

Nov. 30, 1943.

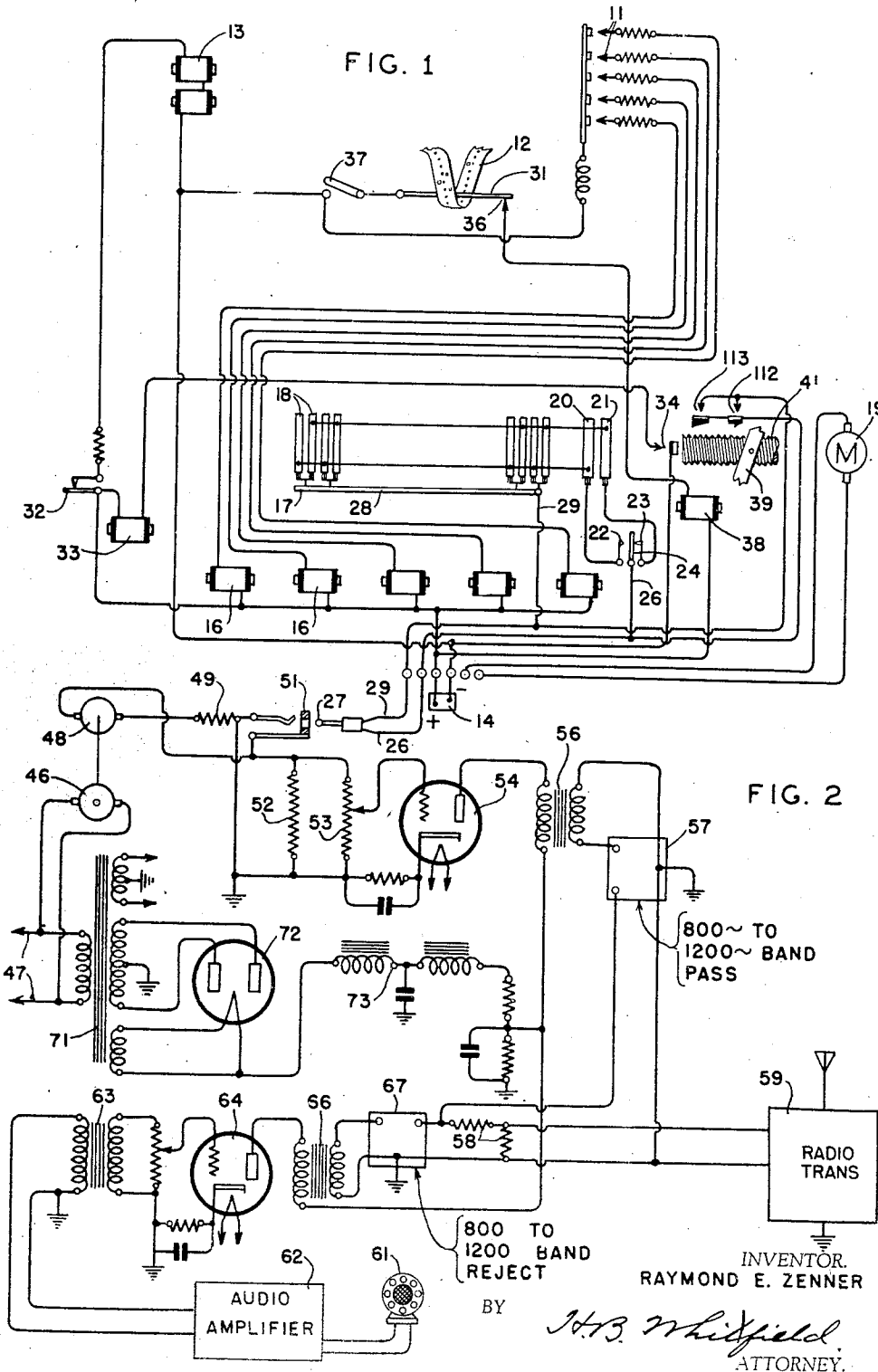
R. E. ZENNER

2,335,335

COMMUNICATION SYSTEM

Filed Jan. 18, 1941

3 Sheets-Sheet 1



Nov. 30, 1943.

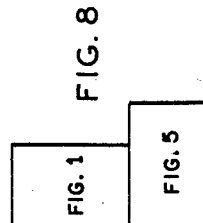
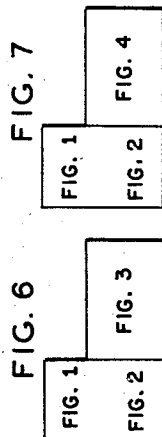
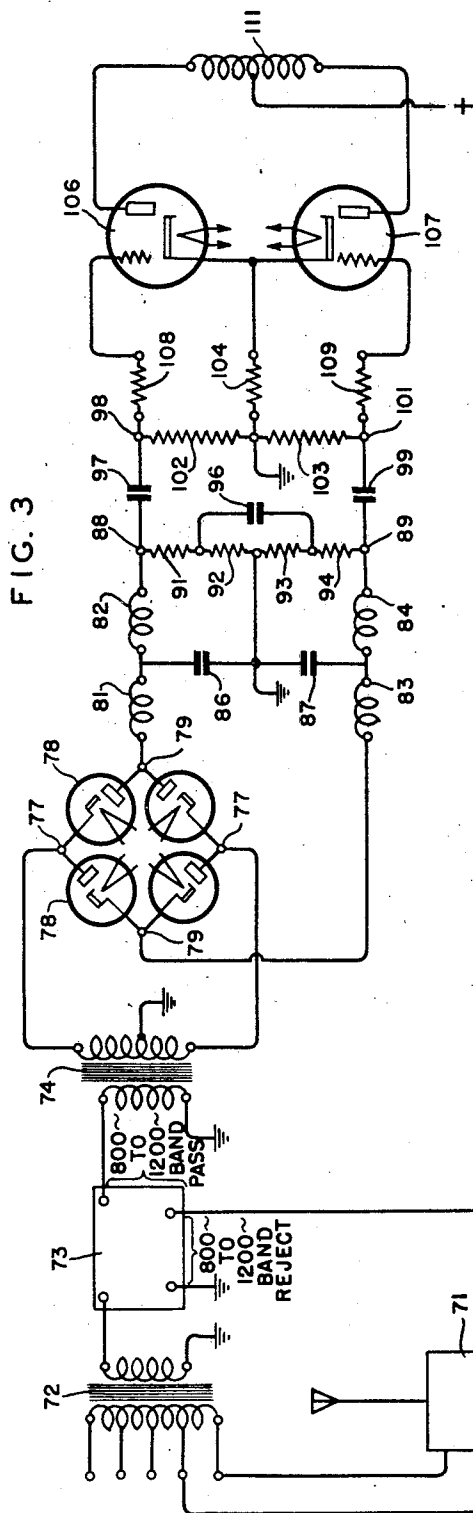
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2,335,335

COMMUNICATION SYSTEM

Filed Jan. 18, 1941

3 Sheets-Sheet 2



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2,335,335

COMMUNICATION SYSTEM

Filed Jan. 18, 1941

3 Sheets-Sheet 3

FIG. 4

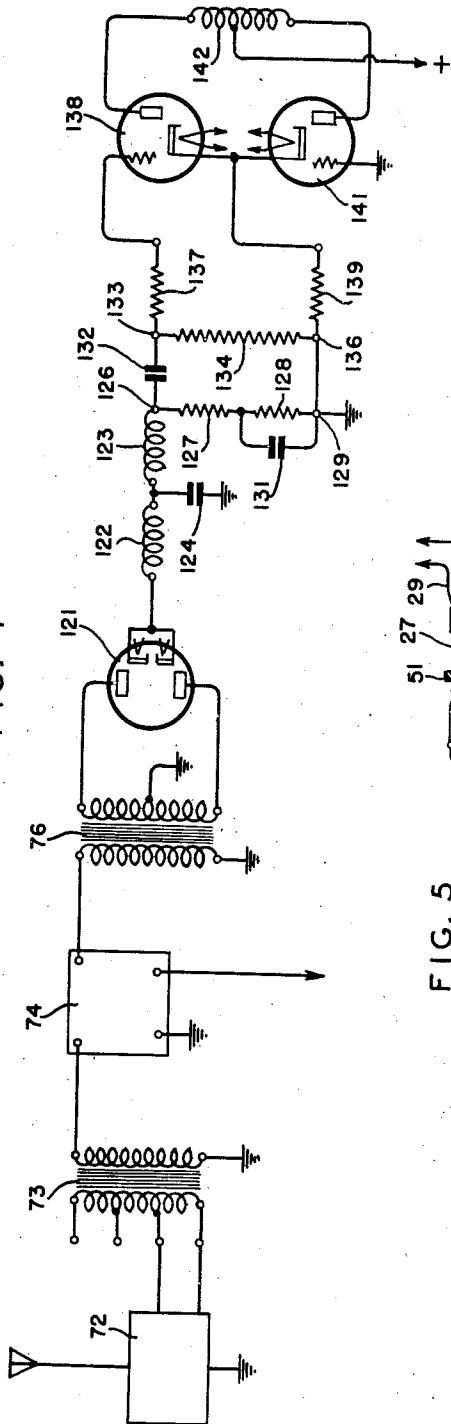
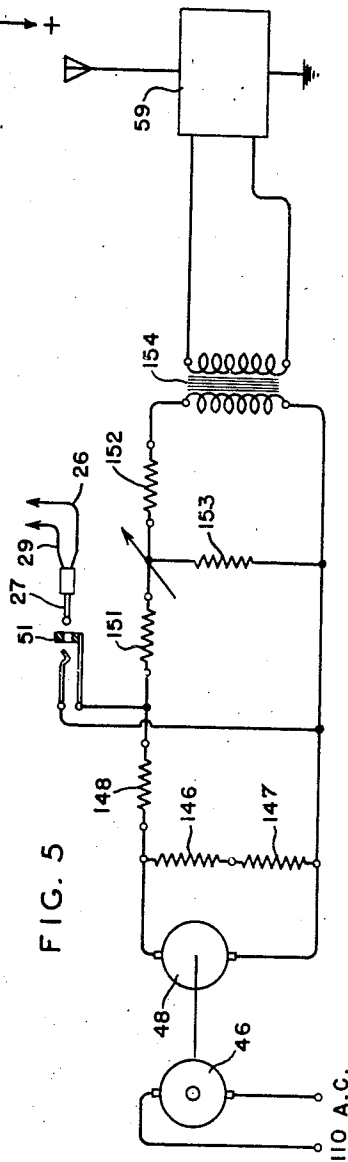


FIG. 5



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2,335,335

COMMUNICATION SYSTEM

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Application January 18, 1941, Serial No. 374,961

13 Claims. (Cl. 173-66)

This invention relates to communications systems and particularly to the radio transmission and reception of speech and of telegraph signals to be recorded in printed form.

The object of the invention is to combine and transmit together on a single radio frequency carrier speech and telegraph signals.

Another object of the invention is to receive combined speech and printing telegraph signals communicated over a single radio frequency carrier to separate and independently amplify the signals, and to reproduce the speech and record the telegraph signals as printed characters.

Another object of the invention is to control automatically the amplification of the printing telegraph signals so as to achieve uniform recording for wide variations in signal strength.

The invention features printing telegraph transmitters and receiving recorders of the kind known as facsimile in which the signal combinations represent the patterns of characters and recording is accomplished by the synthesis of characters according to the signal patterns without the use of character type elements.

The broad aspects of the transmitting and receiving system as a whole are disclosed in copending application Serial No. 302,549 filed November 2, 1939, by R. E. Zenner which eventuated into United States Patent No. 2,254,342, issued Sept. 2, 1941.

The invention further features a communication system in which neutral printing telegraph signals are transmitted over a narrow frequency band to a receiving circuit in which the received signals are supplied to a normally balanced network and disturb the balance of the network in accordance with the nature of the received impulses to generate corresponding polar signal impulses.

According to one embodiment of the invention the transmitting station includes a record tape controlled facsimile signal transmitting distributor, a speech input system and a combined keyer and mixer for combining the speech and printing telegraph signals and for applying them to a radio transmitter to modulate the carrier frequency of the transmitter. The tape controlled facsimile signal transmitting distributor may be of the type disclosed in copending application Serial No. 371,358 filed December 23, 1940, by R. E. Zenner. A feature disclosed but not specifically claimed in the latter copending application is disclosed and will be claimed in the claims accompanying the present specification. That feature pertains to the transmission of a

signaling condition preceding message material transmitted after a shut-down period for conditioning an amplifier in the receiving system to respond to the signals to be transmitted. The transmission of the signaling condition for preparing the receiving amplifier is accomplished by the closure of contacts associated with the transmitting distributor, which contacts are auxiliary to any of the facsimile signal transmitting contacts and are operated by a worm and follower device which is set in operation when signal transmission is to be initiated and which at the conclusion of its operation starts the signal transmission.

Specific details of the speech input system aside from the mixing of the speech with the printing telegraph signals form no part of the present invention and the speech input apparatus may be of a well-known type consisting of a microphone for converting sound waves into oscillatory current, and a pre-amplifier.

The keyer and mixer unit includes an audio tone generator, the effectiveness of which is controlled by the receiver conditioning contacts and transmitting contacts of the transmitting distributor, an amplifier for the keyed tone signals, an amplifier for the output of the speech system pre-amplifier and a plurality of audio tone filters. One of the filters is in the output circuit of the keyed audio tone amplifier and its characteristic is such that it passes a relatively narrow band of frequencies in the center of which is the fundamental frequency of the audio tone generator. This filter provides a narrow transmission band which carries the facsimile signals. The other filter is included in the output circuit of the speech amplifier which is contained in the mixer unit, as distinguished from the pre-amplifier, and this filter rejects substantially the same band of frequencies that the first mentioned filter passes, so that frequencies within this band will be deleted from the speech signals. The filters impart to the speech signals and telegraph signals predetermined characteristics by which they may be subsequently separated, and the outputs of the two filters are connected to a radio transmitter in modulating relation to the carrier frequency generated within the transmitter.

The receiving station includes a radio signal receiver, a signal filtering network, a final amplifier for speech signals, a rectifier and amplifier for printing telegraph signals and the operating magnet of a receiving facsimile recorder.

The radio receiver and final amplifier for the speech signals are of well-known form, hence

specific details are not involved in the present invention.

The filter network includes a band pass filter having the same characteristics as the band pass filter of the transmitter for passing the facsimile printer controlling signals, and a band reject filter having the same characteristics as the band reject filter at the transmitting station for excluding from the final speech amplifier the facsimile printer signals. The final speech amplifier is connected to the output of the band reject filter.

A rectifier and amplifier is connected to the output of the band pass filter for rectifying the audio tone trains which represent the facsimile signals and for converting the rectified signals into polar signals. The amplifier associated with the rectifier is of the resistance capacity coupled, push-pull type and its principal characteristic is substantially uniform output for a relatively wide variation in the strength of the rectified audio tone signals delivered by the rectifier. The amplifier unit comprises a pair of oppositely connected, normally balanced triodes which become unbalanced in alternation through the operation of the rectifier and generate polar signals in accordance therewith. The output of the amplifier is connected to the windings of a facsimile printer controlling magnet which is polar in order to respond to the push-pull type of signals delivered by the amplifier. The signals delivered to the windings of the polar magnet by the operation of the triodes approach rectangular wave form even though the transmitter telegraph signals approach a sinusoidal shape.

The invention contemplates a modified form of radio transmitter keyer for use where printer signals only are to be transmitted. This embodiment of the invention also employs an audio tone generator the output of which is controlled by the facsimile signal transmitting distributor. Since the facsimile tone signals are not to be mixed with speech signals, no filter for confining the transmitted frequency to a specific band is required. Since audio frequency filters tend to attenuate the signals impressed upon them, no such attenuation will occur in a system according to this embodiment of the invention and consequently a tone amplifier is not required but the level of the tone may be regulated merely by means of a resistance network.

Another embodiment of the invention contemplates a rectifier and amplifier for facsimile signals at the receiving station, in which a resistance capacity coupled push-pull amplifier is of a nonsymmetrical type, the rectifier signals exercising direct control over the grid of only one of the electron tubes in the amplifier, the other tube having its grid maintained at a fixed or steady potential, and being controlled by the bias afforded by a cathode resistor which is common to the cathodes of the two electron tubes in the amplifier. The printer magnet which is operated through this amplifier is also polar in characteristic due to the employment of a push-pull type of amplifier.

Either of the rectifier-amplifier systems may be employed for receiving signals from a station which transmits facsimile printer signals only, merely by the omission of the filter networks previously described in brief for segregating the printer signals and speech signals.

For a complete understanding of the invention reference may be had to the following detailed

description to be interpreted in the light of the accompanying drawings wherein:

Fig. 1 is a diagrammatic view showing a record tape controlled facsimile signal transmitting distributor.

Fig. 2 is a diagrammatic view of the combined keyer and mixer unit for the transmission of speech and facsimile telegraph signals simultaneously;

Fig. 3 is a diagrammatic view showing a receiving station including a rectifier and amplifier for facsimile telegraph signals in accordance with one embodiment of the invention;

Fig. 4 is a diagrammatic view showing a receiving station including a rectifier and amplifier for facsimile telegraph signals in accordance with another embodiment of the invention;

Fig. 5 is a diagrammatic view showing a keying unit for accomplishing the transmission of telegraph signals only;

Fig. 6 is a diagrammatic view showing how Figs. 1, 2, and 3 may be arranged to disclose a complete speech and facsimile signal transmitting and receiving system;

Fig. 7 is a diagrammatic view showing how Figs. 1, 2, and 4 may be arranged to disclose a complete alternative form of speech and facsimile signal transmitting and receiving system; and,

Fig. 8 is a diagrammatic view showing how Figs. 1 and 5 may be arranged to disclose a complete transmitting system for telegraph systems only.

Referring now to Fig. 1, the reference numeral 11 designates contacts controlled by tape sensing pins of a tape sensing mechanism such as that disclosed in the copending application Ser. No. 371,358. The closure of contacts 11 is controlled by tape 12 and the sensing of the tape and advancement of the tape are controlled by a magnet 13. A bus bar with which the contacts 11 are engageable is connected to one side of a battery 14 and the contacts 11 are connected individually to magnets 16, the opposite ends of the windings of which are connected to the other pole of battery 14. Upon the engagement of the bus bar by any of the contacts 11, the associated magnet 16 will become energized. As fully disclosed in the copending application, the magnets 16 individually control code bars which are set permutatively by the magnets to select pairs of brushes 17 for engagement with rotatable cams 18. Upon the selection of a pair of brushes 17, the brushes are permitted to move into engagement with the associated pair of cams 18 which are continuously driven by motor 19.

The cams 18 have conductive and nonconductive portions on the periphery corresponding to the facsimile codes of characters. Of each pair of cams 18 one, which may arbitrarily be designated as the left-hand cam, carries the code for the unshift character assigned to the code combination which selects the brushes co-operating with the pair of cams, and the other cam, which will arbitrarily be designated as the right-hand cam, contains the facsimile code for the shift character associated with the same permutation code. All of the left-hand cams are connected electrically to a conductive ring 20 and the right-hand cams are connected electrically to a conductive ring 21. Rings 20 and 21 are connected to contacts 22 and 23, respectively, between which a swinger 24 is movable. The swinger 24 is moved back and forth in response to the shift and unshift code combinations set up in the code

bars controlled by the magnets 16. The contact swinger 24 is connected to conductor 26 which extends to a two-conductor plug 27. All of the brushes 17 are connected to bus bar 28 which is connected to conductor 29 also extending to plug 27. When the contact swinger 24 is in engagement with the right-hand contact 23, which is the condition shown in Fig. 1 and one of the sets of brushes 17 has been selected for engagement with its associated transmitting cams 18, a conductive path is completed, as the cams 18 rotate, from conductor 26 through the swinger 24, right-hand contact 23, conductive ring 21, right-hand cam 18 and right-hand brush of the pair of brushes 17 then co-operating with the cams, bus bar 28 to conductor 29. When the contact swinger 24 engages the left-hand contact 22, a conductive path is completed in accordance with facsimile signals from conductor 26 through swinger 24, left-hand contact 22, conductive ring 20, the left-hand cam 18 and brush 17 to conductor 29.

The operation of tape stepping magnet 13 is controlled jointly by cam operated tape stepping contacts 32 and disabling magnet 33 for the stepping contacts 32. Magnet 33 must be energized in order for contacts 32 to be operative to step the tape 12. The circuit of magnet 33 includes contacts 34 which are open when contacts 36 associated with taut tape arm 31 are open due to a taut tape condition, or when manually operable switch 37 is open, the switch 37 and contacts 36 being in the circuit of a magnet 38. The magnet 38 when energized holds a worm follower lever 39 into co-operation with a worm 41 which is continuously rotatable with the transmitting cams 18. As fully disclosed in the copending application Ser. No. 371,358, follower lever 39 is moved into engagement with worm 41 when magnet 38 becomes energized and is moved in counterclockwise direction by the worm 41. When follower lever 39 reaches the left-hand end of worm 41, it closes contacts 34, thus completing the circuit for magnet 33 which operates to place the tape stepping contacts 32 under the control of the tape stepping cam (not shown), thus permitting magnet 13 to be operated to advance tape 12. The reason for delaying the closure of contacts 34 after the closure of switch 37 or taut tape contacts 36 by providing that follower lever 39 shall travel across worm 41 will be set forth hereinafter.

In Fig. 2 a system for keying a tone source according to facsimile telegraph signals and for mixing the keyed signals and speech signals and delivering them to the input of a radio transmitter is shown. A motor 46 driven from a source of power 47 drives an audio tone generator 48 at uniform speed to generate an audible tone oscillatory current of substantially fixed frequency. According to one embodiment of the invention the frequency chosen is 1,000 cycles per second. The tone generator 48 has in series with it a limiting resistor 49 and the output of the tone generator is connected across a load resistor 52. A potentiometer resistor 53 is connected in parallel with the load resistor 52 and the movable contact of the potentiometer is connected to the grid of an electronic amplifier tube 54.

The plate circuit of amplifier tube 54 extends through the primary winding of an output or coupling transformer 56 and the secondary of the transformer 56 is connected to the input terminals of a band pass filter 57 which, for a tone

of 1,000 cycles per second available at the generator 48 may pass a band of frequencies between 800 and 1,200 cycles per second. The output of filter 57 is connected across an impedance matching network comprising the resistors 58 connected to the input terminals of a modulated carrier radio transmitter 59.

The speech input system for the radio transmitter 59 comprises a microphone 61, pre-amplifier 62, coupling transformer 63 for the amplifier 62 and an electronic amplifier tube 64. Included in the plate circuit of amplifier tube 64 is the primary of an output or coupling transformer 66 the secondary of which is connected to the input of a band reject filter 67. The output of the filter 67 is connected across the resistor network comprising the resistors 58 and thus to the input of radio transmitter 59.

In a voice and facsimile signal mixer employing a generator of a tone of 1,000 cycles for telegraph signal transmission and a band pass filter having a value of 800 to 1,200 cycles for filtering the telegraph tone signals the filter 67 in the speech input portion of the mixer preferably rejects a band of frequencies between 800 and 1,200 cycles. This means that speech frequencies falling within that band will be removed from the signals applied to modulate the carrier frequency of the radio transmitter. It has been found that the removal from speech of a band of frequencies between 800 and 1,200 cycles does not seriously impair the intelligibility of the speech. With this arrangement there is applied to the radio transmitter 59 for modulating the carrier frequency generated in the transmitter, a telegraph signaling tone confined to a band of frequencies which is excluded from speech signals which may be simultaneously applied to the radio transmitter.

In order that the keyer and mixer unit may be a separate unit from the radio transmitter, if that is found to be desirable, the keyer and mixer unit may have its own power supply for furnishing low voltage alternating current to the heaters of the amplifier tubes 54 and 64 and for supplying high voltage direct current to the plates of those tubes. In Fig. 2 a conventional power supply system is shown including power supply transformer 71, full wave rectifier tube 72 and power supply filter 73.

Under some signaling conditions, it has been found advantageous in the radio transmission of facsimile signals by means of interrupted audio frequency tones to have tone-on the transmitter for spacing condition and tone-off for marking. One of the reasons for this is that static discharges which may interfere with the radio reception partake of the nature of audible tone disturbances. By employing tone-on for the spacing condition, no mark will be recorded by a receiving facsimile printer in response to received tone impulses and correspondingly no marks will be recorded in response to received static disturbances. Static disturbances received during marking intervals will, of course, tend to prevent the marking of the recording medium in response to the no-tone marking condition, but the characters are more likely to be legible as a result of omission of parts of them than by obliteration of parts of them which might result in the superposition of a static discharge on a tone-on condition representing a marking signal. This is the reason that the tone generator is permanently connected across the load resistor 52, so that tone shall be on the keyer and mixer sys-

tem when the transmitter shown in Fig. 1 is momentarily idle, it being understood that a spacing or open circuit condition is the idle condition for facsimile signaling.

The plug 27 to which output conductors 26 and 29 of the facsimile signal transmitting distributor are connected is insertable into jacks 51 for connecting the transmitting distributor to the keyer and mixer unit. Upon the insertion of the plug into the jack, a conductive path for short-circuiting the load resistor 52 is extended to the brushes 17 and facsimile code cam 18. When switch 37 is open or taut tape switch 35 is open, none of the brushes 17 engages its associated cam 18 and the load resistor 52 is not short circuited. Thus, the output of the tone generator is connected across the resistor 52 and steady audio tone is amplified in the electronic amplifier tube 54 and is applied to the input circuit of radio transmitter 59 whereby the tone is transmitted as a modulation of the radio frequency carrier generated by the radio transmitter. When signal transmission occurs due to engagement of one of the brushes 17 with conductive portions of its associated cam 18 or to another completion of connections between conductors 26 and 29 which will be described later, the load resistor 52 is short circuited and the tone is removed from the grid of amplifier 54. Thus the transmission of the tone from radio transmitter 59 ceases during the time that conductor 26 is connected to conductor 29 and this condition is the marking condition which is intended to result in the printing of patterns on the recording medium at a receiving station corresponding to the conductive portions of the cam 18 which is engaged by its brush 17.

Referring now to Fig. 3, the reference numeral 71 designates a radio receiver which is tuned to the radio frequency carrier transmitted by the transmitting station 59 to receive the carrier frequency modulated by speech signals, facsimile signals, or both simultaneously. In accordance with the usual practice, the receiver 71 has a detector for demodulating the carrier whereby there will appear in the output circuit of the radio receiver the speech signals, or the facsimile signals, or the mixed signals in the form in which they were introduced into the transmitter. The output of radio receiver 71 is connected to the primary of a coupling transformer 72 the secondary of which is connected across the input terminals of a filter 73 which has two principal components. One of the principal components of filter 73 is a band pass section capable of passing a band of frequencies between 800 and 1,200 cycles. It will be noted that this component of the filter corresponds to the filter 57 in Fig. 2. The output of this component of filter 73 is connected to the primary winding of coupling transformer 74. The other principal component of filter 73 is a band reject section capable of rejecting a band of frequencies between 800 and 1,200 cycles. It will be noted that this component of filter 73 corresponds in characteristics to the filter 67 in Fig. 2. The output of this component of filter 73 is connected to the primary winding of the coupling transformer 76.

The secondary winding of coupling transformer 74 is connected to the input terminals 77 of a bridge type rectifier which consists of four half wave rectifier elements 78 and which, therefore, affords full wave rectification. The rectifier elements 78 may be electronic diode types of tubes having, as shown, indirectly heated cath-

odes, or commercially available multiple purpose tubes of the type known as twin diodes may be employed in which case two such tubes will be required, the two furnishing all of the elements indicated in the four rectifier devices 78 in Fig. 3. The output terminals 79 of the bridge rectifier are connected to a filter network consisting of the inductance or choke elements 81 and 82 in series connected to one of the terminals 79 and the inductances 83 and 84 in series connected to the other of the terminals 79, with condensers 86 and 87 in series between the point of connection of inductance 81 with inductance 82 and the point of connection of inductance 83 with inductance 84. The filter network just described filters out the 2000 cycle oscillations appearing at the terminals 79 of the rectifier so that at the output of the filter represented by the terminals 88 and 89 unidirectional direct current impulses appear.

A series of resistors comprising the resistors 91, 92, 93, and 94 is connected between the filter output terminals 88 and 89 and the direct current impulses flow unidirectionally through this series of resistors. The junction of resistor 92 with resistor 93 is connected through the junction of condenser 86 with condenser 87 to ground, and a condenser 96 is connected in parallel with the resistors 92 and 93.

The terminal 88 at the upper end of resistor 91 is connected to one side of a condenser 97, the other side of which is connected to a terminal 98. Similarly the terminal 89 at the lower end of resistor 94 is connected to one side of a condenser 99, the other side of which is connected to a terminal 101. Between the terminals 98 and 101 resistors 102 and 103 are connected in series and the junction of resistor 102 with 103 is connected to ground and is also connected through a cathode resistor 104 to the cathodes of electron amplifier tubes 106 and 107 so that the resistor 104 is common to the cathode circuit of the two tubes.

The terminal 98 at the upper end of resistor 102 is connected through grid circuit resistor 108 to the grid of amplifier tube 106 and the terminal 101 at the lower end of resistor 103 is connected through grid circuit resistor 109 to the grid of tube 107.

The plates of the amplifier tubes 106 and 107 are connected to the opposite ends of the winding of the signal responsive polar magnet 111 of a facsimile printer such as the one disclosed in the hereinbefore identified copending application No. 371,358. The center tap of the winding of magnet 111 is connected to positive battery, and high voltage for the plates of amplifier tubes 106 and 107 is supplied from the battery through the two halves of the winding of magnet 111.

The oscillatory current at 1000 cycles per second representing the facsimile signals is passed by the band pass portion of filter 73, is rectified in the full wave bridge rectifier, and appears across the terminals 79 as direct current impulses. The inductances 81, 82, 83, and 84 in co-operation with the condensers 86 and 87 remove the alternating components of the output from the rectifier with the result that pulsating direct current flows unidirectionally through resistors 91, 92, 93, and 94. When the voltage rises across the series of resistors 91, 92, 93, and 94 charging current flows through condensers 97 and 99 and through resistors 102 and 103. This results in a potential difference across resistors 102 and 103 of the same polarity as the voltage

across the series of resistors 91, 92, 93, and 94. When the voltage across resistors 91, 92, 93, and 94 decreases at the termination of a train of waves of oscillatory current the condensers 97 and 99 will begin to discharge, their discharge current flowing through resistors 102 and 103 in the opposite direction to the previously described charging currents, resulting in a potential difference across resistors 102 and 103 in the opposite direction. The potential differences across resistors 102 and 103 are impressed on the grids of the two triode electron tubes through resistors 108 and 109 and control the plate current in those tubes. Resistors 108 and 109 are used to limit grid current on strong signals. Tubes 106 and 107 are normally balanced, so that the plate currents which traverse the two halves of the winding of the polar printing magnet are equal and opposite and the magnet exerts no force upon its armature. When a voltage appears across resistors 102 and 103, it results in an unbalance of the plate current of the two amplifier tubes which causes a raising or lowering of the print hammer through the action of the polar printing magnet depending upon whether the voltage results from the charging or discharging of condensers 97 and 99. When the unbalance is such as to raise the print hammer, which is operated by the armature of the magnet, marking occurs upon the record medium of the facsimile printer, whereas when the voltage across resistors 102 and 103 is due to discharging of the condensers 97 and 99, the print hammer is lowered and marking upon the recording medium does not occur.

If a steady condition of tone is applied to the input of this rectifier and amplifier circuit, direct current voltage will be developed across resistors 91, 92, 93, and 94 and charging currents will flow through condenser 97 and 99 and through resistors 102 and 103 until the condensers have become fully charged to the direct current voltage. While this charging is in progress, the charging currents develop a potential difference across resistors 102 and 103 and, therefore, across the grid of the two amplifier tubes 106 and 107 resulting in continuous holding of the print hammer in one position, which for tone-on for spacing will be the lowered position, until the condensers 97 and 99 have become fully charged and charging current ceases, whereupon no further current will flow in the resistors 102 and 103 and the amplifier tubes 106 and 107 will be restored to a balanced condition, whereby the polar magnet 111 will have no further holding effect upon the print hammer while the tone continues to be received.

If the tone is now removed, condenser discharging currents will flow causing a reverse potential difference across resistors 102 and 103 which will unbalance the plate currents of the amplifier tubes 106 and 107 in the opposite direction to hold the print hammer in the opposite or raised position. If tone is not reapplied, the condensers will become fully discharged whereupon there will be no potential difference across resistors 102 and 103 and plate currents in the amplifier tubes 106 and 107 will return to balanced condition so that no further force will be exerted on the print hammer. Thus, it may be seen that the print hammer is only actuated when a change in the state of the tone occurs and not by any steady state of the tone.

During intervals of continuous transmission, the condensers 97 and 99 never become fully charged by the voltage across resistors 91, 92, 93,

and 94, nor do they ever become completely discharged. Instead, they tend to maintain an intermediate, operating charge level and the time constants of the condenser circuits are of such magnitude that the charge level of the condensers increases only slightly above the operating charge level during the intervals between words of a message, which intervals are characterized by the presence of signaling tone since the instant system employs "tone-on" for spacing. However, should the system be permitted to remain idle for an extended period, the condensers 97 and 99 would become fully charged and when transmission is resumed, the first few characters may be distorted because when the signal tone is temporarily removed in response to a received marking impulse, there will be only a small charge leak from the condensers and, accordingly, when tone is again applied in response to a received spacing impulse, the charging current will be very small since the residual charge on the condensers is high and this small charging current may be insufficient to unbalance the tubes 106 and 107 to reverse the print hammer.

In like manner, when the system employs "tone-on" for marking, the first few characters of a message may be distorted when transmission is resumed after an extended idle period during which the condensers 97 and 99 would have become completely discharged. In such case, tone would be momentarily applied in response to reception of a marking impulse and would place a small charge on the condensers so that when the condensers subsequently discharge in response to the receipt of a spacing impulse, the discharge current would be too small to operate the triodes 106 and 107.

Since, as previously set forth, a time interval representing several characters may be required to establish an operating charge level in condensers 97 and 99, it is desirable upon starting signal transmission after an idle period to bring the condensers to the desired level before actual transmission of characters begins. In the case of tone-on for marking signals and tone-off for spacing signals, the condensers should be brought up from discharged condition to the proper level and in the case of tone-on for spacing and tone-off for marking, the condensers should be brought from full charge down to the proper level.

Referring again to Fig. 1 the reference numerals 112 and 113 designate normally open contacts that are in parallel with the cams 18 and their brushes 17 and are therefore closable to connect conductor 26 to conductor 29. The movable elements of the contacts 112 and 113 are in the path of the upper end of worm follower lever 39 so that as the lever 39 progresses leftwardly, the contacts 112 will be closed and permitted to reopen and after an interval the contacts 113 will be closed and permitted to reopen, the closing of the contacts 113 occurring shortly before the closure of contacts 34 by which signal transmission is started. As fully disclosed in the copending application, the closure of contacts 112 and 113 represents a marking condition and effects the starting of the driving motor for the receiving facsimile printer. The contacts 112 and 113, and particularly the latter of these two pairs of contacts, which are operated just before the tape sensing mechanism is set in operation, perform the additional function of conditioning the amplifier shown in Fig. 3 to respond to facsimile signals when a system is formed employing the transmitting units of Figs. 1 and 2, and the receiving units

of Fig. 3, as indicated in Fig. 6. If the spacing or steady condition preceding signal transmission is tone-on, the contacts close to cut off the tone thereby permitting the fully charged condensers 97 and 99 to discharge at least partially. Conversely, if the idle or steady condition preceding signal transmission is represented by tone-off, the contacts 112 and 113 upon closure effect the transmission of tone impulses to permit the then fully discharged condensers 97 and 99 to charge, at least partially. The ideal condition of condensers 97 and 99 is to have them neither fully discharged nor fully charged but to have them charged at a mean value which is approximately that existing during message transmission when marking and spacing impulses are being alternated with sufficient frequency that the condensers can neither become fully charged nor fully discharged and, therefore, the condensers will respond equally to charging or discharging conditions and will produce sufficient potential difference changes across the resistors 102 and 103 to operate the amplifier tubes 106 and 107 in correspondence thereto.

The condensers 97 and 99 present a higher impedance to extremely low frequencies than to somewhat higher frequencies and they therefore produce a greater phase shift in low frequencies than they do in high frequencies. In order for the characters to be properly printed, the phase shifting tendency of these condensers must be counteracted. This is accomplished by the employment of the condenser 96 in parallel with the resistors 92 and 93. The phase shifting tendencies may also be expressed upon the basis that long marking pulses and long spacing intervals have more effect upon the state of charge of condensers 97 and 99 than do short marking or spacing pulses. With condenser 96 included in the circuit, the energy storage capabilities of the circuit are greatly increased and the energy stored in condenser 96 is of such polarity that it opposes changes in the amount of energy stored in condensers 97 and 99. Thus the voltages across condensers 97 and 99 remain more nearly constant even for the long marking and spacing pulses of a facsimile printer code and the charging and discharging currents are enabled to follow more closely the voltages appearing across the resistors 91, to 94, inclusive.

Reference has been made previously to the coupling transformer 76 for speech signals delivered by the band reject component of the filter 73. The secondary of the coupling transformer 76 feeds a speech amplifier which may consist of one or more stages as required and which is indicated in Fig. 3 by the electron amplifier tube 114. The plate circuit of amplifier tube 114 includes the primary of an output or coupling transformer 116, the secondary of which is connected to a speech reproducer which may be a loud speaker as indicated by the reference numeral 117.

The components of the filter 73 separate and channel the mixed signals impressed upon the coupling transformer 72 to their proper reproducing devices. The band pass portion of filter 73 passes the tone impulses which represent facsimile signals and rejects all voice signals so that the rectifier and amplifier and the printer magnet 111 shall not respond to such signals, it being remembered that speech frequencies in the range allotted to the facsimile signal transmission, namely, in the band of 800 to 1,200 cycles, have been deleted from the speech signals by the band

reject filter 67 in the mixer unit (Fig. 2). The band reject portion of the filter 73 blocks and rejects the band of frequencies allotted to facsimile signal transmission and prevents those signals from being heard in the speech reproducer 117. Thus, facsimile telegraph signals and speech signals may be transmitted simultaneously upon one radio frequency channel and be received, separated, and simultaneously reproduced individually at a receiving station.

In Fig. 4 is shown an alternative embodiment of rectifier and amplifier for reproducing facsimile telegraph signals transmitted from the apparatus disclosed in Fig. 1, the apparatus being associated as indicated in Fig. 7. In that system the radio receiver, first coupling transformer, speech and printer separating filter, and second coupling transformer may be identical with those shown in Fig. 3 and they therefore have been identified by the same reference numerals.

The secondary of the coupling transformer 76 in Fig. 4 has the opposite ends of its winding connected to the two plates of a full wave electronic rectifier tube 121, which has been shown as having two independently heated cathodes the particular tube being a multiple purpose tube known as a twin diode, but which might have two plates and a single cathode, since independent connections to cathodes are not required.

The cathodes of rectifier tube 121 are connected together and to one end of a series of inductances 122 and 123 which, with a condenser 124 connected between ground and the junction between inductances 122 and 123, constitute a filter network for filtering out the 2,000 cycle tone oscillations which may pass through rectifier 121. At the free terminal 126 of inductance 123 a series of resistors consisting of the resistors 127 and 128 is connected and the free terminal 129 of resistor 128 is grounded. A condenser 131 is connected in parallel with the resistor 128 to counteract the phase shift tendencies of a condenser 132, in a manner similar to the operation of condenser 96 in Fig. 3, described above. To the terminal 126 one side of condenser 132 is connected and the other side of the condenser is connected at terminal 133. One end of a resistor 134 is connected to terminal 133 and the other end is connected to the lower end of resistor 128 by virtue of the fact that the lower terminal 136 of resistor 134 is connected to terminal 129. The upper end of resistor 134 is connected through grid resistor 137 to the grid of electron amplifier tube 138. The lower end of resistor 134 is connected through cathode resistor 139 to the cathode of amplifier tube 138 to which is also connected the cathode of amplifier tube 141, the grid of which is maintained at ground potential. As in the embodiment of the rectifier amplifier shown in Fig. 3, the plates of the amplifier tubes 138 and 141 are connected to the ends of the winding of polar magnet 142, the center tap of which is connected to positive battery for supplying plate voltage to the amplifier tubes 138 and 141.

In the operation of the system shown in Fig. 4, the rectifier tube 121 rectifies the trains of 1,000 cycle tone oscillations representing the facsimile signaling impulses and interrupted direct current flows unidirectionally through the resistors 127 and 128 causing a rising potential difference across the resistors at the beginning of an impulse and a falling potential difference at the end of an impulse. Changes in potential difference between the terminals 126 and 129

cause current to flow in the circuit including condenser 132 and resistor 134 to charge or discharge the condenser. Thus, when the potential difference across the resistors 127 and 128 rises, current flows through resistor 134 in one direction to charge condenser 132. At the end of the rectified impulse the potential difference across resistors 127 and 128 decreases and condenser 132 discharges, the current flowing through resistor 134 in the opposite direction.

The potential difference across the resistor 134 due to the charging current raises the potential at terminal 133 with respect to terminal 136, which is at ground potential, and thus raises the potential of the grid of amplifier tube 138 so that the plate current of that tube increases and the current flowing through the upper half of the winding of printer magnet 142 operates the print hammer in one direction. The plate circuit return to the cathode of tube 138 includes the resistor 139 and the increase in current flowing through resistor 139 causes an increase in the potential difference across the resistor, making the cathodes of tubes 138 and 141 more positive with respect to ground. In the tube 141 this is equivalent to the application of a negative voltage on its grid, and the plate current of tube 141 is therefore decreased. Conversely, when condenser 132 discharges through resistor 134, the point 133 and therefore the grid of tube 138 become negative with respect to ground and the plate current of tube 138 will be decreased. The current through cathode resistor 139 common to both of the tubes 138 and 141 will be correspondingly decreased and the potential difference across resistor 139 will be accordingly reduced. The reduction in potential difference across resistor 139 will be the equivalent to applying a positive voltage to the grid of tube 141 and the plate current in that tube will increase to move the print hammer in the opposite direction. Thus the tubes 138 and 141 operate in push-pull arrangement although the variations in current in tube 141 are less than those in the tube 138. From this it will be observed that the amplifier shown in Fig. 4 is an unbalanced push-pull amplifier. Such unbalance is not an undesirable characteristic as the amplifier affords good control of the polar printing magnet.

As in the case of the amplifier shown in Fig. 3, the print hammer is actively controlled by the magnet 142, due to opposite responses of amplifier tubes 138 and 141, only during intervals of charging or discharging condenser 132. When a steady state of tone-on or tone-off has existed for a sufficient interval to enable all transient currents to die out, the amplifier returns to normal condition which is with insufficient differential in plate current in either tube for the print hammer to be actively influenced by either half of the winding of polar magnet 142.

In Fig. 5 is shown another embodiment of the invention as regards the keying of a radio transmitter by facsimile printing telegraph signals. This embodiment of the invention contemplates only the transmission of telegraph signals over the radio frequency carrier, and it may be employed where voice transmission over the same channel is not required as indicated schematically in Fig. 5. The same type of tone generator and facsimile signal transmitting distributor may be employed as those shown in Figs. 1 and 2. Accordingly, the tone generator, driving motor, and the transmitting distributor output conductors and connecting jack and plug have been

identified by the same reference numerals as those employed in Figs. 1 and 2.

Load resistors 146 and 147 in series are connected across the output of tone generator 48. In series with the tone generator 48 is a current limiting resistor 148. Across the load resistors 146 and 147 an adjustable network comprising the resistors 151, 152, and 153 is connected. The function of the resistance network is to attenuate the oscillatory current generated by the tone generator 48 and it is made adjustable in order to control the level of the signal impressed upon the input of the radio transmitter 59. The terminals of jack 51 are connected across the input of the network of resistors 151, 152, and 153, so that when the circuit through conductors 29 and 26 is completed the load network will be short circuited and the oscillatory tone current will not be transmitted. A stage of amplification ahead of the radio transmitter is not required in this embodiment of the invention because it is not necessary to put the tone impulses through a band pass filter, as no other signal is to be carried by the same radio frequency channel and the signal therefore does not suffer attenuation in a filter, which necessitated the provision of the amplifier as shown in Fig. 2. Accordingly, the output of the resistor network comprising the resistors 151, 152, and 153 is connected to the primary winding of a coupling or output transformer 154 the secondary of which is connected to radio transmitter 59.

In both embodiments of keyer unit shown and described herein a motor driven magnetomotive tone generator has been shown. It will be understood that a vibratory type of tone generator could be employed and that alternatively an electronic generator of oscillatory current at controlled frequency could be employed.

The transmitting and receiving stations shown herein may be readily arranged for signaling by tone-on for spacing and tone-off for marking, or conversely, by tone-off for spacing and tone-on for marking. Figs. 2 and 5 show the arrangement for tone-on for spacing. Tone may be transmitted for marking by connecting the terminals of jack 51 in the circuit of the tone generator instead of across that circuit. At the receiving station, the change from one type of reception to the other may be made merely by reversing the connections of the printer magnet to the amplifier.

Although certain specific embodiments of the invention have been shown in the drawings and described in the accompanying specification, it will be understood that the invention is not limited to such specific embodiment but is capable of modification, rearrangement, and substitution without departing from the spirit of the invention and within the scope of the appended claims.

What is claimed is:

1. In a signaling system, a source of unidirectional signaling impulses, a resistance and capacitive network comprising an energy storing and releasing system connected to said source, capacitive means in said system arranged in parallel with a certain portion of said resistance to counteract phase shifting tendencies of said system, a pair of electron discharge devices connected in opposed relation to said energy storing and releasing system, and a polar signal responsive magnet connected between said electron discharge devices for polar response according to the alternative operation of said opposed devices

under the joint control of said energy storing and releasing system and said means.

2. In a signaling system, a source of impulse trains of oscillatory current, means for rectifying said impulse trains to produce unidirectional impulses, a resistance and capacitive network comprising an energy storing and releasing means connected to said rectifying means to store and release energy in accordance with the initiation and cessation of said impulse trains, capacitive means arranged in parallel with a certain portion of said resistance for counteracting phase shifting tendencies of said energy storing and releasing means, a pair of electron discharge devices connected to said energy storing and releasing means in opposed relation to be alternately controlled correspondingly in accordance with the storing and releasing of energy by said energy storing and releasing means and said counteracting means, and a polar signal responsive electromagnet connected between said electron discharge devices for polar response according to the alternative control of said discharge devices.

3. In a signaling system, a receiver comprising means to receive oscillatory signaling impulses, a rectifier to convert said oscillatory signaling impulses into unidirectional signaling impulses, a resistance and capacitive network connected to said rectifier to store and release said unidirectional impulses, capacitive means arranged in parallel with a certain portion of said resistance to counteract phase shifting tendencies in said network, a pair of electron discharge devices connected in opposed relation, said electron discharge devices being normally balanced but being unbalanced when said network is storing or releasing said impulses, and a polar magnet connected between said discharge devices and operated thereby when said discharge devices are unbalanced.

4. In a signaling system, a source of oscillatory signaling impulses, means to rectify said oscillatory impulses, a pair of space discharge devices connected in opposed relation, a polar magnet connected between said space discharge devices for response according to the alternative operation of said devices, a resistance and capacitive network connecting said devices to said rectifying means to cause alternative operation of said devices in accordance with said oscillatory signaling impulses, and capacitive means arranged in parallel with a certain portion of said resistance to counteract the phase shifting tendencies of said network.

5. In a signaling system, a source of oscillatory signaling impulses, a rectifier for producing unidirectional impulses from said oscillatory impulses, a resistance and capacitive network having charging and discharging conditions connected to said rectifier, capacitive means arranged in parallel with a certain portion of said resistance to counteract phase shifting tendencies of said network, a pair of space discharge devices connected in opposed relation and connected to said network to be operated in alternation by said charging and discharging conditions of said network under the control of said counteracting means, and a polar signal responsive magnet connected to said space discharge devices for polar response according to the alternative operation of said devices.

6. In a signaling system, a source of unidirectional signaling impulses, a resistance and capacitive network comprising an energy storing and

releasing system connected to said source, capacitive means in said system arranged in parallel with a certain portion of said resistance to counteract phase shifting tendencies of said system, a pair of electron discharge devices connected in opposed relation, each such device including a cathode, an anode, and a grid, a polar signal responsive magnet connected in the anode-cathode circuit of each device and operable in response to the relative conductivity of each electron discharge device, and a circuit connecting the grid of one of said electron discharge devices to said energy storing and releasing system to render under the control of said capacitive means each of said devices alternately more conductive than the other in response to said signaling impulses.

7. A signal receiver including a resistance and capacitive network comprising an energy storing and releasing system conditioned under the control of received signal impulses to store or release energy, capacitive means arranged in parallel with a certain portion of said resistance to counteract phase shifting tendencies of said system, a pair of electron discharge devices connected in opposed relation, each of said electron discharge devices including an anode, cathode and grid, the grid of one of said devices being connected to said system and the grid of the other of said devices being maintained at a constant potential so that said electron discharge devices are rendered alternately operative when said system is storing and releasing energy under the control of said capacitive means, and a polar signal responsive magnet connected in the anode-cathode circuits of said devices to be controlled in accordance with the operation of said devices.

8. In a signaling system, a source of oscillatory signaling impulses, means to rectify said impulses, a resistance and capacitance network connected to said rectifying means and containing charging and discharging currents in response to the operation of said rectifying means, capacitive means arranged in parallel with a certain portion of said resistance to counteract phase shifting tendencies of said network, a pair of space discharge devices connected in opposed relation, a grid, cathode, and anode included in each space discharge device, the grid of one of said devices being connected to said resistance and a capacitance network and the grid of the other being maintained at constant potential whereby one of said space discharge devices is rendered operative by said charging currents and the other is rendered operative by said discharging currents, an anode-cathode circuit for each space discharge device, and a polar magnet connected in the anode-cathode circuit of each space discharge device and responsive to the operation of said devices.

9. In a receiving device, a means to receive oscillatory signaling impulses, means to rectify said oscillatory signaling impulses, a resistance and capacitive network comprising an energy storing and releasing system controlled by said rectifying means to store and release energy in response to received signal impulses, capacitive means arranged in parallel with a certain portion of said resistance to counteract phase shifting tendencies of said system, a pair of electron discharge devices connected in opposed relation to be rendered alternately operative in response to the storing or releasing of energy by said system, each electron discharge device including a grid, cathode, and anode, the grid of one of said

devices being connected to said system and the grid of the other of said devices being maintained at constant potential, an anode-cathode circuit for each of said devices, a cathode resistance common to each anode-cathode circuit, and a polar magnet in the anode-cathode circuit of each device and controlled by the received signaling impulses through said electron discharge devices.

10. In a signaling system, a transmitting station, a receiving station, means to transmit signaling impulses from said transmitting station to said receiving station, an energy storing and releasing system in said receiving station responsive to received signaling impulses to store and release energy, a pair of electron discharge devices connected in opposed relation to said energy storing and releasing system and operable in alternation thereby, a polar signal responsive magnet connected between said devices to be operated in accordance with the operation of said devices, and means at said transmitting station effective upon initiation of transmission to establish in said energy storing and releasing system at said receiving station an operating charge level.

11. In a signaling system, a transmitting station, a receiving station, means to transmit signaling impulses from said transmitting station to said receiving station, an energy storing and receiving system in said receiving station responsive to received signaling impulses to store and release energy, a pair of electron discharge devices connected in opposed relation to said energy storing and releasing system, a polar magnet connected between said electron discharge devices for polar response according to the operation of said devices under the control of said energy storing and releasing system, and means at said transmitting station to insure the establishment in said energy storing and releasing system of

an operating charge level before initiating the operation of said transmitting means.

12. In a signaling system, a transmitting station, means to transmit oscillatory signaling impulses, a receiving station, means at said receiving station to receive said oscillatory impulses, means to rectify said oscillatory impulses, a network connected to said rectifying means, a condenser in said network to be charged and discharged in accordance with the operation of said rectifying means, a pair of space discharge devices connected in opposed relation to said network whereby the charging and discharging of said condenser renders said devices alternately operable, a polar magnet connected between said space discharge devices and operable thereby, and means at said transmitting station to cause said condenser to become charged to a predetermined operating charge level before said transmitting means is rendered effective.

13. In a signaling system, a source of unidirectional signaling impulses, a resistance and capacitive network comprising an energy storing and releasing system connected to said source, capacitive means in said system arranged in parallel with a certain portion of said resistance to counteract phase shifting tendencies of said system, a pair of electron discharge devices connected in opposed relation to said energy storing and releasing system, a coupling system disposed between said energy storing and releasing system and said discharge devices and responsive to changing of the energy in said energy storing and releasing system, and a polar signal responsive magnet connected between said electron discharge devices for polar response according to the automatic operation of said opposed devices under the joint control of said energy storing and releasing system and said coupling system.

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