June 2, 1959 D. SIGEL 2,889,505

DIGITAL-TO-SHAFT POSITION INFORMATION TRANSLATOR

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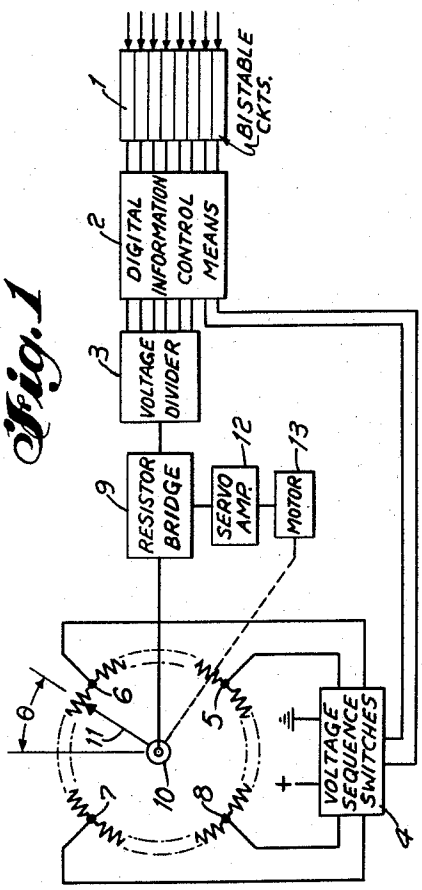
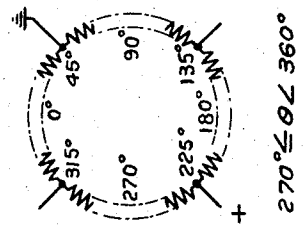
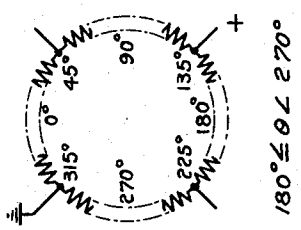



Fig. 1



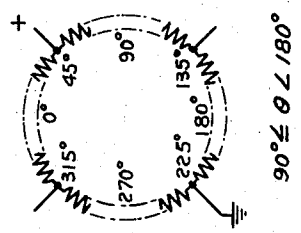

$270° \leq \theta \leq 360°$

Fig. 2D



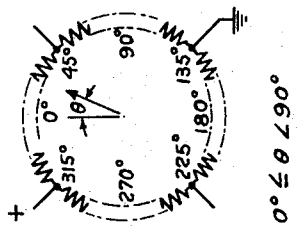

$180° \leq \theta \leq 270°$

Fig. 2C




$90° \leq \theta \leq 180°$

Fig. 2B




$0° \leq \theta \leq 90°$

Fig. 2A

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Fig. 4

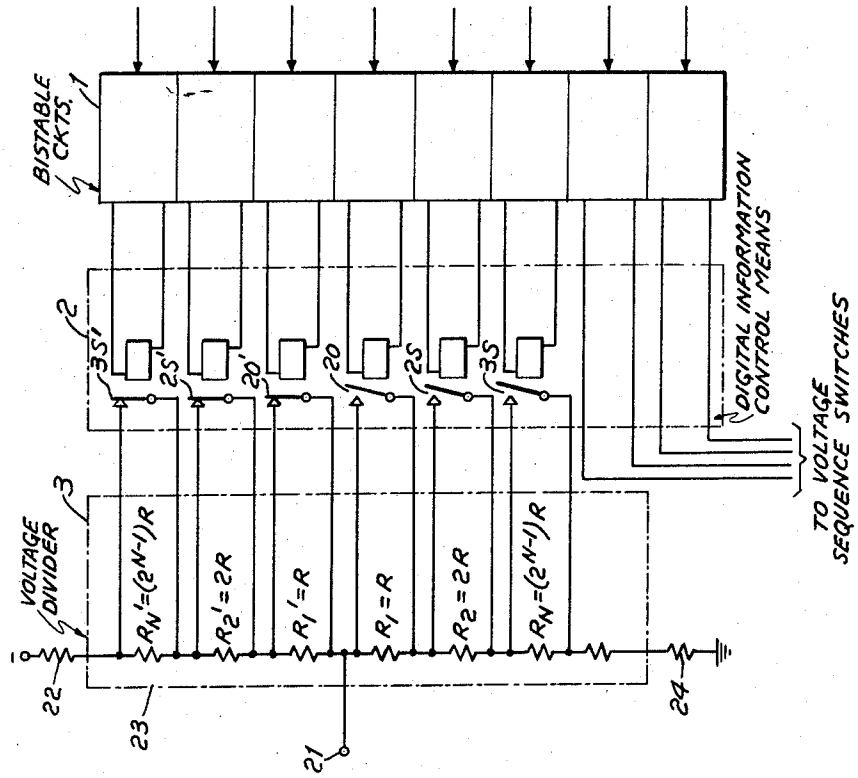
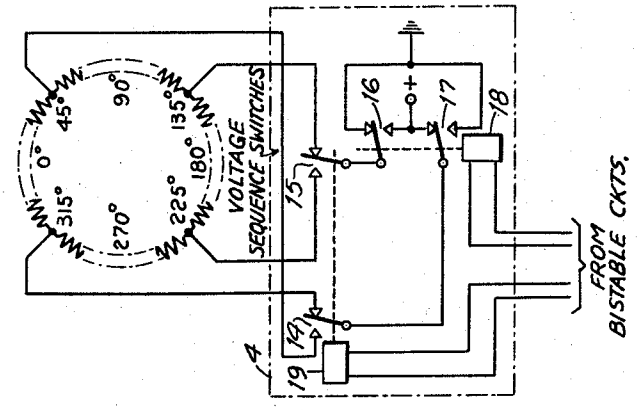



Fig. 5




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# DIGITAL-TO-SHAFT POSITION INFORMATION TRANSLATOR

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4 Claims. (Cl. 318—28)

This invention relates in general to a shaft positioning apparatus and in particular to a positioning device which responds to digital information and translates this information into an angular indication.

It is often desirable to convert digital information which is usually in a binary coded form into an angular position either for direct reading purposes or as used in digital-to-analog computer translations. There are variout methods known to the art for accomplishing this result. A popular method is to use a plurality of servos with combinations of the servos representing the digital bits. Another method is the use of cams with each cam representing the weight of the binary code bits being used, coupled with a relay control and mechanical detenting operation. These various methods accomplish the translation of digital information to shaft position information with varying degrees of speed and varying degress of component requirements.

An object of this invention is to convert electrical signals representing digital information to a shaft position with a combination of resistances and hence with an economy of components while not sacrificing speed or accuracy.

One of the features of this invention is the provision of electrically variable taps on an endless potentiometer. By disposing the taps electrically through switches which are controlled by the digital information, the potentiometer wiper will seek the proper quadrant of the potentiometer and subsequently the proper point to balance the bridge thereby eliminating any possibility of ambiguity which might occur without the variable taps.

A second feature of the invention is the provision of switches used in conjunction with the voltage divider to short out portions of the voltage divider and thereby effectively move the tap on the voltage divider in accordance with the digital information while physically a tap remains stationary.

The above-mentioned and other features and objects of this invention will become more apparent by reference to the following description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a block diagram of the apparatus;

Figs. 2A, 2B, 2C and 2D are illustrations of the various tap positions for various readings;

Fig. 3 is a schematic diagram of the tap switching circuit; and

Fig. 4 is a schematic diagram showing the voltage divider circuit.

As shown in Fig. 1, digital information is received at point **1** and conditions the relays represented by block **2**. Certain relays are energized while others are deenergized to represent a coded number. The relay points act as switches which when used in conjunction with voltage divider **3**, short out certain portions of the divider thus effectively moving the tap up and down the divider. Other relay points at **4** serve as switches to change the tap combinations of points **5**, **6**, **7** and **8** depending on what is the correct selection of taps. The



output of voltage divider **3** is connected to and acts as one leg of the bridge circuit **9**. Depending on the position of shaft **10**, the potentiometer wiper **11** determines a potential value. This potential value is also connected to and represents the other leg of the resistor bridge **9**. An unbalance of the resistor bridge is directed to the servo amplifier **12**, and in turn to the motor **13** which drives the shaft **10** until the wiper **11** reaches a point of balance when compared with the output of voltage divider **3**.

Illustrations 2A, 2B, 2C and 2D represent the taps which are applicable in order for the wiper **11** to find a point of no ambiguity and at the same time a correct indication. The selection of the taps as shown is accomplished by the switches at **4** of Fig. 1 and is set up as soon as the digital information conditions the relays.

In Fig. 3 the circuitry represented in box **4** of Fig. 1 is disclosed. Fig. 3 is shown connecting the taps at **135** degrees and 315 degrees with the positive and negative reference potential points. The arrangement of the relay straps and points at **14**, **15**, **16** and **17** would be effected when digital information such as represented in Fig. 2A was available to condition the relays **18** and **19**. To further illustrate: if digital information which should be represented by an indication on the circular potentiometer between and including 180° to 269°, which would be a condition as shown by Fig. 2C, is presented, then relay **18** would be attracted and relay straps **16** and **17** would transfer to effect a plus terminal at 135° and a ground terminal at 315°. The circuitry of the voltage divider is shown in Fig. 4. The switches operate in pairs as shown by the numbers and their corresponding primed numbers. As the points of **20** are closed the points of **20'** are opened and likewise as any non-primed switch is closed, its primed counterpart is opened. The resistances have weighted values depending on the code being used. A weighted 1, 2, 4 and 8 code is shown by way of illustration. By changing and adding resistances as described above, tap **21** is effectively moved up and down the voltage divider. The overall resistance value shown in Fig. 4 by adding **22**, **23** and **24** is one half the total of the circular potentiometer hence the taps **5**, **6**, **7** and **8** as shown in Fig. 1 on the circular potentiometer are arranged in combination to place a potential on each half of the potentiometer. The total resistance of Fig. 4 less the resistance **22** and **24** (the variable resistance part of the voltage divider) represents only one fourth the resistance value of the circular potentiometer so there is a need of our combinations of taps to represent a full circle. Other resistance and potentiometer relations could be set up depending on the need but the quadrant arrangement is shown here by way of illustration. To eliminate ambiguity of shaft position the principle of the slope of the potential is relied on. Assuming a condition where taps **7** and **5** of Fig. 1 are energized with the positive tap at point **7**, then at first it would seem to be possible for the wiper **11** to be in two positions where a balanced potential could exist with only one position being correct. If the wiper **11** reached a point between zero degrees and 90 degrees, this would be the correct position according to the scheme shown in Fig. 2A. However, it can readily be seen that a point of the same balance potential is found between 135 degrees and 315 degrees following the potential gradient clockwise but this point would be incorrect since the potential at point **7** would be made positive only if the digital information received indicated that the angle $\theta$ which represents this digital information was between zero and 90 degrees. Making a second assumption that if there is an unbalance of bridge **9** and it indicates a lesser potential value on the potentiometer than on the voltage divider the shaft will be driven counter clockwise and vice versa

for a greater potential value of the potentiometer, the prevention of ambiguity becomes apparent. If the wiper were at 230 degrees and this point represented a greater potential than the voltage divider potential, the motor would drive the shaft clockwise and as the wiper traveled toward the tap 7, an even greater potential would be experienced by the wiper. Under my second assumption the greater potential would keep the motor driving clockwise, and hence the wiper would drive beyond tap 7 causing the wiper to travel along the potentiometer until it reached the correct potential between zero and 90 degrees. If the wiper passed beyond the correct point while traveling in this clockwise direction the potential of the endless potentiometer as experienced by the wiper would become less than the voltage divider and this would cause the motor to reverse, moving the wiper to the correct position. If originally when my wiper was sitting at 230 degrees, this point had been a lesser potential than the voltage divider the motor would have been driven counterclockise according to my second assumption. As the wiper moved counterclockwise along the endless potentiometer, the potential experienced by the wiper would be of even a lesser value than the voltage divider as the wiper moved toward tap 5. The motor would continue to drive the shaft and the wiper counterclockwise to the quadrant between zero and 90 degrees until the wiper experienced the correct balanced potential, and in a fashion similar to that described above, if the wiper were overdriven the potential on the endless potentiometer would experience a greater value and reverse the motor. Hence there can be no ambiguity and the digital information received can be represented by only one position of the shaft.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention as set forth in the objects thereof and in the accompanying claims.

I claim:

1. A digital-to-shaft position information translator apparatus comprising a source of coded digital information, a motor, a shaft coupled to said motor and whose position is solely and directly controlled by said motor, an endless potentiometer with a plurality of taps and a wiper coupled for movement with said shaft, a voltage divider circuit, first means coupled to said plurality of taps and responsive to the coded information to be represented by the position of said shaft, to apply a potential to a selected pair of said taps without changing the position of said shaft, said selected pair of taps effecting a potential gradient along the entire endless potentiometer simultaneously clockwise and counterclockwise from the first of said taps to the second of said taps, second means responsive to the input coded information coupled to said voltage divider circuit to vary the output therefrom, a bridge circuit, first circuitry means coupling the respective outputs of said potentiometer and said voltage divider circuit to said bridge circuit, and second circuitry means coupling the output of said bridge circuit to said motor to drive said shaft in accordance with any unbalance present in said bridge circuit.

2. A digital-to-shaft position information translator apparatus comprising a source of coded digital information, a motor, a shaft coupled to said motor and whose position is solely and directly controlled by said motor, an endless potentiometer with a plurality of taps and a wiper coupled for movement with said shaft, a voltage divider circuit, a plurality of relays having associated



relay points coupled to said plurality of taps and responsive to the received coded information, reference potential means coupled to said relays to apply therethrough a potential to a selected pair of said taps without changing the position of said shaft, said selected pair of taps effecting a potential gradient along the entire endless potentiometer simultaneously clockwise and counterclockwise from the first of said taps to the second of said taps, second means responsive to the input coded information coupled to said voltage divider circuit to vary the output therefrom, a bridge circuit, first circuitry means coupling the respective outputs of said potentiometer and said voltage divider circuit to said bridge circuit, and second circuitry means coupling the output of said bridge circuit to said motor to drive said shaft in accordance with any unbalance present in said bridge circuit.

3. A digital-to-shaft position information translator apparatus comprising a source of coded digital information, a motor, shaft coupled to said motor and whose position is solely and directly controlled by said motor, an endless potentiometer with a plurality of taps and a wiper coupled for movement with said shaft, a voltage divider circuit, first means coupled to said plurality of taps and responsive to the coded information to be represented by the position of said shaft to apply a potential to a selected pair of said taps without changing the position of said shaft, said selected pair of taps effecting a potential gradient along the entire endless potentiometer simultaneously clockwise and counterclockwise from the first of said taps to the second of said taps, a plurality of relays responsive to the input coded information whose points serve as switches to vary the output of said voltage divider circuit, a bridge circuit, first circuitry means coupling the respective outputs of said potentiometer and said voltage divider circuit to said bridge circuit, and second circuitry means coupling the output of said bridge circuit to said motor to drive said shaft in accordance with any unbalance in said bridge.

4. A digital-to-shaft information translator apparatus comprising a source of coded digital information, a motor, a shaft coupled to said motor and whose position is solely and directly controlled by said motor, an endless potentiometer with a plurality of taps and a wiper coupled for movement with said shaft, a voltage divider circuit, a plurality of first relays having associated relay points coupled to said plurality of taps and responsive to the received coded information, reference potential means coupled to said first relay points to apply therethrough a potential to a selected pair of said taps without changing the position of said shaft, said selected pair of taps effecting a potential gradient along the entire endless potentiometer simultaneously clockwise and counterclockwise from the first of said taps to the second of said taps, a plurality of second relays responsive to the input coded information whose points serve as switches to vary the output of said voltage divider circuit, a bridge circuit, first circuitry means coupling the respective outputs of said potentiometer and said voltage divider circuit to said bridge circuit, and second circuitry means coupling the output of said bridge circuit to said motor to drive said shaft in accordance with any unbalance present in said bridge.

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