March 3, 1942. V. E. ROSENE 2,274,638

TELAUTOGRAPH SYSTEM

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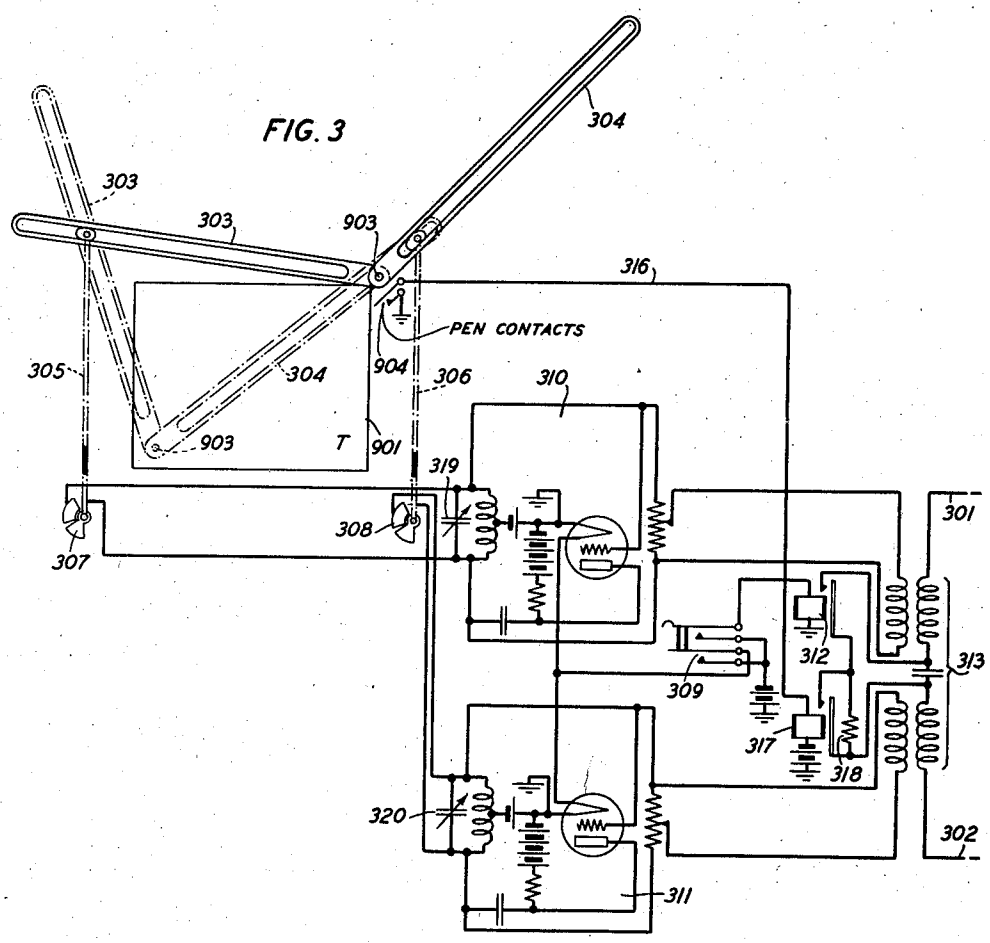
FIG. 3



STATION A

FIG. 1

FIG. 3	FIG. 4	FIG. 5

FIG. 2

FIG. 6	FIG. 7	FIG. 8

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TELAUTOGRAPH SYSTEM

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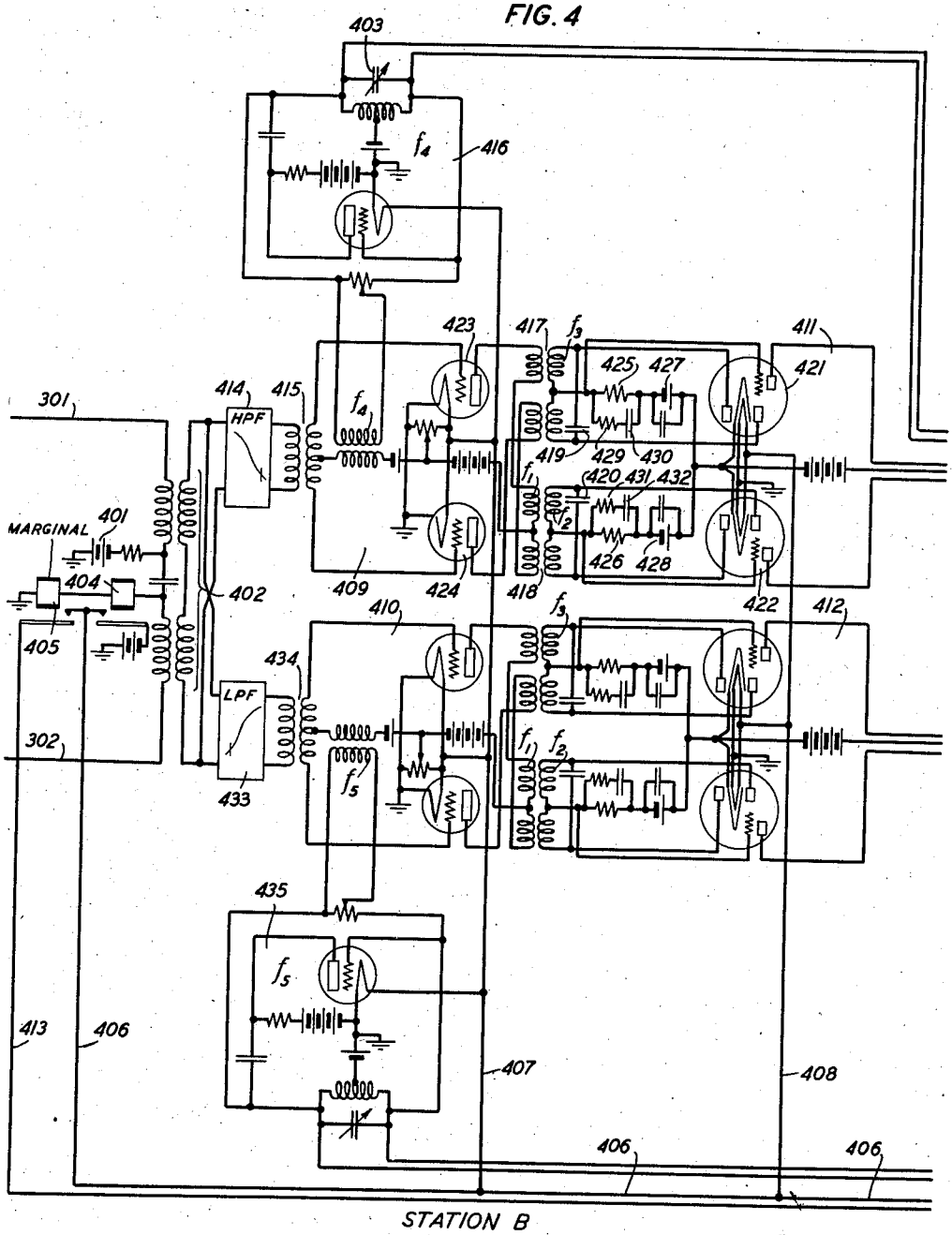
FIG. 4



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TELAUTOGRAPH SYSTEM

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FIG. 5

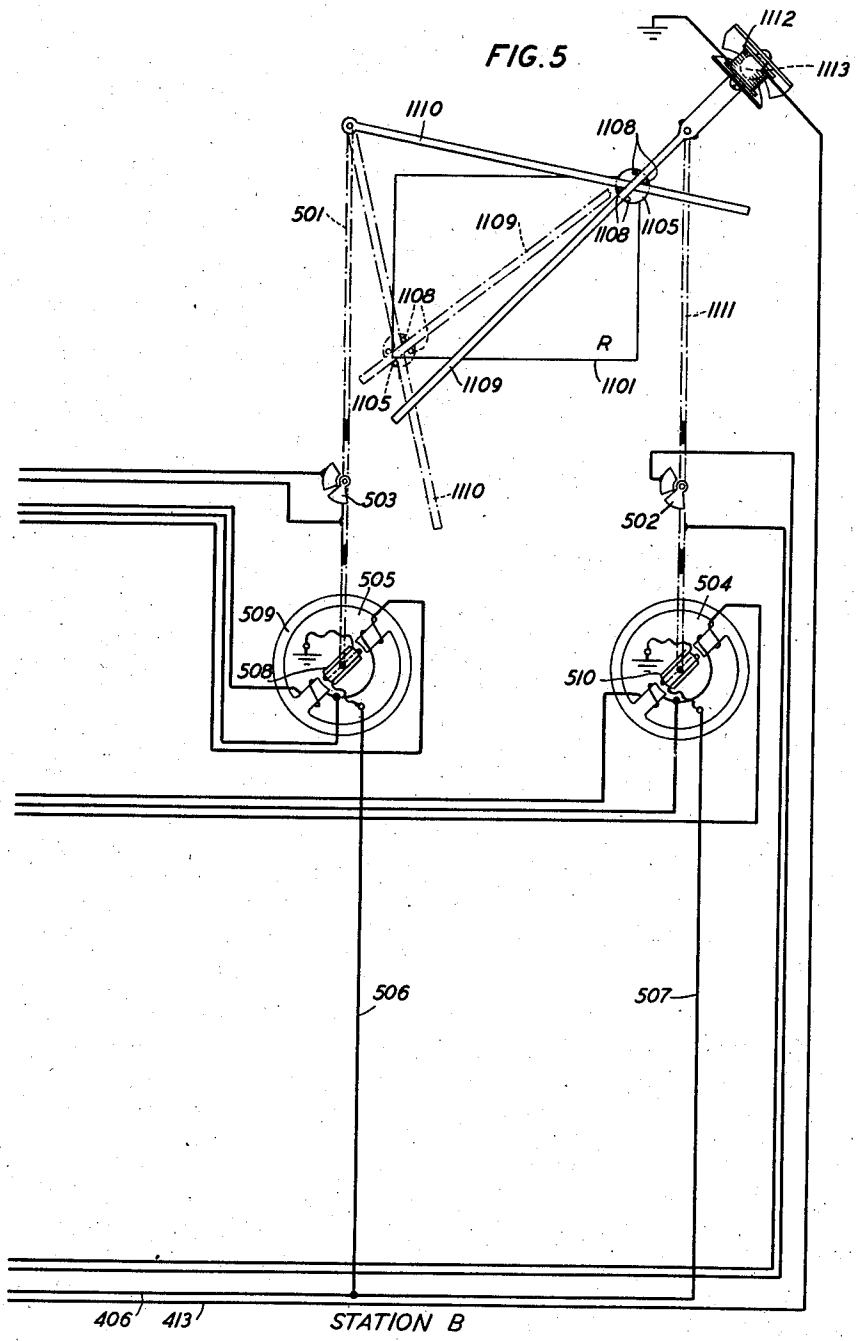

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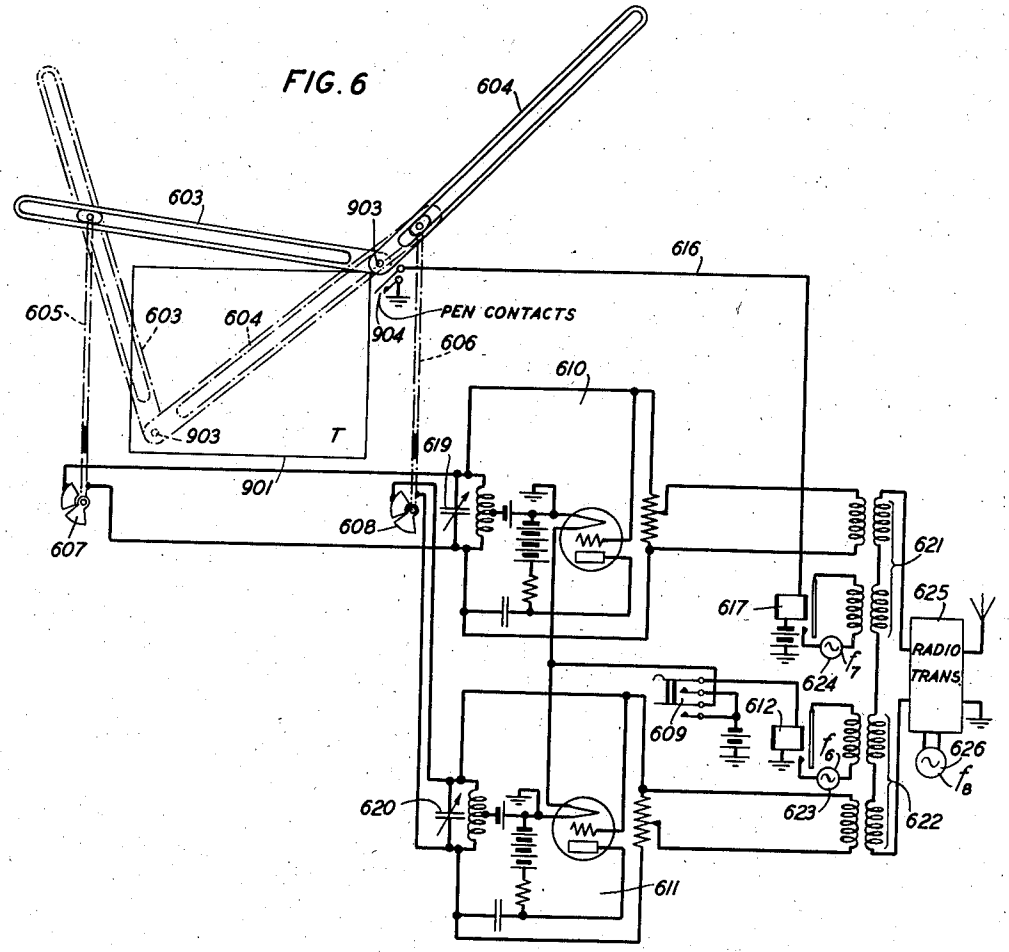
FIG. 6



STATION A

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TELAUTOGRAPH SYSTEM

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FIG. 7

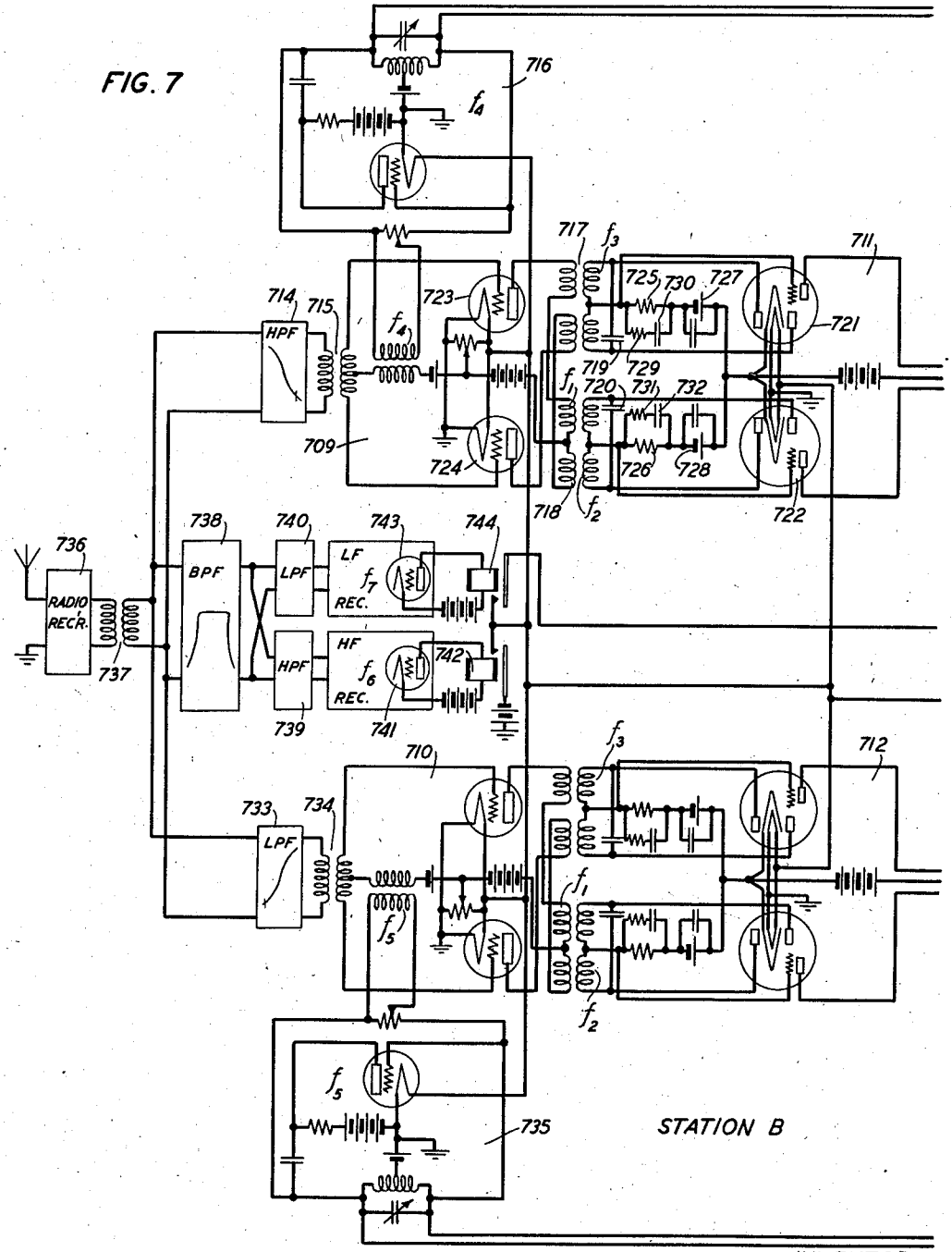

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FIG. 8

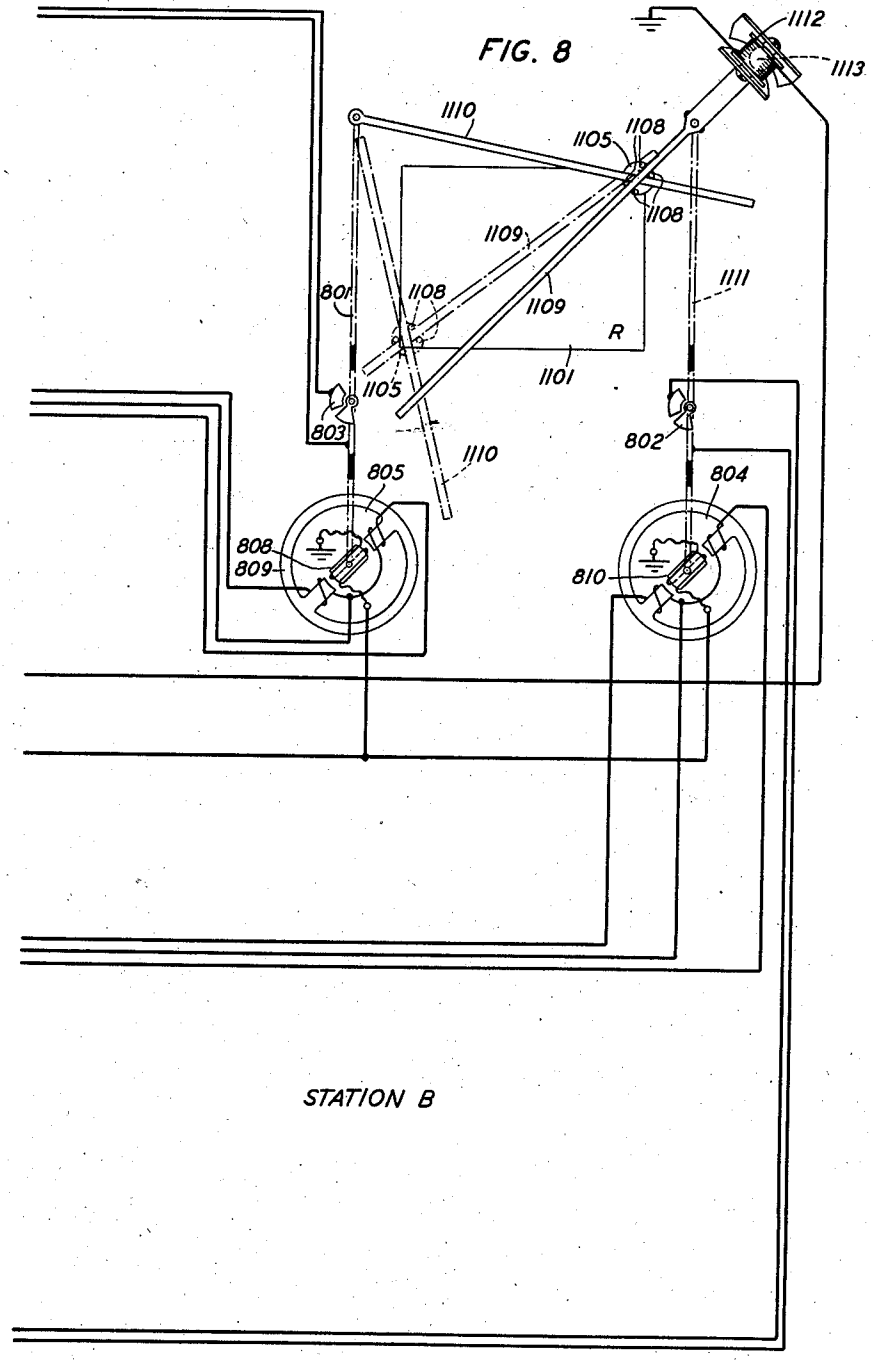

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FIG. 9

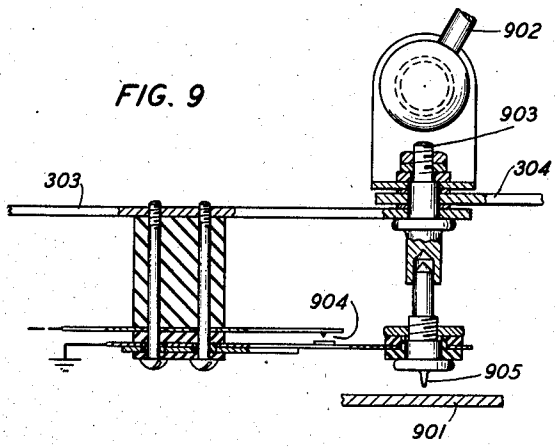
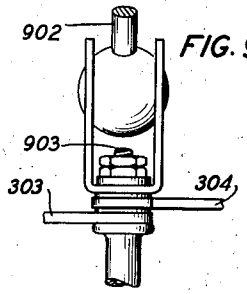


FIG. 9A



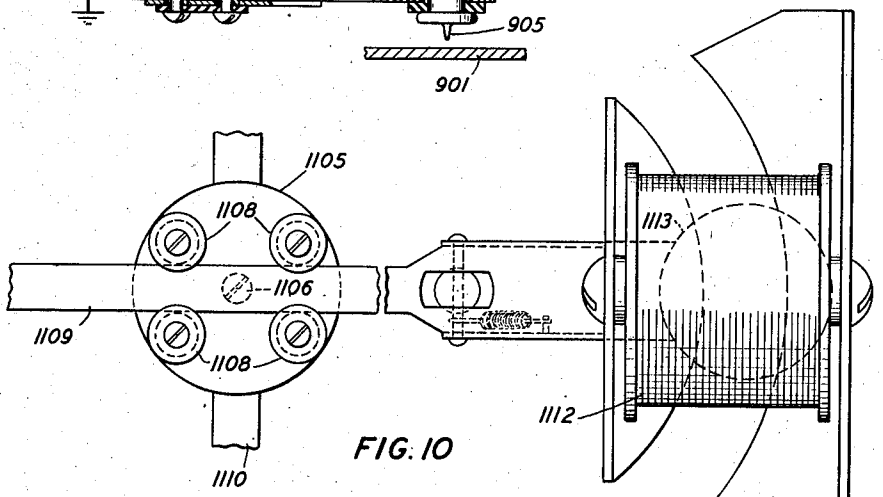
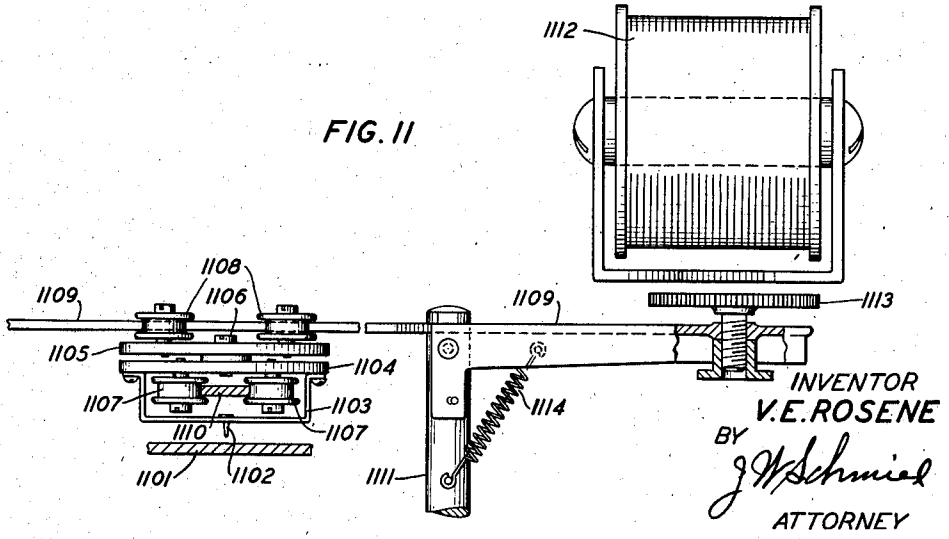


FIG. 10

FIG. 11



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Patented Mar. 3, 1942 2,274,638

UNITED STATES PATENT OFFICE

2,274,638

TELAUTOGRAPH SYSTEM

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Application November 15, 1939, Serial No. 304,455

8 Claims. (Cl. 178—19)

This invention relates to systems for transmission of intelligence over wires or radio circuits and particularly to a telegraph system in which the movements of a stylus or writing point, at a transmitting station, are recorded in facsimile at a distant receiving station.

An object of the invention is to improve transmission in a telegraph system of this type, and this is accomplished by utilizing the changes in frequencies of transmitted electric current rather than the changes in intensities, for reproducing in facsimile in a recording station the transmitted intelligence.

Heretofore in systems of this type, the movement of a directing, or writing, point at the transmitting station was resolved into two component motions which in one case varied the frequencies of two signal currents being transmitted over the line circuit and in another case varied the phase angle of an alternating current voltage applied to the line.

In one type of system, the signal currents of varying frequencies were utilized to produce corresponding movements of the directing, or writing, point at the receiving station. The two signal frequencies, however, were preferably cut in separate concentric grooves on the same phonographic record and the variations in these frequencies corresponding to the movements of the transmitting writing point were obtained by moving reproducers along the grooves to increase or decrease the relative speed of the record with respect to the reproducer stylus. At the receiving station the line frequencies were separated and each was modulated with a local frequency which was obtained from a record similar to the one at the transmitting station. Each of the frequencies generated at the receiving station differs normally from the corresponding line frequency by a predetermined frequency for which the receiving circuit is balanced in such a way that no motion of the receiving, or recording, point is produced but any slight change in the line frequency due to the motion of the transmitting point unbalances the receiving circuit and moves the receiving, or recording, point and the associated reproducers until the balanced condition was restored. By setting up the receiving circuit for a balance, when the difference between the line frequencies and the locally generated frequencies was small as compared with the line frequencies, the changes in line frequency corresponding to even slight movements of the transmitting points produced large unbalancing effects in the receiving circuits and the receiving points followed the movement of the sending point.

In another case, heretofore known, wherein the component motions varied the phase angle of an oscillating potential applied to the line, the varying phase angles of the receiving signals were utilized to move a receiving pen or stylus to reproduce the motions of the transmitting point.

According to the present invention, the movement of the directing, or writing, point at the transmitting station is resolved ino two component motions which likewise vary the frequencies of two signal currents being transmitted over the line wire or radio circuit. These currents are varied in frequency, and are utilized to produce, or indicate, corresponding movements of the writing point at the receiving station. However, the present invention differs from the systems heretofore known in that at the transmitting station, two alternating currents of different frequencies are generated by means of oscillators and transmitted over a wire line or radio circuit to a receiving station where the two currents are separated by means of filters. Each of the currents passing through a filter is then impressed on a vacuum tube modulator circuit together with an alternating current of a distinctive frequency from a local oscillator. Each of the modulator circuits is balanced so as to eliminate in the output the frequency of its local oscillator. The lower or higher side-band products of the modulator circuit outputs are introduced into special vacuum tube circuits. The two special vacuum tube circuits are preferably tuned to the same frequency and respectively operate two receiving elements. On each of two rotatable shafts of the receiving elements is mounted a variable air condenser which controls the frequency of one of the local oscillators and thereby maintains a fixed side-band frequency in the output of each of the modulator circuits. The positions of the receiving elements correspond to the frequencies of the currents received from the transmitting stations. Since the position of the receiving elements is determined by the frequency of the currents received and not by their intensity, the circuit between the transmitting and receiving stations is not required to have a linear frequency versus attenuation characteristic. The transmitting pen, hereinbefore referred to as the directing, or writing, point, at the transmitting station is fastened to two sliding arms each of which is connected to a rotatable shaft. Each shaft when

rotated about its longitudinal axis operates a variable air condenser. The condenser settings determine the frequency of the oscillators used for transmission. The recording pen, or writing point, or, at times, referred to hereinafter as an indicator, at the receiving station, is fastened to a member which slides on two arms, each of which is pivoted to a shaft fixedly mounted on the rotor of one of the receiving elements. The shafts when rotated about their respective longitudinal axes operate variable air condensers which, in turn, vary the frequencies of the two local oscillators respectively to compensate for the unbalance in the outputs of the special vacuum tube circuits which outputs cause the recording pen to take a position corresponding to the position of the transmitting pen.

A feature of the invention is the adaptability of the system to transmission over a wire line or radio circuit.

Another feature is the adaptability of the system to a telephone plant for remote control of the various devices or for the transmission of alarms from an unattended repeater station to an attended station.

Still another feature resides in its use for telemetering purposes by making use of one transmitting oscillator and one receiving element with its associated vacuum tube circuit.

In the drawings:

Fig. 1 shows the relative arrangements of Figs. 3, 4 and 5;

Fig. 2 shows the relative arrangements of Figs. 6, 7 and 8;

Figs. 3, 4 and 5 are a schematic circuit arrangement of a facsimile telegraph circuit according to the invention, wherein line conductors are employed between interconnected stations;

Fig. 3 shows a transmitting station connected to a line circuit;

Fig. 4 shows a line circuit equipment at the receiving station connected to balanced modulator circuits and special vacuum tube circuits;

Fig. 5 shows the receiving elements responsive to the outputs of the special vacuum tube circuits for operating the recording pen;

Figs. 6, 7 and 8 are a schematic circuit arrangement of a facsimile telegraph system according to the invention, wherein a radio circuit is employed between stations;

Fig. 6 shows a transmitting station including the radio transmitter;

Fig. 7 shows a radio receiver operating into balanced modulators and special vacuum tube circuits;

Fig. 8 shows the receiving elements responsive to the outputs of the special vacuum tube circuits of Fig. 7 for operating the recording pen;

Figs. 9 and 9A are side and end elevation views, respectively, of the transmitting pen and operating contacts;

Fig. 10 is a plan view of the operating arms and magnet therefor of the recording pen; and

Fig. 11 is an elevation view of the recording pen and the operating arms and magnet therefor.

Like parts in figures are designated with like reference numerals, that is, the parts in Figs. 6, 7 and 8 which are like their corresponding parts in Figs. 3, 4 and 5 have the same reference characters except for the prefixes which correspond to the number of the figure in which the parts are located.

In the arrangements of Figs. 3, 4 and 5 the system illustrates one form of the invention and comprises only two stations, stations A and B, either one of which may send to or receive from the other over line conductors such as those designated **301** and **302**. Although the system only shows transmitting apparatus at station A and receiving apparatus at station B, it is understood that each station may comprise both transmitting and receiving equipment. Furthermore, by employing either automatic or manually operated switching, facsimile messages may be transmitted to any one or a plurality of stations or to two or more stations for broadcast purposes. The automatic and manually operated switching equipments are well known in the telephone art and therefore are not shown or described herein.

A transmitting unit and a receiving unit may be provided at each of stations A and B. The transmitting unit such as that designated T comprises a table **901** (shown in Fig. 9) a transmitting pen handle **902** which when manually operated through its swivel bushing **903** closes contacts **904** and brings transmitting pen or stylus **905** into engagement with a sheet of paper (not shown) affixed to table **901**. The transmitting pen can be made to leave a record on the paper. The transmitting pen is fastened to two sliding arms **303** and **304** which are respectively connected by means of rotatable shafts **305** and **306** to variable air condensers **307** and **308**. The receiving unit, such as designated R, at station B comprises a table **1101** (shown in Fig. 11) and a recording pen or stylus **1102** which is automatically operated in response to the incoming signal frequencies. The pen, or stylus, **1102** is securely fastened to a bracket **1103** which in turn is fixedly mounted on disc **1104**. Disc **1104** is fixedly secured to a disc **1105** in the manner shown in Fig. 11 by a machine screw **1106**. To the lower side of disc **1104** are mounted in the manner shown in Fig. 11 four rollers **1107** and in a similar manner to the upper side of disc **1105** are mounted four rollers **1108**. Slidably arranged between rollers **1107** is longitudinally movable arm **1110** and similarly arranged between rollers **1108** is longitudinally movable arm **1109**. The recording pen and movable arms therefor are shown assembled in the schematic circuit arrangement in Fig. 5. The movable arms **1109** and **1110** are respectively connected by means of rotatable shafts **1111** and **501** to variable air condensers **502** and **503** and the rotor members of receiving elements **504** and **505**. The recording pen **1102** is caused in response to the incoming signal frequency to take a position corresponding to the position of the transmitting pen **905**. The type of recording pen and paper to be used may be any of those well known in telautographic art.

Auxiliary control circuits are provided to start the circuits operating at each station and to remove the pen from the paper at the receiving station when the pen is lifted from the table at the transmitting station. When a wire line circuit is used direct current is used to operate the relays of the control circuits. When a radio circuit is used pilot frequency alternating currents are used for controlling the relays. These control circuits will be hereinafter described.

The detailed operation of two telautographic systems one employing a wire line circuit and the other a radio circuit as a means for interconnecting a transmitting and a receiving station will now be described.

System employing the wire line circuit for transmission

The operation of the system is started by closing the start switch **309** whereby direct current is furnished at both the lower and upper contacts of the switch to operate the oscillators **310** and **311** and to close the operating circuit for start relay **312**. Relay **312** operates and closes a circuit extending from grounded battery **401**, upper primary winding of transformer **402**, line conductor **301**, upper secondary winding of transformer **313**, contact and armature of relay **312**, resistance **318**, lower secondary winding of transformer **313**, line conductor **302**, lower primary winding of transformer **402**, through the windings, in series, of relays **404** and **405**, to ground. Relay **405** is of the marginal type and because of resistance **318** which is of comparatively high value, the relay does not operate at this time. Relay **404**, however, operates and closes a conditioning circuit from grounded battery, armature and contact of relay **404**, conductor **406**, conductors **407** and **408** in parallel, vacuum tube filaments, to ground, thereby lighting the filaments of the vacuum tubes in the oscillators **416** and **435**, balanced modulators **409** and **410** and the filaments of the full wave rectifier-amplifier vacuum tubes in the special circuits **411** and **412**. The conditioning circuit including conductor **406** also extends over conductors **506** and **507**, in parallel, to ground through the windings of the rotors of the receiving elements **505** and **504**, respectively. The system is now conditioned to receive the signals transmitted by transmitting pen **905**. Any pressure on the transmitting pen **905** closes contacts **904** which establishes a circuit extending from ground, conductor **316**, through the winding of relay **317**, to grounded battery. Relay **317** operates and establishes at its armature and contact a shunt path around resistance **318** whereby relay **405** is operated. Relay **405** in operating closes a circuit from grounded battery, the armature and contact of relay **404**, contact and armature of relay **405**, conductor **413**, through the winding of magnet **1112**, to ground. As hereinbefore explained the transmitting station apparatus changes the capacitance of two variable air condensers **307** and **308** and causes the receiving station apparatus to assume a similar position.

Two oscillators **310** and **311** are provided at station A for transmitting and are capable of generating current oscillations of different frequencies, one of which is of a higher range than the other.

The movement of transmitting pen **905** on a sheet affixed to table **901** causes arms **303** and **304** to move correspondingly. Arms **303** and **304** are pivotally mounted on swivel bushing **903** as shown in Figs. 3 and 9. Each of the arms is slotted for approximately its full length to engage an oblong-shaped member that is fixedly mounted on the top of each of the rotatable shafts **305** and **306** so that any movement of the transmitting pen **905** resolves itself into two component motions which through the corresponding motions of arms **303** and **304** rotates shafts **305** and **306** to vary the capacities of condensers **307** and **308** and consequently the frequencies of the two oscillators **310** and **311** whereby two variable signal currents are transmitted by the oscillators through the primary windings of transformer **313**.

Condensers **307** and **308** are respectively shunted by variable condensers **319** and **320** which are used to adjust the frequencies of oscillators **310** and **311** when condensers **307** and **308** are in their minimum positions as shown in Fig. 3. The two ranges, or bands, of frequencies of oscillators **310** and **311** each made variable within its range by the movement of transmitting pen **905** are impressed simultaneously on the wire line conductors **301** and **302** through the windings of transformer **313**. At receiving station B the variable frequency in the higher range which is produced by oscillator **310**, is passed through transformer **402** and high-pass filter **414** and impressed on balanced modulator circuit **409** through the transformer **415**. A carrier frequency f_4 from a local oscillator **416** is introduced into the modulator circuit **409** and combines with the variable frequency received from the transmitting station through high-pass filter **414** to generate side-band frequencies in the modulator output. The carrier frequency f_4 from oscillator **416** is higher than the band of transmitted frequencies and is suppressed in the modulator circuit and the lower side-band is transmitted to transformers **417** and **418**. The frequency f_4 from oscillator **416** may be adjusted by the variable condenser **403**. The differential character of the plate circuits of the balanced modulator prevents voltage of the frequency of the unmodulated carrier current generated by oscillator **416** from being induced in the output circuit.

The output or lower side-band transmitted to transformers **417** and **418** is impressed on a special vacuum tube circuit **411**. Transformer **417** is tuned to a frequency f_3 by condenser **419** and transformer **418** is tuned to a frequency f_2 by condenser **420**. The frequencies are referred to herein as the lower side-band although the upper side-band could be used. The side-band frequency f_1 from the modulator is approximately midway between the frequencies f_2 and f_3 when the circuit is balanced.

The special vacuum tube circuit **411** comprises an input which represents a variable condition to be recorded, two vacuum tube full-wave rectifier-amplifiers, and a receiving element of the galvanometric type having two windings connected for differential energization by the output of the rectifier-amplifiers. Any change in the output frequency f_1 of the modulator **409** causes a corresponding change in the output of special circuit **411**. If we assume that the modulator output frequency f_1 approaches nearer to the frequency f_2 of the tuned transformer **418** and at the same time is farther away from the frequency f_3 of the tuned transformer **417**, the output of vacuum tube **421** will increase while the output of vacuum tube **422** will decrease. The energization of the two differential windings of the receiving element **505** is consequently caused to be unbalanced and thereby produces movement of the rotor of the receiving element **505** and the movable element of condenser **503** until the oscillator **416** has changed its frequency f_4 to a value which will combine with the frequency from the transmitting station through high-pass filter **414** to restore the side-band frequency f_1 to its normal value. When this condition is restored the outputs of vacuum tubes **421** and **422** are again balanced and the receiving element **505** will come to rest.

The receiving element or galvanometer **505** comprises rotor **508** energized by a circuit including conductor **506**, a field structure **509** having two differential windings thereon adapted to

be respectively energized by the output of full-wave rectifier-amplifiers **421** and **422**, and rotatable shaft **501** which is fixedly mounted on rotor **508** for varying the capacity of condenser **503** in accordance with any unbalance in the currents respectively flowing through the two windings on field structure **509**. The rotatable shaft **501**, when rotated, causes the movement of arm **1110** and the consequent movement of receiving pen **1102** as hereinbefore stated. Rotor **508** has no restoring spring or other biasing means. It moves only when the current in either of the differential windings exceeds the current in the other. The direction of motion depends on which of the two differential windings carries the greater current.

The outputs of transformers **417** and **418** are respectively impressed on the rectifier-amplifiers **421** and **422** each of which is a double-diode triode with a heater type cathode. The rectifier circuit of tube **421** includes the right-hand, or secondary, winding of transformer **417** and the cathode and two like rectifier elements in the lower part of the tube. This circuit is tuned by condenser **419** to a frequency slightly below the normal frequency of output of modulator tube **423**. The rectifier circuit of tube **422** includes the right-hand winding, or secondary, of transformer **418** and the cathode and two like rectifier elements in the upper part of the tube. This circuit is tuned by condenser **420** to a frequency slightly above the normal frequency of the output of modulator tube **424**. The grid elements of tubes **421** and **422** are connected to the midpoints of the secondary, or right-hand, windings of transformers **417** and **418**, respectively, so that the pulsating direct current resulting from the full-wave rectifying action of the diodes causes a drop in the potential across resistors **425** and **426** through which the grid elements of tubes **421** and **422** are respectively connected to the grid biasing batteries **427** and **428**. Resistor **429** and condenser **430** are provided to delay change in the potential of the grid of tube **421**; and resistor **431** and condenser **432** are provided to delay change in the potential of the grid of tube **422**. The output circuit of tube **421** includes one winding of field structure **509** of the receiving galvanometer **505** and the output circuit of **422** includes the other winding on field structure **509**. These windings, as hereinbefore stated, are differential so that with the input circuit of tube **421** tuned to a frequency as much lower than the normal frequency of the output circuit of modulator tube **423** as the input circuit of tube **422** is tuned to a frequency higher than the normal frequency of the output circuit of modulator tube **424**, the current in one winding on field structure **509** will balance the current in the other winding and no movement of rotor **508** will result.

As soon as there is current in the circuit over wire line conductors **301** and **302** caused by the movement of transmitting pen **905** and the consequent movement of the rotatable element of condenser **307** to increase the latter's capacitance, the transmitted frequency is lowered. The lowering of the transmitted frequency causes the side-band frequency f_1 of the modulator to be increased. Frequency f_1 is therefore nearer the frequency f_2 of the tuned circuit of transformer **417** and farther away from the frequency f_3 of the tuned circuit of transformer **418**. The rectified current through resistance **426** will be increased and the rectified current through resistance **425** will be decreased thereby increasing the negative voltage on the grid of rectifier-amplifier **422** and decreasing the negative voltage on the grid of rectifier-amplifier **421**. Rapid fluctuations of voltage on the grids of the rectifier-amplifiers **421** and **422** are prevented by resistances **429** and **431** and condensers **430** and **432**. The plate current of rectifier-amplifier **421** will be increased and the plate current on rectifier-amplifier **422** will be decreased thereby setting up a magnetic field in the field structure **509** of the receiving element **505** which will cause the rotor coil **508** to turn in a direction to increase the capacitance of condenser **503**. The change in capacitance of condenser **503** lowers the frequency of oscillator **416** to a point where the side-band frequency f_1 of the modulator will return to its original value. When this condition is restored, the plate current of tubes **421** and **422** will again be equal and the rotor coil **508** will cease to turn. The movement of rotor coil **508** caused shaft **501** to rotate correspondingly and the rotation of shaft **501** changed the position of arm **1110** to correspond to the operated position of arm **303** attached to shaft **305** at station A, the latter arm having been operated through the movement of the transmitting pen **905**. The movement of arm **1110** will operate in conjunction with a simultaneous movement of arm **1109**.

The movement of arm **1109** like arm **1110** is controlled through intermediate equipment by the movement of its corresponding arm at station A, the controlling arm in this case being that designated **304**. The operation resulting from the movement of arm **304** will now be described. The movement of arm **304** like arm **303** is controlled by the operation of transmitting pen **905**. The position of arm **304** which is attached by means of shaft **306** to variable condenser **308** determines the frequency of oscillator **311**. Condenser **308** is connected in parallel with the variable condenser **320** which is used to adjust the frequency of oscillator **311** when condenser **308** is in its minimum position. The frequency of oscillator **311** is transmitted over line wire conductors **301** and **302** through transformer **313** simultaneously with the frequency of oscillator **310** as hereinbefore described and is received by transformer **402** at station B. The frequency of oscillator **311** upon being received at station B, is, however, passed through low-pass filter **433** to balanced modulator circuit **410** through transformer **434**. The frequency f_5 of a local oscillator **435** is adjusted to obtain a side-band frequency f_1 from the modulator **410** which is the same as frequency f_1 from modulator **409** as hereinbefore described. Tuned circuits and arrangements of the vacuum tubes in the special vacuum tube circuit **412** are similar to those of the special vacuum tube circuit **411**. Although a normal frequency f_1 from modulator **410** has been chosen similar to that of f_1 from modulator **409** so that circuit **412** may have the same characteristics as circuit **411**, this arrangement is not necessary. Circuit **412** may be designed to have circuits tuned to frequencies different from those of the tuned circuits of vacuum tubes **421** and **422**. The receiving element **504** is similar to the receiving element **505** and condenser **502** is in the minimum position when condenser **308** is in its minimum position. The action of the frequency of oscillator **311** on circuits **410** and **412** and receiving element **504** is similar to that of the frequency of oscillator **310** on circuits **409** and **411** and receiving element **505** as hereinbefore

described. The positions of the arms **303** and **304**, respectively control the condensers **307** and **308**, will determine the frequency transmitted over wire line conductors **301** and **302**, and will cause arms **1110** and **1109** of the receiving pen **1102** to take up positions corresponding to these frequencies. The cross-point of the arms at the transmitting table **901** will therefore determine the position of the cross-point of the arms at the receiving table **1101**. In this way the receiving, or recording, pen will follow the motion and position of the transmitting pen.

In order to control the circuits at the receiving station B, there is provided relays and a pen control magnet at the receiving station which are controlled by starting switch **312** and pen contacts **904** at the transmitting station as hereinbefore described. Receiving pen **1102** is controlled by magnet **1112**. When magnet **1112** is energized, the soft iron pole-piece **1113** (Fig. 11) which is adjustably mounted on the end of the arm **1109**, moves upward and the other end of armature **1109** moves downward until the receiving pen, or stylus, **1102** engages the paper on table **1101**. Arm **1109** is pivotally fixed on top of shaft **1111** and is therefore permitted to operate in a see-saw fashion under the influence of magnet **1112**. The iron pole-piece **1113** may be arcuate in shape in order that shaft **1111** in rotating under the influence of rotor **510**, may rotate arm **1109** and still maintain the receiving pen **1102** in an operated position. When the magnet **1112** is deenergized coil spring **1114** will hold the recording pen **1102** suspended above the recording table **1101**.

System employing the radio circuit for transmission

When a radio circuit is employed to transmit the two control frequencies from the transmitting station, standard radio transmitters and receivers are used. The output of the radio receiver contains the two control frequencies such as described hereinbefore in the system wherein a wire line circuit was used for transmission. These control frequencies are separated by the high-pass and low-pass filters as hereinbefore described. There are, however, in addition to the control frequencies, two other pilot frequencies which must be respectively employed for starting the operation of the circuits at the receiving station and for controlling the recording pen. At the transmitting station in this case oscillators would be employed for generating the pilot frequencies and their outputs would be respectively controlled by the start and the pen relays. At the receiving station the pilot frequencies would be present in the output of the radio receiver and pass through, first, the output transformer and then, a band-pass filter. The band-pass filter passes a band of frequencies which are between the "cut-off" frequencies of the high-pass and the low-pass filter. Included in the range of frequencies readily passed through the band-pass filter are the higher pilot and the lower pilot frequencies added at the transmitting station. The higher pilot frequencies would be used to control a start relay for starting the receiving circuit in operation and for furnishing grounded battery to light all the tube filaments and to energize the rotors of the receiving elements. The lower pilot frequency would be used to control a pen relay which when operated controls the pen magnet.

The system employing the radio circuit for transmission will now be described in detail. Referring to Fig. 6 the start switch **609** at station A is operated to close at its upper and its lower contacts, respectively, circuits for operating oscillators **610** and **611** and start relay **612**. Relay **612** on operating closes a circuit for impressing a frequency f_6 on transformer **622**. The system is now in condition to receive signals transmitted by transmitting pen **905**. Any pressure on transmitting pen **905** closes contacts **904** which establishes a circuit extending from ground, conductor **616**, through the winding of relay **617** to grounded battery. Relay **617** operates and closes a circuit for impressing a frequency f_7 on transformer **621**. As hereinbefore described a transmitting pen **905** upon being moved over table **901** changes the capacitance of two variable air condensers such as those designated **607** and **608** of Fig. 6 and consequently the frequencies of oscillators **610** and **611** are varied to correspond to the movement of transmitting pen **905**. Two different ranges, or bands, of frequencies are respectively produced by oscillators **610** and **611**. By moving transmitting pen **905**, the frequencies of each of the oscillators **610** and **611** are made variable within their respective ranges and these variable frequencies are impressed on the secondary windings, connected in series, of transformers **621** and **622** at the same time that the fixed pilot frequencies f_6 and f_7 of oscillators **623** and **624** are impressed on the secondary winding of transformers **621** and **622**. The variable frequency produced by oscillator **610** is of a higher range than that produced by oscillator **611** and the fixed frequency of oscillator **623** is higher than that of oscillator **624**. The four frequencies in the output of transformers **621** and **622** are impressed on a radio transmitter **625** together with a source **626** of carrier current having a frequency f_8, the output of the transformers serving to modulate carrier current for transmission to receiving station B. At receiving station B the incoming modulated carrier current is received by radio receiver **736** wherein the demodulation takes place in the well-known manner, and the demodulator output of the receiver is impressed on transformer **737**. The demodulator output now contains the two control frequencies that respectively originated in oscillators **610** and **611** and the two pilot frequencies which respectively originated in the oscillators **623** and **624**. The demodulator output which passes through transformer **737** is impressed on three filters connected in parallel, namely, high-pass filter **714** for readily passing the controlling frequency originating in oscillator **610**, low-pass filter **733** for readily passing the controlling frequency originating in oscillator **611**, and band-pass filter **738** for readily passing the frequencies originating in oscillators **623** and **624**.

The controlling frequencies readily passing filter **714** control the receiving element **805** in the same manner as the controlling frequency controls the receiving element **505** which was hereinbefore described. Likewise the controlling frequency readily passing filter **733** controls the receiving element **804** in the same manner as the controlling frequency controls the receiving element **504** which was hereinbefore described.

The pilot frequencies readily passing the band-pass filter **738** are impressed on high-pass filter **739** and low-pass filter **740**. The cut-off frequencies of the band-pass filter are between the cut-off frequency of each of filters **739** and **740**. The frequency f_6 readily passing high-pass filter

739 is impressed on a rectifier-amplifier tube 741 to operate start relay 742 and the frequency f_7 readily passing low-pass filter 740 is impressed on rectifier-amplifier tube 743, to operate pen relay 744. Relays 742 and 744 operate to thereby connect grounded battery to light the filaments of all the tubes of the receiving equipment at station B, to energize the windings of the rotors of receiving elements 808 and 810, and to energize pen magnet 1112.

The controlling frequencies impressed on the differential windings of receiving elements 805 and 804, respectively cause the arms 1110 and 1109 to change positions corresponding to the positions of the transmitting arms 604 and 603 at station A in the same manner as hereinbefore described for the system employing a wire line circuit for transmission between stations.

Telemetering

Should it be desired to use the invention for telemetering purposes, one of the transmitting oscillators only such as that designated 310 in Fig. 3 and one receiving element only, such as that designated 505 of Fig. 5 would be employed. In this case the filters would be omitted since a wire line circuit and one frequency only would be used. At the transmitting station the variable air condenser connected to the transmitting oscillator would be securely fastened to the rotatable shaft, such as that designated 305 in Fig. 3, of the device whose position is to be recorded at the receiving station. The receiving element such as that designated 505 in Fig. 5, will assume a position corresponding to the frequency transmitted. Since only an indicator is required at the receiving station for telemetering an indicating type wattmeter having a center-tapped potential coil could be used in place of the receiving element such as that designated 505. The spiral spring usually furnished on the wattmeter potential coil should be replaced with flexible leads in this case.

What is claimed is:

1. A telautograph system comprising a receiver having a scribing point, an electrostatic capacity, means whereby said capacity is varied as the scribing point moves in one direction of a coordinate system, means for establishing the frequency of an alternating current at said receiver by said capacity, means operable to transmit current of varying frequency from a transmitter, means for receiving said varying current at said receiver and producing under the control thereof a force for changing the capacity, which force is proportional to the instantaneous difference of the transmitted current and the frequency of alternating current established at said receiver.

2. A telautograph receiving system comprising a scribing point, a source of incoming waves and a local source of waves, means for causing said waves to interact to produce a force, means for applying said force to cause movement of said scribing point, and electrostatic capacity controlled means determining the position of said scribing point at which no further moving force is applied thereto.

3. In a transmission system, a transmission circuit, means connected to said circuit and movable in a plurality of directions, an oscillator circuit and elements responsive to the movement of said means for varying the capacitance of said oscillator circuit whereby the frequency of current from said oscillator circuit when impressed on said transmission circuit is varied in accordance with the movements of said means.

4. In a transmission system, in combination with a transmitting station, a receiving station, a transmission circuit interconnecting said stations, a directing point at said transmitting station, an electricity storing element controlled by said directing point, a source of signal current at said transmitting station controlled by said storing element to vary the frequency of current from said source for transmission over said transmission circuit, galvanometric means in said receiving station responsive to said variations in the frequency of current from said source, and an indicator at said receiving station responsive to the operation of said galvanometric means for indicating the different positions through which said directing means is operated.

5. A facsimile telegraph system, having a transmitting station, a receiving station, and a transmission circuit interconnecting said stations, a directing point capable of assuming a plurality of positions, a signal frequency source and an electricity storing element cooperating therewith at said transmitting station to transmit over said circuit to said receiving station, current of a frequency corresponding to each of the operable positions of said directing point, a source of current at said receiving station, a balancing circuit for first simultaneously receiving the current from both of said sources and then suppressing current waves of the frequencies from said second-mentioned source whereby one of the sidebands of the frequency generated at the first-mentioned source is further transmitted, a rectifier-amplifier circuit for receiving said one sideband, a receiving element comprising a magnetized coil and responsive to the output of said rectifier-amplifier for indicating at said receiving station successive positions of said directing point.

6. In a transmission system, in combination with a transmitting station, a receiving station, a transmission circuit interconnecting said stations, a directing point at said transmitting station movable in any direction in a plane, a plurality of electricity storing elements controlled by said directing point, a plurality of sources of waves of different signal frequency ranges respectively controlled by said storing elements to vary the frequency of waves from each of said sources for transmission over said transmission circuit, a plurality of channels at said receiving station, means at said receiving station for selecting the different signal wave frequencies received for transmission over said channels respectively, galvanometric means comprising a plurality of magnetizing elements respectively responsive to the different frequency ranges and an indicator responsive to said magnetizing element for indicating the plurality of positions to which said directing point is moved.

7. In a transmission system, in combination with a transmitting station, a receiving station, a radio transmission circuit extending from said transmitting station to said receiving station, a directing point at said transmitting station movable in all directions in a plane, a plurality of electricity storing elements controlled by said directing point, a plurality of sources of signal currents of different frequency ranges respectively controlled by said storing elements to vary the frequency of each of said sources for transmission over said transmission circuit, other

sources of alternating current of different frequencies, a radio transmitter and a source of carrier current therefor, means for impressing on said radio transmitter current of the frequency of each of said other sources simultaneously with current of the frequencies of the different signal ranges of said plurality of sources, a radio receiver at said receiving station, a plurality of networks connected to said receiver for respectively selecting for further transmission currents of the frequencies originating in the first-mentioned sources, a second plurality of networks connected to said receiver for respectively selecting, for further transmission, currents of the frequencies originating in said other sources, a receiving circuit, means responsive to the currents selected by said second plurality of said networks for conditioning for operation said receiving circuit, means responsive to the currents selected by first-mentioned plurality of networks for operating said receiving circuit, and an indicator responsive to the operation of said receiving circuit for duplicating the movements of said directing point.

8. A telautograph system comprising two oscillators for generating current of different frequency ranges, a transmission circuit for receiving current from said oscillators, a switch and means controlled thereby for starting said oscillator to transmit over said circuit currents of different frequencies, a receiving circuit comprising a high and low-pass filter, two balanced modulator circuits respectively connected to said high and low-pass filters, a balanced rectifier-amplifier circuit connected to each of said modulator circuits, galvanometric devices respectively responsive to the output current waves of said rectifier-amplifier circuits, a transmitting pen for controlling the frequencies transmitted from said oscillators over said transmission circuit and receiving pen controlled in its movement by said galvanometric devices, a writing surface in engageable relation with each of said pens, electromagnetic means operatively responsive to the engagement of said transmitting pen and writing surface therefor for causing the engagement between said receiving pen and said writing surface therefor.

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