Sept. 28, 1937. T. G. KINSLEY 2,094,039

TELAUTOGRAPH

Filed June 11, 1935 2 Sheets-Sheet 1

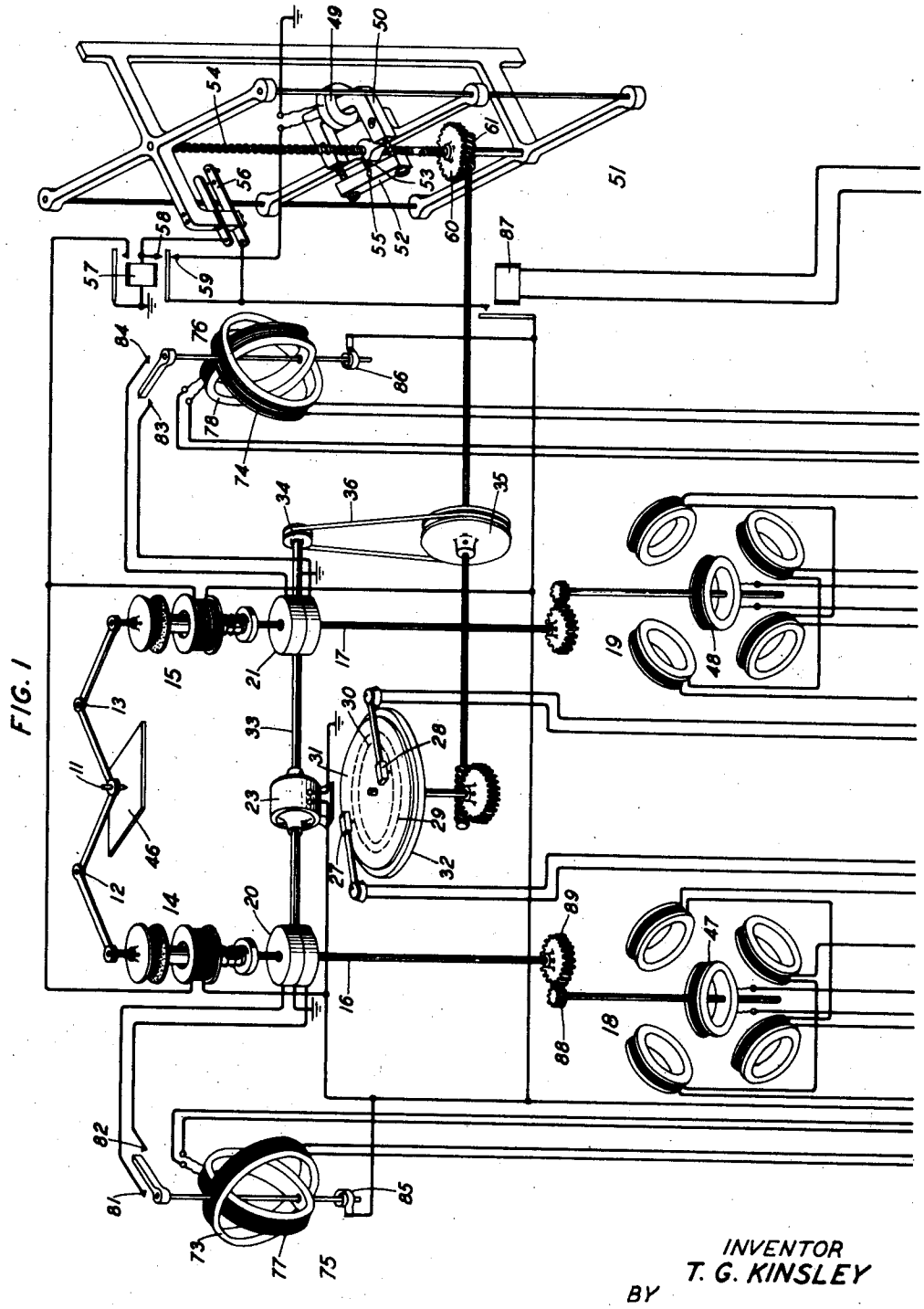


FIG. 1

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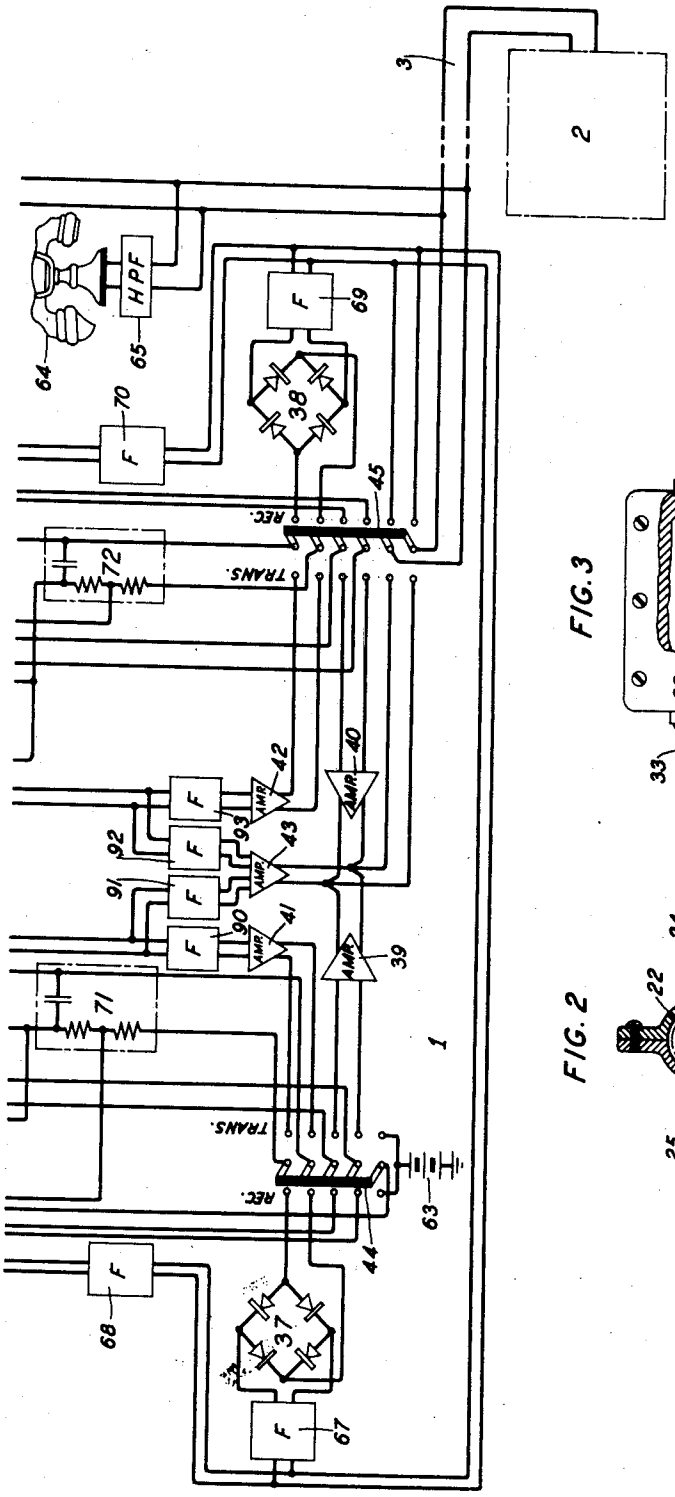



FIG. 3

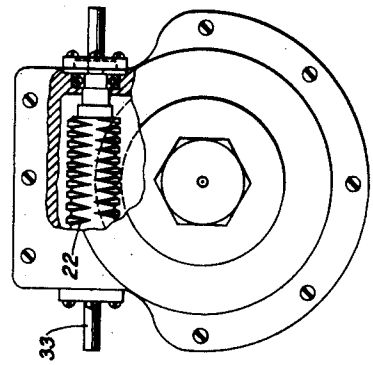
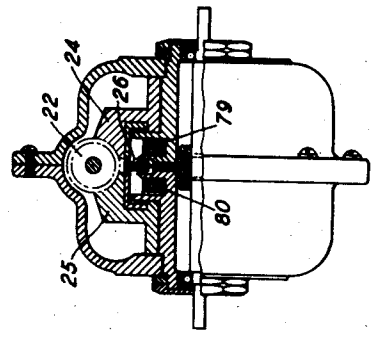



FIG. 2

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# UNITED STATES PATENT OFFICE

2,094,039

## TELAUTOGRAPH

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Application June 11, 1935, Serial No. 26,013

10 Claims. (Cl. 178—19)

This invention relates to telautographs and the object of the invention is a telautograph or facsimile telegraph system suitable for use on telephone lines and capable of functioning independently of variations in the amplitude and frequency of the signal currents.

According to the invention the motion of a transmitting point is resolved into two components and each component motion varies the phase angle of an alternating potential applied to the line. At the receiving station the varying phase angles of the received signals are utilized to move a receiving pen or stylus to reproduce the motion of the transmitting point.

In the preferred embodiment the linkages of the stylus at each station are connected to shafts associated with suitable phase shifting mechanism and dual direction clutch units for driving the shaft in either direction. At the receiving station a source of potentials having the same frequencies as the received signals and zero phase angle is required for operating the phase shifting mechanism. These pilot frequencies are conveniently provided, according to the invention, by generating multiple or sub-multiple frequencies of those used for signaling and transmitting these other frequencies without change in phase over the line along with the signals to receiving mechanism which derives from them potentials of the same frequency as the signals.

There is then available at the receiving station two potentials of each frequency transmitted, one of which is of varying phase with respect to the other. The potentials of constant phase are used to operate the phase shifters, which are preferably of the Drysdale type, one pair of the stationary windings being energized directly and the other pair by the same potential but through suitable means for shifting its phase through 90 degrees. A phase shifter of the Drysdale type is shown, for example in "Electrical Measurements" by Frank A. Laws (McGraw-Hill 1917) on page 290, Fig. 166. Each potential of varying phase from the transmitting station is applied to one winding (preferably the stationary one) of a wattmeter type relay which controls the corresponding clutch unit. The other relay winding is energized by the potential generated in the moving element of the phase shifter which is mounted on the shaft of the clutch unit.

When the transmitting point is moved the movable coils of the phase shifters are rotated and the phase angles of the signal currents transmitted are varied with the result that the relays at the receiving station are unbalanced and selectively operate the clutches at the receiving station to rotate the associated phase shifter elements until the phase angles of the potentials generated in the movable coils have varied in the same manner as the phase angles of the corresponding signal frequencies, at which time the relays are again in balance and the clutches disengage. The shaft of the clutch unit at the receiving station will, therefore, follow the rotation of the corresponding shaft at the transmitting station and the receiving stylus will reproduce the movements of the transmitting stylus.

By connecting the clutch shaft to the phase shifter through gears of a suitable ratio, the system can be made very sensitive to small phase differences and therefore capable of reproducing the motion of the transmitting stylus with great accuracy. It will be observed that the receiving mechanism will be operated by either leading or lagging phase and that due to its sensitivity it moves substantially synchronously with the transmitting mechanism so that the transmitting mechanism may operate over any range of phase angle desired.

Since the operation of the system depends solely on phase differences and is not limited to any particular range of phase angle, the system differs from variable frequency and variable amplitude systems in that it may be made as sensitive as desired without complicating the transmission problem.

These and other features of the invention will be more clearly understood from the following detail description and the accompanying drawings in which:

Fig. 1 is a telautograph system according to the invention and Figs. 2 and 3 are detail views of the dual direction clutch units for driving the shafts associated with the stylus.

In the drawings the apparatus and circuits are not shown in detail at station 2 since this station is merely a duplicate of station 1. The transmitting and receiving unit at each station has a stylus 11 mounted in linkages 12 and 13 of the usual type connected through magnetic clutches 14 and 15 to the shafts 16 and 17 which are suitably geared to the phase shifters 18 and 19. When the stylus 11 is transmitting it drives the shafts 16 and 17 but when receiving is driven by the shafts which are rotated in accordance with the received signals by the dual direction clutch units 20 and 21.

These units are preferably of the type disclosed in the copending application of T. Aamodt,

Serial No. 22,689, filed May 22, 1935, and as shown in Figs. 2 and 3, consist essentially of a worm 22 having both right- and left-hand threads driven by the motor 23 and two worm wheels 24 and 25 with right- and left-hand threads, respectively driven in opposite directions by the worm. Each worm wheel has associated with it an electromagnet which when energized in the manner to be described attracts a disc 26 secured to the shaft and causes it to revolve with the worm wheel.

The necessary signal frequencies may be generated in any well known manner as for example by vacuum tube oscillators but a very simple and inexpensive generating system for the purpose comprises phonograph reproducers 27 and 28 engaging concentric grooves 29 and 30 in the record 31 on a turntable 32 which is driven by the shaft 33 of the motor 23 in any suitable manner such as by pulleys 34 and 35 and a belt 36 as shown. For telautograph transmission these signal frequencies energize the stationary windings of the phase shifters 18 and 19 as will be more fully explained below and for the proper operation of the phase shifters at the receiving station potentials of the same frequency and phase relation are required. In order to avoid the necessity of synchronizing these potentials with those at the transmitting station the potentials for the phase shifters at the receiving station are derived from multiple or submultiples of the signal frequencies transmitted over the line with the signals.

In the preferred system shown, each of the grooves therefore contains a record of two frequencies, one for signaling purposes and the other a submultiple thereof for energizing the corresponding phase shifter at the receiving station and suitable filters 90, 91 and 92, 93 are provided to pass each frequency to its proper circuit. The signal frequencies selected by the filters 90 and 93 and applied to the transmitting phase shifters may be 200 and 300 cycles respectively and the frequencies transmitted selected by the filters 91 and 92 and for the receiving phase shifters may be 100 and 150 cycles respectively over the line. These latter frequencies are then doubled at the receiving station by any suitable means such as Wheatstone bridge rectifier units 37 and 38 to produce 200 and 300 cycle frequencies for the receiving phase shifters.

The telautograph is shown as an adjunct to a telephone set so that when the subscriber at station 1 is conversing with the subscriber at station 2 over the line 3 he may request the latter to condition his telautograph for receiving. When used as an independent system the apparatus would normally be set for receiving with the driving motor running and the amplifiers energized or alternately means such as a voice frequency relay at the receiving station operated by the frequencies transmitted from the transmitter station may be provided for conditioning the apparatus at the distant station to receive the matter to be transmitted.

Assume that station 1 is about to transmit to station 2. The amplifiers 39 to 43 are energized from sources not shown and the switches 44 and 45 are closed to the transmitting position. In actual practice these switches would preferably be replaced by relays operated by a starting key which also energizes the amplifiers and motor 23. The amplifiers at the receiving station are also energized and the receiving station switches 44 and 45 are closed to their receiving positions either by the receiving operator or automatically as outlined above. At this time the stylii at the sending and the receiving stations are in their wells 46 in accordance with usual telautograph practice.

There is no assurance, however, that the movable elements 47, 48 of the phase shifters are in the same relative positions at the two stations. For this reason the clutches 14 and 15 are provided at each station between the stylus linkages and the drive shafts 16 and 17. When the switches 44 and 45 are closed, the motor 23 is energized by the battery 63 and the turntables begin to rotate but these clutches remain open until the frequencies sent over the line have time to move the phase shifters to correct any difference that may exist. The delayed operation of the clutches may be effected in the following manner. The voice frequency relay 87 at each station is tuned to 300 cycles or one of the other frequencies used for telautograph transmission and is therefore operated and held up by this frequency when it is impressed on the line at either station. The operation of this relay completes a circuit from the battery 63 at the switch 44 for the winding 49 of the electromagnet 50 in the delay mechanisms 51 at each station and the armature 52 of the magnet forces the pin 53 into contact with the thread of the screw 54 which is driven from the pulley 35 by the gears 60 and 61. The magnet thereupon is carried upwardly until the boss 55 closes the contact 56 and operates the relay 57. The relay springs are arranged so that contact 58 makes before contact 59 breaks so that the relay 57 is locked up independently of contact 56 and the magnet 50 is deenergized by the opening of contact 59 and falls back to its former position. The clutches 14 and 15 are energized by the operation of relay 57 to lock the stylus linkages at each station to the shafts driving the phase shifters. The delay interval may be varied to suit the requirements of the particular system by proper choice of the ratio of the gears 60, 61 or of the position of contact 56 with respect to the screw 54 but in general a few seconds will be sufficient to bring the receiver shifters into phase with those of the transmitting station.

When the transmitting stylus is moved in accordance with the writing to be transmitted the shafts 16 and 17 will rotate the coils 47 and 48 of the phase shifters so that their 200 and 300 cycle output potentials vary in phase in accordance with the component motions of the stylus in the two coordinates. These frequencies of varying phase are fed into the line 3 through the switches 44 and 45 and the amplifiers 39 and 40 and the 100 and 150 cycle frequencies of constant phase from the reproducers 27 and 28 are fed into the line through filters 90 and 91 and the common amplifier 43.

The operation of the receiving system will be more clearly understood by considering the signals as transmitted from station 2 (which is identical with station 1) to station 1. In this case the switches 44 and 45 will be in their receiving positions and the clutches 14 and 15 are assumed to have operated in the manner already described. The telephone set 64 at each station is connected to the line through the filter 65 which is designed to pass only frequencies above about 350 cycles so that the telautograph frequencies from the line will pass through the switch 45 to the filters 67 to 70. Filters 67 and 69 select, and the units 37 and 38 double, the 100 and 150 cycle frequencies

and the resulting 200 and 300 cycle currents are fed through the switches 44 and 45 to the fixed phase shifters 71 and 72 which supply potentials in phase quadrature to the two pairs of stationary coils on the rotary phase shifters 18 and 19 in the well known manner. The filters 68 and 70 pass the 200 and 300 cycle signal frequencies of varying phase from the line to the stationary windings 73 and 74 of the relays 75 and 76. The moving coils 47 and 48 of the phase shifters are connected at this time through the switches 44 and 45 to the moving coils 77 and 78 of the relays 75 and 76.

As soon as the transmitting station (2 in this case) is conditioned for operation and while the transmitting stylus is still in its well 46, all four frequencies 100, 150, 200 and 300 cycles per second are sent over the line and impressed on the receiving mechanism at station 1. If at this time the coils 47 and 48 are in such positions as to have induced in them 200 and 300 cycle frequencies out of phase with those being supplied to the windings 73 and 74 of the relays 75 and 76, these relays will operate to close one or other of their contacts 81 or 82 and 83 or 84 and energize one of the clutch windings 79 or 80 of each of the units 20 and 21 from the battery 63 associated with the switch 44. The discs 26 are therefore magnetically locked to one of the worm wheels of each unit and the shafts 16 and 17 rotate until the phase angle of the potential generated by the coils 47 and 48 of the phase shifters and applied to the coils 77 and 78 of the relays 75 and 76 is in phase with the incoming signals impressed on each relay. When this condition is reached, the springs 85 and 86 will return the relays to their neutral positions and release the clutches of the units 20 and 21. In the meantime the delay mechanism 51 at each station has been energized and sometimes after the phase correction has been completed the clutches 14 and 15 will be operated in the manner already described to lock the stylus at each station to the drive shafts. (If desired suitable means may be provided for locking the stylus in its well until the clutches have operated.) The system is then in condition to receive the signals being transmitted.

The varying phase of the received signal frequencies again unbalances the relays 73 and 74 as in the case of the phase correcting operation already described so that the clutches of the units 20 and 21 are selectively operated to rotate the coils 47 and 48 as before to bring the relays again into balance but at this time the stylus 11 is also driven in accordance with the rotation of the shafts 16 and 17 and reproduces the motion of the transmitting stylus. By proper choice of the ratio of the gears 88 and 89 the rotation of the shafts through a small angle will rotate the phase shifter elements through a large angle so that the receiving stylus can be made to follow accurately very slight movements of the transmitting stylus. Due to this high sensitivity, the receiving phase shifters will follow the motion of the transmitting phase shifters very closely in point of time. The movable elements are free to rotate in either direction and hence will respond to either leading or lagging phase differences. It should also be noted that the rotation of the coils 47 and 48 is limited only by the stylus linkages and the ratio of the gears 88, 89 so that in practice the phase of the potentials generated in these coils will often be varied continuously in one direction through a number of complete cycles.

When transmission is completed the switches 45 and 44 are opened at each station thereby disconnecting the telautograph apparatus from the line and opening the energizing circuit from the battery 63 at the switch 44. This stops the motor 23 and releases the clutches 14 and 15 so that the phase angle between phase shifters at the two stations may be again corrected in the manner already explained before the system is used again.

While the invention has been described with reference to a particular embodiment it will be understood that the system shown may be modified in various ways within the scope of the following claims.

What is claimed is:

1. A telautograph system comprising a transmitting stylus and means for generating and transmitting two pilot frequencies of constant phase and two signal frequencies each varying in phase in accordance with the movement of said transmitting stylus.

2. In a telautograph system, a transmitting station, a receiving station, a line connecting the stations, means for transmitting over the line two signal currents of different frequency and two pilot frequencies, a stylus at the transmitting station, means for varying the phase of the signal currents in accordance with motion of the stylus in two coordinates, means at the receiving station for deriving from the pilot frequencies currents of the same frequency as the signals, a receiving stylus and means operated by differences in phase between the signal currents and those derived from the pilot frequencies for driving the receiving stylus in accordance with the motion of the transmitting stylus.

3. In a telautograph system, a transmitting station, a receiving station, a line connecting the stations, and telautograph apparatus at each station connected to said line, said apparatus including a stylus, two phase shifters having operating shafts, stylus linkages, clutches for locking the linkages to the shafts, and means controlled by current in the line for operating the clutches.

4. A telautograph system according to claim 3 in which the clutch operating means includes means for effecting a predetermined delay in the operation of the clutches.

5. In a telautograph transmitter, a stylus, two shafts, linkages connecting the stylus to the shafts, a rotary phase shifter for each shaft having stationary coils and a movable coil mechanically connected to the shaft and sources of alternating current of different frequencies for energizing the stationary coils of the phase shifters.

6. In a telautograph transmitter, a stylus, means for resolving the motion of the stylus into two component motions, two recordings of different signal frequencies, means for generating alternating potentials from the recordings and means for varying the phase of the potentials in accordance with the component motions of the stylus.

7. A telautograph receiver comprising a stylus and means for driving the stylus in each of two coordinates comprising a shaft, linkages between the stylus and the shaft, a rotary phase shifter having stationary coils and a movable coil mechanically connected to the shaft, a source of alternating current for energizing the stationary coils, and means operated by differences in phase between received signals and the output of the movable coil for rotating the shaft to bring the output of the coil into phase with said signals

8. In a telautograph system, the combination with a transmitting stylus, a line, a means for impressing on the line two potentials of constant phase and two other potentials of different frequency each varying in phase in accordance with motion of the stylus in one of two coordinates, of a receiving stylus, linkages for moving the stylus in two coordinates and means for driving each linkage comprising a pair of oppositely rotating members, a phase shifter having stationary coils energized by one of the potentials of constant phase and a rotary coil mechanically connected to the linkage, a relay operated by differences in phase between the output of the rotary coil and one of the potentials of varying phase for selectively connecting the linkage to one of the oppositely rotating members.

9. In a telautograph system, a recording stylus, a source of alternating current of substantially constant frequency modulated with respect to phase in accordance with signals, a source of unmodulated current of said frequency, and means controlled jointly by currents from said sources for controlling the movement of the recording stylus.

10. In a telautograph system, a transmitting stylus, a receiving stylus, means at a transmitting station for generating an alternating current of substantially constant frequency and an alternating current the frequency of which is a harmonic of the frequency of said first current, means for modulating the current from one only of said sources with respect to phase in accordance with the movement of said transmitting stylus, transmission means for connecting the transmitter with the receiver, and means under control of current from said other source and said phase modulated current for controlling the movement of said receiving stylus.

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