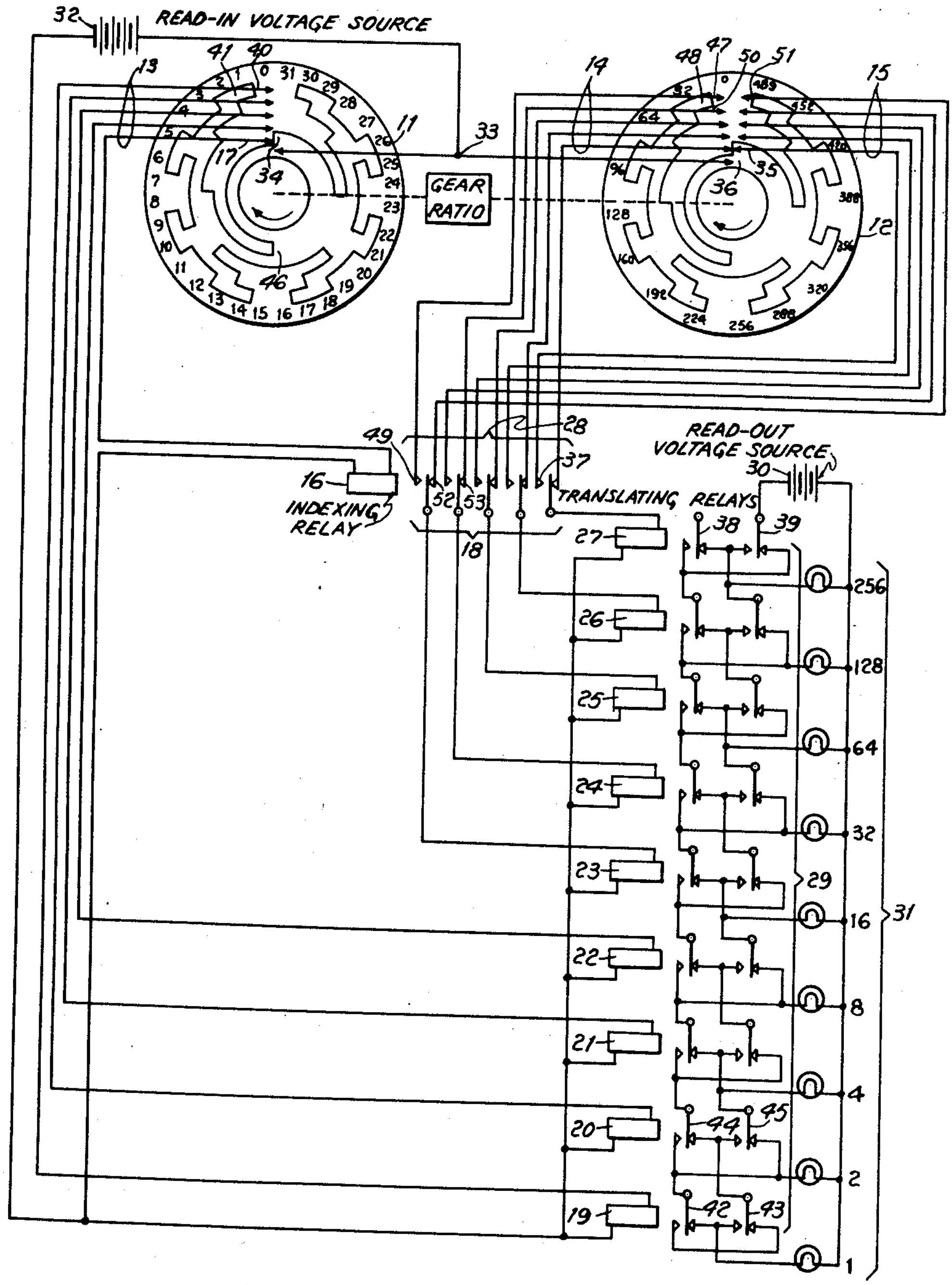
June 28, 1960 G. D. HULST 2,943,311

ANALOG-TO-DIGITAL TRANSLATOR

Filed Jan. 7, 1957



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2,943,311

Patented June 28, 1960

2,943,311

ANALOG-TO-DIGITAL TRANSLATOR

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Filed Jan. 7, 1957, Ser. No. 633,173

2 Claims. (Cl. 340—347)

This invention relates generally to analog-to-digital translation devices and in particular to a device for translating the value of angular shaft positions into coded electrical pulses.

In analog-to-digital translation devices, it becomes necessary to channel the energy pulses from the shaft read-out elements to some means which is capable of translating these pulses into the language of the machine for computation or storage purposes. In the prior art, such a translation has been accomplished by means of banks of relays or switching matrices. The use of banks of relays in the prior art involved holding circuits which were operated for switching advantage by having one relay drop out another relay as the first relay was picked. There very often is a chain reaction with this arrangement or a series of relay actions, to wit: picking, holding and dropping, for a single data bit change. It is obvious that such a chain reaction of the relays results in relatively slow operation and a requisite sensitive timing.

It also has been necessary in the translation operation to assure a non-ambiguous read-out from the shaft elements. For instance, in reading out the numbers **39**, **40** and **31** and assuming a separate read-out positoin for the units and tens position, it is conceivable that if the brushes did not read exactly together, but instead one brush led the other, the translation might read **39**, **30**, **40** and **41** or **39**, **49**, **40** and **41**. To overcome this problem, there is brought into use the lead and the lag brush. The lead and lag brushes are set respectively far ahead and far behind the normal read-out point; and by reading from the lag brush up to a "carry" time and from the lead brush at and beyond the "carry" time, there is insured a non-ambiguous read-out. It is clear that to accomplish the lead and lag read-out there must be a controlling device. In certain translation devices the controls are accomplished by having conductive strips of 180 degrees added to the shafts. By controlling relays with these commutator straps and having the read-out pass through these relays, it is possible to have either lead or lag read-out for one-half the shaft rotation. It also becomes clear that the above-mentioned commutator strap, with its inherent mechanical characteristics in combination with the relays, gives rise to considerations of mechanical tolerance and speed limitations, the improvement of which is desirable for the higher speed operations such as those desired in analog computers or high-speed control systems.

It is therefore the object of this invention to provide an improved analog-to-digital translation device.

It is a further object of this invention to provide a translation device which provides an output digital change of "one" or one bit by means of transferring only one relay.

It is a further object of this invention to provide a translation device wherein the tolerances for the read-out means associated with the shaft rotating elements is not critical.

In accordance with the above objects the invention

features logical relay circuitry which provides for adding or subtracting from the translation answer one digit value at a time while only requiring one relay operation at a time to accomplish the change. A relay may be "picked" to add an additional single digit value or "dropped out" to add a single digit value depending on its energized or deenergized status before the addition is sensed. The invention further features coded wheels attached to the shaft which serves as a primary source of shaft position information. An additional feature of the invention is the provision of lead and lag readout means to insure a non-ambiguous readout. In conjunction with the coded wheels and the lead and lag readout the invention further features that the code inscription itself serves as a control for the lead and lag readout. Conductive material on a lower ordered wheel is arranged to be operative in conjunction with a control brush for a certain portion of the lower ordered wheel's rotation to effect a lead and lag readout control. As higher ordered wheels are added to the device, the lower ordered wheels act in this control capacity as well as a source of shaft angular position information.

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 drawing in which the figure is a combination schematic and circuit representation of an analog-to-digital translation device.

In the figure there are shown two code wheels **11** and **12**. On code wheel **11** there is a set of read-out brushes **13**. On code wheel **12** there is a set of lead read-out brushes **14** and a set of lag read-out brushes **15**. The index relay coil **16** is connected to the read-out brush **17**. The movable contacts **18** are connected mechanically with and actuated by the relay coil **16**. The relay coils **19** through **27** are connected through the movable contacts **18** and points **28** to the lead and lag readout brushes **14** and **15**. The relay points **29** are coupled to the read-out voltage source **30** and to the output means **31** shown as light bulbs in the figure reading in binary number notation. A more comprehensive understanding of the invention will result from the following discussion taken in conjunction with the figure.

The figure shows the device reading 511. On wheel **11** only brush **17** is resting on conductive material. A circuit from the read-in supply **32**, to junction **33**, to conductive strip **34**, through brush **17**, through coil **16**, to the other side of the supply **32** causes coil **16** to be energized. With coil **16** energized, the movable contacts **18** are attracted to rest on the normally open points of **28**. On wheel **12** the only read-out brush on the conductive material is brush **35**. A circuit from the read-in supply **32**, through junction **33**, to segment **36**, through brush **35**, through normally open point **37**, through coil **27**, to the other side of the supply **32** serves to energize coil **27** and thus transfer the movable contacts **38** and **39**. With movable contacts **38** and **39** transferred, all the bulbs are illuminated, which results in a device reading additively, in binary numbers, the value 511. As the wheels **11** and **12** rotate clockwise, the brush **17** moves off the segment **34**, and the relay coil **16** becomes deenergized dropping out the movable contacts **18**. The transfer of the movable contacts **18** results in the deenergization of coil **27** which, in turn, causes the movable contacts **38** and **39** to shift to their unenergized position. With the movable contacts **38** and **39** now resting on the normally closed points, the circuits for lighting the bulbs have been opened; and hence, none of the bulbs are illuminated. As wheel **11** continues to rotate clockwise, brush **40** comes in contact with the segment at **41**. A circuit from the read-in supply **32** through brush **40** causes the relay coil **19** to be energized, and thus the straps **42** and **43** are transferred. With the straps **42** and **43** resting on the normally open side, the light bulb number **1** is illuminated, giving a correct reading of the shaft position. By following the rotation of wheel **11** and noting the position of the brushes on the segment, it becomes clear that relay coil **20** will next be energized, which will transfer the movable contacts **44** and **45**. With the transfer of the movable contacts **44** and **45**, the circuit continuity to light bulb **1** is opened, and simultaneously the circuit continuity to light bulb **2** is closed. It is significant that the output value has been changed by one bit with only one relay action. At the time that the number **2** bulb is glowing, relay **19** is still energized; and as wheel **11** approaches the value 3, relay **19** is deenergized. With the deenergization of relay **19** and the dropping out of the movable contacts **42** and **43**, the bulb **1** is again illuminated, thus having bulbs **1** and **2** glowing at the same time to give the correct additive answer of 1+2=3. This circuitry pattern follows, and the next significant step in the discussion occurs at the time that wheel **11** reaches the value 16. When wheel **11** reaches the value 16, brush **17** makes contact with the conductive material at **46** and thereby causes relay coil **16** to be energized. At this same time, wheel **12** has moved to a position where brush **47** is making contact with the conductive segment at **48**. Coil **16** having been energized, the straps **18** are transferred and brush **47** reads out through the normally open point **49** and the relay coil **23** is energized to light up bulb **16**. As wheel **11** continues to rotate until brush **17** leaves the segment at **34**, wheel **12** will have moved into a position where brushes **48**, **50** and **51** will be on the conductive segment. When brush **17** leaves the segment **34** and coil **16** is deenergized, the lag brush **51** will read through the normally closed brush **53**, thus energizing the coil **24** to permit the bulb **32** to remain illuminated. The operation of the circuit continues in this same fashion, changing the value of the output by one digit at a time with a single relay action at a time. The device as shown here will continue to shift the read-out of the higher ordered wheel **12** from lead to lag, thus insuring non-ambiguity of read-out.

I claim:

1. A translation device for translating angular shaft positions into coded electrical pulses comprising an input shaft, first and second code wheels, means coupling said code wheels to said shaft for rotation therewith whereby said first code wheel rotates a smaller amount than said second code wheel for the same amount of shaft rotation, lead and lag readout means coupled with said first code wheel, single readout means coupled with said second code wheel, an indexing relay having a plurality of normally open points, normally closed points and movable contacts coupled to said lead and lag readout means, indexing relay control means coupled to said second wheel to control the transfer of the readout from said first wheel between said lead and lag readout means for a particular angular rotation of said second wheel, output means for representing said shaft angular positions in coded form, a plurality of output relays arranged in two groups, each group coupled respectively to a corresponding code wheel, and each assigned a different order of value, each output relay having a pair of movable contacts, each of said movable contacts having an associated normally open point and normally closed point, connecting means associated with each output relay coupling the normally associated open point of one of said movable contacts to the normally associated closed point of the other of said movable contacts, logical circuitry means coupling each of said movable contacts to an associated one of said connecting means of the next higher ordered output relay, and circuitry means coupling said logical circuitry means between said output means and both said single and said lead and lag readout means to effect a change of one digit value in said translation output by a single transfer of said movable contacts.

2. A translation device for translating angular shaft positions into coded electrical pulses comprising an input shaft, first and second code wheels, means coupling said code wheels to said shaft for rotation therewith whereby said first code wheel rotates a smaller amount than said second code wheel for the same amount of shaft rotation, lead and lag readout brushes coupled with said first code wheel, single readout brushes coupled with said second code wheel, a transfer relay with a plurality of normally open points, normally closed points and movable contacts, said transfer relay points coupled to said lead-lag brushes whereby each pair of lead-lag brushes for any coded bit is coupled to the normally open and normally closed points associated with a particular movable contact, a transfer relay control circuit coupled to said single set of readout brushes to control the transfer of the readout from said first wheel between said lead and lag readout brushes for a particular angular rotation of said second wheel, a plurality of devices for representing said shaft angular positions in coded form, a plurality of output relays arranged in two groups, each group coupled respectively to a corresponding code wheel, and each assigned a different order of value, each output relay having a pair of movable contacts, each of said movable contacts having an associated normally open point and normally closed point, connecting means associated with each output relay coupling the normally associated open point of one of said movable contacts to the normally associated closed point of the other of said movable contacts, logical circuitry means coupling each of said movable contacts to an associated one of said connecting means of the next higher ordered output relay, and circuitry means coupling said logical circuitry means between said means and both said single and said lead-lag readout means to effect a change of one digit value in said translation output by a single transfer of said movable contacts.

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