

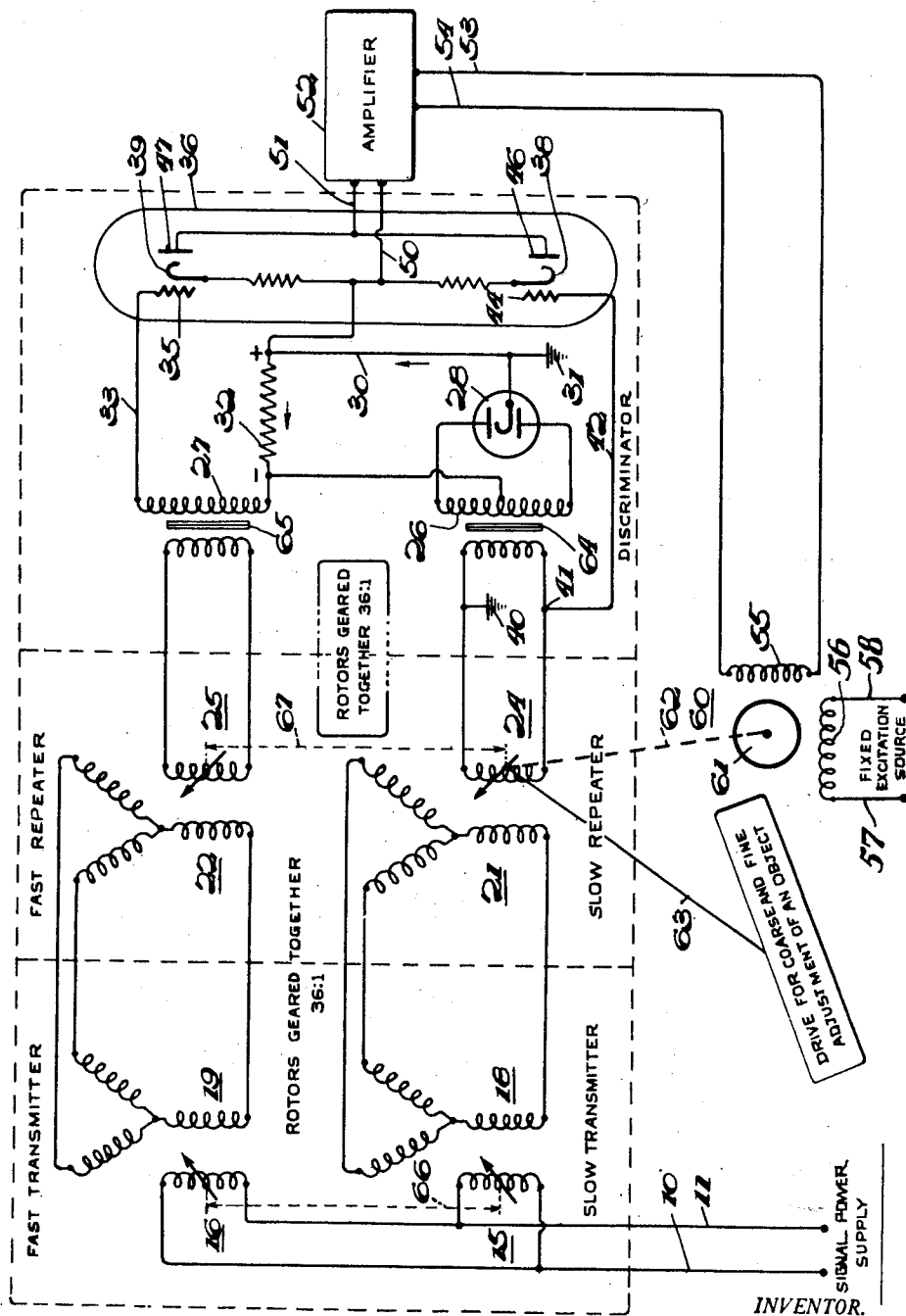
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SERVO SYSTEM WITH FINE AND COARSE ADJUSTMENT

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SERVO SYSTEM WITH FINE AND COARSE
ADJUSTMENTKeith B. Eller, Tenafly, N. J., assignor to Bendix
Aviation Corporation, Teterboro, N. J., a corpo-
ration of DelawareContinuation of application Serial No. 515,286,
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4 Claims. (Cl. 318—30)

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The present invention relates to remote control systems and particularly to a dual self-synchronous electro-mechanical servo control system for selective adjustment of an object to be angularly positioned with precision, and is the same as the invention disclosed in my abandoned application Serial No. 515,286, filed December 22, 1943, in which the following prior art was cited: Mittag, 1,547,435, July 28, 1925; Edwards, 1,985,982, January 1, 1935; Beyerle, 2,184,576, December 26, 1939; Ryder, 2,333,393, November 2, 1943; Agins, 2,409,970, October 22, 1946.

This application is a continuation of the application Serial No. 515,286 mentioned above.

Prior to the present invention, systems having coarse and fine adjustments for compasses, gun mounts, search lights and other remotely positioned apparatus have been relatively heavy and bulky when compared with the present invention, which now provides improvements for such coarse and fine remote positioning of apparatus with a materially simplified discriminator network in place of the prior art systems, which utilized heavy transformers and complex networks to accomplish such results.

Also, in prior systems of this type wherein a slow synchronous self-induction system and a fast synchronous self-induction system are combined, such slow and fast synchronous systems must be kept in synchronism with respect to each other for precision adjustment of a controlled object. Accordingly, it is an object of the present invention to provide novel means for maintaining the slow and fast self-synchronous systems in synchronism with each other at a desired ratio for a prior coarse adjustment and a subsequent fine adjustment.

Another object is to provide a novel electro-mechanical remote control system, which is relatively much simpler in construction, easier to install and more durable than prior systems of this type.

The foregoing and other objects and advantages of the present invention will appear more fully hereinafter from a consideration of the detailed description which follows, taken together with the accompanying drawing, wherein one embodiment of the invention is illustrated by way of example. It is to be expressly understood, however, that the drawing is for purposes of illustration and description only and is not designed as a definition of the limits of the invention.

In the drawing, the single figure is a circuit

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diagram of a system embodying the present invention.

Broadly, the present invention comprises dual self-synchronous transmitter and repeater systems. The two units of the dual transmitter and repeater may have any desirable ratio of operation with respect to each other such as 36:1, so as to provide a prior coarse adjustment system operating from a frequency cycle of one for each thirty-six cycles of the subsequently operated fine adjustment system which remains inoperative until the first system is near synchronism.

The rotors of the transmitters are geared together and the rotors of the repeaters are geared together at a ratio, such as 36:1, for example, so as to drive a follow-up mechanism connected to a polyphase motor through a discriminator unit adapted to provide priority of the coarse signal over the fine signal. When the coarse or slow and fine or fast signal voltages are present at the input of the discriminator network, and a suitable amplifier is connected to the output of the discriminator network, the discriminator circuit becomes energized so as to pass first only the coarse signal voltage and then only the fine signal voltage to drive a polyphase motor. The polyphase motor when thus energized drives first the coarse self-synchronous system to null and then drives the fine self-synchronous system to its null position, to thereby balance both systems at null in synchronism with the newly adjusted position of the transmitters.

Referring now to the drawing, the novel system of the invention may be powered from a suitable alternating current source such as a craft's power supply represented by leads 10 and 11 shown connected to the rotors 15 and 16 which are responsive to any signal introducing means such, for example, as a gyro compass, or a master magnetic compass having a magnet rotatable or driven under the influence of the earth's magnetic field, or the like (not shown). Rotors 15 and 16 are geared together by a mechanical arrangement having a ratio, such as 36:1, so that upon rotation, rotor 16 rotates 36 times as fast as rotor 15. Such ratio of rotation provides a corresponding frequency ratio in the voltage signals induced in the windings of each stator 18 and 19 of the respective slow or coarse and fast or fine transmitters which, as shown, are of the "Selsyn" or "Autosyn" type.

The signal voltage so induced in stators 18 and 19 is introduced correspondingly into repeater stators 21 and 22. This signal voltage will then, through induction be introduced from slow re-

peater stator 21 into slow repeater rotor 24 and from fast repeater stator 22 into fast repeater rotor 25. The receivers 21, 24 and 22, 25 are also shown, by way of example, as being of the "Selsyn" or "Autosyn" type.

Connected to each rotor winding or coil 24 and 25 are transformers 64 and 65 having secondary windings 26 and 27. Winding 26 of transformer 64 supplies signal voltage from rotor 24 to the grids or plates of a rectifier tube 28 having its cathode or exciter filament connected to an output lead 30 grounded at point 31 and includes a resistor element 32 in one side of secondary winding 27 of transformer 65. Winding 26 is divided and connected at the center to one side or negative end of winding or coil 27 and between the latter and the resistor 32 and constitutes a voltage divider.

The secondary winding 27 of the fast speed signal system has the other side thereof tapped by lead 33 to control grid 35 of a tube, such as twin triode or phase shifter tube 36 of a discriminator network including a bias circuit or biasing means such as the resistor element or resistance 32 in one side of the secondary winding of the transformer 65. The circuit is completed to this side of the tube 36 by connection to the other end of resistance 32, which is connected to the output lead 30 and is therefore common to the conducting path of rectifier tube 28.

Rotor winding 24 is grounded at one side as indicated at point 40 and connected at the other side as indicated at point 41 through lead 42 to grid 44 of twin triode tube 36. The double triode or twin tetrode discriminator tube 36 is provided on each side of its exciter or repeater filaments 38 and 39 with the usual plates 46 and 47, which filaments 38 and 39 and plates 46 and 47 of tube 36 are connected to each other, respectively, and tube 36 is thus connected on its output side through leads 50 and 51 to the input side of amplifier 52, which may be of any suitable conventional type.

The output of amplifier 52 is connected by leads 53 and 54 to each side of a winding 55, which is the second phase of a servomotor 60. The first phase of motor 60 comprises a winding 56 which has a phased excitation source which is supplied by the ship's supply line or by any suitable generator system, (not shown) by leads 57 and 58.

Rotor 61 of motor 60 is provided with take-off connections, namely shaft 62 connected, through gearing or the like to rotor 24, which is connected to rotor 25 by gearing or the like, represented diagrammatically by line 62 and line 67. Take off shaft 63 from rotor 24 is adapted to drive any object to be controlled to a position in synchronism with the transmitters of the two systems. The transmitter rotors 15 and 16 are also connected as represented diagrammatically by line 66. The object to be controlled is thus driven to a position in synchronism first with the slow or coarse control side of the system and then by the fast or fine control side of the system. When such position has been reached by the positioned object the transmitter and repeater positioned object positioning systems are maintained in synchronism by the fast or fine control portion of the system.

Briefly summarizing the operation of the combined systems to clearly indicate their differential relations and the novel operation thereof, let us assume that signal voltages having a periodic relation of 36:1 are present at the secondary windings 26 and 27 of transformers 64 and 65, re-

spectively. As long as a signal voltage is present at secondary winding 26, the rectifier tube network automatically introduces a bias voltage, which appears across resistance element 32. This bias voltage is sufficiently high in value so that grid 35 is biased beyond its operating range, thus suppressing or cutting off the fast signal voltage into the amplifier.

While this bias voltage is present, grid 44 connected to rotor winding 24 receives voltage corresponding to the slow or coarse signal voltage and by virtue of amplifier 52 releases power to the second phase winding 55 of the servomotor 60. Power thus introduced into winding 55 operates the motor 60 to drive take-off gearing connections or like mechanism 62 and the object positioning take-off shaft 63, until the rotor 24 is rotated by mechanism 62 to an angle corresponding to the transmitter rotor 15. When such corresponding positions are reached by the rotors 15 and 24, the slow self-synchronous system is near synchronism and no signal voltage is present at grid 44 of tube 36.

Simultaneously there is no voltage induced in winding 26 of transformer 64 and consequently no cut-off bias or fast signal suppressing bias voltage appears across element 32. For this condition of no cut-off bias applied to grid 35 of tube 36, the fast or fine control portion of the system is operative and causes motor 60 to receive power controlled by the fast transmitter.

Having gained control of the power delivered to motor 60 the fast or fine control circuit will maintain the system as a whole in synchronism with the slow and fast self-synchronous systems in synchronism with each other at a desired ratio for a prior coarse adjustment and a subsequent fine adjustment.

As repeater rotors 24 and 25 are geared together, so that rotor 25 rotates 36 times as fast as rotor 24 and correspondingly fast transmitter rotor 16 also rotates 36 times as fast as slow transmitter rotor 15, the signal voltage has a fine sine curve adapted to pass zero for each cycle of rotation 36 times in one sine curve of rotation for the slow self-synchronous system. Thus, when current stops at the null or zero voltage position of the slow system the gear connection 62-67 to the fast system will permit a continued rotation, within limits, of the fast repeater rotor 25 driven thereby before its null or zero voltage position is reached.

For example, for about 5 degrees to either side of the slow system's synchronous position or null point, motor 60 will be energized by the fast system only for a finer positioning of the apparatus being controlled, until the fast system has also reached its null point within this 5 degree cycle period.

Reversal of direction of torque to the induction motor 60 is accomplished by a reversal of phase of the output of the amplifier in accordance with a corresponding reversal of phase of the controlling voltage.

Thus, there is provided a novel dual self-synchronous electromechanical selective remote or servo control and follow-up system, wherein a relatively slow or coarse self-synchronous remote control system connected to a fast or fine self-synchronous remote control system is connected through a novel discriminator network so that said slow system first operates to position an object to the exclusion of the fast system, until it reaches synchronism for its slow or coarse output with respect to the new position of the

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controlled object, whereupon the fast or fine system originally suppressed by the bias voltage from said coarse signal now proceeds to function and drives the object to a finer setting.

Although the present invention is described and illustrated in detail for only one embodiment thereof, it is to be expressly understood that the same is not limited thereto. For example, any desired ratio may be provided for between the coarse and fine systems and any reversible follow-up arrangement may be substituted for that shown in the drawing. Also various changes may be made in design and arrangement of the embodiment illustrated, as will now be apparent to those skilled in the art.

I claim:

1. In a remote control system comprising coarse and fine self-synchronous repeater systems each including a transmitter and a repeater connected in parallel in an electrical circuit having a source of signal power supply and having the rotors of the transmitters and the rotors of the repeaters connected together at a predetermined gear ratio, a pair of transformers connected to the repeater rotors to pass coarse and fine signal voltages introduced by said repeater systems, a rectifier connected to the secondary coil of the coarse repeater transformer and connected to one side of the secondary coil of the fine repeater transformer through a resistor, a twin triode discriminator tube having one grid connected to the other side of the latter secondary coil and another grid connected to the output of the coarse repeater, the secondary coil of the transformer of the coarse repeater having a divided voltage connection with the secondary coil of the fine repeater transformer between said side and said resistor, an amplifier having its input connected to the outputs of the tube, a polyphase motor having a fixed excitation source connected to one phase winding thereof and a second phase winding connected to the output of the amplifier, operative connections between the rotor of the motor and the repeater rotors and an operative connection between the repeater rotors and the object to be adjusted, whereby when coarse and fine signal voltages are introduced by the repeater systems and passed by the transformers, said rectifier automatically introduces a bias voltage across the resistor of sufficiently high value to bias the grid connected to the secondary coil of the fine repeater transformer beyond its operating range to suppress the fine signal voltage into the amplifier and cause the motor to drive only the coarse repeater rotor by the coarse signal voltage to a position near synchronism with the rotor of the transmitter thereof and then cause the motor to be driven by the fine signal voltage before and after the coarse repeater system is deenergized and subsequently drive the fine repeater rotor until the same is in synchronism with the transmitter rotor thereof to a finer adjustment of the object than obtained by the coarse repeater rotor.

2. In a system for controlling movement at a remote point, the combination with means for introducing slow signal voltage having a wound transmitter rotor and a wound receiver rotor and means for introducing a fast signal voltage having a wound transmitter rotor and a wound receiver rotor, each of said transmitter rotors being connected together so as to provide a ratio of one greater than that of the other, and each of said receiver rotors being connected together at a ratio similar to said transmitter rotors to provide

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a faster signal voltage in the winding of one receiver rotor than in the other, a polyphase motor having one phase thereof connected to a fixed source of power, a rectifying and discriminator network connected to the outputs of the receiver rotors, an amplifier connected to said outputs, the other phase of the motor being connected to the output of said amplifier, drive means connecting said motor and said receiver rotors to drive the same in synchronism at the ratio specified, and drive means connecting said motor to an object to be controlled at a remote point, said network including electric valve means for controlling said signal voltage in each of the receiver rotor windings, comprising a pair of transformers each having the primary winding thereof connected to an output of a repeater rotor, a thermionic tube having a pair of grids one of which is connected to the secondary winding of the transformer into which the fast signal voltage is introduced and the other connected to the secondary winding of the transformer into which the slow signal voltage is introduced, and a bias circuit network connected to the secondary winding of the slow signal voltage transformer and to one side of the secondary winding of the fast signal voltage transformer so that when said voltages are introduced into said secondary windings, said bias network feeds back a bias voltage through said fast signal voltage secondary winding of sufficiently high value to suppress the fast signal voltage present therein and pass only slow signal voltage to the motor winding connected thereto to drive said motor until said slow signal voltage receiver rotor approaches the same angle of position as the transmitter rotor connected thereto to deenergize said slow receiver rotor to thereby cut out said bias voltage and pass only fine signal voltage to the motor to further drive the fast receiver rotor until the same is in the same angular position as the transmitter rotor connected thereto for a fine adjustment of said object.

3. In a system for controlling movement at a remote point, the combination with means for introducing slow signal voltage having a wound transmitter rotor and a wound receiver rotor and means for introducing fast signal voltage having a wound transmitter rotor and a wound receiver rotor, signal power supply means connected to said transmitter rotors, each of said transmitter rotors being connected together to provide a ratio of one greater than the other and each of said receiver rotors being connected together at a ratio similar to the transmitter rotors to provide a faster signal voltage in the winding of one of the receiver rotors than in the other, a polyphase motor having one phase thereof connected to a fixed source of power, means connecting said motor and said receiver rotors together to correct for variations between the transmitter rotors and receiver rotors of each respective signal voltage introducing means, means connecting said motor and an object to be controlled at a remote point through the slow receiver rotor; of electric valve means for controlling said signal voltage in each of said receiver rotor windings comprising a pair of transformers each having the primary winding thereof connected to the output of a receiver rotor, secondary windings across each of said primary windings, a thermionic tube having a pair of grids one connected to said fast transformer secondary winding and the other connected to the output of said slow signal voltage rotor, a rectifier tube having plates connected to the sides

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of the slow signal voltage secondary winding and its output connected to one side of the fast transformer secondary winding, a resistance in said rectifier output circuit, an intermediate point of the slow transformer secondary winding connected to said side of the fast transformer secondary winding, and an amplifier connected to the output of the thermionic tube, the output of the amplifier being connected to another phase of said polyphase motor, whereby when slow and fast signal voltages are inductively introduced into said secondary windings at a ratio stated, a bias voltage is automatically introduced across said resistance of sufficiently high value to bias the grid connected to the fast transformer secondary winding beyond its operating range, cut off the fast signal voltage into the amplifier and cause the grids to receive and pass slow signal voltage to the amplifier and thence to the second phase of the motor to drive the latter and the slow receiver rotor and object to be controlled until the slow receiver rotor is near a position in synchronism with the position of its corresponding transmitter rotor and until said positions correspond to thereby cut off said slow signal voltage and pass only the fast signal voltage to drive said motor and said fast receiver rotor further until its position corresponds to the position of the fast transmitter rotor and correspondingly cause a finer adjustment of the object being controlled.

4. In a remote control system comprising coarse and fine self-synchronous repeater systems each including a transmitter and a repeater connected in an electrical circuit having a source of signal power supply and having the rotors of the transmitters and the rotors of the repeaters connected together at a predetermined gear ratio, a pair of transformers connected to the repeater rotors to pass coarse and fine signal voltages introduced by said repeater systems, a rectifier connected to the secondary coil of the coarse repeater transformer and to one side of the secondary coil of the fine repeater transformer through a resistor, a pair of electronic control devices, the input of one of said control devices being connected to the other side of the secondary coil of the fine repeater transformer and the input of said other

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electronic control device being connected to the output of the coarse repeater, the secondary coil of the coarse repeater transformer having a divided voltage connection with the secondary coil of the fine repeater transformer at the point where the secondary coil of the fine repeater transformer is connected to said resistor, a thermionic amplifier having its input connected to the outputs of said pair of electronic control devices, a polyphase motor having one phase thereof connected to a fixed excitation source and another phase connected to the output of said amplifier, and operative connections between the rotor of the motor, the repeater rotors and the object to be adjusted, whereby when coarse and fine signal voltages are introduced by the repeater systems and passed by the transformers, said rectifier automatically introduces a bias voltage across the resistor of sufficiently high value to bias the electronic control device connected to the secondary coil of the fine repeater transformer beyond its operating range to suppress the fine signal voltage and prevent it from being impressed on the amplifier, thereby causing the motor to drive the coarse repeater rotor by the coarse signal voltage to a position near synchronism with the rotor of the transmitter thereof and then causing the motor to be driven by the fine signal voltage before and after the coarse repeater system is deenergized and subsequently driving the fine repeater rotor until the same is in synchronism with the transmitter rotor thereof to a finer adjustment of the object than obtained by the coarse repeater rotor.

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The following references are of record in the file of this patent:

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