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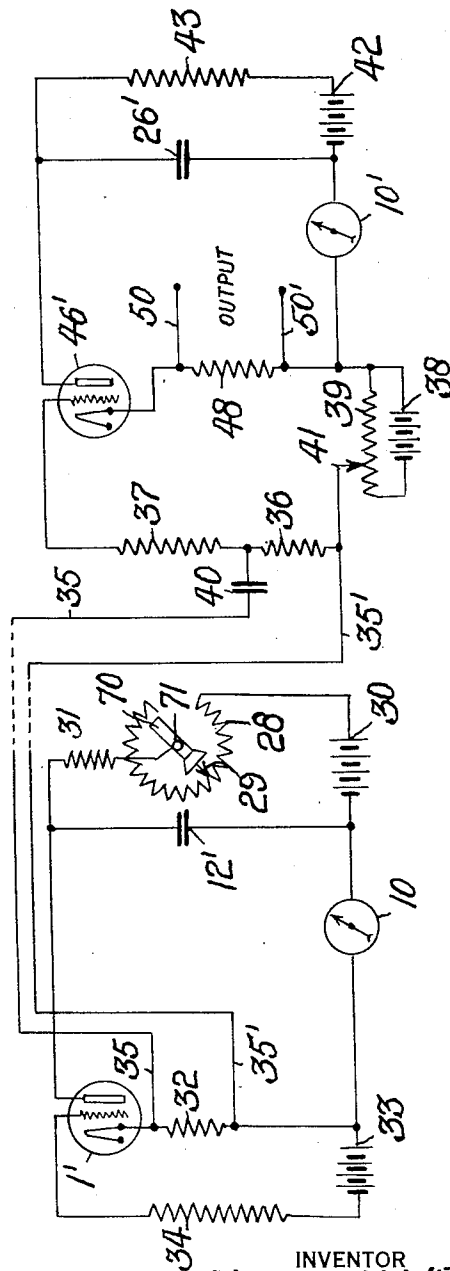
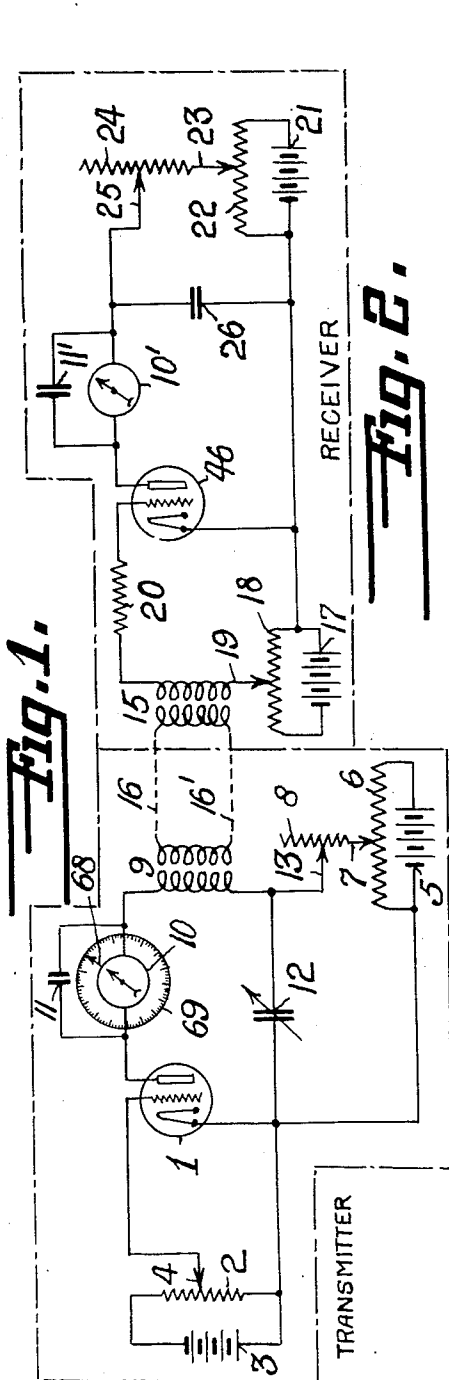
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2,203,478

DATA TRANSMISSION AND CONTROL SYSTEM

Original Filed April 21, 1936

2 Sheets-Sheet 1



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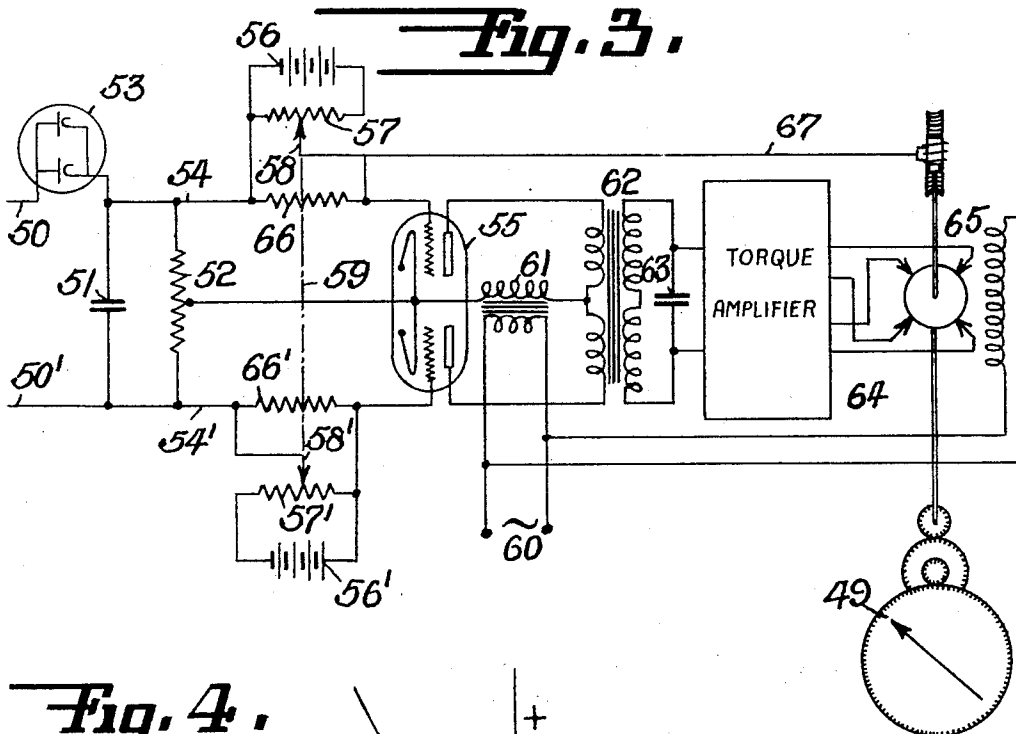
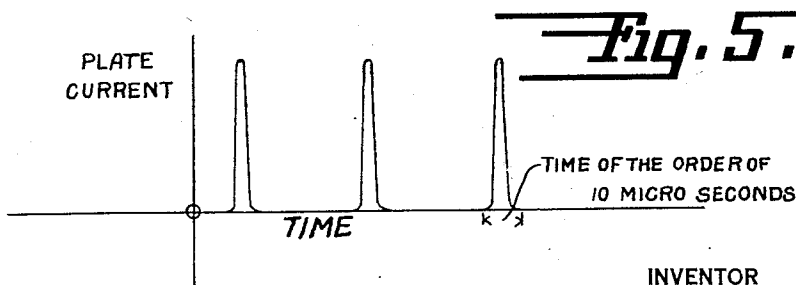
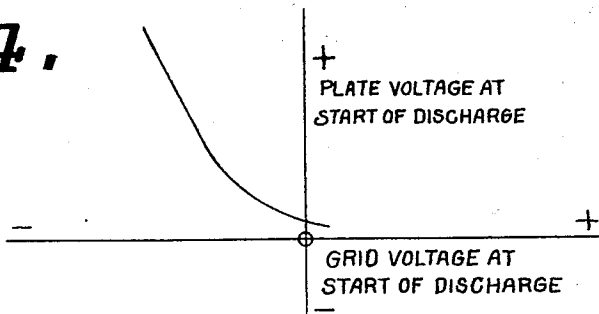


Fig. 4.



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DATA TRANSMISSION AND CONTROL SYSTEM

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4 Claims. (Cl. 172-239)

This invention relates, generally, to data transmission systems, and the invention has reference, more particularly, to a novel variable frequency two-wire data transmission and control system.

Data transmission systems, i. e., systems employed for transmitting various data such as angular data or data that are susceptible of indication on a suitable sheet, card or other member having relative movement with respect to a pointer or other designating means, as heretofore constructed, have generally been more or less complicated in nature and require five or more wires extending between the transmitting and receiving stations in order to function. Ofttimes, five wires are not available for use in transmitting data, when it is not practicable to string five wires from a transmitting station to a receiving station which may be several miles away. Also, such five-wire systems are particularly susceptible to all kinds of interference picked up in the transmitting lines. In such cases, it becomes highly desirable to provide a two-wire data transmission system, and one in which ordinary telephone wires may be used for transmitting the desired data, such wires being usually available in most locations.

The principal object of the present invention is to provide a novel, simply constructed and operated, reliable data transmission and control system, which system employs but two wires extending between the remotely located transmitting and receiving points.

Another object of the present invention lies in the provision of a novel data transmission and control system of the above character wherein a variable transmitting frequency is employed for transmitting the desired data, the said system consisting essentially of a transmitting oscillator of variable frequency and a frequency receiver.

Still another object of the present invention is to provide a novel data transmission system of the above character having frequency responsive meter means connected in the transmitter and receiver circuits, said meter means serving to visually indicate the data transmitted.

A further object of the present invention lies in the provision of a novel data transmission and control system of the above character that is suitable for the remote control of objects from a distance.

Other objects and advantages will become apparent from the specification, taken in connection with the accompanying drawings wherein the invention is embodied in concrete form.

In the drawings:

Fig. 1 is a wiring diagram of one form of the novel data transmission and control system of this invention.

Fig. 2 is a wiring diagram similar to Fig. 1 of a somewhat modified form of the invention.

Fig. 3 is a wiring diagram illustrating the adaptation of the system for controlling a ponderable object from a remote point.

Fig. 4 illustrates the characteristics of the grid controlled rectifier used.

Fig. 5 illustrates the plate current discharge of the rectifier through the ammeter used.

Similar characters of reference are employed in the above views to indicate corresponding parts.

Referring now to Fig. 1 of the drawings, the reference numeral 1 designates a gas-filled grid controlled rectifier tube having its grid connected through an arm 4 of a variable resistance 2 to a C-bias battery 3. The anode of tube 1 is shown energized from a B-battery 5 through a variable resistance 6 having an arm 7, a variable resistor 8 having an arm 13, the primary winding of an output transformer 9, and an ammeter 10 of the D. C. type. Ammeter 10 is preferably shunted by a condenser 11 for bypassing harmonics, although this condenser is not essential. A variable condenser 12 is connected at one side to the plate supply of tube 1 at a point between resistor 8 and the transformer 9, and is connected at its other side to the tube cathode.

The circuit so far described constitutes the transmitter of the system, which transmitter comprises essentially an oscillator or variable frequency generator. The characteristics of the tube 1 are illustrated in Fig. 4 so that the minimum plate voltage at which the tube will start to discharge may be varied by varying the grid bias as determined by the position of resistor arm 4 along resistor 2 and, if desired, by applying sufficient grid bias the tube may be prevented from passing current.

Assuming that the grid has control, the condenser 12 will be charged by current supplied from battery 5 through the resistor 6 and current limiting resistor 8 in the plate circuit. While condenser 12 is charging, the plate voltage applied to tube 1 through the primary of transformer 9 and meter 10 is steadily raised until it reaches a critical value, whereupon the grid loses control and the tube 1 starts to pass current, causing the condenser 12 to discharge through the tube 1. Due to the approximate short circuiting effect of the tube discharge on

the condenser 12, the potential of this condenser, and hence that of the tube plate, drops below that necessary to sustain the discharge in a very short period of time (this period being of the order of microseconds) and before the condenser can recharge due to the resistances 6 and 8, with the result that the tube 1 shuts off and its grid again regains control preparatory to the repetition of the cycle. Thus, the transmitter will oscillate at a frequency determined by three factors, i. e., the values of resistances 6 and 8, the capacity of condenser 12, and the magnitude of the grid potential. Consequently, the frequency of oscillation of the system may be made any desired function of any external device by properly linking the device with either the arm 4 of resistance 2, or the arm 13 of resistance 8 or the variable condenser 12.

The current discharge through the ammeter 10 for a series of oscillations has the characteristics shown in Fig. 5. Oscillographic measurements of this pulsating wave form show that the amount of electricity passed per discharge of the condenser 12 is independent of the frequency of oscillation. Thus, if the ammeter 10 reads I when the frequency is, for example, 20 cycles per second, then if the frequency is raised to 40 cycles per second by decreasing the value of resistance 8, twice as much electricity will be passed per second and the ammeter 10 will read 2I. In other words, a linear relation exists between the ammeter reading and the frequency of oscillation. Thus, by adjusting the position of arm 13, the pointer of ammeter 10 may be caused to follow a pointer 68, if desired, the said pointer 68 being movable over a scale 69 in accordance with changes in the magnitude of any condition or quantity.

The receiver of the system is very similar to the transmitter and comprises an input transformer 15 having its primary winding connected by the two line leads 16 and 16' to the secondary terminals of transformer 9. The line leads 16 and 16' may be any desired length and interconnect the transmitter and receiver stations. In practice it is feasible, in those cases where the transmitter and receiver are miles apart, to use ordinary telephone lines for this purpose. The gas-filled grid controlled rectifier 46 has bias applied to its grid from a C-battery 17 through a resistor 18 having an adjustable arm 19, the secondary of transformer 15 and the fixed grid resistor 20.

The plate of tube 46 is energized from B-battery 21 through resistor 22 having adjustable arm 23, resistor 24 having adjustable arm 25 and ammeter 10' similar to ammeter 10. A fixed condenser 26 is connected to the plate circuit at a point between resistor 24 and meter 10'. The receiver has its grid biased by battery 17 enough to prevent self oscillation. By an inspection of Fig. 4, it will be seen that values of the plate potential and the grid potential of tube 46 may be so chosen that the grid potential is too negative with respect to the cathode for the selected value of the plate potential for any discharge to take place.

If, however, a signal voltage impulse of sufficient magnitude is supplied from the transmitter through leads 16 and 16' and transformer 15 to the grid of tube 46 to decrease the negative potential of the grid to a point below the critical discharge value, then the tube 46 will be rendered conducting and the condenser 26 will discharge through the ammeter 10' in the manner

of Fig. 5. Also, for each successive signal voltage impulse received by the grid, the condenser will discharge through the ammeter 10' and consequently the ammeter 10' serves as an indicator of the frequency of the discharge of tube 46 and hence also serves as an indicator of the frequency of the signal voltage impulses arriving at the grid of tube 46 corresponding to the frequency of oscillation of the transmitter.

For successful operation of the receiver it is merely necessary that the signal voltage impulses arriving at the grid of tube 46 be of sufficient amplitude to trip the tube each time, and actually these voltage impulses may vary in magnitude to a large extent as long as the same remain above such minimum amplitude. Also, it is necessary that the time constant of the condenser resistance circuit, i. e., 22, 24, 26 be sufficiently short so as to insure the charging of the condenser 26 during the period between successive signal voltage impulses. Actually, this time constant is properly chosen for the band of frequencies it is desired to measure. The ammeter range of frequencies may therefore be easily controlled by the use of condensers 26 and resistances 24 of proper value for the range of frequencies desired. Thus, in use, the meter 10' has a reading that is the same as or proportional to the reading of meter 10.

In the form of the invention shown in Fig. 2, the frequency of oscillation of the transmitter is determined by the adjustment of the arm 29 of variable current limiting resistor 28 connected in circuit between B-battery 30 and the plate of grid controlled rectifier 1'. If desired, the arm 29 may be connected to be actuated by any suitable operating means or controlling object, such as the telescope 70 or knob 71. A fixed current limiting resistor 31 is also shown included in circuit between battery 30 and plate of tube 1'. In this form of the invention the condenser 12' is shown fixed, the same being connected as in Fig. 1 to the negative side of battery 30 and to the plate supply at a point between the current limiting resistor 31 and the plate.

A resistor 32 is provided in the cathode portion of the external cathode-plate circuit, i. e., between the cathode of tube 1' and the negative side of battery 30, the resistor 32 being also included between the cathode and the C-battery 33. A fixed resistor 34 is shown connected between battery 33 and the grid of tube 1'. The ammeter 10 is connected in the external cathode-plate circuit at a point intermediate the resistor 32 and the negative terminal of battery 30.

The transmitter output leads 35 and 35' are shown connected to the terminals of resistor 32. The advantage of this arrangement lies in the fact that when the tube discharges, the voltage developed across the resistor 32 serves to drive the grid more negative, thereby causing the grid to resume control in a shorter time than that obtaining in the structure of Fig. 1. The leads 35 and 35' extend to the receiver, where they are connected to the terminals of a resistor 36 that is connected through a resistor 37 to the grid of the grid controlled rectifier 46'. A blocking condenser 40 is shown included in lead 35.

A C-battery 38, bridged by adjustable resistor 39, is connected through resistor arm 41 and resistors 36 and 37 to the grid of tube 46'. The arm 41 is adjusted so that tube 46' is biased enough to prevent self oscillation of the receiver circuit. The B-battery 42 is shown connected through the current limiting resistance 43 to the

plate of tube 46' and a condenser 28', similar to condenser 26 of Fig. 1, is used. The ammeter 10' is connected between battery 42 and the cathode of tube 46'. In the event that it is desired to control a servo mechanism from the receiver, a resistor 48 is included in the external cathode-plate circuit of the tube 46'.

In operation, assuming that the grid of transmitter 1' has control, the condenser 12' will be charged through current limiting resistors 28 and 31 in the plate circuit. While condenser 12' is charging, the plate voltage rises on tube 1' until it reaches a critical value determined by the amount of grid bias on this tube, whereupon the grid loses control and the condenser discharges through the tube. This discharge is accompanied by a decrease in the plate voltage, at which time the grid again assumes control, its control being hastened by the output voltage drop across resistor 32 which momentarily increases the bias on the grid, and thereafter the cycle repeats, the period of the cycle being determined by the setting of resistor arm 29.

The output voltage applied across resistor 32 each time the condenser 12' discharges is transmitted over leads 35 and 35' and applied across the receiver resistor 36, thereby raising the potential on the grid of receiver tube 46', i. e., making the grid less negative, and causing condenser 26' to discharge through tube 46'. Thus, each time that condenser 12' discharges, the condenser 26' is also caused to discharge so that the readings of ammeters 10 and 10' are the same. Hence, by changing the position of arm 29 of resistor 28 in accordance with changes in magnitude of any condition or quantity, the reading of meters 10 and 10' are correspondingly changed, thereby immediately indicating at any desired remote point such change in condition or quantity.

If desired, the system may be employed for controlling a servo mechanism whereby, for example, a ponderable object may be controlled from a remote point. Thus, in Fig. 3, an object 49 is adapted to be controlled from a remote point by means of the novel data transmission and control system of this invention. In this figure, the leads 50 and 50' for supplying a servo system are adapted to be connected to the terminals of the receiver output resistor 48, shown in Fig. 2. The output voltage of the receiver serves to charge a condenser 51 that is shunted by a center-tapped resistor 52.

A twin diode tube 53 is shown inserted between the receiver and the servo-mechanism to prevent condenser 51 from discharging through the receiver cathode resistor 48. The charge built up on condenser 51 discharges slowly through resistor 52 and is applied through leads 54 and 54' to the grids of a twin amplifier type tube 55 connected in push-pull. It is evident that the potential supplied from condenser 51 to the grids of tube 55 acts always in the same direction, though the magnitude thereof will depend upon the frequency output of the receiver and hence upon the frequency of oscillation of the transmitter. Thus, since the potential supplied from condenser 51 serves to always bias one grid of tube 55 positive with respect to the other, it is necessary to apply polarizing grid bias potentials as by means of C-batteries 56 and 56' connected to the terminals of resistors 66 and 66' included in leads 54 and 54'. The values of the respective grid bias potentials are adjustable by use of potentiometers 57 and 57', the arms 58 and

58' of which are connected together in tandem as by suitable linkage 59, whereby the setting of one potentiometer also causes the simultaneous setting of the other.

The plates or anodes of tube 55 are supplied from a commercial A. C. supply 60, such as a 60 cycle 115 volt source, through a transformer 61 having one end of its secondary winding connected to the center-tap of the primary winding of an output transformer 62 that has the ends of its primary winding connected to the plates of tube 55 so that both of these tubes are positive at the same time. The other end of the secondary winding of transformer 61 is connected to the cathodes of tube 55. The cathodes of this tube are connected through resistance 52 and leads 54 and 54' to the grids of tube 55.

A condenser 63 connected across the secondary winding of output transformer 62 serves to improve the wave form of the output. The output of transformer 62 is supplied to a torque amplifier 64 which may be of any suitable type, such as disclosed in the patent to Cooke, Moseley and Frische, No. 2,139,558, December 6, 1938, and is connected to control the driving motor 65 for the driven object 49, such motor being supplied from A. C. supply 60.

In operation, with the net potentials on both grids of tube 55 the same, i. e., with the grids balanced, the net output of tube 55 is zero, but as soon as the frequency of the voltage supplied to the servo apparatus changes corresponding to a change in the position of arm 29 of the transmitter, one of the grids of tube 55 will become more positive than the other, depending on the direction in which arm 29 is moved, with the result that the corresponding plate-cathode circuit of that half of the tube will carry more current than the other half, so that an alternating control potential appears across the output transformer 62. Thus, if the source 60 supplies 60 cycle current, a 60 cycle output will appear across the output of transformer 62. Thus, with one grid made more positive than the other, an output of 180° phase shift is obtained, whereby the phase sensitive apparatus serves to selectively operate motor 65 in either direction.

A follow-up connection 67 is provided between the motor 65 and linkage 59 whereby, as the object 49 is moved into correspondence with the new position of transmitter rheostat arm 29, the bias on the grids of tube 55 will vary to bring the object to rest in desired positional agreement with that of the arm 29.

If desired, the leads 50 and 50' of the detector circuit may be connected directly to the transmitter output leads 35, 35' of Fig. 2, thereby eliminating the receiver, but at the same time eliminating the visual indication provided by meter 10'. Obviously, instead of controlling the transmitter frequency by means of varying the current limiting resistor 28, this may be done by any of the methods explained in connection with Fig. 1. If the two-wire transmission line 16, 16' or 35, 35' should be of such nature as to produce distortion of any form, resulting in harmonics, the same may be eliminated at the receiving end by the insertion of a suitable filter, as is well known to those skilled in the art. It will be apparent that if the length of the transmission line requires it, the variable frequency currents transmitted may be amplified at any desired point or points.

As many changes could be made in the above construction and many apparently widely different embodiments of his invention could be made

without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

Having described my invention, what I claim and desire to secure by Letters Patent is:

1. In a data transmission and control system, a variable frequency transmitter for producing electric signal impulses of changing frequency to correspond to changes in data transmitted, a variable frequency receiver for receiving said signal impulses, said receiver having means for visually indicating the data transmitted, a two wire transmission system interconnecting said transmitter and receiver for transmitting said signal impulses to the latter, and a positional control servo system connected to said receiver to be controlled therefrom, said servo system comprising amplifier tube means fed from said receiver and operating to produce a control potential capable of 180° phase shift, a phase sensitive torque amplifier connected for receiving said control potential, and a servo motor controlled from said torque amplifier.

2. In a data transmission and control system, controlling and controlled objects, a variable frequency transmitter comprising an oscillator circuit and means operated from said controlling object for varying the constants of said circuit to obtain a variable frequency current output for conforming to changes in data to be transmitted, a variable frequency receiver for receiving the variable frequency current output of said transmitter, said receiver comprising an oscillator circuit arranged to oscillate in conformity with the

variable frequency current received from said transmitter, and a positional control servo system connected to said receiver to be controlled by the latter, said servo system comprising amplifier tube means, a torque amplifier, and a servo motor for driving said controlled object, said amplifier tube means serving to detect the variable output of said receiver and to apply the same in 180° out of phase relation to said torque amplifier to control the operation of said servo motor in both directions.

3. In a positional control system for heavy objects, a sending device including a variable frequency transmitter and means for varying the frequency of the impulses produced thereby in accordance with the position of said device, a variable frequency receiver means responsive to the frequency of transmitted impulses, a power motor for driving said object into positional agreement with said device, and a control circuit for said motor, said circuit including a thermionic amplifier fed from said receiver means, means for applying polarized grid bias potentials to said amplifier, and a follow-back connection from said motor to said polarized biasing means.

4. A data transmission and control system as defined in claim 2, wherein said tube means comprises a double triode, a direct current potential means, said double triode having its grids oppositely biased by said direct current potential means and being arranged to receive said control potentials of varying frequency, and a follow-back connection from said servo motor to said potential means.

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