

Jan. 16, 1940.

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2,187,158

TELEGRAPH SYSTEM

Filed Aug. 22, 1936

2 Sheets-Sheet 1

FIG. 1

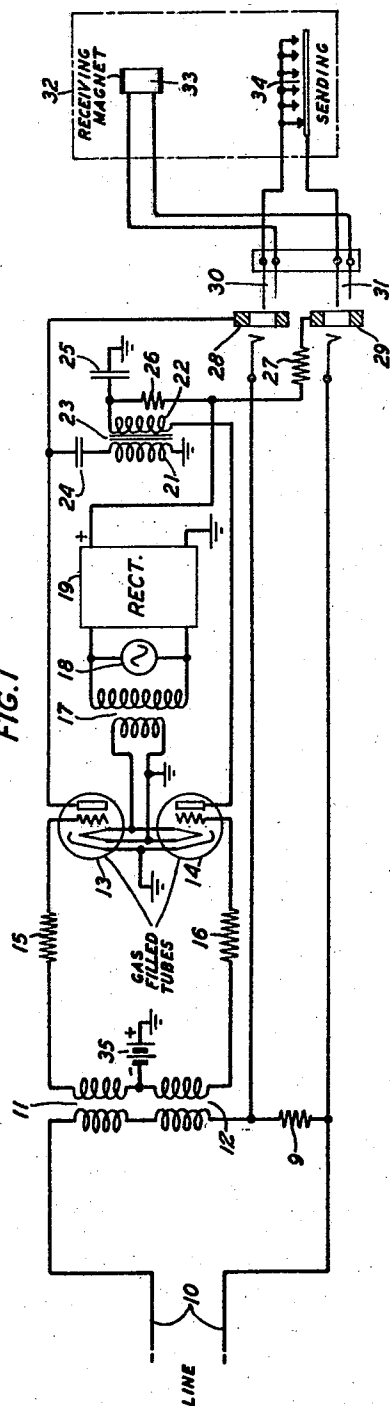
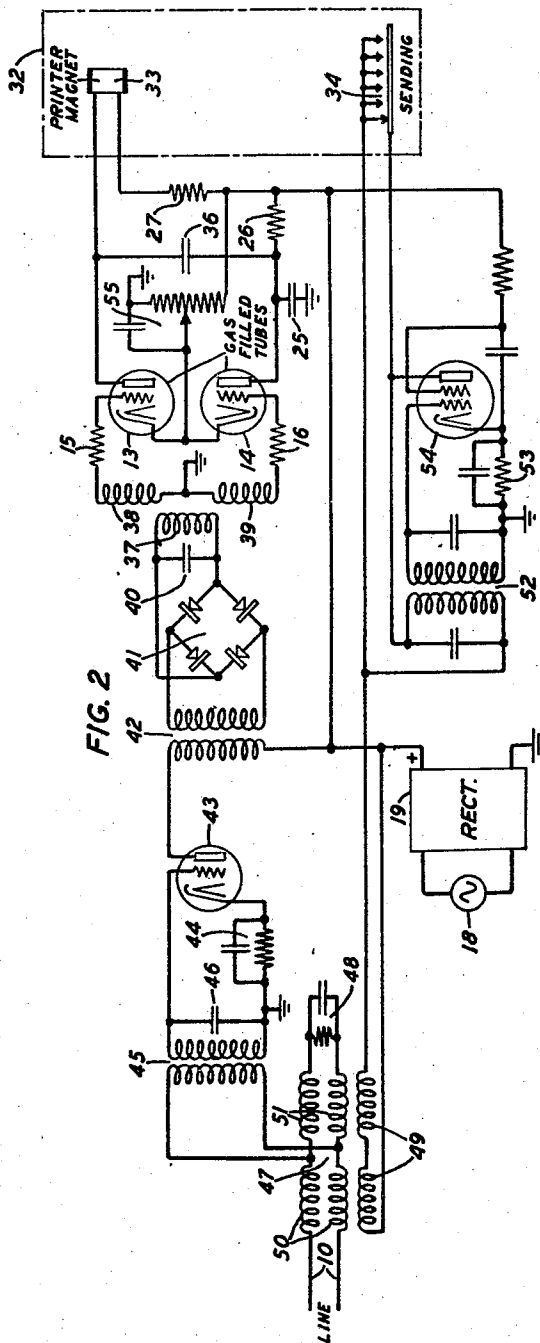


FIG. 2



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2 Sheets-Sheet 2

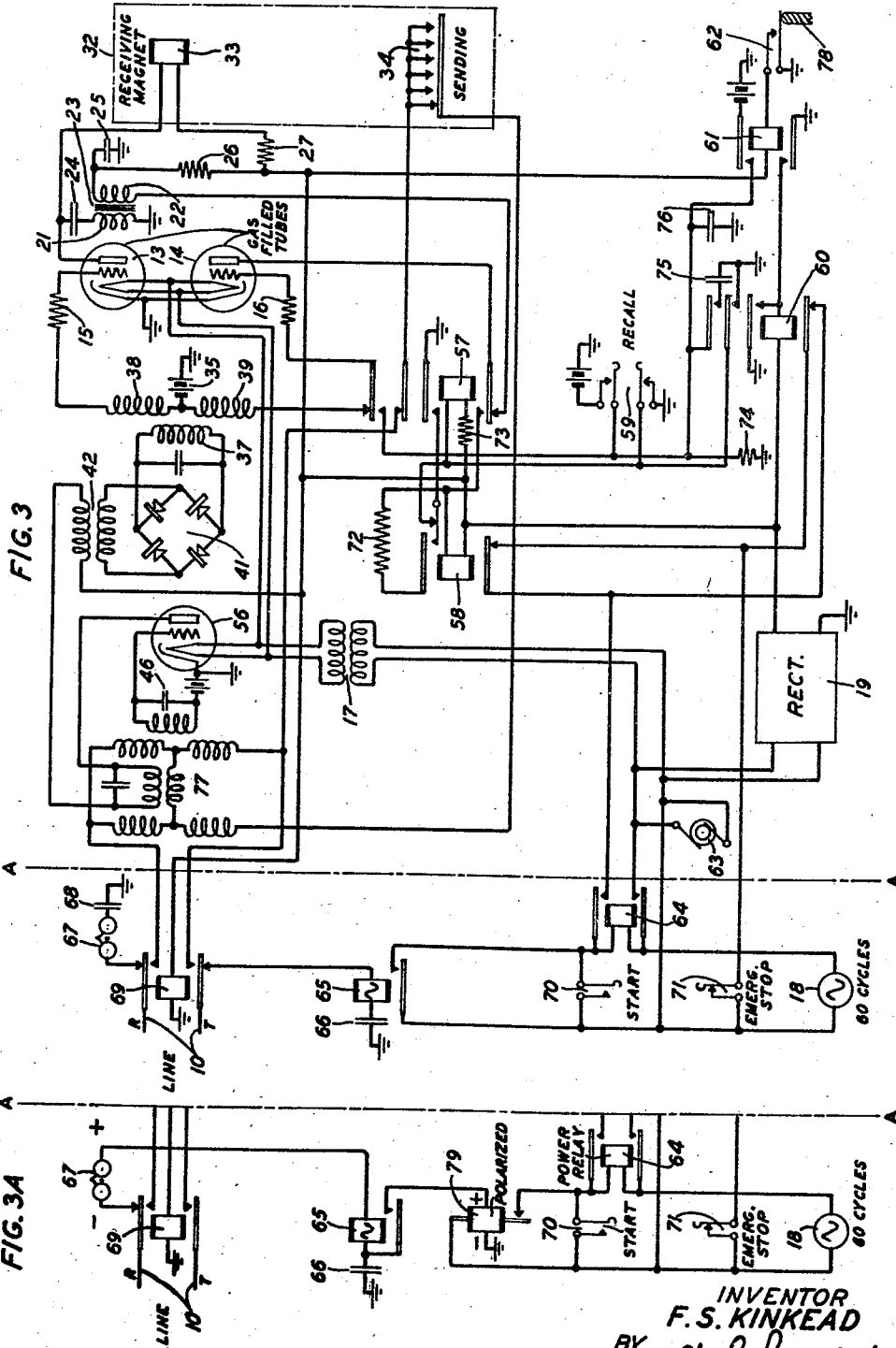


FIG. 3A

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TELEGRAPH SYSTEM

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Application August 22, 1936, Serial No. 97,361

7 Claims. (Cl. 178-70)

This invention relates to telegraph systems and more particularly to telegraph systems subjected to interfering fields employing gaseous conduction tubes.

Gaseous conduction tubes are usually employed in pairs in telegraph systems for repeating telegraph signal impulses. Each tube of a pair usually restores the other tube to its non-conducting condition when it starts to conduct current, and one or both of the tubes serve to repeat the signal impulses.

In telegraph systems subjected to interference and particularly carrier current telegraph systems subject to static interference employing gaseous conduction tubes, the interference frequently renders both tubes conducting at the same time. When this occurs it is necessary to restore one or both tubes to the non-conducting condition by momentarily removing the tube or tubes from the circuit or the potential supplied to the tube before the circuit will again repeat the signal impulses.

It is an object of this invention to provide additional restoring means which is operative to restore one of the tubes after a predetermined interval of conduction independently of the condition of the other tube.

Inasmuch as one of the major reasons for using gaseous conduction tubes in telegraph systems is that they eliminate relay contacts and related trouble and maintenance, a feature of this invention relates to restoring means, the circuits of which are free from relay and other moving contacts, in other words, these restoring circuits are in a state of fixed or unvarying continuity.

The terms, "in a fixed state of continuity", "in an unvarying state of continuity", are used in this application to indicate that during the normal operating conditions of these circuits they are not interrupted by relay or switch contacts and that they do not depend upon the operation of relay or switching contacts for performing their functions. These terms do not exclude relay or switching contacts used to establish the circuits. Neither do they exclude main battery or power supply switch contacts, the contacts in the tube sockets, or other contacts used to establish the various circuits. However, once the circuits are established they remain in a fixed state of continuity during their operation.

In accordance with one embodiment of the invention a pair of gaseous conduction tubes are employed to receive direct current or low frequency telegraph signal impulses. In other em-

bodiments of the invention a pair of gaseous conduction tubes are employed in carrier current telegraph station circuits in combination with high vacuum tubes which act as receiving amplifiers and transmitting oscillators to amplify received carrier current signal impulses and to generate and transmit carrier current signal impulses.

These and other objects and features of this invention, the scope of which is set forth in the appended claims, may be more readily understood from the following description when read with reference to the accompanying drawing in which:

Fig. 1 shows a direct current telegraph subscriber's station circuit employing a pair of gaseous conduction tubes controlled in accordance with this invention for receiving and repeating direct current signal impulses;

Fig. 2 shows a carrier current telegraph station employing a pair of gaseous conduction tubes controlled in accordance with this invention in combination with high vacuum tubes for receiving and transmitting carrier current telegraph signal impulses. In the embodiment shown in Fig. 2 a rectifier is provided for supplying all of the biasing potentials for the various tubes;

Figs. 3 and 3A show a carrier current telegraph subscriber's circuit adapted to transmit and receive both carrier current signaling impulses and also carrier current supervisory impulses employing a pair of gaseous conduction tubes controlled in accordance with this invention, in combination with a single high vacuum tube for amplifying received carrier current impulses and also for generating and transmitting carrier current impulses.

Referring now to Fig. 1 line 10 is from a distant telegraph station and is connected to the primary windings of transformers 11 and 12 and transmitting resistance 9. The sending contacts 34 are connected in parallel with fixed resistance 3 through the tips of jacks 28 and 29 and plugs 30 and 31, it being assumed that these plugs are inserted in the respective jacks to connect the teletypewriter 32 with the station circuit shown in Fig. 1. Resistance 9 is provided to improve the wave shape of transmitted signals. The use of this fixed resistance 9 is possible with sensitive gas-filled tubes 13 and 14 for receiving signal impulses and tends to make the impedance of the line more constant during the transmission of signal impulses. The secondary windings of transformers 11 and 12 are connected to the grids of tubes 13 and 14 through current-limiting re-

distances 15 and 16, respectively. The center point of the secondary windings of transformers 11 and 12 is connected through battery or biasing potential 35 to ground. Battery 35 provides a suitable grid bias for tubes 13 and 14. As shown in Fig. 1 this biasing battery applies a negative potential to the grids of tubes 13 and 14 but may equally well apply a positive potential if tubes 13 and 14 are of a type which requires positive bias on the respective grids. The heaters of tubes 13 and 14 are energized from the source of alternating current 18 through a transformer 17. Rectifier 19 is also connected to the source of alternating current 18 and supplies the plate potential for tubes 13 and 14. Rectifier 19 may include any filter network such as is commonly used to smooth out the rectified current.

Tubes 13 and 14 as shown in Fig. 1 comprise a heated cathode, a heater for heating the cathode, a grid or control member and an anode. These elements are enclosed in an envelope which contains a suitable gas such as mercury vapor or argon at a low pressure. In tubes of this type the grid or control member is usually effective to control the starting of a discharge current between the anode and cathode but is ineffective to stop the current once it is started. Tubes of this type have been called by various names, such as trigger tubes, grid controlled arc discharge tubes, grid controlled rectifiers, thyratrons, etc.

It is to be understood that while three-element gaseous conduction tubes 13 and 14 have been shown in Fig. 1, other types of tubes may be used equally well. For example, directly heated cathodes may be employed or multi-element or screen-grid gas-filled tubes may be employed.

The anodes or plates of tubes 13 and 14 are inductively connected together through windings 21 and 22 of transformer 23 and condensers 24 and 25. The output of tube 13 is connected to the receiving magnet 33 of the teletypewriter 32. The output circuit of tube 14 is provided with resistance 26 which cooperates with condenser 25 in such a way that tube 14 is extinguished a short interval of time after it is rendered conducting. The operation of resistance 26 and condenser 25 to restore tube 14 to the non-conducting condition is independent of the operation of tube 13.

The operation of the sending contacts 34 of teletypewriter 32 in accordance with the signal impulses to be transmitted is well known and need not be described in detail. These contacts transmit the signal impulses by short-circuiting resistance 9 in accordance with the signal impulses to be transmitted in the usual manner and need not be repeated here. A more complete description of suitable teletypewriter apparatus may be found in U. S. Patents 1,595,472 granted August 10, 1926, to H. L. Krum and 1,904,164 granted April 18, 1933, to S. Morton et al. It is to be understood, however, that other teletypewriter apparatus may be used equally well with the circuits shown in the various figures of the drawings.

It is to be noted that the transmitted impulses will affect transformers 11 and 12 in substantially the same manner as the impulses received from line 10 and will actuate the teletypewriter and will cause it to print a "home copy" of the transmitted message.

When power is connected to the tubes 13 and 14 of Fig. 1 either or both of the tubes may become conducting or neither of them may become conducting until signal impulses are received. If tube 13 becomes conducting it remains conduct-

ing until a spacing impulse is received. If tube 14, however, becomes conducting when the power is turned on it will be extinguished a short time afterwards because resistance 26 is of such a value that the potential drop across it rises to such a value that the potential between the anode and cathode of tube 14 falls below the value required to maintain a discharge through tube 14 whereupon tube 14 is extinguished. If neither tube becomes conducting when the power is turned on, the first impulse received will cause the corresponding tube to become conducting and the next impulse of the opposite character will cause the other tube to become conducting, and so on. In order to more fully explain the operation of these tubes in repeating signal impulses assume that tube 13 is conducting, that tube 13 is rendered conducting by marking impulses and that tube 14 is momentarily rendered conducting by spacing impulses. Assume further that the contacts of transmitting device 34 of teletypewriter 32 remain closed during the reception of signaling impulses. This is the normal manner of operation of teletypewriter apparatus.

During the time tube 13 is conducting, a path may be traced from the positive terminal of the rectifier 19 through resistance 27, sleeve of jack 29 and plug 31, the receiving magnet 33 of teletypewriter 32, sleeve of plug 30 and jack 28 to the plate or anode of tube 13. Current flowing in this path causes the receiving magnet 33 to remain operated. When a spacing or no-current impulse is received over line 10 a potential will be induced in the secondary winding of transformer 12 in such a direction as to cause tube 14 to become conducting. Tube 14 in becoming conducting causes condenser 25, which had previously become charged through resistance 26, to discharge through winding 22 of transformer 23 and the anode-cathode circuit of tube 14. The discharge of this condenser 25 through winding 22 of transformer 23 induces a voltage in the winding 21 of transformer 23 which is applied to the anode of tube 13 through condenser 24 in such a direction as to momentarily reduce the potential of the anode of tube 13 below the value required to maintain tube 13 ionized or conducting. Tube 13 will thereupon be rendered non-conducting. A short interval of time later when condenser 25 has been completely discharged tube 14 will also cease to be conducting because the value of resistance 26 is so high that the potential drop across it causes the potential applied to the anode of tube 14 to become less positive than that required to maintain the tube conducting. If the next marking impulse arrives before tube 14 is extinguished as pointed out above it will render tube 13 conducting through transformer 11. Tube 13 in becoming conducting will cause condenser 24, which has become charged during the interval when tube 13 was non-conducting, to discharge through winding 21 of transformer 23 and the anode-cathode circuit of tube 13. The discharge of condenser 24 through winding 21 of transformer 23 will induce a voltage in the winding 22 of transformer 23 which is applied to the anode or plate of tube 14 in such a direction that tube 14 will be extinguished because the anode-cathode potential will be reduced below the value required to maintain tube 14 conducting. In the preferred embodiment of this invention, however, tube 14 becomes extinguished due to the action of resistance 26 and condenser 25 before the arrival of the next marking impulse, when this impulse arrives it will render tube 13 conducting again, 75

but will produce no further effect upon the operation of tube 14, because the potential induced in winding 22 is in such a direction as to reduce the potential applied to the anode of tube 14. This tends to cause the tube to become extinguished and not to become conducting.

When tube 13 is conducting current flows in the printing magnet 33 over the circuit previously traced, and when tube 13 is non-conducting current does not flow in this path. If, as assumed, tube 13 is conducting during the time marking impulses are received over line 10 current will flow through magnet 33 in response to marking impulses received over line 10 and will be interrupted in response to spacing impulses received over line 10 because tube 13 is extinguished during the reception of spacing impulses over line 10.

It is evident that if both tubes 13 and 14 are simultaneously rendered conductive by disturbing voltages induced in line 10, tube 14 will become non-conducting a short interval of time later and that tube 13 will become non-conducting upon the reception of the first spacing impulse so that the system will again become operative and will require no attention either to extinguish one or both of the tubes or to insure that the proper tube is operating at any given time.

The signal impulses arriving over line 10 may either be of current and no-current or they may be positive and negative signal impulses. As shown in Fig. 1, the transmitting contacts 34 of teletypewriter 32 are arranged to transmit signal impulses of current and no-current to line 10. Under these conditions it is the usual practice to receive the same kind of impulses over line 10. It is to be noted, however, that the receiving circuit shown in Fig. 1 will operate equally well with neutral impulses, i. e., current and no-current impulses or polar signal impulses, that is, positive signal impulses and negative signal impulses.

The circuit in Fig. 2 is adapted to receive and transmit carrier current telegraph signal impulses.

The transmitting contacts 34 of the teletypewriter 32 are connected to an oscillator tube 54. During the time these contacts are closed the feedback or plate coil of transformer 52 is short-circuited so that the tube 54 will not oscillate. When these contacts are open, however, tube 54 will oscillate at a carrier current frequency largely determined by the constants of transformer 52 and the condensers connected to its windings. This carrier current is then transmitted through windings 49 of the hybrid coil 47 to line 10 and balancing network 48. In case it is desired to receive a "home copy" of the message currents transmitted over line 10 balancing network 48 is slightly unbalanced so that sufficient energy flows through transformer 45 to actuate amplifier tube 34 which in turn will cause the home printer to be actuated in accordance with the signal impulses transmitted. The operation of the transmitting circuit is well known and need not be repeated in greater detail.

As shown in Fig. 2 the oscillator tube 54 is a pentode tube. It is to be understood, however, that a three-element, four-element or other type of tube may be employed to transmit the signal impulses when it is so desired. As shown in Fig. 2 the plate potential for tube 54 is supplied by rectifier 19 which, in turn, is connected to a source of alternating current 18. Rectifier 19 may be of any suitable type and may include the

usual filters and networks commonly employed in rectifiers for supplying plate battery for vacuum tubes. The filament or heater circuit of tube 54 has not been shown. It is to be understood that this heater circuit as well as the heater circuit for the other tubes 43, 13 and 14 shown in Fig. 2 may be of any suitable or convenient type. These filaments or heaters may be energized from the source 18 of alternating current through a suitable transformer or they may be energized from any other suitable source of electric power.

The carrier current signal impulses received over line 10 pass through windings 50 of hybrid coil 47 and divides part of each impulse passing through coils 51 to balancing network 48. The remaining portion of each of the impulses pass through the primary winding of transformer 45 and induce voltages in the secondary winding thereof which may be tuned to the frequency of the carrier current in any suitable manner as for example by condenser 46. The secondary winding of transformer 45 is connected to the input circuit of amplifier tube 43. Amplifier tube 43 as shown in Fig. 2 is a high vacuum three-element heater type amplifier tube. It is to be understood, however, that other types of tubes may be employed such as directly heated cathode tubes or a multi-element vacuum tube in case higher amplification is desired. As shown in Fig. 2 the grid bias for tube 43 is provided by network 44. The anode-cathode current flowing through this network produces a voltage drop which tends to make the cathode more positive with respect to ground and therefore more positive with respect to the grid. In other words, the grid is more negative than the filament by the amount of voltage drop across network 44. The anode potential is supplied from rectifier 19 in the same manner as it is supplied for the oscillator tube 54.

The received signal impulses are amplified by tube 43 and transmitted through the output transformer 42 to demodulator bridge 41. Here the signal impulses are demodulated and applied to the primary winding 37 of the input transformer of gaseous conduction tubes 13 and 14. Thus when impulses of carrier current are received over line 10 the amplified impulses are applied to the demodulator bridge 41 which demodulates the signal impulses and supplies the low frequency impulses to the primary winding of transformer 37 causing direct current to flow through this winding 37 when carrier current is received from line 10.

As shown in Fig. 2, a single input transformer having windings 37, 38, 39 is provided for applying the signal impulses to the gaseous discharge tubes 13 and 14. It is to be understood, however, that two separate impulse transformers may be employed as shown in Fig. 1 or that a single impulse transformer as shown in Fig. 2 may be employed in Fig. 1 when it is so desired.

The demodulated carrier current flowing in winding 37 of the input transformer induces a voltage in the winding 39 in such a direction as to cause tube 14 to become conducting. If tube 13 is non-conducting at this time no further action takes place until condenser 25 is discharged sufficiently so that the potential drop across it is insufficient to maintain a discharge through tube 14. At this time tube 14 will become extinguished. Resistance 26 is provided to charge condenser 25 during the time tube 14 is non-conducting but is of so high a value that it will not supply sufficient current to maintain the poten-

tial drop across the tube 14 above the critical value required to maintain current flowing between the anode and cathode circuit of the tube. When the carrier current impulse ceases in line 10 the amplified and demodulated current will also cease flowing through winding 37 of the input transformer. This will induce a voltage in winding 38 of the input transformer in such a direction that tube 13 will become conducting. This will cause the current to flow through the anode-cathode circuit of tube 13 and through the printer magnet 33 of the teletypewriter 32 which is in series with the anode-cathode circuit of tube 13. Upon the reception of another carrier current impulse the amplified and demodulated current will again flow through transformer winding 37. This will again cause tube 14 to become conducting. Tube 14 in becoming conductive supplies an extinguishing voltage to the anode of tube 13 through condenser 36 in a well-known manner which causes tube 13 to become non-conducting. A short interval of time later, as previously described, when the potential of condenser 25 falls below a certain value tube 14 will also become non-conducting providing tube 13 has not again become conducting in response to the cessation of the received carrier current signal impulse. If tube 13 becomes conductive before tube 14 becomes non-conductive tube 13 causes tube 14 to be extinguished by applying an extinguishing potential through condenser 36 in a well-known manner.

If, due to some interfering or static potential received from line 10, both tubes 13 and 14 are simultaneously rendered conducting, tube 14 will be extinguished by potential across condenser 25 falling to below the critical value independently of the condition of tube 13. When then an impulse of carrier current is again received from line 10 tube 14 will be rendered conducting and extinguish tube 13 as previously described and the circuits operate thereafter in a normal manner. Thus under these conditions the circuit will automatically resume an operative condition without any attention or maintenance as soon as signal impulses are again received.

It should be noted that the contacts 34 of teletypewriter 32 are shown normally closed in Fig. 2 just as they are shown in Fig. 1. However, when the contacts 34 are closed in Fig. 2 no carrier current is transmitted over the line 10 whereas in Fig. 1 when the contacts are closed direct current is transmitted over line 10. It is to be further noted that as in Fig. 1 tube 13 is normally conducting responds to current in line 10 and causes current to flow through the printer magnet 33 whereas in Fig. 2 tube 13 while normally conducting and causes current to flow through printer magnet 33 it responds to no-current impulse in line 10. However, since the teletypewriter responds in both cases exactly the same a similar type of instrument may be used, the inversion of the impulses in line 10 being accomplished within the circuit of Fig. 2 by, as for example, reversing the circuit connections to the input transformer comprising windings 37, 38 and 39 or demodulator bridge 41 and by the connection to oscillator 54.

A feature of Fig. 2 is that the circuits of all of the tubes are arranged to have all their biasing potentials supplied from a single rectifier source 19. As previously pointed out network 44 provides grid bias for tube 43. In a similar manner network 53 provides the required grid bias for

oscillator tube 54. Network 55 provides, in a similar manner, a bias for the gaseous conduction tubes 13 and 14. However, since neither of these tubes may be conducting for intervals of time, it is necessary to provide a potentiometer arrangement which will insure that there will always be sufficient bias on the grids of the tubes to maintain them in a non-conducting condition.

By suitable choice of the potentiometer resistance, the desired bias under the various conditions of the operation of these tubes may readily be obtained. While similar arrangements for supplying the biasing potentials to the tubes of the other figures have not been shown in the other figures, it is to be understood that the biasing potentials for the tubes shown in the circuits of the other figures may be readily obtained in the same manner by the use of networks such as shown in Fig. 2.

Figs. 3 and 3A show a carrier current teletypewriter subscriber's station circuit which may be connected to a distant teletypewriter switching exchange through intermediate telephone switching exchanges and over telephone wires and equipment similar to the circuit shown in applicant's application Serial No. 11,194 filed March 15, 1935, Patent No. 2,106,352 issued Jan. 25, 1938, but employing gaseous conduction tubes. Gaseous conduction tubes controlled in accordance with this invention have the following advantages: they are sensitive and readily operate a printing magnet in response to attenuated impulses received over such an extended line. However, such an extended line is susceptible to interfering fields, such as static, so care must be taken to prevent improper operation of the tubes due to this static. Means are provided for transmitting carrier current supervisory signals as well as carrier current intelligence signals over the same wires and having the same carrier current frequencies or channels. In addition, the teletypewriter motor control, as well as the control of the various tubes and relays, are shown in Figs. 3 and 3A.

Normally the circuit is as shown in Fig. 3 with all the apparatus unenergized and disconnected from sources of power.

In order to initiate a call, the subscriber momentarily depresses the start key 70 which closes its contacts and causes relay 64 to operate in a circuit through the contacts of key 70, the winding of relay 64 to the source of alternating current 18. Relay 64 in operating locks operated in a path from source 18 through its own winding and upper made contacts, the lower contacts of relays 58 and 60 in parallel, contacts of the emergency stop key 71 to the opposite side of the source of power 18. Relay 64 in operating also connects source 18 to the printer motor 63, to rectifier 19 and to transformer 17. This causes printer motor 63 to operate, rectifier 19 to furnish power for the anode circuits of the various tubes employed and current for the operation of the associated relays. Transformer 17 is provided to change the voltage from source 18 so that it is suitable for energizing the heaters of the cathodes of the various tubes.

When the rectifier 19 has assumed its operating condition and it is supplying voltage to its output leads, it will cause relay 60 to operate in a circuit from positive terminal of the rectifier through the winding of relay 60 to ground and thence back to the grounded terminal of rectifier 19. The operation of relay 60 transfers the T and R leads of line 10 from ringer 67 and relay 75

65 to a bridge network 77 which provides a path for direct current between T and R leads of line 10. This direct current path causes a signal at the telephone or telegraph exchange to which the operators thereat respond.

After waiting a short interval of time during which the cathodes of the tubes employed reach their operating temperature and after a response of the operator or operators, the subscriber will actuate the sending mechanism of teletypewriter 32 to send the desired interconnecting information to the operator at the telegraph switchboard. In sending this information the sending contacts 34 of teletypewriter 32 will be actuated in accordance with the signal impulses to be transmitted. The operation of contacts 34 open-circuit certain coils of the bridge network 77 which causes this bridge to become unbalanced. When this bridge becomes unbalanced it provides a feedback path from the plate circuit of tube 56 to its input or grid circuit which causes tube 56 to oscillate at a frequency determined by the constant of its circuits including condenser 46. The oscillation of tube 56 transmits a carrier current impulse over line 10. A portion of the oscillating current of tube 56 is also transmitted through transformer 42 and demodulating network 41 to tubes 13 and 14 to actuate receiving printer magnet 33 of teletypewriter 32 to print a "home copy" in a manner similar to the manner which will be described hereinafter when the teletypewriter responds to carrier current impulses received over line 10 from a distant point. Tube 56 may be of any suitable type of high vacuum tube capable of both amplifying and oscillating.

As shown in Fig. 3 a heater type cathode three-element vacuum tube is employed. It is to be understood, however, that other types of vacuum tubes may be employed equally well as, for example, if a greater output power or amplification is required, a power output pentode tube may be employed as will be readily understood by anyone skilled in the art.

After the operator at the central station has received the necessary information she will respond by transmitting signal impulses to the subscriber. These impulses arrive over line 10 and are applied to the bridge network 77 and thence to the grid circuit of tube 56 where they are amplified and applied to the output transformer 42. Under these conditions the sending contacts 34 of the teletypewriter 32 are closed so bridge 77 will be substantially balanced. Consequently there will be no feedback path between the anode or output circuit of this tube and its input or grid circuit.

If it is desired, the balance of the bridge or bridge arrangement 77 may be purposely made imperfect so that a small amount of feedback or regeneration between the input and output circuits of tubes 56 is obtained thereby increasing the amplification and output of this tube. However, it is essential that under these conditions the feedback remains below the value necessary to maintain oscillations between the circuits of this tube.

The amplified carrier current signal impulses are applied to demodulating network 41 through transformer 42 where they are demodulated. The resulting low frequency direct current impulses flow through the winding 37 of the input transformer to tubes 13 and 14. Under these conditions tubes 13 and 14 operate in the manner described with reference to Fig. 2 to repeat the signal impulses to the receiving magnet 33

of the teletypewriter 32, each tube serving to extinguish the other when it starts conducting. Tube 14 is provided with additional extinguishing networks comprising resistance 26 in combination with condenser 25 which will extinguish tube 14 a predetermined time interval after it has become conducting independently of the condition or operation of tube 13 should both tubes become conducting at the same time due to any accidental or stray fields being simultaneously applied to the input circuits of both tubes as a starting condition.

After the connection has been established between two telegraph stations similar to Fig. 3 or between Fig. 3 and any other teletypewriter station which is capable of transmitting and receiving telegraph signal impulses through suitable circuits to Fig. 3, the subscribers at the two stations may communicate with each other. During this time the operation of the circuit shown in Fig. 3 will be as described above, sending contacts 34 causing the bridge 77 to be unbalanced whereby tube 56 will act as an oscillator and transmit corresponding carrier current signaling impulses over line 10. Likewise, during the time impulses are being received, amplifier 56 will amplify the carrier current impulses and transmit them to tubes 13 and 14 through transformer 42 and demodulator network 41 to actuate the receiving magnet 33 of the teletypewriter 32.

If at any time either before, during, or after the transmission of signaling impulses between the subscribers' stations, subscriber's station shown in Fig. 3 desires to recall the telegraph switching operator, he will momentarily depress recall key 59. The operation of recall key 59 causes the operation of relay 57 in a circuit traced from ground at the bottom contacts of recall key 59, winding of relay 57, current regulating resistance 73 to the positive terminal of rectifier 19. This causes relay 57 to operate. Relay 57 in operating disconnects the grid circuit of tube 14 from the winding 39 and connects it to resistance 74 and condenser 76. The upper contacts of the recall key 59 charge condenser 76 to a negative potential considerably greater than that required to prevent discharges through tube 14. When recall key 59 is released, condenser 56 will start to discharge through resistance 74.

Relay 57 in operating also open-circuits the lower left-hand coil of the bridge network 77 which will cause tube 56 to become an oscillator and transmit carrier current to line 10 similar to the operation of contacts 34 which open-circuit the same coils or circuits of bridge 77 as described above. The innermost top contacts of relay 57 causes relay 57 to lock up independently of the position of recall key 59 over a path traced from ground through its own contacts, upper break contacts of relay 58, winding of relay 57 through current limiting resistance 73 to the positive terminal of rectifier 19. The lower contacts of relay 57 transfer the plate or anode of tube 14 from the extinguishing circuit of tube 13 to the positive terminal of rectifier 19 through the winding of relay 58. If, as would usually be the case, tube 13 is conducting at the time recall key is depressed it will continue to conduct throughout the time a recall signal is being transmitted to the teletypewriter switching exchange because the extinguishing circuit for this tube is interrupted by the lower contacts of relay 57 as above described.

An interval of time, as for example five seconds, after the recall key 59 is released the

charge on condenser 76 will have been discharged through resistance 74 so that the potential on this condenser will fall to a value to permit or cause a discharge through tube 14. The discharge through this tube will cause relay 58 to become energized.

The operation of relay 58 first completes a locking circuit through its make contact from ground through the innermost top contacts of relay 57 through the made contacts of relay 58, resistance 72, the winding of relay 58 to the positive terminal of rectifier 19. Resistance 72 is also connected in parallel with the anode-cathode circuit of tube 14 and is of such a value as to reduce the potential drop between the anode and cathode of this tube below the critical value required to maintain a discharge through the tube so that the tube is extinguished. The upper contacts of relay 58 in further operating break the locking circuit of relay 57 traced above from ground on its innermost top contacts, through the top break contacts of relay 58 to the winding of relay 57. Relay 57 in releasing closes the circuit of the lower left-hand coil of bridge 77 and thus interrupts the carrier current transmitted to line 10. Relay 57 in releasing also releases relay 58 and restores the signaling circuit to its signaling condition whereupon the operator after having recognized the recall signal will transmit signaling impulses to the subscriber to determine what additional service is required. The subscriber then may communicate with the operator and other subscribers' stations to which he may be connected as hereinbefore described. At the termination of a call, the normal way of restoring the teletypewriter and circuit to normal is to transmit some particular character or group of characters, such as "upper case H". Upon the transmission of upper case "H" all the teletypewriters equipped with the motor stop feature, a code bar or lever 78 will be momentarily actuated. This momentarily closes contact 62 which completes the circuit of relay 61 from ground through contacts 62, winding of relay 61 to the positive terminal of rectifier 19. The operation of relay 61 will through its bottom contact cause the operation of relay 60 in a circuit from ground through the bottom contacts of relay 61, winding of relay 60, the positive terminal of rectifier 19. Relay 60 then locks operated in a circuit from ground through its innermost top contacts and windings to the positive terminal of rectifier 19. Relay 60 in operating connects ground to the winding of relay 57 in the same manner that the recall key connected ground through the winding of this relay and, in addition, connects an additional condenser 75 in parallel with condenser 76. The upper contacts of relay 61 charge both condensers 75 and 76 to a negative potential considerably higher than the potential required to prevent a discharge through tube 14. The ground connected to the winding of relay 57 by relay 60 operates relay 57 and causes the transmission of carrier current signal impulses over line 10 in a manner similar to that above described when recall key 59 was operated. In this case, however, condenser 75 being in parallel with condenser 76 further increases the time required for the potential of these condensers to fall to the value which will permit or cause a discharge through tube 14 to operate relay 58. This longer period of time during which carrier current is continuously transmitted over line 10 is interpreted by apparatus at the teletypewriter switchboard as a disconnect signal so that the

operator will disconnect the subscribers. The operation of relays 57 and 58 are with this exception substantially the same as described when a recall key is operated. However, when relay 58 operates it opens the locking circuit of relay 64 because, under this condition, relay 60 is also operated. Relay 64 in releasing due to the opening of its locking circuit disconnects the source of power 18 from the teletypewriter motor 63, rectifier 19, and the cathode heaters of tubes 56, 13 and 14. When the potential is removed from the rectifier, the potential of the positive terminal falls to zero and relay 60 will release thus restoring the entire circuit to normal.

In case there is trouble which renders the "upper case H" motor start mechanism inoperative, the subscriber may stop the teletypewriter motor and return the circuit of Fig. 3 to normal by momentarily operating the emergency stop key 71. The operation of this stop key opens the locking circuit of relay 64 which causes this relay to release and restores the circuit to normal and stops motor 63 as previously described.

It should be noted that under signaling conditions, that is, the transmission of message current impulses, tubes 13 and 14 are extinguished by circuit arrangements which do not employ relay contacts. The operation of the supervisory relays is much less frequent than the receiving magnet and tubes so that these relays will not require much attention or maintenance.

In order to call the subscriber at station 3, the operator at the central station or switchboard will cause ringing current or alternating current to be applied to one of the conductors of the line, for example the ring R, which will cause ringer 67 to ring in a circuit from the ring R conductor through the winding of ringer 67 to ground through condenser 68. In case the subscriber does not answer and the operator or the station desiring to communicate with the subscriber wishes to leave a message, the operator will apply ringing current to the tip conductor of the line 10 which will apply ringing or alternating current to the tip conductor which will cause relay 65 to operate in a circuit through condenser 66 to ground. The operation of relay 65 will cause relay 64 to operate in a manner similar to the operation of the start key hereinbefore described and the operator or other subscribers of the system may then transmit message currents to the teletypewriter which will be recorded by it after which the teletypewriter station of Fig. 3 may be restored to normal by the reception of a motor stop signal as, for example, "upper case H".

Fig. 3A shows a modified calling arrangement which may be substituted for the arrangement shown in Fig. 3 to the left of the dot-dash line A-A. In the modification shown in Fig. 3A all the calling signals are transmitted over one conductor of line 10, for example the ring conductor R. In case it is desired to merely call the subscriber, alternating current superimposed upon negative direct current is transmitted over this conductor. The alternating current flows through the windings of ringer 67, relay 65 and condenser 66 to ground. Relay 65 operates on the alternating current and connects the winding of polarized relay 79 in parallel with condenser 66. This provides a path of direct current in addition to the alternating current path permitting negative current to also flow over the line and through ringer 67 and relay 65. Ringer 67 is polarized so that it will ring when supplied

with negative current and alternating current Relay 79 is polarized, however, so that it will not respond to negative current. In case the subscriber does not answer, the operator can then apply a positive current in addition to the ringing current to the ring conductor in which case relay 65 again operates and connects the polarized relay winding 79 in parallel with condenser 66. In this case, however, ringer 67 will not respond to positive current plus alternating current flowing through its winding. Relay 79, however, will respond and will close an operating circuit for relay 64 which will lock up and condition the apparatus at the subscriber's station for receiving messages as hereinbefore described.

The choice of the signaling systems shown in Figs. 3 and 3A will depend largely upon the facilities provided for sending ringing current over the various subscriber line circuits at either the telephone exchange or the telegraph exchange through which line 10 passes and is terminated.

While several specific embodiments of the invention have been described, it is obvious that there are many other modifications which will readily occur to anyone skilled in the art. For example, the signaling arrangement shown in Fig. 2 may be employed in combination with the switching and supervisory circuit shown in Fig. 3. Again the circuit shown in Fig. 3 may be adapted to receive all the necessary biasing and other potentials from rectifier 19 as shown in Fig. 2.

What is claimed is:

1. An electric impulse repeater comprising a pair of gaseous conduction tubes, input and output circuits therefor, a source of unidirectional potential connected in said output circuits which has a value greater than zero at all times, means connected to said input circuit to initiate a discharge through either of said tubes, means connected between the output circuits of said tubes to extinguish either one of said tubes when a discharge is initiated through the other of said tubes, and additional means in the output circuit of one of said tubes to extinguish said tube independently of the condition of the other of said tubes.
2. An impulse repeater circuit in a fixed state of continuity comprising a plurality of multi-element gaseous conduction tubes, input circuits therefor for initiating discharges through said tubes, output circuits for said tubes, a source of potential connected in said output circuits which has a value greater than zero at all times, inductive coupling between said output circuits for extinguishing one of said tubes when a discharge is initiated in another of said tubes, and additional means in a fixed state of continuity for extinguishing one of said tubes independently of the condition of said other tubes.
3. An electric impulse repeater for repeating impulses of different character comprising a pair of gaseous conduction tubes, input circuits therefor arranged to initiate a discharge through one of said tubes in response to the impulses of one character and to initiate a discharge through the other tube in response to impulses of another character, output circuits for said tubes, a source of direct current having a value greater than zero at all times during the operation of said tubes connected in said output circuits, circuit instrumentalities connected between said output circuits to extinguish a discharge through either

of said tubes when a discharge is initiated through the other of said tubes, and additional means operating independently of said instrumentalities for terminating a discharge through one of said tubes every time a discharge there-through is initiated.

4. An impulse repeater circuit comprising a pair of gaseous conduction devices, input circuits connected to said devices, output circuits connected to said devices, a source of substantially constant potential having a value greater than zero connected in said output circuits, inductive and capacitive means interconnecting said circuits for extinguishing one of said tubes when a discharge is initiated in the other of said devices, and resistive means connected in a fixed state of continuity to one of said output circuits for extinguishing said one tube a short interval after a discharge is initiated therethrough.

5. A carrier current telegraph station circuit comprising in combination carrier current generating and transmitting apparatus and carrier current receiving and amplifying apparatus including a repeating circuit employing a plurality of gaseous conduction tubes, means for supplying potential to the operating circuits of said tubes which has a value at all times greater than zero, and means in said circuit in a fixed state of continuity operating independently of all of but one of said tubes for rendering the said one tube non-conducting after it has been rendered conducting, and further means in a fixed state of continuity for terminating discharges through any of said tubes when a discharge is initiated through any other of said tubes.

6. A carrier current telegraph station circuit comprising a single electric discharge tube for generating and transmitting carrier current impulses and for receiving and amplifying received carrier current impulses, a rectifying device for demodulating said received and amplified carrier current impulses, a repeating circuit comprising a plurality of gaseous conduction tubes, input circuits therefor connected to said rectifying device, output circuits for said gaseous tubes, a source of substantially constant potential having a value greater than zero connected in said output circuits, circuit elements connected between said output circuits to extinguish a discharge through either of said tubes when a discharge through the other is initiated, and additional circuit means operating independently of said circuit elements for extinguishing a discharge through one of said tubes a predetermined interval of time after said discharge has been initiated.

7. An electric impulse repeater comprising a pair of gaseous conduction tubes, input and output circuits therefor, a source of potential having at all times a value greater than zero connected in said output circuits, means connected to said input circuit to initiate a discharge through either of said tubes, extinguishing means connected between the output circuits of said tubes to extinguish either one of said tubes when a discharge is initiated through the other of said tubes and additional means connected in the output circuit of one of said tubes operating independently of said extinguishing means for extinguishing said one tube.

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