

July 30, 1940.

F. E. D'HUMY ET AL
FACSIMILE TELEGRAPH SYSTEM

2,209,326

Filed July 9, 1935

2 Sheets-Sheet 1

FIG. 1

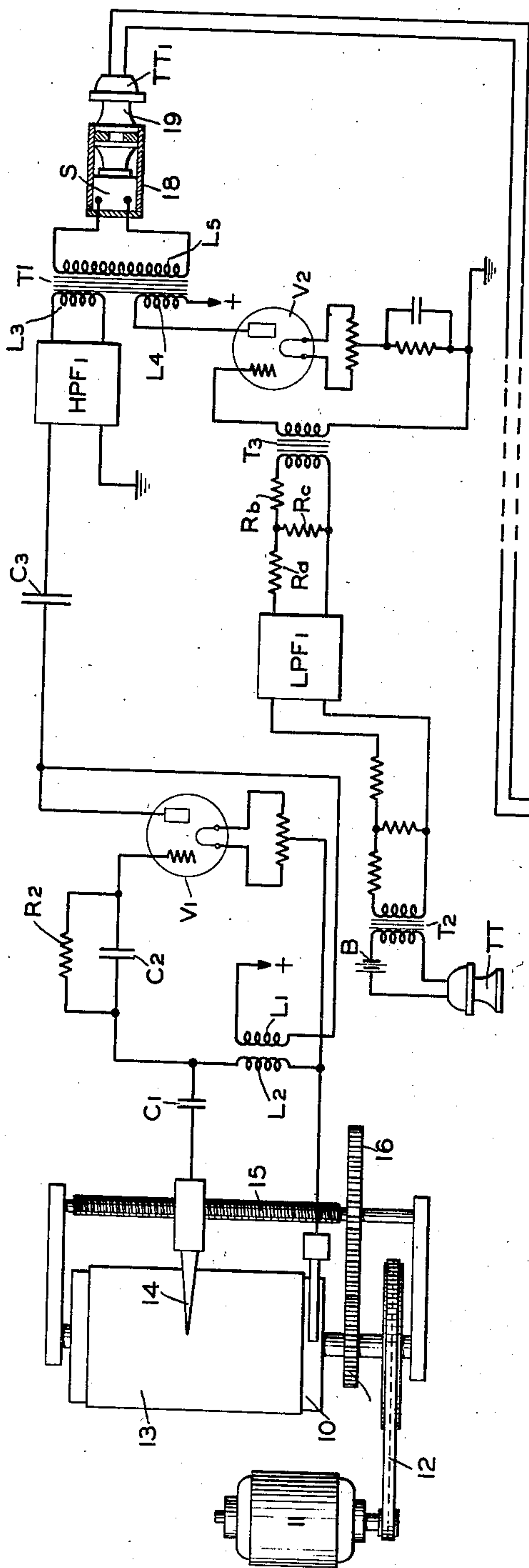
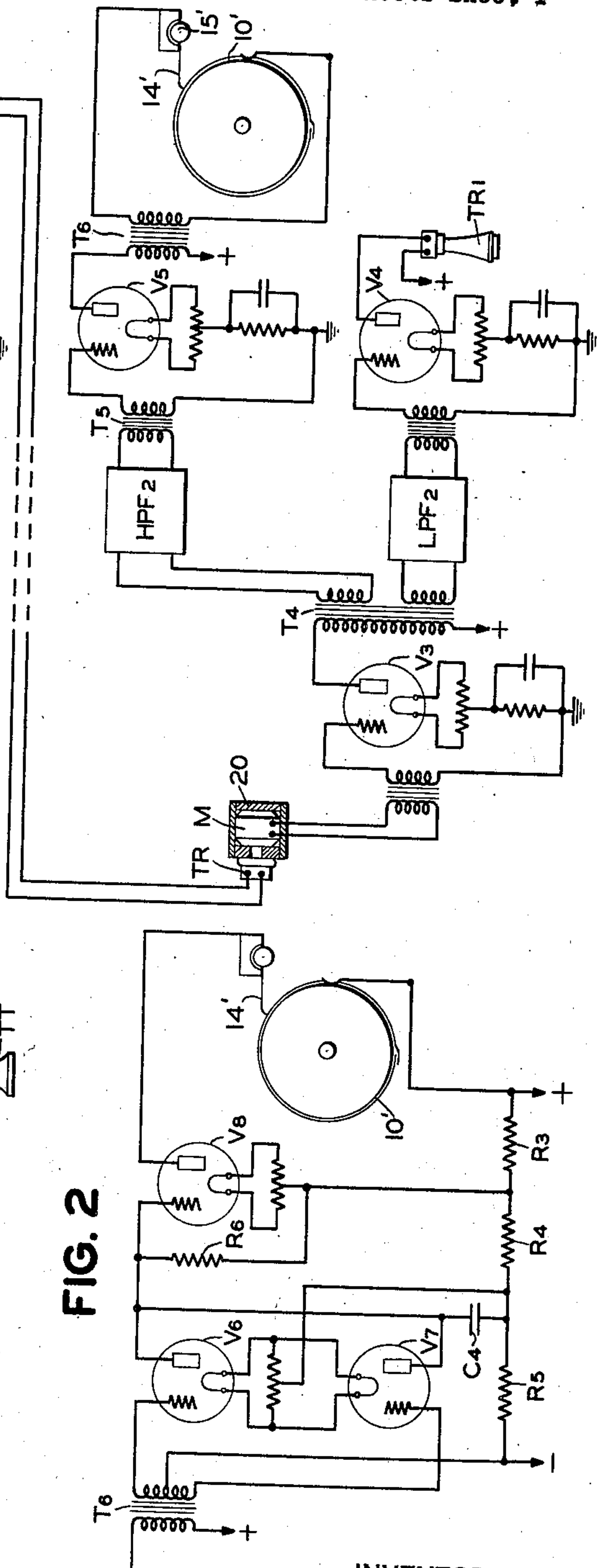


FIG. 2



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2 Sheets-Sheet 2

FIG. 3

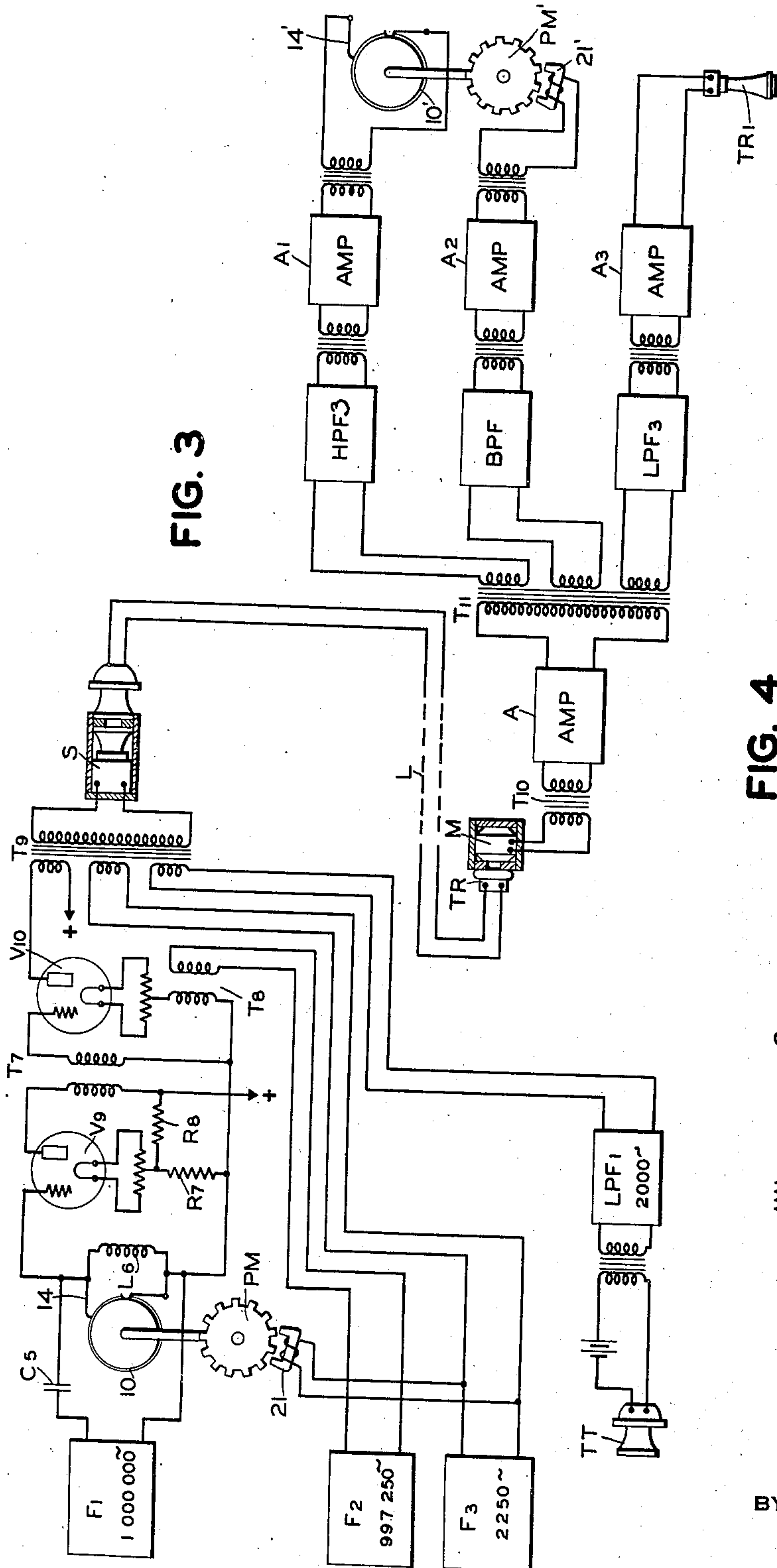
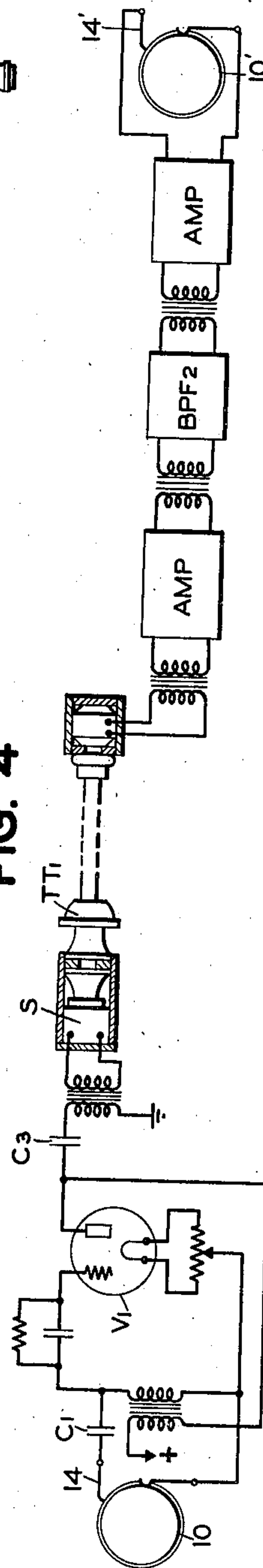


FIG. 4



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2,209,326

FACSIMILE TELEGRAPH SYSTEM

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Application July 9, 1935, Serial No. 30,544

5 Claims. (Cl. 178—5.6)

This invention relates to a facsimile telegraph system and more particularly to the transmission over a telegraph wire, radio band, or a standard telephone circuit, of telegrams and other subject matter written or printed on, or otherwise applied to, a sheet or other carrier member.

The present invention relates to the production of facsimile signals and the transmission thereof over a standard telephone circuit, currently with other types of signals which by way of example may be ordinary telephone conversation, code telegraph signals, facsimile synchronizing signals, or any other type of impulse or voice frequency signals.

One of the objects of this invention is to provide an improved system of facsimile reproduction which is simple, reliable and sensitive to tonal variations of the image being reproduced.

Another object of the invention is to provide a system of facsimile recording adapted to be operable over a standard telephone system.

Another object is to transmit the facsimile signals simultaneously with signals of a different nature.

Still another object is to provide a facsimile system employing signals of varying frequencies for denoting the varying tonal values of the elemental areas of the scanned picture or message.

A still further object is to enable facsimile transmission over a standard telephone circuit simultaneously with ordinary telephone conversation.

Other objects and advantages of the invention will appear from the following description taken in connection with the accompanying drawings, in which:

Fig. 1 is a circuit diagram of a combined facsimile telegraph system and telephone system embodying features of the present invention;

Fig. 2 is a circuit diagram of a modified receiving arrangement for inverting the received facsimile signals;

Fig. 3 is a circuit diagram of a modified facsimile transmitting system; and

Fig. 4 is a circuit diagram of a still further modified form of facsimile system.

Referring first to Fig. 1, there is shown a system for the production of facsimile signals and the simultaneous transmission thereof with voice frequency signals so as to permit facsimile transmission to be conducted over a standard telephone system without interfering with ordinary telephone conversation thereover. The facsimile system comprises the transmitting drum 10 driven at a uniform speed by a motor 11 through

a chain 12. The picture or message 13 to be reproduced is prepared in conducting ink, or other conducting medium, upon an insulating background, such as paper, which is wrapped about the cylinder 10. A stylus 14 is moved longitudinally along the drum 10 by the screw 15 and gears 16 and 17, as the drum rotates, so as to trace a helical path on the sheet 13. The drum 10 is of metal or other conducting substance and is insulated from the stylus 14, these elements forming part of a vacuum tube oscillator of the inductively coupled feed-back type comprising a vacuum tube V1, feed-back coil L1 inductively coupled to a tuned grid circuit including the grid coil L2 and associated tuning capacity comprising the capacity between the stylus 14 and the drum 10. A small condenser C1 may be inserted in series with the stylus 14 if desired, the purpose of which will hereinafter appear. A grid condenser C2 and leak resistance R2 may also be included in the grid circuit.

The system of the invention operates most effectively when transmitting from subject-matter embodying an image-bearing surface upon which the images, such as words or pictures, are delineated by alternate conductive and non-conductive areas. Such subject-matter may be provided, for example, by printing, writing or drawing with a conducting ink or other conducting substance upon a non-conducting or dielectric substance, such as paper. Matter written with an ordinary graphite or lead pencil or like conductive material deposited upon the paper may also be employed. Messages typewritten with a ribbon impregnated with conducting ink or by carbon paper is another form which the subject-matter may assume.

Subject-matter of this character comprises areas of a conductive layer or coating, for example, the letters or words of a telegram, separated by areas which are substantially non-conductive, as the blank portions of the paper sheet on which the telegram is written. The conductive areas are for the most part separate individual areas varying through a wide range of sizes from a minimum useful size upward, which minimum useful size may, in the case of printed or written matter, be regarded as the dot for a small letter "i" or a period.

In accordance with the invention, the area of subject-matter of the character described is disposed upon or brought near a conductive surface of appreciable size, such as the cylinder 10 or other metallic plate, with the conductive surface areas spaced from the larger surface or plate by

a dielectric substance, as the paper of the telegraph blank. In this manner, each of the individual conductive areas of the subject-matter together with the plate form the two plates of a small condenser. When the metallic drum 10 is connected to one side of the grid circuit, and the electrode or stylus 14 is connected to another side of the grid circuit and is disposed in opposed relation to the drum or plate and arranged to engage the image surface of the subject-matter between it and the plate, and when relative movement between the stylus and subject-matter is effected in such a manner as to produce scanning action, the individual conductive areas of the subject matter are successively connected in the tuned grid circuit and produces a variable capacity therein. Variations in frequency of the oscillations produced by the tube V1 will occur, in response to such changes in capacity, the increase in the capacity occurring between the stylus 14 and drum 10, as a conductive area is traversed, causing a decrease in the frequency of the oscillations, and a decrease in the capacity occurring between the stylus 14 and the plate 10, as a non-conductive area is engaged by the stylus, causing an increase in the frequency of the oscillations of tube V1.

The flow of signal current of decreased frequency produced by the stylus or other scanning means is of a duration corresponding to the length of time of contact of the stylus point with the letter, character, or other conductive area as it is scanned, and the frequency of the respective signal currents in the scanning circuit will in general vary in accordance with the different sizes of the letters or other conductive areas comprising the subject matter transmitted.

The output of the oscillator tube V1 may be coupled through a condenser C3 or other coupling means to a high-pass filter HPF1, the function of which is to pass the higher frequency oscillations produced when the stylus is on a non-conducting area of the image bearing sheet and to highly attenuate all lower frequencies produced when the stylus is crossing a conductive area. Consequently, the current through the primary winding L3 of the transformer T1 will consist of groups or trains of oscillations of a definite frequency occurring as the stylus passes over the non-conductive areas of the image bearing surface, with interruptions in the continuity of the oscillations as the stylus passes over conductive areas of the image bearing surface.

The value of the inductance L2 and condenser C1 relative to the capacity existing between the stylus 14 and drum 10 when the stylus is on a non-conducting portion of the image bearing surface, determines the highest frequency obtained from the tube V1, which is the frequency of the current to be transmitted to the distant station. In the embodiment shown in Fig. 1, the signals are transmitted over a standard telephone circuit concurrently with the voice signals. Therefore, it is desirable to employ a maximum or background frequency near the upper range of efficient telephone transmission, as for instance, about 2750 cycles per second and the filter HPF1 may be designed to attenuate all frequencies materially below about 2500 cycles per second. It is to be understood that these values are arbitrary and may be varied to suit the conditions of operation. They have been selected with reference to the transmission of facsimile signals concurrently with voice signals over a standard telephone system. The lower limit of the high-pass filter

HPF1 is determined by the maximum dot frequency of the facsimile signals, that is, by the minimum time required for the stylus to cross the smallest area of the image being transmitted, as for instance, a dot or narrow line of conducting material, or the crossing of a narrow zone of the background or non-conducting portion of the characters, pictures, or other material being scanned. Assuming the maximum dot frequency to be 250 cycles per second, which means that the time required to cross a minimum conducting or non-conducting area of the image is one-five hundredth of a second, then it is evident that the filter HPF1 will be required to pass the fundamental background frequency of 2750 cycles plus and minus the 250 cycle dot frequency or a band of from 2500 cycles to 3000 cycles per second. The dot frequency is determined, of course, by the speed of scanning and the nature of the subject matter being transmitted.

By employing a background frequency of the order of 2750 cycles and a maximum dot frequency of 250 cycles for the facsimile transmission, the frequency band below 2500 cycles down to about 200 cycles may be used for regular telephone conversation. For this purpose a separate telephone transmitter TT in circuit with a battery B and the primary of a coupling transformer T2 is provided for telephone conversation over the telephone system. The voice signals picked up by the transmitter TT are passed through a low-pass filter LPF1 designed to highly attenuate all frequencies above about 2250 cycles per second. The output side of the filter is coupled through a transformer T3 to the grid circuit of a vacuum tube amplifier V2. A T-shaped network of resistances, Ra, Rb, Rc, may be provided before and after the filter LPF1 to match the filter impedance to the coupling transformers T2 and T3 so as to increase the efficiency of the filter.

The output circuit of the amplifier tube V2 is completed through the primary winding L4 of the transformer T1, whereby the facsimile signals comprising the oscillations of the higher frequency and the voice signals of the lower frequency are combined in the secondary winding L5 of the transformer T1. The terminals of the winding L5 are connected to a sound producing device S.

The sound producing device S is enclosed in a sound insulating casing 18, the open end of which may be placed in contact with the mouthpiece 19 of a standard telephone transmitter TT1 so that the composite facsimile tone signals and voice signals will be impressed on the diaphragm of the telephone transmitter and hence reproduced in the telephone receiver TR and microphone M at the distant end of the telephone circuit. Instead of employing the acoustic coupling elements S, TT1, TR and M, it is obvious that various other means for impressing the signals upon the telephone transmission circuit and detecting the same at the receiving end of the circuit may be utilized if desired.

The tone signals produced by the telephone receiver are picked up by the microphone M, preferably enclosed in a sound insulating container 20 having its open end disposed in contact with the telephone receiver TR. The signals produced in the microphone are amplified by the amplifier tube V3, of conventional design, and are applied through the output transformer T4 to a high-pass filter HPF2 and a low-pass filter LPF2. The low-pass filter LPF2 is designed to pass fre-

quencies below 2250 cycles and to highly attenuate higher frequencies. A telephone receiver TR1 is connected in the output circuit of the low-pass filter and serves to reproduce the voice frequencies introduced into the telephone transmitter TT at the sending station. An amplifier tube V4 may be inserted between the low-pass filter and the telephone receiver TR1 if desired.

The high-pass filter HPF2 is designed to pass all frequencies above about 2500 cycles and thus to transmit the facsimile signals while suppressing the voice signals. The facsimile signals are repeated through the transformer T5, vacuum tube amplifier V5, and coupling transformer T6, to the stylus 14' and drum 10', respectively, of the receiving cylinder. The cylinder 10' is rotated in synchronism with the transmitting cylinder 10 by means of a motor (not shown), which is kept in step with the sending motor 11 by any of the well known methods of maintaining synchronism.

The recording paper is chemically treated so that the passage of signal current therethrough produces color changes therein, such process being well known and therefore not described in detail. Preferably, a dry recording web is employed, such as shown in the application of R. J. Wise et al., Serial No. 23,928 filed May 28, 1935, in which the web is effected by the application of electrical potential to the stylus or scanning electrode of the receiver to record the subject matter transmitted. The stylus 14' is mounted upon a carriage resting upon a threaded shaft 15' rotated with the cylinder 10' in the same manner as described with reference to the transmitter, whereby similar scanning action is obtained.

When synchronism of the rotating parts and the scanning movements of the styli at the sending and receiving stations is properly maintained, the image upon the blank 13 at the transmitter will be reproduced upon the recording blank at the receiver as scanning proceeds. The image produced will be in reverse color, however, that is, the marks will be applied to the receiving paper when the transmitting stylus is crossing an unmarked or background portion of the image being transmitted, and no marks will be reproduced at the receiver when a conducting portion of the image being transmitted is traversed by the sending stylus 14. However, a positive image may be obtained by inverting the signals, as for instance, by the use of a rectifier and an inverting relay inserted between the amplifier tube V5 and the stylus 14'. Such an arrangement is shown in Fig. 2.

Referring now to Fig. 2, it will be noted that the signals which have been amplified by the tube V5 of Fig. 1 are supplied through the transformer T6 in push-pull to the grids of vacuum tubes V6 and V7. As stated, the function of tubes V6 and V7 is to rectify the signals full wave, amplify them, and, in combination with the output tube, V8, to invert the signals so they will be adapted for the operation of the facsimile recorder. These functions are performed in the following manner:

A bleeder circuit is provided from positive battery through resistances R3, R4 and R5, to ground return, or negative battery, as shown. Tubes V6 and V7 obtain their plate voltage from a point on this voltage divider or bleeder circuit through the coupling resistor R6. This point is the junction of R3 and R4 and is also the point of the filament return of the output tube V8. The rectifier tubes V6 and V7 have their filament

return to the junction of resistors R4 and R5. The grid return from the center-tap of the secondary winding of transformer T6 is made to the negative end of the bleeder circuit. Therefore, the negative grid bias on tubes V6 and V7 is the voltage drop across the resistance R5; the plate voltage applied to tubes V6 and V7 is the voltage drop across the resistance R4, less the voltage drop across resistance R6. The grid bias on the output tube V8 is the voltage drop across resistance R6 and the plate voltage applied to tube V8 is the voltage drop across resistance R3, less the voltage drop across the drum 10' and stylus 14'. The value of resistance R5 is of such value that the plate current, with no signal applied to the grids, is cut off, or nearly so, in tubes V6 and V7. With this plate current interrupted, or nearly so, there is little or no current flow through resistance R6 and therefore little or no negative bias on the output tube V8. Maximum plate current will be impressed across the stylus 14' and drum 10' at this time, the value of the current being determined by an appropriate choice of the values of resistances R3 and R6 and of the characteristics of tube V8.

When a tone is received from the telephone line, indicating what is normally a spacing or background signal, this tone is amplified in tube V5 and applied to the grids of tubes V6 and V7. On one half cycle the grid of tube V6 is either positive, or at least less negative, than before, therefore, plate current will flow through this tube and through resistance R6. On alternate half cycles the grid of tube V7 becomes less negative, and also passes current through resistance R6. A small condenser C4 is connected between the paralleled plates of tubes V6 and V7 to the filament or other unipotential point. The value of this condenser is such that the charging of this condenser during the time that neither tube is passing current through resistance R6, and the discharging of the condenser during the time that either tube is passing current through resistance R6 will effect a filtering action which will hold the voltage on the grid of the output tube V8 at an essentially constant value during any marking period.

The direct current applied to the stylus 14' causes a mark to be produced as the cylinder 10' revolves as long as the current is applied to the stylus, that is, during the period when no oscillations are being received from the facsimile transmitter. Consequently, the marks produced on the recording medium correspond to the passage of the transmitting stylus 14 over the conducting portions of the image bearing sheet 13.

In Fig. 3 there is shown a modified form of facsimile transmitting and receiving system operable over a telephone circuit. In this form a source of high frequency oscillations F1 is employed which by way of example may be 1,000,000 cycles. The output of the oscillator F1 is fed to a vacuum tube amplifier V9 through a condenser C5, although if desired other coupling means may be employed. The conventional grid leak between the grid and the ground or source of negative voltage of V9 is replaced by a tuned circuit comprising the inductance L6 and the capacity existing between the scanning stylus 14 and the sending drum 10. The value of L6 is chosen relative to the value of the capacity existing between the stylus 14 and the drum 10, when the stylus is on a non-conducting or background portion of the image bearing surface, so that this parallel-resonance circuit is tuned to

the frequency of the oscillator F1 and thus has substantially infinite impedance at this frequency. When the stylus crosses a conducting portion of the image, the capacity of this tuned circuit increases, resulting in the circuit being tuned to a lower frequency than F1. Since in this latter case the tuned circuit offers less impedance to the oscillations from the source F1, the voltage applied to the grid of the vacuum tube amplifier V9 will be less with the stylus on a conducting portion of the image bearing surface than when on the nonconducting or background portion thereof. Consequently, the amplitude of the oscillating currents of the frequency of source F1 will be less when the stylus 14 traverses the conducting portions of the characters or images being transmitted than when it traverses a non-conducting portion.

The output of the tube V9 is coupled through the radio frequency transformer T7 to the input circuit of a vacuum tube V10. The amplifier tube V9 may be biased to slightly beyond cut-off, by the resistances R7 and R8 so as to suppress the low amplitude oscillating currents corresponding to the scanning of conducting areas of the image. A second source of high frequency oscillations F2, the frequency of which may be, by way of example, 997,250 cycles per second, is also impressed on the input circuit of the tube V10 through the radio frequency transformer T8. The oscillations from the sources F1 and F2 are mixed in the tube V10 producing in the plate circuit of the tube oscillating currents of the frequency of F1, F2, F1 plus F2 and F1 minus F2, or frequencies of 1,000,000 cycles, 997,250 cycles, 1,997,250 cycles, and 2750 cycles. The plate circuit of the tube V10 is coupled through the audio frequency transformer T9 to a sound producer S. The 2750 cycle oscillations are the only ones which will be passed by the audio transformer T9 to the sound producer S, the remaining or higher frequencies being suppressed.

The drum 10 is driven as a constant predetermined speed by a phonic motor PM having a driving coil 21 supplied with alternating current from an oscillator or frequency source F3. The source F3 may be of a frequency of 2250 cycles per second although of course, any other suitable frequency may be employed. The desired scanning speed of the drum 10 may be obtained by selection of the proper number of teeth on the rotor of the phonic wheel or by appropriate gearing between the motor PM and the drum 10.

The synchronizing oscillations from the source F3 may also be applied through the transformer T9 to the sound producer S, together with voice signals. The voice signals may be introduced into the transmitter TT and passed through a low pass filter LPF1, designed to attenuate currents of a frequency above about 2000 cycles. The output side of the filter LPF1 is likewise coupled to the sound producer S through the transformer T9.

By employing facsimile signals of a frequency band between 2500 and 3000 cycles (assuming a dot frequency of 250 cycles) and voice signals up to 2000 cycles, the synchronizing signals of 2250 cycles may, with reasonably efficient filters, be transmitted without trouble from interaction. The frequency sources F1, F2, and F3 may be of any convenient type, such as vacuum tube oscillators, and therefore, have not been shown in detail.

The sound producer S is disposed in sound transferring relation to the transmitter TT of

a standard telephone system so that the composite facsimile, synchronizing and voice tones produced thereby will be transmitted over the telephone line L to the receiving instrument TR at the distant station.

The receiver TR is disposed in sound transferring relation to a microphone M coupled through a transformer T10 to an amplifier A and thence through the transformer T11 to the high pass filter HPF3, band pass filter BPF and low pass filter LPF3. The high pass filter is designed to pass currents of a frequency above 2500 cycles and to attenuate all lower frequencies. The band pass filter BPF passes current of 2250 cycles and attenuates higher and lower frequencies, and the low pass filter LPF3 attenuates all frequencies above 2000 cycles.

The facsimile signals transmitted by the high pass filter are applied through an amplifier A1 to the stylus 14' and drum 10' of the facsimile receiver. The synchronizing signals passed by the band pass filter BPF are applied through an amplifier A2 to the driving coil 21' of the phonic wheel PM' to drive the receiving drum 10' in synchronism with the transmitting drum 10. The voice signals from the filter LPF3 are applied through an amplifier A3 to a telephone receiver TR1 whereby the telephone conversation may be heard.

It is to be understood that while the motors PM and PM' have been shown driven directly by the oscillating current supplied by the frequency source F2, other means of controlling the speed of operation of the drums 10 and 10' from these signals may be employed. For instance, the 2250 cycle oscillations may be modulated by a sixty cycle current and a sixty cycle current may be used to operate or control the phonic motors.

In Fig. 4 a still further modification is shown in which the facsimile transmitting means is the same as that illustrated in Fig. 1 with the exception that the high pass filter HPF1 of Fig. 1 is omitted and the sound producer S is coupled directly to the output of the vacuum tube amplifier V1. It will be recalled that the facsimile transmitting system of Fig. 1 produced oscillations of a frequency varying with the area of the conducting portion of the image in contact with the stylus 14 at any time. This frequency, as stated, may vary from the maximum frequency obtained when the stylus is on a non-conducting or background portion of the image bearing sheet down to a frequency determined by the maximum conductive area. A small condenser C1 is inserted in series with the stylus 14 to limit the minimum frequency obtained to a value sufficiently above the maximum voice or synchronizing frequency employed, to preclude interaction therewith. The variations in frequency of the facsimile signals produce variations in tone in the sound producer S which tonal variations are transmitted over the telephone system and at the receiving end are reproduced by the telephone transmitter and applied to the microphone M. They are then amplified and passed through a band pass filter BPF2 which is designed to highly attenuate the maximum or background frequencies and to pass all lower frequencies down to the minimum frequency as determined by the frequency limiting condenser C1, including a bandwidth of at least twice the dot frequency. The filter BPF2 passes trains of oscillations differing somewhat in frequency as conductive areas of different sizes are scanned but corresponding in

time to the time of contact of the stylus with a conducting area. The output side of the filter BPF2 is coupled through an amplifier to the stylus 14' and drum 10' of the receiving facsimile apparatus and the signals supplied to these elements produces a positive image on the recording paper. Obviously synchronizing signals or voice signals may be transmitted concurrently with the facsimile signals.

Obviously, various other modifications and changes in the system may be made within the scope of the invention and therefore it is not desired to be limited to the exact circuit arrangements and details shown and described herein or to the particular values of frequency and frequency bands specified.

What is claimed is:

1. The method of facsimile reproduction over a telephone system which comprises scanning a surface having markings thereon, modulating electrical oscillations in accordance with the markings on said surface, utilizing said oscillations to produce tone signals of variable amplitude and substantially constant frequency, transmitting said tone signals over a telephone system and concurrently transmitting voice signals having a maximum frequency below the frequency of said tone signals, over said telephone system.

2. A facsimile system comprising a surface having markings thereon, means for scanning said surface, a source of electrical oscillations, means for modulating said electrical oscillations in accordance with the markings on said surface, a source of synchronizing current for controlling the operation of said scanning means, a telephone transmitter adapted to receive voice tones, and to convert the same into voice currents, a filter for suppressing said voice currents in the range of frequency of said source of oscillations and said synchronizing currents, means responsive to said modulated oscillations, synchronizing currents and filtered voice currents for producing audible tones, a telephone system having a transmitter disposed in sound transferring relation to said tone producing means, means associated with the distant receiver of said telephone system responsive to received tone signals for producing electric current variations, means for filtering out said voice currents and applying them

to a sound reproducer, a facsimile recorder and means under the control of the remaining current variations for controlling the operations of said recorder.

3. A facsimile system comprising scanning means, a source of electrical oscillations, means including said scanning means for modulating said electrical oscillations in accordance with the variations in light and shade in the subject-matter to be transmitted to generate audible frequency current constituting facsimile signals, a telephone system, means for impressing said facsimile signals on said telephone system and means for impressing voice currents on said telephone system, said last-mentioned means including means for suppressing voice current components of the frequency of said facsimile signals.

4. A facsimile system comprising scanning means, a source of electrical oscillations, means including said scanning means for modulating said electrical oscillations in accordance with the variations in light and shade in the subject matter to be transmitted to generate audible frequency current constituting facsimile signals, a telephone system, means for impressing said facsimile signals on said telephone system and means for impressing other currents of audible frequencies on said telephone system, said last mentioned means including means for suppressing audible frequency components of said other currents of the frequency of said facsimile signals.

5. A facsimile system comprising scanning means, means including said scanning means for generating modulated oscillations in accordance with variations in light and shade in the subject matter to be transmitted to generate audible frequency current constituting facsimile signals, a telephone system, means for impressing said facsimile signals on said telephone system and means for impressing other currents of audible frequencies on said telephone system, said last mentioned means including means for suppressing audible frequency components of said other currents on the frequency of said facsimile signals.

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