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FACSIMILE TELEGRAPH SYSTEM

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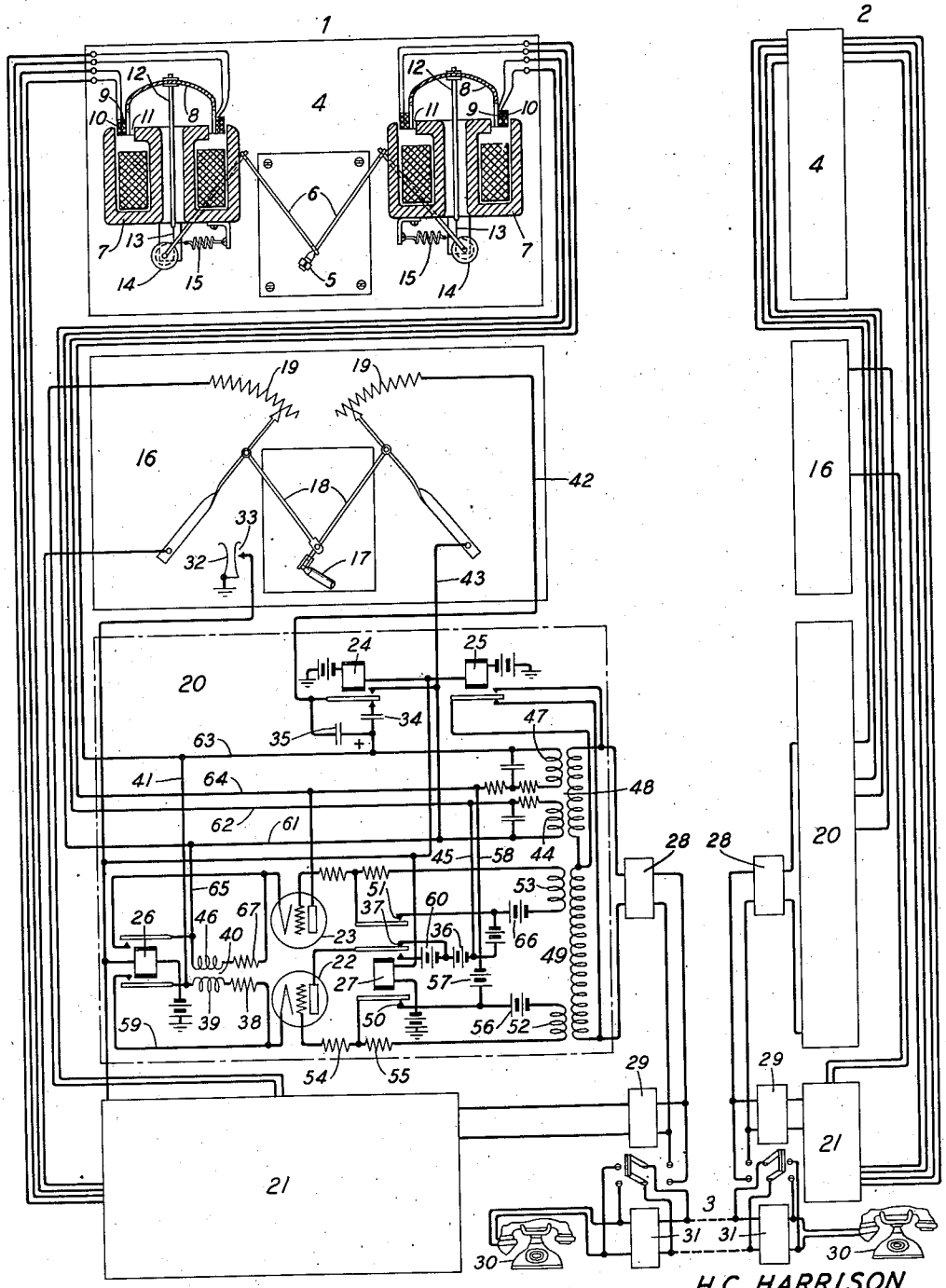

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FACSIMILE TELEGRAPH SYSTEM

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

The object of the invention is a facsimile telegraph system which operates independently of attenuation in the line over a wide range of line current amplitudes and utilizes the mechanical structure in common use for systems of this type.

According to the invention each coordinate of motion of the transmitting point varies the frequency of an oscillator connected to the line and at the receiving station the bands of frequencies are impressed on separate receiving units connected with the receiving pen or writing point. Each unit has two unilaterally conducting devices such as gas-filled electronic relays which are operated alternately by the successive half waves of the line current to produce a unidirectional current varying in magnitude with the line frequency and controlling the corresponding coordinate of motion of the receiving pen.

In the preferred system each station is equipped with a transmitting point and a receiving pen operatively connected by separate linkages to the circuits of the electronic relay units which may be readily conditioned for either transmitting or receiving as for example by providing a relay operated by the transmitting pencil when not in use for restoring the unit to the receiving condition. When connected for transmitting the relay tubes are biased to produce a sustained oscillatory current, the frequency of which is determined by the time of charge and discharge of an associated condenser. The linkages connected to the transmitting point operate rheostats in the charge and discharge circuits to vary the time of charge and discharge and hence the frequencies sent over the line, according to the coordinates of the pencil motion. The receiving pen is driven by electrodynamic motor elements which may be included in the respective charge and discharge circuits during transmission, thus making possible the production at the transmitting station of a facsimile of the matter being transmitted.

When the units are connected for receiving, the tubes are biased so that substantial plate current flows in either tube only when the bias is reduced by the alternate half waves of the line current and the average value of the plate current will therefore depend on the frequency of the received signal. These currents flow through bucket coils in the electrodynamic receiving elements and control the position of the receiving pen.

According to a further feature of the invention, the bucket coils are mounted to travel from a position wholly within the gap to a position only partially within the gap. If the variation in the resistance of the rheostat necessary to produce this motion is uniform, the sensitivity of the unit will be substantially the same over the whole range of operating frequencies.

This invention will be more clearly understood from the following detailed description and the accompanying drawing.

In the drawing two telautograph stations 1 and 2 are connected by a line 3. Since the stations are identical, only station 1 has been shown in detail and at station 1 the complete circuit has been shown for only one coordinate of motion. The apparatus at station 2 is indicated by the same numerals as the identical apparatus at station 1 and it will be understood that similar additional stations may be connected to the line in the same manner and that each station may transmit to or receive from any other station.

The mechanical structure may be, in general, similar to that commonly used in telautographs of the variable current amplitude type. The receiving units 4 each comprise a receiving pen 5, linkages 6—6 for moving the pen in two coordinates and electrodynamic driving units 7—7 for the linkages. The cup members 8 of each unit support signal or bucket coils 9 and 10 in the air-gap 11 and a rod 12 projects through the magnetic structure of the unit and drives the pen linkages by means of a flexible wire or band 13 wrapped around the wheel 14. The pen linkages are secured to the wheel and the wire is tensioned by a spring 15 to bias this moving system to the position in which the coils 9 and 10 are wholly within the air-gap of the driving unit.

The mechanical transmitting mechanism 16 at each station is also of a conventional type comprising a transmitting pencil 17 and associated linkage members 18 for varying the setting of a rheostat 19 in accordance with each component of the pencil motion.

The transmitting and receiving mechanisms are operated by the electronic relay units 20 and 21, one of which is provided for each component motion. These units each comprise a pair of gas-filled tubes 22, 23 associated transmitting and

receiving circuits and relays 24 to 27 under the control of the transmitting mechanism for conditioning the unit for transmission or reception. While a number of relays have been shown to simplify the wiring, it will be understood that in practice a single relay could perform the functions of all of the relays 24 to 27. Each unit operates over a frequency range of about 200 cycles and is connected to the line through a suitable band-pass filter 28 or 29. The telephone subset 30 at each station is connected to the line through a high-pass filter 31 and the filter characteristics are correlated in a manner well understood in the art so that speech and telautograph signals may be transmitted over the line simultaneously. The filter 28, for example, may pass frequencies 175 and 375 cycles per second, filter 29, frequencies between 400 and 600 cycles per second, and filter 31, all frequencies above about 650 cycles per second.

While the elimination of the speech frequencies below 650 cycles during telautographic transmission does not materially affect the intelligibility of the telephone conversation, it may be desirable in some cases to make the whole frequency band available for telephone transmission when the telautograph is not being used. This is readily accomplished as for example by providing at each station a line switch 68 which in one position connects all three filters 28, 29 and 31 to the line and in the other position disconnects the telautograph filters from the line and connects the line directly to the telephone set. This switching operation may also be carried out automatically in various ways as for example by a relay operated by the pen lifting mechanism not shown here but commonly used in telautograph systems.

Assume that matter is to be transmitted from station 1. The removal of the pencil 17 from its holder 32 breaks the contact 33 thereby releasing all of the relays 24 to 27 in the units 20 and 21 as shown in the drawing. Under this condition each of the circuits will generate an oscillatory current. The space current of the tube 22 will charge the condensers 34 and 35 over a circuit extending from the battery 36, back contact 37 of relay 27, tube 22, resistor 38, winding 39 of the transformer 40, conductor 41, through the condensers 34, 35, conductor 42, rheostat 19 to conductor 43, then through bucket coil 9 and transformer winding 44 in parallel, to conductor 45 and the other terminal of the battery 36. As the condensers become charged, the flow of space current in tube 23 is prevented by the voltages induced in the bucket coil 10 and the winding 46 of the transformer 40 by the decaying charging current in the coils 9 and 39, respectively.

When the condensers are fully charged no space current flows in the tube 22 and tube 23 may then operate to discharge the condensers 34, 35 over a circuit extending from the positive condenser plate through the bucket coil 10 and winding 47 in parallel to the anode of the tube and from the filament to winding 46 of transformer 40, conductor 43, and the rheostat 19 to the other plates of condensers 34, 35. As the discharge current decays, voltages are induced in the bucket coil 9 and the winding 39 of transformer 40 which delay the operation of tube 22 which would otherwise occur as soon as the condenser begins to discharge. When the discharge current approaches zero, the tube 22 will recharge the condenser and the above cycle will be repeated to produce an oscillatory current in the bucket coil of the right-hand driving unit 7 and in the line 3 through the transmitting transformer 48. The frequency of this current will depend on the time of charge and discharge of the condensers 34 and 35 and this time varies with the setting of the right-hand rheostat 19.

Similarly, the unit 21 will produce an oscillatory current in the line and in the bucket coils of the left-hand driving unit which varies in frequency in accordance with the variations in the setting of the left-hand rheostat 19.

The combined capacity of the condensers 34 and 35 in each unit is such that as the rheostat settings vary in accordance with the designs traced out by the pencil 17, the current generated by the unit 20 varies in frequency between the extreme limits of 175 and 375 cycles per second and the current generated by unit 21 between the extreme limits of 400 and 600 cycles per second. Since these currents flow through the bucket coils of the driving units 7 as already explained, the coils will vary their positions in the air-gap 11 in accordance with the changes in the settings of the rheostat and the design traced out by the pencil 17 will be reproduced by the pen 5 where it can be readily observed by the transmitting operator as a check on the signals being transmitted over the line.

At station 2, filter 28 passes the lower band of signal frequencies to the unit 20 at that station and the filter 29 passes the upper band of signal frequencies to the unit 21. These units at this time will be conditioned for receiving and the pen in the receiving unit 4 will trace out a facsimile reproduction of the motion of the pencil 17 at the transmitting station.

The manner in which these signals are reproduced will be clearly understood by assuming the signals to be transmitted from station 2 and received by station 1 in which the details of the circuit are shown. Under this condition pencil 17 will be in the holder 32 so that the relays 24 to 27 in each of the units 20 and 21 are energized by their associated batteries. If for any reason the line frequencies become so high that the second tube flashes before the first tube is extinguished a path is provided for the plate currents of the tubes which extends through both tubes and both bucket coils in series so that the flash persists and the receiving circuit is blocked and cannot function. To prevent this the charging time is reduced when the circuit is receiving and the margin of safety thereby increased by short-circuiting one of the condensers 34 and the resistors 38 and 67 by relays as stated below.

The operation of relay 24 disconnects the condenser 34 from the circuit and also short-circuits the rheostat 19 of the transmitting mechanism. Relay 25 disconnects the transmitting transformer 48 from the line and connects the receiving transformer 49 to the line. Relay 26 short-circuits resistors 38 and 67 and both windings of transformer 40 which is not required for receiving and relay 27 opens contacts 50 and 51 to remove the short circuits from the secondary windings 52 and 53 of the receiving transformer 49. The grids of tubes 22 and 23 are connected to relatively opposite ends of the secondary windings 52 and 53 so that the grids become positive on alternative half waves of the incoming signal current.

The grid circuit of tube 22 comprises resistors 54 and 55, the transformer secondary winding 52, grid biasing batteries 56 and 57, conductor 58, the bucket coil 10, conductors 41 and 59 and the filament of the tube. The increased grid bias

provided for the tubes 22 and 23 by the batteries 56 and 66, respectively when the circuit is conditioned for receiving prevents the tubes from flashing prematurely so that transformer 40 is not required for this purpose during reception and is therefore short-circuited as described above. When the incoming signal voltage exceeds that of the grid bias, space current flows in tube 22 and charges the condenser 35 over a circuit extending from batteries 36 and 60 through the tube, conductors 59 and 41, condenser 35, front contact of the relay 24, conductors 43 and 61, the bucket coil 9, conductors 62 and 45 to battery 36. During the second half cycle of the line signals, the grid of tube 23 becomes positive and the condenser 35 discharges over a circuit extending from the conductor 63 through the bucket coil 10, conductor 64, the tube 23 and from the filament of the tube to the other plate of the condenser through the upper back contact of relay 26, conductors 65, 61 and 43 and the front contact of relay 24. This charging and discharging of condenser 35 is repeated for each cycle of the received signals so that with any suitable values of condenser capacity and anode voltage, a pulsating current having an average value approximately proportional to the frequency of the received signal is passed through the coils 9 and 10 of the right-hand driving unit.

The filter 29 passes from the line to the receiving unit 21, the frequency component representing the changes in the other coordinate of motion of the sending pencil. These alternating currents operate the unit 21 in the manner already described for unit 20 to pass through the coils of the left-hand driving unit 7, pulsating charge and discharge currents which vary in value with the variations in the signal frequency.

Each driving unit of the system is therefore supplied with a unidirectional current varying with the changes in one coordinate of motion just as in conventional variable amplitude telautograph systems and the receiving pen 5 will accordingly reproduce the trace of the transmitting pencil. It is highly desirable that the telautograph be equally sensitive at all positions of the pencil and pen. When the pencil 17 is in such a position that only a small part of one of the rheostats is in circuit, a small change in the rheostat setting will produce a larger change in the time of charge and discharge of the condenser than when a large part of the rheostat is in the circuit. In other words, equal increments in the portion of the rheostat in circuit produce progressively smaller changes in the frequency of the signal. The magnetic fields in the air-gap of the driving unit 7 are substantially uniform and the bucket coils are preferably proportioned to exactly fill these gaps, that is, the axial length of each coil is identical with the thickness of the pole faces. The driving units are then adjusted that as each rheostat moves from the position of zero resistance to a position in which the rheostat resistance is equal to one-half the resistance of the whole circuit, the bucket coils move from a position in which only one-half of the coils are in the gap to the position where they are wholly within the gap. As the coils move into the gap the sensitivity of the unit increases due to the increasing number of flux linkages with the coil turns and this variation in sensitivity compensates for the variation due to the rheostat as described above, and makes the device of more nearly substantially constant sensitivity for all positions of the pen and pencil.

Alternatively the pole faces may be made long enough so that field is uniform for all coil positions and the sensitivity may be kept constant by using suitably tapered resistors in the rheostats 18.

What is claimed is:

1. Telautograph apparatus comprising a writing point, two circuits each including a pair of electronic tubes, means in the output circuit of each pair of tubes for driving the point along one coordinate of motion, means for conditioning each tube to respond to alternate half waves of currents of predetermined frequencies, and means for converting each pair of tubes into a generator of oscillatory current.

2. Telautograph apparatus comprising a writing point adapted to move in two coordinates, driving mechanism for each coordinate comprising a pair of electronic tubes having input and output electrodes, a condenser, a charging circuit for the condenser including the output electrodes of one of the tubes, a discharge circuit for the condenser including the output electrodes of the other tube, means for alternately flashing the tubes to charge and discharge the condenser at varying frequencies in accordance with telautograph signals to be reproduced, and means responsive to the charging and discharge currents for driving the writing point along the one coordinate of its motion.

3. Telautoraph apparatus comprising a transmitting stylus and a writing stylus adapted to move in two coordinates, means for moving the writing stylus in each coordinate including a pair of electronic tubes having input and output electrodes, a condenser, charging and discharging circuits therefor including the output electrodes of said tubes, respectively, means associated with the input electrodes for alternately flashing the tubes at a frequency varying with the position of the transmitting stylus in one coordinate, and means for driving the writing stylus in accordance with the variations in said frequency.

4. A telautograph system comprising a transmitting point adapted to move in two coordinates, a line, means for feeding into the line two currents each varying in frequency with the motion of the point along one of the coordinates of its motion, a receiving stylus adapted to move in two coordinates, linkages for driving the stylus along each of its coordinates of motion, two pairs of electronic tubes, means responsive to successive half waves of one of the line currents for alternately operating the tubes of each pair, and means responsive to the output of each pair of tubes for driving one of the linkages.

5. A telautograph transmitter comprising a transmitting point, means for resolving the motion of said point into two components, an oscillator for each of the component motions comprising a condenser, an electronic tube for charging the condenser, an electronic tube for discharging the condenser, means for successively operating the tubes, and means for varying the time of operation in accordance with one of the component motions of the transmitting point, and means for producing alternating signal voltages varying with the charging and discharge currents.

6. In a variable frequency telautograph transmitter, a writing point, means for resolving motion of the point into two component motions, an oscillating current generator for each component motion comprising a condenser, a charging

circuit for the condenser including an electronic relay and a source of plate potential therefor, a discharge circuit for the condenser including a second electronic relay and an element inductively associated with the input circuit of the first mentioned electronic relay, means for coupling said circuits to a transmission line, and means for varying the resistance of each charging circuit in accordance with one of the component motions of the writing point.

7. A telautograph receiver comprising a writing point adapted to move in two coordinates, two receiving units each responsive to a predetermined band of frequencies and comprising a pair of electronic tubes respectively operated by successive half waves of said frequencies, and means responsive to the output of each pair of tubes for driving the writing point along one of the coordinates of its motion.

8. A telautograph according to claim 7 in which each writing point driving means includes two inductively related coils in the output circuits of each pair of vacuum tubes.

9. In a variable frequency telautograph receiver, a writing point, and two receiving units for driving the point in two coordinates in accordance with received currents of varying frequency, each unit comprising a pair of electronic relays each having a grid electrode positively biased by alternate half waves of one of the received currents, a condenser, a charging circuit therefor including the output circuit of one of the relays, a discharge circuit including the output circuit of the other relay and a motor element for driving the writing point along one coordinate of its motion having a coil in each of said circuits.

10. In a telautograph system, two telautograph stations, a line connecting the stations and transmitting and receiving apparatus at each station comprising a transmitting stylus and a receiving pen each adapted to move in two coordinates, driving units for the pen, operating circuits for each coordinate including a pair of electronic tubes having input and output electrodes, a condenser, charging and discharging circuits for the condenser each including a pen driving unit and the output electrodes of one of the tubes, means at each station for conditioning the operating circuit to generate and transmit over the line alternating currents varying in frequency with the motion of the transmitting stylus, and means at each station for conditioning said circuit to drive the pen in accordance with alternating current transmitted from the other station.

11. In a telautograph system, a transmitting station having a transmitting stylus and a transmitting condenser, a receiving station having a receiving stylus and a receiving condenser, a line connecting the stations, transmitting condenser charging and discharging circuits associated with the line, means for causing said transmitting condenser to be charged and discharged alternately at a frequency varying with the position of the transmitting stylus, receiving condenser charging and discharging circuits associated with the receiving stylus, and means for causing said receiving condenser to be alternately charged and discharged at a rate varying in accordance with the frequency of the line current.

12. A telautograph system according to claim 11 in which the time of charging and discharging of the receiving condenser is less than the time of charging and discharging of the transmitting condenser.

13. The combination with two telephone sets, two high-pass filters, a line connecting the telephone sets to the filters, telautograph apparatus and low-pass filters connecting the apparatus to the line, of means for connecting the telephone sets to the line independently of the filters when the telautograph apparatus is not in use.

14. Image producing apparatus comprising means for receiving from a transmitting station an alternating current of varying frequency, a condenser, a gas-filled electric discharge tube under control of said received current through which said condenser is charged, means for building up an image element by element, and means under control of said condenser for controlling the action of said last mentioned means.

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