 19, 1938

7 Sheets-Sheet 5

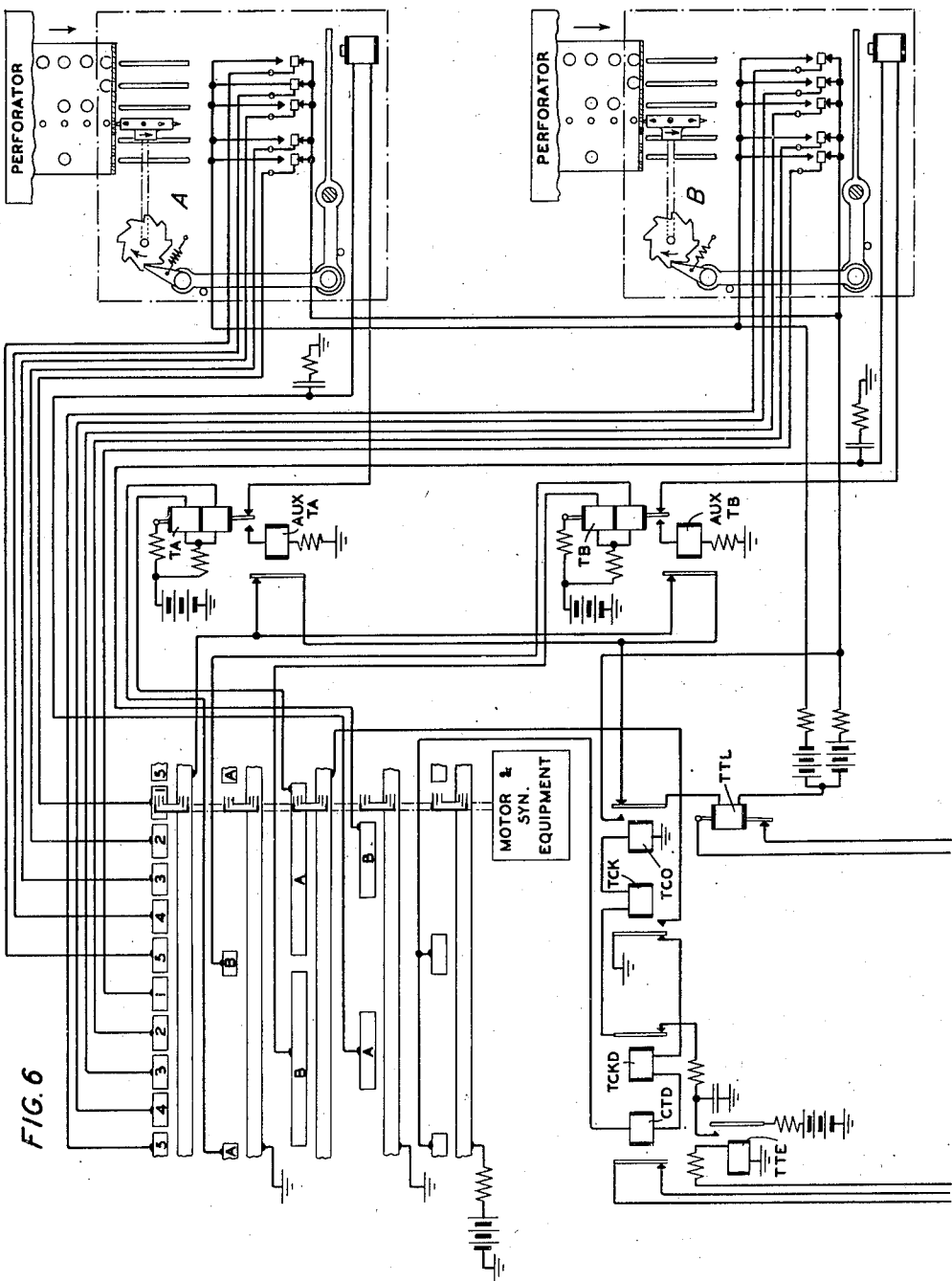


FIG. 6

INVENTORS: I.E. COLE
A.E. MELHOSE
BY *S. Wadman*
ATTORNEY

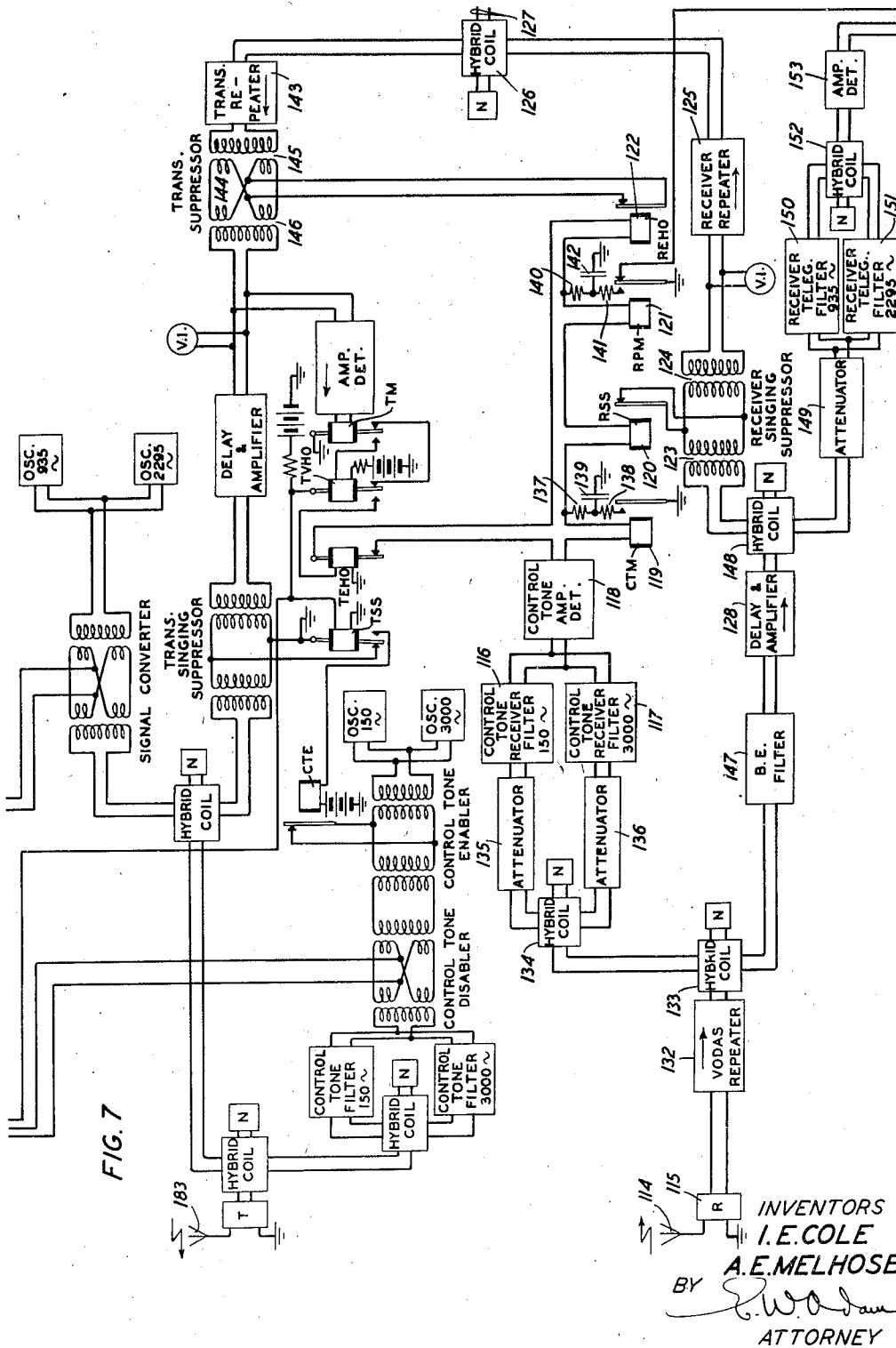
July 16, 1940.

I. E. COLE ET AL
COMMUNICATION SYSTEM

2,207,720

Filed July 19, 1938

7 Sheets-Sheet 6



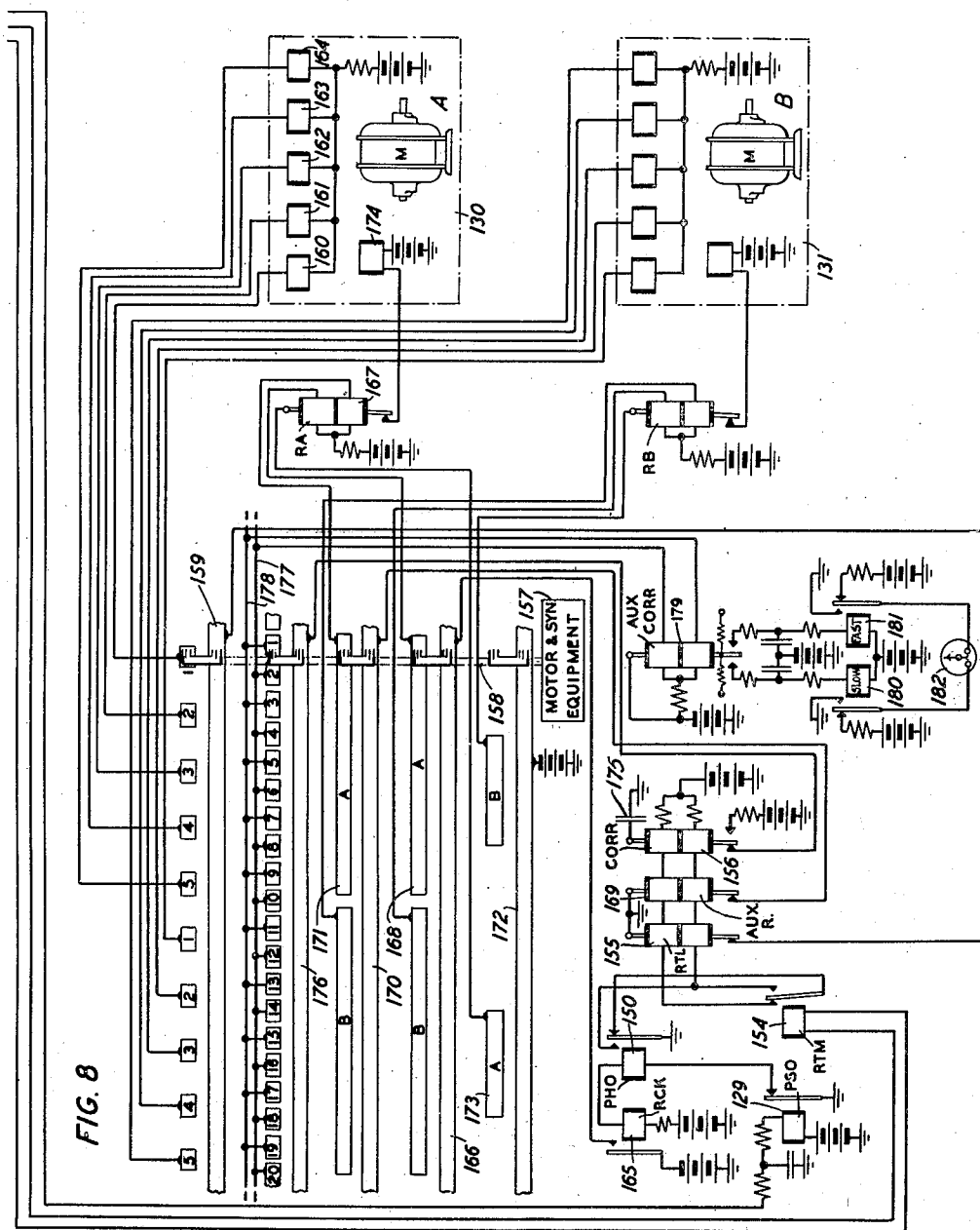
July 16, 1940.

I. E. COLE ET AL
COMMUNICATION SYSTEM

2,207,720

Filed July 19, 1938

7 Sheets-Sheet 7



INVENTORS: I. E. COLE
A. E. MELHOSE
BY *E. W. Adams*
ATTORNEY

UNITED STATES PATENT OFFICE

2,207,720

COMMUNICATION SYSTEM

Ira E. Cole, Montclair, N. J., and Alfred E. Melhose, St. Albans, N. Y., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application July 19, 1938, Serial No. 219,964

10 Claims. (Cl. 179—4)

This invention relates to communication systems and particularly to combined telephone and telegraph systems in which the telegraph signals are interpolated in a telephone conversation.

Where long and highly expensive communication channels are employed, it becomes economically desirable to use these facilities up to full capacity. Heretofore, systems for interpolating telegraph signals in telephone conversations have been devised which, under voice-operated device control, took advantage of every lull and pause in the conversation even down to fractional parts of a second for carrying on telegraph transmission so that the channel was used practically one hundred per cent of the time. For example, Patent 1,754,240 to Nyquist et al. granted April 15, 1930, and Patent 1,895,461 to R. A. Heising granted January 31, 1931, both show systems in which telegraph transmission is carried on not only in one direction while speech is being transmitted in the other direction but also in the other direction during the pauses in the speech.

It is an object of the present invention to improve systems of this nature by providing special means for insuring the correct transmission of the telegraph signals without any interference with the telephone conversations.

Accordingly, a feature of the invention is means to hold up and retransmit any telegraph signal that has been partially transmitted at the time the voice-operated controls take over the circuit. Since the circuit used in this way is primarily designed for telephone conversations, the telegraph transmission must be immediately cut off whenever a subscriber starts to talk and since these periods occur at random provision must be made to retransmit any telegraph code combination which has been only partially transmitted.

In one embodiment of the invention, the telegraph apparatus used at the receiving end comprises a printer which responds to the telegraph transmission and mechanically locks up devices selected by the code impulses and thus if a code is cut off at the transmitting end before it has been fully transmitted, the apparatus will be partially operated, but since under these conditions the same code will be retransmitted at the next opportunity, the receiving apparatus will be properly operated. Means are provided to start transmission again only at the beginning of a code so it may happen that those devices which have previously been energized and locked will be energized again but this will not change the combination and hence no error will be introduced.

Another feature of the invention is a means for permitting a code combination which has been almost completely transmitted and hence almost completely received to reach completion with a slight impairment of the speech. Actually this impairment of speech is only theoretical for it cannot be detected by the ear since it is only necessary to clip off the voice currents for a period of a maximum of a few milliseconds on rare occasions which occur when a number of adverse conditions arise simultaneously. In practice and since this is a purely random occurrence, the clipping is rare and the clipping for the maximum period is still more rare, so that detection by a listener is practically impossible.

The system is operated by control currents accompanying speech. When speech starts the amplifier detector means responds and starts the flow of such control currents. For a certain distance the control currents and the speech are carried in different paths and delay circuits are introduced in the speech path so that the control currents may be transmitted ahead in point of time in order to prepare the circuits ahead for the proper transmission of speech. There is in addition a certain delay in the response of the amplifier detector means due to, and known as, syllabic variation and the measure of the delay in the speech path is made of an order equal to or slightly greater than the maximum delay due to syllabic variation plus the time required for the switching operations carried out upon the arrival of the control currents.

When a code has been transmitted up to a certain predetermined point, the starting of the flow of control currents in response to the starting of speech anywhere between the predetermined point and the end of the transmission of the code is delayed for a very short period. Under most circumstances, this delay will not be enough to hold up switching operations to the point of clipping the speech. It is only when the speech starts at the beginning of the predetermined point of code transmission and when a maximum syllabic variation delay has been encountered that any clipping of speech might take place. This is an extraordinary combination of circumstances and the probability that it will occur is extremely remote. Practical working of the circuits has led to the observation that it is undetectable by the listener.

This delay in the application of control current is controlled by the transmitting apparatus since the decision as to whether the receiving apparatus shall print or shall store must be kept at one

point. Given a variation in the time of transmission, and the possibility of slight error in synchronism, the telegraph circuits at the receiving end must be held intact for a period long enough to insure the correct reception of the last pulse of a code under any combination of adverse circumstances. This will insure against any one of three errors which might otherwise occur, such as the omission of a character, the printing of a wrong character or the duplication of a character. Hence, the introduction of a slight theoretical impairment of speech is entirely justified and the means for controlling this forms one of the novel features of the invention.

As in other well-known voice-operated device anti-singing circuits characterized Vodas, there is a speech hang-over means to keep the established speech circuit intact without unnecessary switching. In addition, there is here provided another delay, known as a telegraph delayed start which is introduced at the end of speech and which is provided to prevent too many switching operations found by experience to be unnecessary. Since it is intended that advantage be taken of all small lulls or pauses in the speech, the switching could be made to take place almost instantly at the end of speech, but since experience gained by actual working shows that there is little to be gained by using the very short lulls and pauses in the conversation, this telegraph delayed start is introduced to minimize excessively frequent operation of the switching means. This delay may be adjusted to any time interval greater than the speech hang-over and the decision of the telegraph apparatus to start transmitting or not is controlled thereby. It has been found that a delay of one-tenth of a second is practicable, though the use of a delay of longer duration even up to a full second makes little difference in the total amount of telegraph transmission.

The drawings comprise seven sheets. The first of these, containing Fig. 1, shows the invention in schematic form and the rest when placed as in Fig. 2 show the invention in diagrammatic form with certain well-known elements, such as repeaters, amplifiers, delay circuits, filters and hybrid coils indicated by labeled rectangles.

In general, as shown in Fig. 1, a telephone conversation may be carried on between subscribers connected to lines 1 and 2. The voice of the subscriber on line 1 is directed through the hybrid coil 3 and thence over the heavy line path 4 to the radio transmitting antenna 5 and thence to the radio receiving antenna 6 through the apparatus represented generally by box 7 which is identical with the apparatus shown in the rest of the figure as connected to radio receiving antenna 8, thence over a path therein corresponding to the heavy line path 9 to a hybrid coil and out to line 2 and to the subscriber thereon. The voice of the subscriber on line 2 is transmitted from radio antenna 10 to receiving antenna 8 over the heavy line path 9 through hybrid coil 3 to line 1, and to the subscriber thereon. The invention is not limited to the use of radio links as various other kinds of channels may be used.

The voice of the subscriber on line 1 traveling through hybrid coil 3, path 4, repeater 11, transmitting suppressor 12 reaches path 14 where it encounters a delay and amplifier circuit 15 which delays the voice currents in reaching the antenna 5. From the path 14 a portion of the voice currents flows over path 16 through an amplifier detector 17 and thence to a voice-operated

switching circuit 18. It will be noted that certain lines extend from this voice-operated switching circuit 18 ending at various places in arrow-heads. These indicate that the voice-operated switching circuit has control over the other apparatus to which the arrow-heads point. Thus, voice-operated switching circuit 18 has control over the transmitting singing-suppressor 13, the control tone-enabler 20, the control circuit 25 for the two channels of the telegraph transmitting means, the switching relays 26 for the two channels of the telegraph receiving means, and a switching point between the tone-operated switching circuit 21 and switching relays 26. This last switching point comprising an arrow-head from the voice-operated switching 18 to a pair of arrow-heads in the line leading from the tone-operated switching circuit 21 indicates that the circuit from the tone-operated switching circuit 21 is normally closed and that the control exercised by the voice-operated switching circuit 18 is to open this path at a proper time.

The voice-operated switching circuit 18 under the influence of voice currents from the subscriber on line 1 operates the transmitting singing-suppressor 13 to open a clear path for the voice currents traversing path 14. Switching circuit 18 at this time controls the control circuit 25 to prevent telegraph transmission therefrom. Switching circuit 18 controls the switching relays 26 to give a clear path for telegraph transmission from the channel A and B transmitters within box 7 into the receiving printers of channels A and B to the left of box 26. At the same time switching circuit 18 opens the control from tone-operated switching circuit 21 to the control points indicated thereafter so that such control will not interfere with telegraph transmission into receiving channels A and B. Furthermore, voice-operated switching circuit 18 controls the control tone-enabler 20 so that control tone which accompanies speech will be fed into the hybrid coil 27 along with the speech currents from paths 14 and 28 so that these two currents will be fed into the radio transmitter 29 and then transmitted from the antenna 5 to the antenna 6.

Within the apparatus designated generally by the box 7 the control tone and speech currents will be received by a radio receiver such as 30 and thence pass through the repeater 31 to the hybrid coil 32. At this point the speech currents, or as will later appear the telegraph currents, will traverse the path 33 since they encounter a band-elimination filter 24 which will block off the control tone. The speech currents passing therefrom will next encounter a delay and amplifier circuit 22 and be fed into the hybrid coil 23 and from thence through the receiving singing-suppressor 34, the repeater 35, path 9, hybrid coil 3 to line 2. The control tone which meets impedance by the band-elimination filter 24 will leave the hybrid coil 32 and traverse the control tone filter 36 which acts to block off the voice currents while passing the control tone. The control tone next encounters a control tone-amplifier detector 37 and operates the tone-operated switching circuit 21.

At the transmitting end, the voice-operated switching circuit 18 will have the control path leading from tone-operated switching circuit 21 opened but at the other end such control path will be closed and at that point the receiving singing-suppressor 34 will be operated as well as the transmitting suppressor 12 and the switching

relays 26. The delay 22 is introduced so that the control tone will have ample time to operate the switching circuit 21 before the voice reaches the path 9.

Thus while the voice of the subscriber is passing from line 1 to line 2, the telegraph apparatus for transmitting in the same direction is blocked off while the telegraph apparatus for transmitting in the opposite direction toward the receiving printers of channels A and B shown in the lower left-hand corner of this figure will be placed in operative condition.

If during the transmission of voice currents from line 1 to line 2, the subscriber thereat should pause for more than a predetermined interval of time, known as the voice hang-over, the voice-operated switching circuit 18 will restore and then after another short interval, known as the telegraph delayed start, telegraphic transmission will proceed from channels A and B indicated in the upper left-hand corner of this figure so that during such lull in the conversation telegraphic transmission may be carried on simultaneously in both directions. During this period if either the subscriber on line 1 or the subscriber on line 2 starts to speak, the appropriate voice-operated switching circuit 18 or its companion circuit within the box 7 will operate and stop the telegraph transmission over the lines in the same direction in which the voice now is transmitted.

The invention in more detail is illustrated in Figs. 3 to 8, inclusive, when placed as indicated in Fig. 2.

It is believed that a short explanation of certain well-known pieces of apparatus will help to a better understanding of the invention.

The hybrid coil 38 when connected to line 39, and paths 40 and 41 and network 42 is a circuit arrangement whereby voice currents entering the hybrid coil over path 39 will be transmitted over path 40, and whereby voice currents entering the hybrid coil over path 41 will be transmitted to path 39. While transmission from line 39 emerges into both paths 40 and 41, it is only effective in path 40 because the repeaters employed are unidirectional transmitting devices and such transmission can only pass through the repeater 43. Again, while wave energy from path 41 enters equally into line 39 and network 42, it performs no useful purpose in the network other than to insure good transmission into line 39 on account of the balancing properties of network 42. The transmitting repeater 43 is a well-known device for repeating and amplifying voice currents in one direction, as indicated by arrow.

The next piece of apparatus, known as a transmitting suppressor, is a combination of two transformers 44 and 45 having their secondary coils divided into two parts and connected in a crossed circuit. A pair of leads is taken from the cross-connections and led to the contacts of a relay 46. Under normal conditions, as shown, with the relay contacts closed, the transmission will freely pass through the transformers 44 and 45 but when the contacts of relay 46 are opened then transmission is suppressed. With an arrangement of this kind, opening and closing the contacts of relay 46 introduces little change in the impedance characteristics of the circuit.

Another piece of apparatus, shown as a circle with the designation "VI" within, is the volume indicator 47. This is generally in the form of a meter and in most cases, is a millivoltmeter. The amplifier detector 48 is another well-known piece of apparatus which will respond to voice

currents to operate a relay 49. The box 50, marked "Delay and amplifier," is an electrical or electroacoustic network which will delay the voice currents for a given period; in the present instance, about twenty-three milliseconds. Since the delay involves a certain transmission loss, this circuit is combined with an amplifier to compensate for such loss so that the box 50 is actually a no-loss delay circuit. Next in line is a piece of apparatus known as a transmitting singing-suppressor. This is similar to the transmitting suppressor heretofore described with the exception that the two transformers 51 and 52 have their secondaries connected directly together. In this case, for transmission to freely pass through this network the connection between the leads taken from the secondaries must be open. In the position shown, with the contacts of relay 53 closed, this transmitting singing-suppressor will prevent transmission.

Shown directly above this transmitting singing-suppressor is a signal converter comprising two transformers 54 and 55 connected together in exactly the same arrangement as the transmitting suppressor heretofore described. In this case, two sources of tone 56 and 57 supply current to the transformer 54. When the leads from the secondaries of transformers 54 and 55 are opened, then the tone from sources 56 and 57 is not transmitted to the hybrid coil 58 but when these leads are closed, then the tone freely passes into this hybrid coil. It will later appear that the leads running from the secondaries of these transformers are controlled by a pulse relay so that when the relay contacts are closed marking pulses comprising tones from these sources 56 and 57 will enter the hybrid coil 58 and when the contacts are opened the absence of tone will constitute a spacing pulse.

There are also shown on Fig. 4 certain rectangles designated as filters, for instance, control tone filters 59 and 60. These, as well as other filters shown on the drawings, are of well-known type.

In Fig. 3 certain other pieces of apparatus are shown by conventional diagrams. For instance, a perforator 61 is indicated and a tape 62, perforated thereby, is shown leading to a box 63 which represents a tape controlled transmitter. These are pieces of telegraph apparatus so well known that further description is unnecessary. A rectangle 64 is labeled "Motor and synchronous equipment." This represents the motive power and the other apparatus controlled necessary for rotating a distributor brush carrying shaft under exactly controlled conditions of phase. Running from rectangle 64 there is indicated a shaft 65 carrying a number of sets of brushes moving over distributor faces which are indicated in a well-known manner. In Fig. 5 there is a similar distributor, denoted here by rectangle 66, representing the motor and synchronous equipment for this distributor. Rectangle 67 indicates, generally, a telegraph printer. The motor, five selecting magnets and a printing magnet are indicated.

It will be understood that the motor and synchronous equipment 64 for the transmitter and 66 for the receiver are run in exact synchronism.

Similarly, the corresponding pieces of apparatus in Figs. 6 and 8 are run in exact synchronism and as will appear hereinafter, means are provided to maintain synchronism between the distributors of Figs. 3 and 5 and Figs. 6 and 8.

In operation, if no voice currents are being

transmitted over line 39 and path 40 then the telegraph apparatus shown in Fig. 3 will be fully enabled. Let us assume for the time being that relays 49, 68, 69, and 53 are in the position shown.

If tone from sources 56 and 57 is getting into the hybrid coil 58 it cannot feed back through the transmitting singing-suppressor since relay 53 has the secondaries of transformers 51 and 52 short-circuited and such tone will only go out through hybrid coil 70 and radio transmitter 71 and antenna 72. Two frequencies are used to make telegraph tone and are widely separated and adjusted to volumes such that either or both frequencies received will work the receiving printing equipment. This insures against the adverse effects of selective fading in the radio circuit.

The tape transmitter 63 has five pins, such as 73, which will engage perforations in the tape 62. When this occurs, the contact 74 is moved from its lower contact 75 to its upper contact 76. The upper contact 76 represents a marking condition and the lower contact 75 represents a spacing condition. When, in the course of operation of the distributor, the shaft 65 brings a brush into position to make the contact between segment 77 and ring 78, either spacing current from contact 75 or marking current from contact 76 will be extended to the telegraph transmitting line relay 79. If marking current is transmitted, then the polar relay 79 will be left in the position shown, whereby the secondaries of transformers 54 and 55 are closed and tone from sources 56 and 57 is transmitted into the hybrid coil 58 and thereafter out over antenna 72. If spacing current is transmitted to the relay 79, then the armature will move to the left and the signal converter comprising crossed coil transformers 54 and 55 will prevent any tone being transmitted into the hybrid coil 58, thus establishing a spacing signal condition.

Let us assume that the shaft 65 is just coming to a position where it will make a connection from segment 80 to ring 81 and where the brush working on ring 78 will successively pass over the segments 82, 83, 84, 85 and 77 comprising the five code segments from the channel A transmitter. Under the assumption that the voice circuit is not being used at this time, the relays 86, 87, 88 and 89 will be in positions shown. As just previously, a connection has been made between ring 90 and segment 91, thus connecting ground to the lower winding of relay 92. Relay 92 will then have moved its contact to the position shown so that battery is connected to one side of the stepping magnet 93 in the channel A tape transmitter. This magnet is not energized at this time. Since relay 87 is in the position shown, the connection between common ring 81 and segment 80 is ineffective and therefore relay 92 is left in the position shown. Now as the brush successively passes over segments 82, 83, 84, 85 and 77, the marking or spacing signal current, as the case may be, is transmitted through the back contact and armature of relay 94 to the contact and armature of relay 86, winding of relay 79 to the common point of the marking and spacing batteries. As the brushes connected to shaft 65 pass further along and are now in the position of transferring the record from tape transmitter 95, a connection will be made from ring 96 to segment 97 and thence to the other side of stepping magnet 93 so that while the record from tape transmitter 95 is being transmitted the shaft 98 of tape transmitter 63 will be rotated and the tape advanced to the next set of code perforations.

In a similar manner, during the movement of the shaft 65 a connection will be made to segment 99 while the record from tape transmitter 63 is being transmitted and shaft 100 will be rotated through the energization of magnet 101. In this manner the record of the two transmitters will be alternately transmitted by the relay 79.

Suppose now that voice currents are transmitted over paths 39 and 40. Amplifier detector 48 will pick up these voice currents and cause the energization of transmitting master relay 49. This relay will cause the energization of transmitting voice hang-over relay 68 and transmitting echo hang-over relay 69. Under normal conditions, a ground is extended from the armature of relay 49 through its left contact to the left contact of relay 68 where it is connected to the armature and this direct ground connection on conductor 102, through the agency of resistance 103, keeps the normal battery potential from affecting relays 53 and 104. With this ground removed, transmitting singing-suppressor relay 53 and transmitting telegraph enabler relay 104 become energized. Relay 53 puts the transmitting singing-suppressor into condition so that voice currents will freely pass from path 40 to the hybrid coil 58. Transmitting telegraph enabler relay 104 connects battery through its armature and front contact to the windings of relays 87 and 86 in series to ground, causing these relays to become energized. Relay 86 connects a steady spacing current to relay 79 so that the signal converter comprising cross-coil transformers 54 and 55 is put in condition to block out the tones from tone sources 56 and 57 so that such tones will not be mixed with the speech in hybrid coil 58. Relay 87 will bring up its armature to put ground on the ring 81.

Now if the shaft 65 is in position where the brush is passing over any one of segments 82 to 85, inclusive, then ground on ring 81 will energize the upper winding of relay 92, driving this relay to its spacing contact where auxiliary relay 94 will become energized. Relay 92, by moving its armature, removes the possibility of stepping magnet 93 becoming energized and relay 94 opens the connection between ring 78 and the back contact of relay 86. As long as transmitting telegraph enabler relay 104 remains operated, relays 86 and 87 will remain operated and both the transmission relays 92 and 105 will be kept on their spacing contacts and the tapes for both of the tape transmitters will remain stationary. Actually each time a connection is made between ring 90 and segment 91 or segment 106, relay 92 or 105 will be driven to its marking contact but immediately thereafter as a connection is made between ring 81 and segment 80 and so forth, the relay 94 or 105 will be driven back again to its spacing contact. As soon as the telegraph transmitting enabler relay 104 becomes deenergized and thereafter when a connection is made to either segment 91 or 106, the corresponding relay 92 or 105 will be driven to its marking contact and since ground will now be removed from ring 81, transmission from the tape transmitter will be resumed.

If relay 104 becomes operated while a connection is being made between segment 77 and ring 78 or, in other words, at the same time as contact is being made between segment 107 and ring 108, then a connection will be established from battery, ring 108 and segment 107, windings of relays 89 and 88 in series, back contact and armature of relay 87 to ground so that the

effect of the operation of relay 104 is nullified until the brush on shaft 65 leaves segment 107. During this very brief period the control tone-disabler relay 89 opens the connection between crossed coil transformers 109 and 110, forming the control tone-disabler, so that even though the voice may now take charge of transmitting master relay 49 and thereby cause the energization of control tone-enabler relay 111, the transmission of control tone from the sources 112 and 113 is held up. The delay thus introduced in the transmission of control tone is enough to allow the completion of the code while the brush is passing over segment 77. This enables the receiver at the other end of the channel to properly record the code. Even when this relay in the transmission of control tone through the operation of control tone-disabler relay 89 takes place just as a connection is being established between segment 107 and ring 108, the delay introduced is not of greater magnitude than the delay introduced in the speech path by the delay amplifier 50 and other apparatus which the speech encounters further on. It should be noted that if the voice takes charge of transmitting master relay 49 before connection is made between ring 108 and segment 107 by even the slightest interval that the resulting energization of relay 87 will prevent the energization of control tone delay relay 89.

As the transmission from antenna 72 is received over antenna 114 and thence by the radio receiver 115, the control tone when it is finally put onto hybrid coil 70 by the release of relay 89 will pass through the control tone filters 116 and 117 and thence through the control tone-amplifier detector 118, causing the operation of relays 119, 120, 121 and 122. Relay 120, known as the receiving singing-suppressor relay, takes a short circuit off the secondaries of transformers 123 and 124, thus opening the path for voice currents to go through the receiving repeater 125 and hybrid coil 126 to the line 127. Since the voice coming into radio receiver 15 encounters another delay 128 of approximately twenty-three milliseconds, it will be seen that the delay to control tone introduced by the operation of control tone-disabler relay 89 will not actually affect the speech. Since the control tone operating relay 121 allows the printer slow-operate relay 129 to release and since the release of this relay starts in motion a chain of other operations to stop the printing of characters by the two printers 130 and 131, it is necessary to introduce this short delay which equals that incurred in delay 128 in order to insure the printers 130 and 131 completing their operation.

It will be noted that the sources of tone 112 and 113 are marked, respectively, 150 cycles and 3000 cycles, and that the control tone filters 59 and 60 are also marked, respectively, 150 cycles and 3000 cycles. These two tones are used as extra band frequencies in accordance with well-known practice to render such control tone distinctive and separable from the voice band frequencies. The control tones are of such volume that either or both of the frequencies can operate the receiving circuit in order to reduce the adverse effects of selective fading. As this tone is transmitted from antenna 72 and received by antenna 114 and the radio receiver 115, it passes through the repeater 132 and the hybrid coils 133 and 134 whence it divides and passes through the attenuators 135 and 136 and filters 116 and 117, which again are marked, respectively, 150

cycles and 3000 cycles. After this, the outputs of these filters are combined and enter the control tone-amplifier detector 118 from which the relays 119 to 122 are operated. The armature of control tone master relay 19 is subject to vibration at the lower frequency and hence a hang-over circuit consisting of two resistances 137 and 138 and a condenser 139 is provided to render the other relays 120 and 121 in circuit therewith not subject to such vibration. The last relay in line, 122, known as the receiving echo hang-over relay, must be given another slight delay in returning to normal and hence another hang-over circuit comprising resistances 140 and 141 and condenser 142 is provided and operated by the receiving printer master relay 121. The receiving echo hang-over relay 122 by opening the connection between the cross-coils of the two transformers 145 and 146, is provided to block any echo that might otherwise be transmitted through repeater 143 and transmitting suppressor 144.

The voice itself will be received on antenna 114 and radio receiver 115 and thence pass through the repeater 132 and hybrid coil 133 and through the band-elimination filter 147, after which it strikes a delay circuit 128. By the time the voice arrives at hybrid coil 48, the receiving singing-suppressor comprising the transformers 123 and 124 will be put in condition to transmit by the operation of the receiving singing-suppressor relay 120. Thereafter the voice passes through the receiving repeater 125 into the hybrid coil 126 and to the subscriber on line 127.

Let it be assumed that telegraph tone pulses are being received by antenna 114. These tones will pass through hybrid coil 148 into attenuator 149 and thence through two filters 150 and 151 which, like other filters, are constructed and arranged to pass the frequencies transmitted from the sources 56 and 57. The filtered tones then enter hybrid coil 152 and through the amplifier detector 153 operate the receiving telegraph master relay 154. Such tones, representing a marking pulse, will bring relay 154 to its front contact and therefore establish a circuit from the armature of printer hang-over relay 150, its back contact, the armature and front contact of relay 154 and the upper windings of receiving telegraph line relay 155, auxiliary receiving relay 169 and corrector relay 156 to battery. These three relays will move their armatures to their marking contacts, as shown. Receiving telegraph master relay 154 responds to the code impulses by moving its armature into the position shown for marking impulses and releasing it to the other position for spacing impulses. The three relays 155, 169 and 156 will follow and accordingly move their armatures either to their marking or spacing positions.

The motor and synchronous equipment 157 moves a shaft 158 in exact synchronism with the shaft 65 of the transmitting apparatus in Fig. 3. Hence, as the marking or spacing impulses applied to ring 78 are sent out and received by the relay 154, corresponding impulses will be placed on the ring 159 and as the brush which connects this ring to the row of small segments above passes over these small segments it will, in effect, connect the selecting magnets 160, 161, 162, 163 and 164 of channel A printer, respectively, to the five contacts of channel A transmitter, ending with contact 74. Hence selecting magnets 160 to 164, inclusive, will be operated in accordance with the perforated tape 62. As the shaft 158 moves

on to the next set of segments associated with ring 159, the selecting magnets of printer 131 will, in effect, be connected to the contact of the tape transmitter 95. While impulses are being received by receiving telegraph master relay 154, printer slow-operate relay 129 will be energized and hence printer hang-over relay 150 will be de-energized and the receiving check relay 165 will be in the position shown, that is, deenergized.

Therefore, as the brush on shaft 158 which connects to ring 166 passes over those segments having to do with channel A, the relay 167 whose upper winding is connected to segment 168 will be unaffected. The operation of auxiliary relay 169 during a marking impulse closes a connection from ground through its armature and marking contact to ring 170 and thence to segment 171 through the appropriate brush on shaft 158 to the lower winding of relay 167 to positive battery.

This drives relay 167 to its marking contact as shown, and since this is a polar relay and will keep its armature where last placed until it is energized in the opposite direction, this relay will remain as shown until relay 165 is energized.

Now as the shaft 158 moves along and is controlling the set of selecting magnets of channel B printer 131, a connection will be made between ring 172 and segment 173 which will cause the energization of printer magnet 174. Since if shaft 158 gets beyond the five small segments connecting selecting magnets 160 to 164, inclusive, the relay 167 cannot be driven to its spacing contact again until the shaft gets back to near the position shown. The small delay to the control tone introduced at the transmitter by the control tone-disabler relay 89 will insure the last of the selecting magnets 164 being properly operated and thereafter the printer magnet 174. If the control tone from sources 112 and 113 comes on before the shaft 158 has reached the position for affecting selecting magnet 164, then relay 129 will become deenergized and this will result in the energization of checking relay 165, whereupon battery is connected through ring 166 and segment 168 to the upper winding of relay 167 to drive this relay to its spacing contact and thus prevent the energization of printer magnet 174.

Whenever a spacing impulse is received by receiving telegraph master relay 154 and hence the relay 156 is moved to its spacing contact, condenser 175 is charged. When the relay 156 is driven to its marking contact, this charged condenser is connected through the armature and marking contact of this relay to ring 176, whence it discharges either into conductor 177 or 178 depending on the exact position of the brush traveling over ring 176. Conductors 177 and 178 lead to the two windings of auxiliary corrector relay 179 and, this relay being polarized and spring centered to stay in the position shown, will momentarily move its armature in either one direction or the other. Under the best conditions, when the shaft 158 is in exact synchronism with the shaft 65, the two windings of relay 179 will be equally energized and hence the relays 180 and 181 are not energized, resulting in the stationary response of indicator 182. Such an indicator is put in at this point merely to indicate the method of correcting the speed of the motor and synchronous equipment 157, since methods of actually doing this are well known in the art. If the shaft 158 begins to lag in time relation to the shaft 65, then the armature of relay 179 will tend to stay for a greater proportion of the time on its left contact, thereby operating the slow-indi-

cating relay 180, and vice versa, if the shaft 158 begins to lead in time relation to shaft 65 the fast-indicating relay 181 will become operated. This correction circuit comprising corrector relay 156 and auxiliary corrector relay 179 with its circuit shown below forms no essential part of the present invention other than to illustrate a method of keeping the shafts of the transmitters and printers in synchronism.

The apparatus shown in Fig. 6 is a duplicate of the apparatus shown in Fig. 3 and is used for transmitting telegraphic messages out over antenna 183 into antenna 184 and thereby operating the printer mechanism shown in Fig. 5. This, again, is a duplicate of the circuits and mechanism shown in Fig. 8.

As has been generally explained in connection with Fig. 1, both the telephone and interpolated telegraphic transmission may be carried on in both directions at the same time, that is, if voice currents are traveling from the path 39 to the line 127, telegraphic messages may be transmitted simultaneously from the transmitters of Fig. 6 to the receivers of Fig. 5. If there comes a pause in the voice currents then the messages stored on the tape of the transmitters of Fig. 3 will be transmitted to the printers of Fig. 8. In practice, pauses of the nature of even a fraction of a second are used for this purpose and perfect transmission of telegraph code is insured by the provision of means for stopping the transmission of a code message at any point in the code and retransmitting this same code again when the telegraphic apparatus is enabled. The addition of the means for holding up the control tone for a very short time when the speech comes on during the last impulse of a series of code impulses so that the printer at the other end may operate, is of great importance in the prevention of printing errors. Practically, it has been found that due to delays applied to voice currents in these circuits, this delay to the control tone does not adversely affect speech.

What is claimed is:

1. In a communication system, a transmission channel, a permutation code sender normally connected to one end of said channel, a receiver responsive thereto normally connected to the other end of said channel, voice-operated means for operatively disconnecting said sender and said receiver from said channel, and means in said sender for storing any code partially transmitted upon disconnection and for retransmitting in full such partially transmitted code when transmission is resumed.

2. In a communication system, a transmission channel, a permutation code sender normally connected to one end of said channel, a receiver responsive thereto normally connected to the other end of said channel, switching means for operatively disconnecting said sender and said receiver from said channel and for rendering said channel suitable for voice transmission, amplifier-detector means responsive to voice currents for operating said switching means and means in said sender for storing any code partially transmitted and for retransmitting in full such partially transmitted code when transmission is resumed.

3. In a communication system, a transmission channel, a normally operating permutation code sender connected to one end of said channel, a normally operating receiver responsive thereto connected to the other end of said channel, voice controlled switching means for operatively dis-

connecting said sender and said receiver from said channel, means operative during the transmission of a code up to a given percentage of its length upon the operation of said switching means for storing and preparing for retransmission of such a partially transmitted code and means operative during the transmission of a code beyond said given percentage of its length for delaying the action of said switching means.

4. In a communication system, a transmission channel, a normally operating permutation code sender connected to one end of said channel, a normally operating receiver responsive thereto connected to the other end of said channel, switching means for operatively disconnecting said sender from said channel, switching means responsive to a control tone for operatively disconnecting said receiver from said channel, means responsive to voice currents for operating said first switching means and for applying control tone to said channel for operating said second switching means, means responsive to the operation of said first switching means before the transmission of a given percentage of a complete code for storing and preparing for the retransmission of said partially transmitted code and means for delaying the application of control tone to said channel when the operation of said first switching means occurs after the transmission of said given percentage of a complete code.

5. In a communication system, a transmission channel, a permutation code transmitter normally connected to one end of said channel, a printer responsive thereto normally connected to the other end of said channel, voice-operated switching means for stopping the operation of said transmitter and printer when operated prior to the transmission by said transmitter of a given percentage of a complete code and means for delaying the operation of said switching means when operated subsequent to the transmission by said transmitter of said given percentage of a complete code.

6. In a communication system, a transmission channel, a permutation code tape transmitter normally connected to one end of said channel, a printer responsive thereto normally connected to the other end of said channel, voice-operated switching means for operatively disconnecting said transmitter and said printer from said channel and for halting the functioning thereof, means for storing and retransmitting a code transmitted for less than a given percentage of its total length and voice delay means for insuring the printing of a character represented by a code and for advancing the tape in said transmitter when a code has been transmitted for more than a given percentage of its total length.

7. In a communication system, a transmission channel, a permutation code sender at one end of said channel, a receiver responsive thereto at the other end of said channel, synchronously running distributors for feeding code impulses from said sender into said channel and from said channel into said receiver, voice-operated switching means for stopping the flow of said code impulses and for preventing the functioning of said sender and said receiver and means operative upon the release of said voice-operated means for entirely retransmitting any code partially transmitted before stoppage.

8. In a communication system, a transmission channel, a permutation code sender at one end of said channel, a receiver responsive thereto at the other end of said channel, synchronously running distributors for feeding code impulses from said sender into said channel and from said channel into said receiver, voice-operated means for halting the functioning of said sender and said receiver up to a given point in the rotation of said distributors and means for delaying the action of said voice-operated means beyond said given point in the rotation of said distributors, said given point being fixed sufficiently near the end of a code to insure the completion of the functioning of the said sender and said receiver without noticeable penalty to speech.

9. In a communication system, a transmission channel, a permutation code sender, a receiver responsive thereto, synchronously running distributors for feeding code impulses from said sender into said channel and from said channel into said receiver, voice-operated devices for interrupting the transmission of code impulses at random and means for resuming the transmission of code impulses only at the beginning of a code.

10. In a communication system, a transmission channel, a permutation code sender having a magnet for advancing to another code when one code has been completely transmitted, a receiver responsive to said sender and having a recording magnet for recording a code completely transmitted by said sender and for preparing to receive another code, synchronously running distributors for feeding code impulses from said sender into said channel and from said channel into said receiver, voice-operated devices for cutting off transmission of code impulses at random, means for resuming the transmission of code impulses on the release of said voice-operated devices only at the beginning of a code, and means operative when the transmission of a code has progressed to a certain point to delay the effect of said voice-operated devices for a time sufficient to insure the operation of said magnets.

IRA E. COLE.

ALFRED E. MELHOSE.