Sept. 28, 1937. T. AAMODT 2,094,052

FACSIMILE TELEGRAPH SYSTEM

Filed May 22, 1935 2 Sheets-Sheet 1

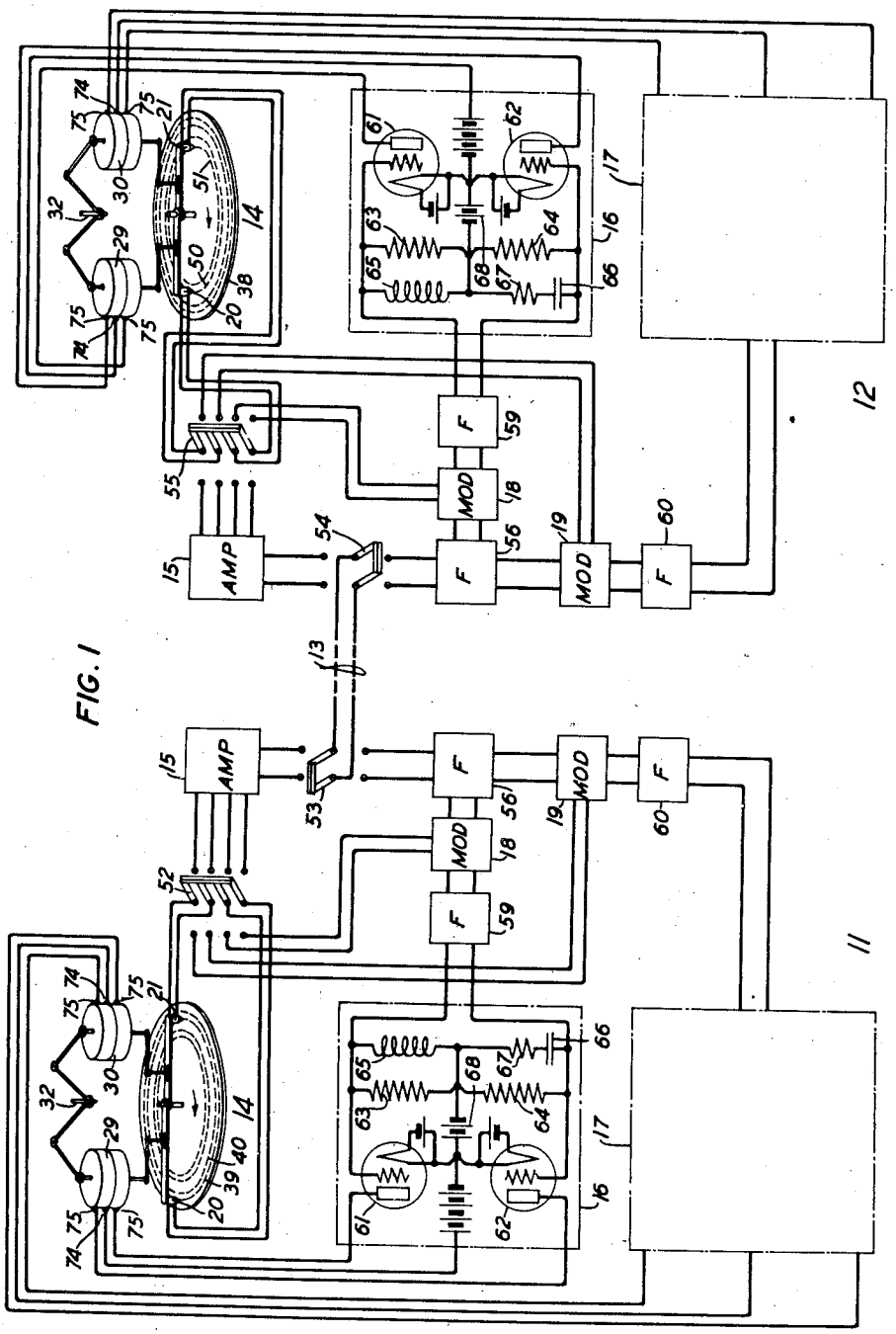

FIG. 1

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FIG. 2

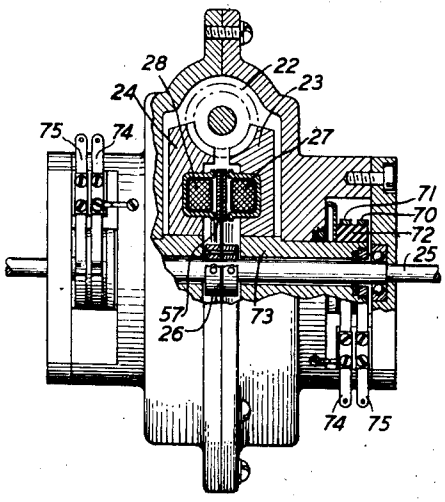


FIG. 3

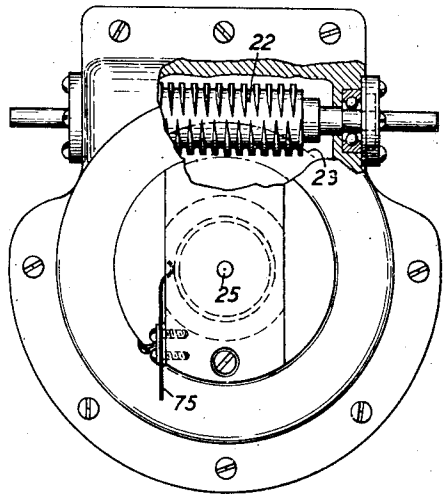
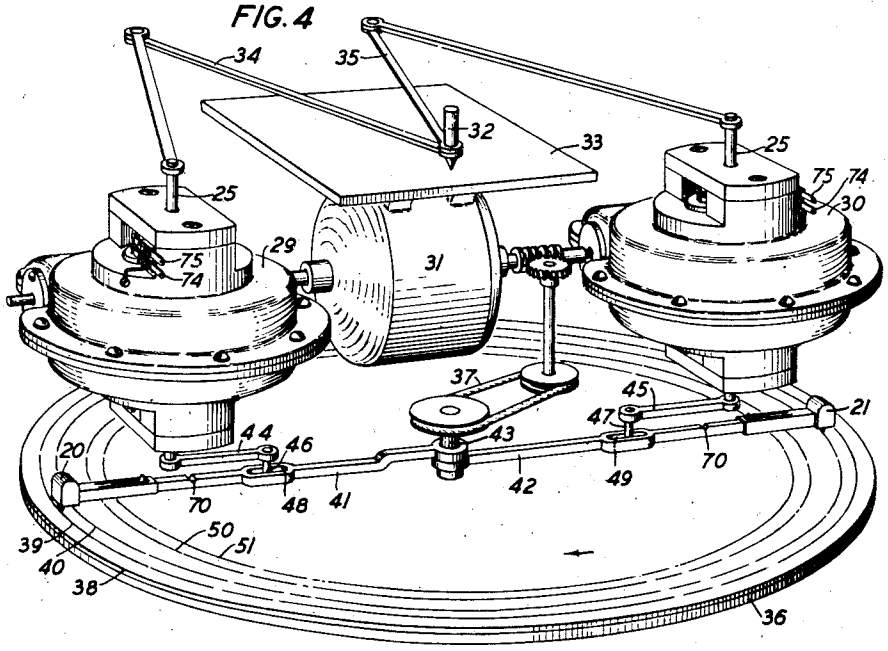


FIG. 4



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UNITED STATES PATENT OFFICE

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FACSIMILE TELEGRAPH SYSTEM

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11 Claims. (Cl. 178—19)

This invention relates to systems for the transmission of intelligence over wires 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.

The object of the invention is a telegraph system of this type which is very sensitive in operation and which is not affected by variations in the strength of the line current.

According to the invention the movements of a writing point at the transmitting station are resolved into two component motions which vary the frequencies of two signal currents being transmitted over the line and these currents of varying frequency are utilized to produce corresponding movements of the writing point at the receiving station. The two signal frequencies are preferably cut in separate concentric grooves of the same phonograph record and the variations in these frequencies corresponding to the movements of the transmitting writing point are 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 are separated and each is modulated with a local frequency which may be obtained from a record similar to the one at the transmitting station. The frequencies generated at the receiving station each differ 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 writing 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 point and the associated reproducers until the balanced condition is restored. By setting up the receiving circuit for a balance when the difference between the line frequencies and the locally generated frequencies is small as compared with the line frequencies, the changes in line frequency corresponding to even slight movements of the transmitting point will produce large unbalancing effects in the receiving circuit and the receiving point will follow the movements of the sending point with great accuracy.

An important feature of the invention is a dual direction clutch unit associated with each reproducer and connected by linkages to the writing point for moving the reproducer back and forth in the groove to produce the necessary variations in the frequency of the reproducer output.

Another feature of the invention is a tuned rectifier for each clutch unit in the receiving circuit which, when unbalanced in either direction, selectively operates the clutch unit to produce the corresponding motion of the receiving point and the associated reproducer.

By providing both sending and receiving apparatus and the necessary switching facilities at each station connected to the line, any station may receive matter transmitted from any other station and may transmit to any or all of the other stations. Since the system of this invention operates on variations in the frequency rather than variations in the amplitude of the line current, it is unaffected by changes in the line impedance and many receiving stations at different distances from the transmitting station may be operated simultaneously in a satisfactory manner.

In the drawings:

Fig. 1 is a circuit diagram of a facsimile telegraph system according to the invention;

Fig. 2 is a view partly in section of one of the dual direction clutch units;

Fig. 3 is a plan view of the clutch unit; and

Fig. 4 is a perspective view of one of the transmitting and receiving units shown schematically in Fig. 1.

In the diagram of Fig. 1 the system shown to illustrate the invention comprises only two stations 11 and 12, either one of which may send to or receive from the other over the line 13, but other similar stations may be connected to the line as required.

Each station is equipped with a transmitting and receiving unit 14 as shown in detail in Fig. 4, a transmitting amplifier 15, two tuned rectifiers 16, 17, one for each coordinate of motion of the writing point, modulators 18, 19 for modulating the line frequencies with those generated locally by the reproducers 20 and 21 in the transmitting and receiving units, the necessary filters for eliminating undesired frequencies, and switching facilities for conditioning the station for transmitting or receiving as desired.

The dual direction clutch unit of Figs. 2 and 3 consists essentially of a worm 22 and two worm wheels 23 and 24 concentric with the shaft 25 which carries a magnetic disc or diaphragm 26. The worm has both left and right-hand threads as shown but the worm wheels are cut with left and right-hand threads respectively so that they are driven in opposite directions by the worm. The wheels are both normally free to turn with respect to the shaft 25 but each is provided with a winding 27, 28 which when energized in a manner to be described attracts the ring 57 on the

diaphragm 26 which is keyed to the shaft 25 and rotates the shaft in the direction in which the corresponding wheel is turning.

The leads for each magnetizing winding are brought to slip rings 70, 71 on an insulating block 72 mounted on the sleeve 73 which turns with the associated worm wheel. Brush contacts 74, 75 are provided for each pair of slip rings and these contacts are connected with the output circuit of the corresponding rectifier unit 16 or 17.

The transmitting and receiving unit of Fig. 4 comprises two clutch units 29, 30 of the type just described, a motor 31 for driving the worms of these units, and writing and frequency generating mechanism associated with the shafts 25 of the units. The writing point 32 is positioned above the writing pad 33 by linkages 34, 35 of the usual type connected to the shafts 25 of the clutch units. The turntable 36 is driven in any convenient manner as by a belt 37 driven from the motor 31 and carries a record 38 having two pairs of concentric reentrant grooves 39, 40 and 50, 51 in which suitable single frequencies are recorded. The reproducers 20, 21 are adjustably mounted on arms 41, 42 in such a way that they may be quickly and accurately brought into engagement with either groove. For example, the reproducer supporting structure may be fitted with a spring 69 which engages slots 70, 70 located in the reproducer arms in the proper positions to lock the reproducer above either selected groove. The arms are pivoted on the spindle 43 of the turntable and connected by cranks 44, 45 to the shafts 25 of the clutch units 29 and 30 respectively. The cranks are fitted with pins 46, 47 which slide in slots 48, 49 in the reproducer arms 41 and 42 so that when either shaft 25 is rotated either by the motion of the writing point in transmitting or by the action of one of the clutches in the clutch unit itself when the station is receiving, the corresponding reproducer will be moved longitudinally in its groove. During such movement the frequency of the reproducer output will be higher or lower than the frequency recorded in the groove depending upon the direction of the reproducer movement.

One pair of grooves on each record is used for transmitting and the other pair for receiving. The signal frequencies are preferably below the range necessary for satisfactory speech transmission so that the system may function over telephone lines which are being used for the transmission of telephone messages. For example, grooves 39 and 40 may be cut at 100 and 200 cycles per second respectively and grooves 50 and 51 at 90 and 180 cycles per second respectively.

Assume now that writing or other matter is to be transmitted from station 11 to station 12. Since all stations would normally be conditioned for receiving it is first necessary to condition station 11 for transmission. That is done by moving the reproducers 20 and 21 into engagement with the grooves 39 and 40 as shown, closing the switch 52 to connect the reproducers to the amplifier 15, closing switch 53 to connect the amplifier to the line 13 and starting the driving motor 31 to drive the turntable and the worm wheels of the clutch units 29 and 30.

At station 12 switches 54 and 55 are closed to connect the line and the phonograph reproducers to the tuned rectifiers 16, 17, the driving motor is running and the reproducers are engaging grooves 50 and 51 of the record 38. Under these conditions, the 100 and 200 cycle currents from the reproducers at station 11 will be fed over the line to the filter 56 at station 12 which selects the 100 cycle current and delivers it to the modulator 18 and passes the 200 cycle current to the modulator 19. At the same time modulator 18 is being supplied with a 90 cycle current from the local reproducer 20 and the modulator 19 with a 180 cycle current from the local reproducer 21.

The filters 59 and 60 select the 10 cycle and 20 cycle difference frequencies in the modulator outputs and transmit them to the rectifiers 16 and 17 respectively. The rectifiers each comprise two vacuum tubes 61, 62 with their input circuits in push-pull and their output circuits connected to the two magnetizing windings 27 and 28 of one of the clutch units already described. Grid leak resistors 63 and 64 are connected across the tube inputs, resistor 63 being shunted by an inductance 65 and resistor 64 by a capacitance 66 and a small resistor 67 to balance the resistance of the inductance 65. The values of the inductance 65 and the capacitance 66 are such that the rectifier input is tuned to the normal difference frequency, in this case 10 cycles per second for rectifier 16 and 20 cycles per second for the rectifier 17. When current is supplied to the rectifier unit at its resonant frequency, the voltages across the tube input circuits will be equal so that equal currents flow in the two windings of the clutch unit and no clutching action takes place. It will be understood that in practice several stages of amplification may be required for the rectifier units and that rectifying devices of other types such as copper oxide rectifiers may be used to supply power to the clutch units, if desired.

When the writing point 32 at station 11 moves, one or both of the reproducer arms will be rotated and during this motion the frequencies sent over the line will differ from the recorded frequencies by an amount proportional to the angular velocity of the arms and will be higher or lower than the recorded frequencies depending on the direction of motion of the writing point. Assuming that the motion of the point 32 is such that the 100 cycle current increases in frequency to 101 cycles, the input to the rectifier 16 at station 12 is then 11 cycles which constitutes a ten per cent change for a one per cent change in line frequency and makes the system inherently of high sensitivity. Under this condition the impedance of the inductance 65 is greater than normal and the impedance of the capacitance 66 is correspondingly less than normal. Therefore, the electromotive force impressed upon the input circuit of tube 61 is greater than the electromotive force impressed across the input circuit of tube 62 and the rectified current flowing in the output circuit of tube 61 through the lower winding of clutch unit 29 is greater than the current flowing in the output circuit of tube 62 through the upper winding of clutch unit 29. The flux set up in the diaphragm 26 due to the current in the lower winding of clutch magnet 29 rotates the diaphragm and the shaft 25 with the worm wheel 23 in a clockwise direction so that the reproducer 20 is moved against the rotation of the turntable to increase the frequency of the reproducer output. When this frequency becomes 91 cycles the input to the rectifier which is always of a frequency equal to the difference between the frequencies generated by the corresponding reproducers at the two stations, is again 10 cycles, the rectified

plate current in the tubes 61 and 62 falls to zero or a low value to cause the clutch to release the diaphragm and the shaft 25 to stop. Since the writing point 32 at the receiving station is connected to the shafts 25 of its clutch units in the same manner as in the transmitting mechanism the point 32 will trace a line similar to the one traced by the transmitting point in changing the transmitted frequency from 100 to 101 cycles per second.

When the motion of the transmitting point is such that the line frequency becomes 99 cycles, the receiving mechanism is operated in a similar manner except that in this case the rectifier input is now of 9 cycle frequency so that the electromotive force across the input of tube 62 is increased and current flows to the upper clutch winding 28 and the shaft 25 is rotated contra-clockwise by the worm wheel 23. The point 32 at station 12 is therefore moved in the opposite direction in accordance with the motion of the transmitting point and the reproducer 20 is moved with the rotation of the record until the frequency of its output is reduced from 90 to 89 cycles per second at which time the rectifier is again balanced and the clutch disengaged.

In most cases the motion of the transmitting point will be such as to vary both line frequencies so that rectifier 17 at station 12 is also unbalanced and operates one or the other of the clutches of the unit 30 to reproduce the other coordinate of the motion of the transmitting point and to move the reproducer 21 along its groove and change the frequency of its output until the rectifier 17 is again in balance. Since this operation is identical with that already described for the unit 20 it is believed unnecessary to describe it in detail. It should be noted however that the sensitivity of the system is the same for both coordinates since the motion of the transmitting point which changes the 100 cycles current to 101 cycles per second if in the proper direction would change the 200 cycle current to 202 cycles per second and this modulated with 180 cycle current at the receiving station gives a 22 cycle difference frequency which also represents a ten per cent change.

When transmission from station 11 has been completed the apparatus is reset for receiving by moving the reproducers 20 and 21 at that station into contact with the grooves 50 and 51 to generate frequencies of 90 and 180 cycles per second respectively, and the switches 52 and 53 are closed in their other positions so that incoming line signals and the local frequencies are conducted to the modulators. Then any other station, such as 12 can transmit to station 11 and the operation of the system under these conditions will be clearly understood from the foregoing description.

For purposes of illustration certain definite frequencies have been mentioned but it will be understood that these may be modified to suit the requirements of a particular case and that various other modifications may be made within the scope of the following claims.

What is claimed is:

1. In a facsimile telegraph system the combination with a writing point, a plurality of moving single frequency recordings, a transmitting line and a plurality of reproducers for the recordings connected to the line, of means for moving each of the reproducers along its recording in accordance with a coordinate of motion of the writing point to vary the frequencies of the reproducer output.

2. In a facsimile telegraph system the combination with a transmitting station, a receiving station, a line connecting the stations, a movable member at the transmitting station and means for feeding into the line a plurality of currents each varying in frequency according to the velocity of the member along one coordinate of its motion, of a second movable member at the receiving station, means for generating a plurality of local currents each varying in frequency according to the velocity of said second member along one coordinate of its motion, means for intermodulating each line current with one of the local currents and means responsive to the output of each of the modulating means for moving the second member along one coordinate of its motion.

3. In a facsimile telegraph system, the combination with a line, a writing point, two rotatable shafts, linkages between each shaft and the writing point and means associated with each shaft for generating an alternating current, of a pair of oppositely rotating members for each shaft and means, controlled in accordance with a characteristic of the current from the line and of one of the alternating currents, for operatively associating the shaft with one or the other of said members.

4. In a facsimile telegraph system, a writing point, a line carrying a current varying in frequency according to the velocity of the point along one coordinate of its motion, a second writing point, driving means for moving the second point and a source of current varying in frequency according to the motion of the second point, a modulator for intermodulating the currents, a rectifier connected to the output of the modulator for controlling the driving means, and a circuit in the rectifier tuned to a frequency equal to the normal difference in the frequencies of the currents.

5. A facsimile telegraph system according to claim 2, in which the currents of variable frequency are generated by reproducers secured to the movable members and moving longitudinally in operative relation to moving single frequency recordings.

6. In a variable frequency facsimile telegraph system, a stylus, a phonograph record having a plurality of single frequency recordings, reproducers engaging two of the recordings and means for moving each reproducer along its groove in accordance with the motion of the stylus in one of two coordinates.

7. In a variable frequency facsimile telegraph system, the combination with a transmitting stylus, linkages for resolving the motion of the stylus into two components, a transmitting line, a disc record having a plurality of concentric recordings of different frequencies and two reproducers connected to the line and engaging different grooves of the record, of reproducer supporting arms pivoted concentrically with the record, and means for rotating each of the arms in accordance with the motion of one of the stylus linkages.

8. In a facsimile telegraph system, a line carrying two signal currents each varying in frequency and receiving mechanism connected to the line comprising a receiving stylus, two drive shafts for imparting motion to the stylus in two coordinates, a pair of oppositely rotating members for driving each shaft, means for generating a

local current normally differing in frequency from one of the line currents and varying in frequency with the angular velocity of the shaft, a circuit tuned to the normal difference between the frequencies of the local and said one of the line currents, and means controlled by the circuit and responsive to changes in the frequency of the line current for operatively associating the shaft with one or the other of the rotating members.

9. In a facsimile telegraph system, a transmitting station, a receiving station, a line connecting the stations, a transmitting stylus, means for impressing on the line two currents each varying in frequency in accordance with the velocity of motion of the transmitting stylus in one of two coordinates, a receiving stylus, two shafts for imparting motion to the receiving stylus in two coordinates, means associated with each shaft for generating a local current varying in frequency with the speed of rotation of the shaft and means for each shaft operative when the difference in the frequency between the local current and one of the line currents differs from a predetermined normal value for selectively rotating the shaft to move the receiving stylus and vary the local frequency to restore the difference frequency to its predetermined normal value.

10. In a facsimile telegraph system, the combination with a writing point, a single frequency recording, a reproducer for said recording, and means for effecting relative motion between said reproducer and said recording, of means for changing said relative motion between the reproducer and the recording in accordance with a coordinate of motion of the writing point to vary the frequency of the reproducer output.

11. In a facsimile telegraph system, a writing point, means including a rotatable shaft for moving said writing point along a coordinate of motion, a pair of oppositely rotating members, a source of signaling current, and means for causing said shaft to be operatively associated with one or the other of said oppositely rotating members in accordance with a characteristic of said signaling current.

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