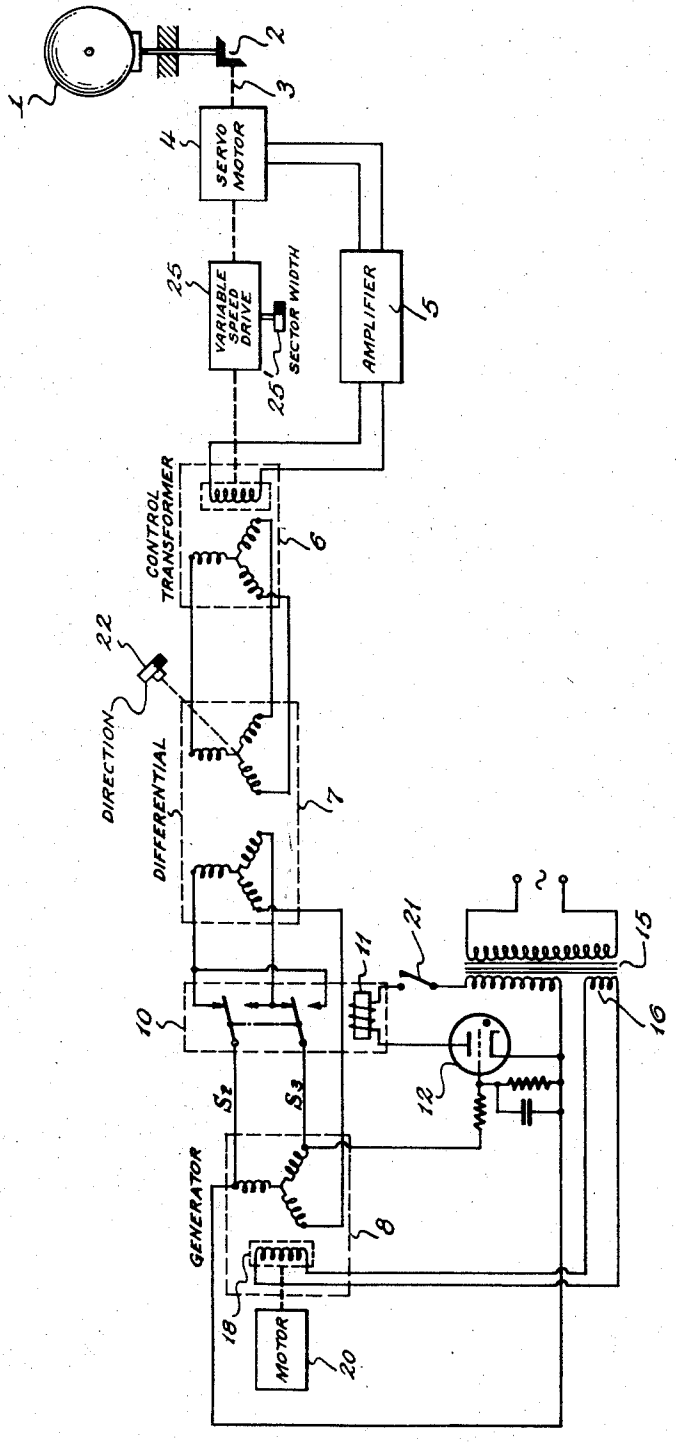
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REVERSIBLE SERVO APPARATUS

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REVERSIBLE SERVO APPARATUS

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1

This invention relates to servo mechanism apparatus and more particularly to reversible drives for such apparatus.

In the operation of search radar systems and other detection systems, it is frequently desirable to rotate an antenna about a reference axis. For instance, in conventional search radar, the antenna rotates about a vertical axis and receives signals from all azimuthal directions successively. Such an antenna may be arranged to rotate continuously by rotating it with an electric motor in a conventional manner. The angular direction of received signals are conveyed to the radar indicator by means of synchros or selsyns, also in a conventional manner.

Frequently, it is desirable to pay particular attention to a certain direction, rather than the entire 360°, and in such cases, it is desirable to drive the antenna so it will scan back and forth through a certain sector rather than completely around. It is also desirable to be able to position the average direction of this sector scanning and vary the width of the sector.

Accordingly, a principal object of the invention is to provide new and improved sector scanning apparatus for servo mechanisms.

Another object of the invention is to provide new and improved sector scanning apparatus wherein the scanning direction is adjustable.

Another object of the present invention is to provide new and improved sector scan apparatus, wherein the sector width is adjustable.

Another object is to provide new and improved apparatus for affording a smooth reversing drive for angular rotation apparatus.

Another object of the present invention is to provide a new and improved reversible drive.

These and other objects will be apparent from the following specification and the drawing, which is a schematic diagram of an embodiment of the invention.

Referring to the drawing, the rotatable member 1 is adapted to be rotated about its vertical axis by means of the gear 2 and drive shaft 3. The rotatable member 1 may be a radar antenna or other device having directivity, such as a searchlight. However, the invention is not limited to antenna driving systems, but it may be used wherever it is desired to obtain a back and forth angular motion.

The rotatable member 1 is driven by the motor 4, which is energized by servo amplifier 5, which, in turn, is energized by the error signal derived from the synchro control transformer 6. The servo loop comprising control transformer 6, amplifier 5 and motor 4 is entirely conventional and need not be discussed in detail in order to understand the operation of the present invention. It may be mentioned at this time that all the rotatable transformers, generally known as synchro or selsyn elements, mentioned in this discussion are conventional and commercially available. Synchros are well known and are theoretically treated as salient pole, bipolar, alternating current excited, synchronous machines. The standard synchro has a two-pole single phase rotor field and a Y-connected single phase variable voltage stator. If the rotor is mechanically driven, the device is generally called a synchro generator, and if a mechanical output is taken from the rotor, the device is generally referred to as a synchromotor.

2

The synchro control transformer 6 has a Y-connected input, which is connected to a Y-connected output from synchro differential 7. Differential 7 has a Y-connected input, which is connected to synchro generator 8 through the reversible contacts of relay 10. The relay 10 is connected to reverse the connections of two of the leads connecting differential 7 and generator 8. The effect of this reversal will be to reverse the direction of rotation of the rotatable member 1.

The discussion thus far describes entirely conventional apparatus. The present invention resides primarily in the means for providing the smooth reversal, sector scan control signals to the above mentioned conventional apparatus. It has been noted that the action of the relay 10 will cause a reversal in direction of rotation of the rotatable member 1. The relay coil 11 is adapted to be energized by the thyratron switch tube 12, and in order to provide smooth reversal of the rotation, it is desirable that the connections be reversed by relay 10 when there is zero voltage existing between the leads S2 and S3 of synchro generator 8, otherwise the result will be erratic and jerking motion of member 1. This point will be discussed more fully in connection with the further operation of the circuit.

The plate of thyratron 12 is adapted to be energized by an alternating voltage through transformer 15. This voltage is also connected through secondary coil 16 to the rotor 18 of the synchro generator 8. The rotor 18 is mechanically connected to a constant speed motor 20.

In order to understand the operation of the invention, it may be advisable at this point to say a few words about the voltages appearing in synchros. Due to the way the rotor and stator windings are arranged on a standard synchro,

these curves have the shape of a sine-curve. In other words, they would look like time-graphs of sinusoidal voltages. They show something entirely different, however, and should not be confused with time-graphs. In thinking about a synchro system, remember that all of the voltages in the system are alternating, varying positive and negative X times per second, that they are either in phase, or 180° out of phase with each other. Their effective values vary, for various positions of the rotor, from zero to positive (in phase) maximum, to zero, to negative (out of phase) minimum and back to zero, in sinusoidal fashion.

The switch 21 connects the output from the secondary of transformer 15 through the relay coil 11 to the plate of the thyratron 12. When the switch 21 is open, the thyratron will not operate and the rotatable device 1 will rotate continuously in one direction synchronously with the constant speed motor 20. This operation is completely conventional and may be briefly described as follows. As the constant speed motor 20 rotates, the rotor 18 applies continuously varying voltages to the Y-connected stator of generator 8. These voltages are connected through differential 7 to control transformer 6. The rotor of control transformer 6 is mechanically connected to the rotatable member 1. The servo arrangement is designed so that if there is any non-correspondence between the ordered direction and the actual direction of rotatable member 1, then there will be an error signal generated in control transformer 6, which is applied to the motor 4 through the amplifier 5, so as to drive the rotatable member 1 into angular correspondence with the direction ordered by synchro generator 8. Since the input of synchro generator 8 rotates at constant speed by means of motor 20, the rotatable member 1 will be driven at constant speed.

The sector scan feature of the present invention is provided by the thyratron switch tube 12 and is initiated by closing the switch 21. There is an alternating voltage applied to the plate of thyratron 12 and to the rotor 18 of generator 8, and the voltage between leads S2 and S3 of generator 8 are applied to the grid of thyratron 12. The voltage applied to the grid of the thyratron 12 is either in phase or 180° out of phase, with the voltage applied to the plate depending upon the position of the rotor 18.

Assuming that the rotor position is such that the grid voltage is out of phase wtih the plate voltage, the thyratron is cut off. The constant speed motor 20 will gradually turn the rotor 18 to a position where the out of phase voltage between leads S2 and S3 is zero. At this point, the voltage between leads S2 and S3 changes 180° in phase and is now in phase with the voltage applied to the plate of the thyratron, and the thyratron will now conduct. This will energize relay 10, which will reverse the connections of the leads from S2 and S3 of generator 8. This action will reverse the rotation of the rotatable member 1. The thyratron will conduct until its plate voltage drops to the extinction voltage, at which time the relay will be de-energized, and the connections will be reversed to their original positions, again reversing the rotation of the rotatable member 1, to provide a sector scan motion.

The datum direction about which the sector scan movement takes place, that is the average direction of the sector, may be chosen by rotating the knob 22, which is mechanically connected to the Y-connected output of synchro differential 7. The rotation of the knob 22 causes a relative motion between the input and output members of the differential 7 thereby changing the angular reference direction.

The width of the sector scan may be varied by changing the variable speed drive 25, by means of knob 25'. The variable speed drive may be a ball and disc device, a transmission system having variable gear ratios or other conventional variable speed arrangements. The effect of this adjustment is that a complete cycle of the constant speed motor may provide an adjustable angular rotation of the rotatable member 1. For instance, if there is a 36 to 1 ratio in the variable speed drive 25, then a half revolution of the constant speed motor 20 will only rotate the rotatable member through a sector of 5°. The variable speed drive is preferably connected as shown before the servomotor as this arrangement only puts a light load on the variable drive. The variable speed drive could be connected to the output of the servomotor if desired.

An important advantage of the invention is that the reversal of connections takes place at zero voltage between them. Therefore, it is a smooth change and there is no jumping or jerking of the rotatable member 1. It comes to a smooth stop and starts again smoothly in the opposite direction.

Other equivalent means may be substituted for various components of the invention. For instance, other types of control means may be substituted for the thyratron 12 or other types of electronic tubes might be utilized in a similar circuit. Also different servo mechanism arrangements may be used.

The invention is not limited to rotating an antenna but may be used as a general power control circuit. It will be advantageous, for instance, in a steel rolling mill, a textile rolling or pressing machine, a gun control system or wherever a smooth reversal of a power drive is desired.

What is claimed is:

1. Means to effect smooth reversals of a servo system of the type utilizing rotary transformers with Y-connected stators for the transmission of angular information, comprising switching means connecting two of said rotary transformers and adapted to reverse two of the leads from said Y-connected stators, and control means connected and adapted to energize said switching means when the voltage between said two leads is substantially zero.

2. Means to effect smooth reversals of a servo system of the type utilizing rotary transformers with Y-connected stators for the transmission of angular information, comprising switching means connecting two of said rotary transformers and adapted to reverse two of the leads from said Y-connected stators, and control means connected and adapted to energize said switching means when the voltage between said two loads is substantially zero, comprising a multi-element electron discharge tube having its output connected to said switching means and having its input connected across said two leads.

3. Sector scan apparatus comprising a load member adapted to rotate about an axis, servo motor means connected and adapted to rotate said load member, means connected to apply a sector scan control signal to said servo motor comprising a control transformer having a Y-connected input and having its output connected

to said servo motor, and circuit control means connected and adapted to reverse two leads of said Y-connected input at the moment when the voltage between them is substantially zero, to thereby provide a smooth reversible drive to said load member.

4. Apparatus as in claim 3 wherein said circuit control means comprises a relay switch connected to reverse said two leads, a switch tube connected and adapted to energize said relay and triggering means connected to trip said switch tube when the voltage between said leads is substantially zero.

5. Apparatus as in claim 4 wherein said triggering means comprises a synchro generator having a Y-connected output, two leads of which are connected to said relay switch, a constant speed motor connected to and adapted to rotate the rotor of said synchro generator, said two leads being connected to the input of said switch tube whereby the switch tube is tripped when the voltage between said two leads is substantially zero.

6. Means to effect smooth reversals of a servo system of the type utilizing rotary transformers with Y-connected stators for the transmission of angular information, comprising switching means connecting two of said rotary transformers together and adapted to reverse two of the leads from said Y-connected stators, control means connected and adapted to energize said switching means when the voltage between said two leads is substantially zero, comprising a multi-element thyratron type tube connected to said switching means, means to apply an alternating voltage to the plate of said thyratron tube, and means to apply to the grid of said tube a version of said alternating voltage that is periodically in phase and 180° out of phase.

7. Alternating voltage switching means adapted to be energized when said alternating voltage is substantially zero comprising a rotary transformer having at least two output leads, relay means connected to said output leads and adapted to reverse them, a control tube having a cathode, grid, and plate and adapted to energize said relay means, means to energize the plate of said control tube and said rotary transformer with an alternating voltage, means to rotate the rotor of said rotary transformer, and means connecting said two output leads between said grid and plate whereby said tube is energized when the voltage across said two leads is substantially zero.

8. A reversible drive for a servo system of the type utilizing rotary transformers with Y-connected stators for the transmission of angular information, comprising switching means connecting two of said rotary transformers together and adapted to reverse two of the Y-connected leads from said rotary transformers, control means connected and adapted to energize said switching means when the voltage between said two leads is substantially zero.

9. A reversible drive for a servo system of the type utilizing rotary transformers with Y-connected stators for the transmission of angular information, comprising switching means connecting two of said rotary transformers together and adapted to reverse two of the Y-connected leads from said rotary transformers, control means connected and adapted to energize said switching means when the voltage between said two leads is substantially zero, comprising a multi-element electron discharge tube having its output connected to said switching means and having its input connected across said two leads.

10. An oscillatory power drive for a system of the type utilizing rotary transformers with Y-connected stators for the transmission of angular information; comprising switching means connecting two of said rotary transformers together and adapted to reverse two of the leads from said Y-connected rotary transformers, control means connected and adapted to energize said switching means when the voltage between said two leads is substantially zero, comprising a thyratron type tube, means to apply an alternating voltage to the plate of said thyratron tube, and means to apply to the grid of said tube a version of said alternating voltage that is periodically in phase and 180° out of phase.

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