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A COMMUTATING DEVICE FOR TRANSFORMING SHAFT POSITION INTO BINARY DIGIT INFORMATION

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WARREN ROBERTS

NOVEMBER 1953

RESEARCH SERVICES DIVISION
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AIR RESEARCH AND DEVELOPMENT COMMAND

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SPECIALIZED SERVICES

A Laboratory Note

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NOVEMBER 1953

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ABSTRACT

This note describes a 9-digit commutating device for coding shaft position in binary digit form, one of several developed in a general commutator research program of the AFCRC. A feature of the design is the use of the "line contact" method for preventing bounce and establishing clean and reliable contact between the brushes and tracks.

A COMMUTATING DEVICE FOR TRANSFORMING SHAFT POSITION INTO BINARY DIGIT INFORMATION

INTRODUCTION

The fixed contact plate used in present-day switches and commutators is usually made up of a series of flat circular fixed contacts of the stud type, either flush with or raised above a supporting plastic base. The sliding contact is usually a flat or hemispherical button affixed to a cantilever spring formed from beryllium-copper or a similar spring alloy, and "run in" to smooth out both the commutator and contact surfaces. Since a large mass of contact is affixed to the end of a relatively light spring, this type of contact has a natural tendency to bounce. Even though the contact pressure used is high, the resultant pressure per unit area between the contacts is relatively low. The nature of the make-and-break action on this type of switching, sometimes referred to as the "tangent circle" method, is illustrated in Fig. 1. For the area in contact in positions 1, 2, 4, and 5, the pressure per unit area is insufficient to guarantee low and uniform contact resistance for quiet switching or voltage pulse generation.

A cleaner and more reliable sliding contact between two metallic conductors was achieved through a basically different approach, after several design and material studies previously completed.* This contact was the one subsequently used in the study and development of a number of commutating devices, including the one described in this report.

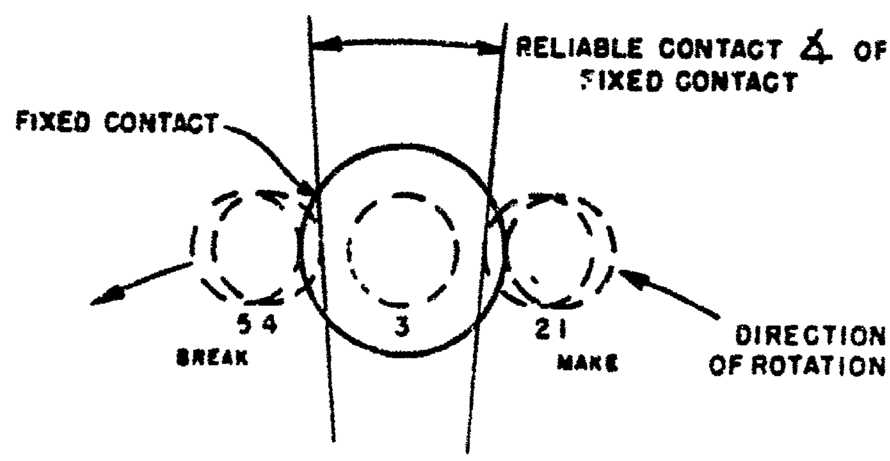

Fig. 1.---Tangent circle sliding contact switching method.

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*Technical Progress Reports Nos. 16 (E3104) and 17 (E3109) to the AFCDC Steering Committee from the Electromechanical Laboratory, April and June 1951.

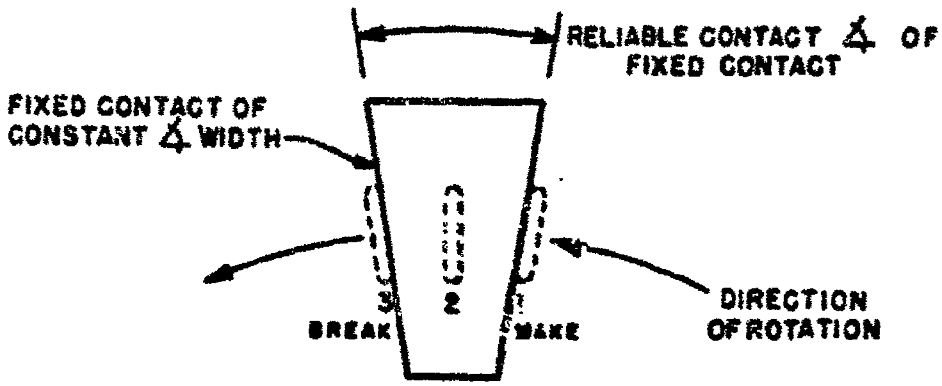

Fig. 2.---Line contact switching method.

Figure 2 illustrates the method chosen. In this "line contact" method, the area of the sliding contact is kept small and the total brush pressure low (a few grams), but the resultant pressure per unit is high. Contact bounce is avoided by having the brush spring and contact formed from a single piece of precious metal wire. Details on the actual shape and and size of both the fixed and sliding contacts will be found in the following sections. It has been established that clean and reliable contact is made between the fixed and moving contact---at almost the very instant that they touch, two good-size areas under high relative pressure are immediately brought into intimate contact.

GENERAL DESCRIPTION OF COMMUTATOR

Figure 3 shows the general external construction of the binary digit commutator. The unit is 5 in. in diameter, 2-3/8 in. wide, and weighs approximately 2-1/2 lb. The stainless steel shaft, which may protrude from either end of the commutator housing, is supported by two ball bearings for low and uniform torque. The machined aluminum alloy housing is anodized for protection against the corrosive atmospheres often encountered in service applications.

The internal construction of the commutator is shown in Figs. 4 (cover removed) and 5 (disassembled); as can be seen in Fig. 5, the shaft actually supports four double-track commutator disks back-to-back in pairs. Each of the commutator tracks is divided into an equal number of conducting (on) and nonconducting (off) segments. Beginning with 1 conducting and 1 nonconducting on tracks 1 and 2, the total number of segments doubles with each successive track, to 128 conducting and 128 nonconducting on track 9. Each of the commutator tracks is contacted by a brush (see Figs. 5 and 6). The commutator disks rotate, with all of the conducting segments interconnected and terminating at a slip ring through which external connection can be made.

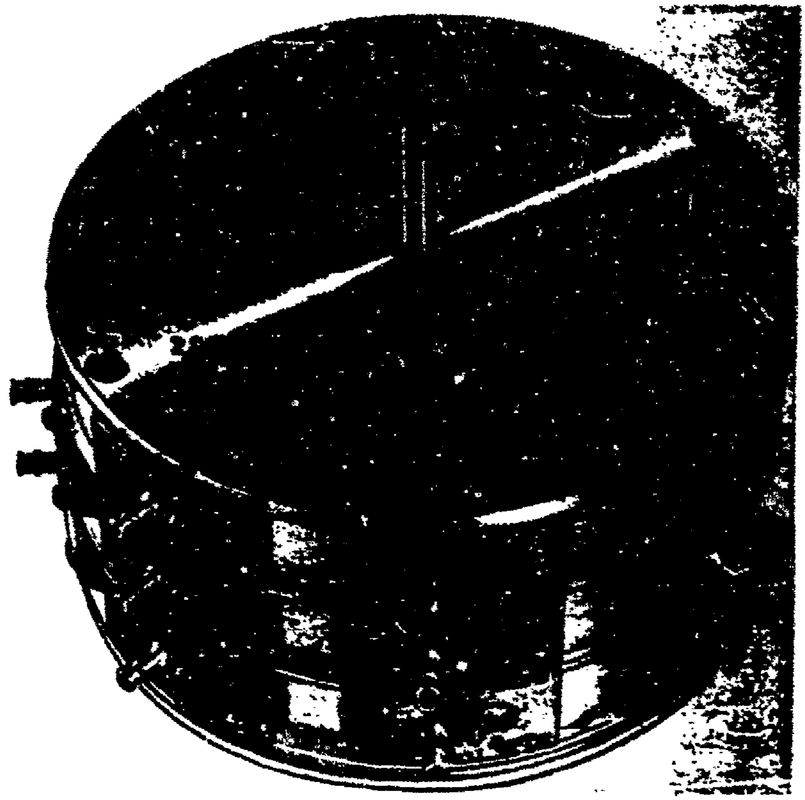

Fig. 3.--Assembled binary code commutator.

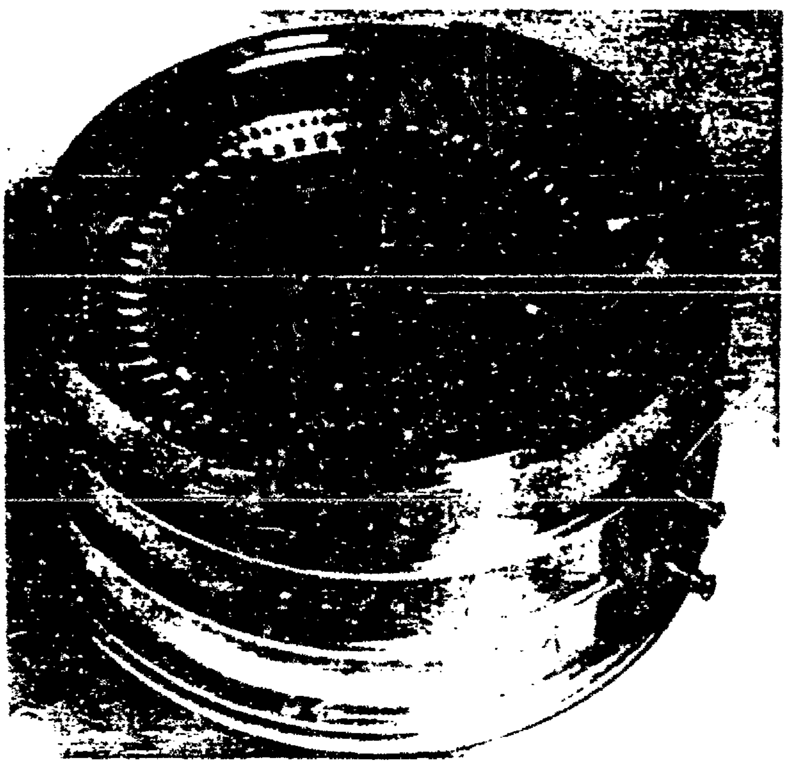

Fig. 4.--Assembled binary code commutator, cover removed.

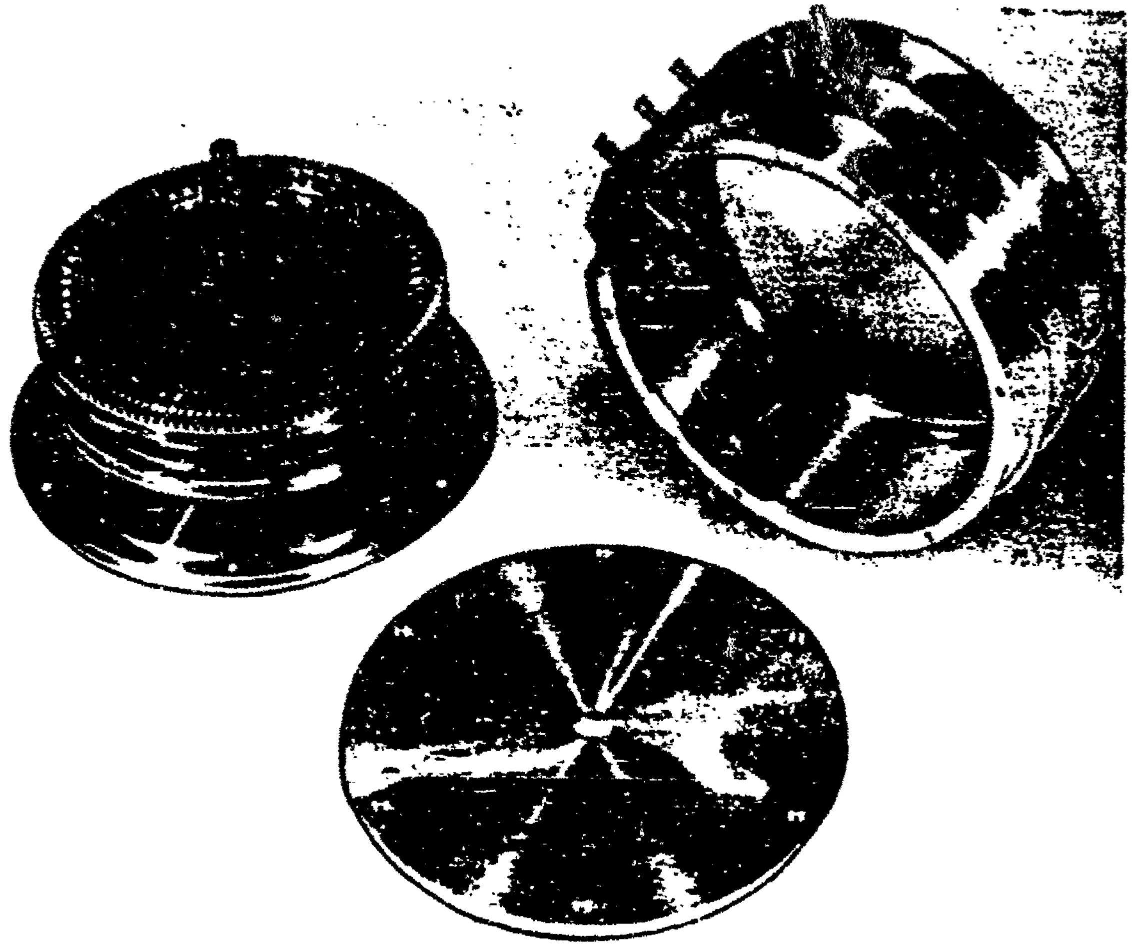

Fig. 5.---Disassembled components of binary code commutator.

To prevent ambiguity or anomalous indications, a cyclic binary, or Gray, code is used. The output from the brush terminals, in the form of either an open circuit or a connection to an ungrounded common terminal, makes up the code. Digits 1 and 2, which each require 180° on and 180° off time but phased 90° apart, are obtained by having two brushes operate on the same disk track.*

FABRICATION AND MATERIALS

Figure 7 shows details of the 256-segment disk before the slots have been filled. The disk is a brass and coin silver laminate, with the backing surface made of the coin silver. Its inner and outer tracks are milled so that the slots and the lands are of a constant and

*The application of this device is described in an AFCRC Report entitled *Shaft Position to Binary Digit Transformation*, now in preparation by Robert Angus of the Digital Communications Project.

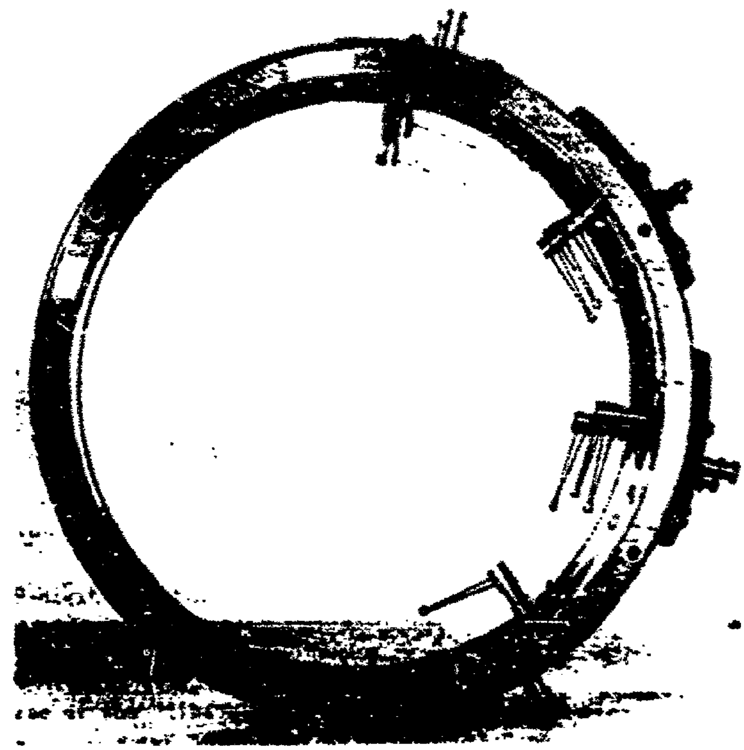

Fig. 6.--Output brushes of binary code commutator.

nearly equal angular width. The angular width of the conducting segments is slightly less than that of the nonconducting segments in order to compensate for the effective width of the output brushes.

After the milled disk is thoroughly cleaned and degreased, the slots are filled with an abrasion-resistant epoxide resin potting compound to just above the surface of the coin silver conductors. The resin is then oven-cured for approximately two hours at 140°C, the excess faced off in a lathe, and the segments polished smooth and finished off by wet-polishing with a 600-grit emery paper.

The "cobra" brushes are made of .01 in. half-hard Paliney #7 alloy wire that has high tensile strength and excellent resistance to corrosion (see Figs. 5 and 6). Contact pressure is adjusted to approximately 6 gm at assembly. Final phasing of the brushes is made by slight adjustment of the individual terminal and brush support blocks shown in Figs. 3 and 5.

PERFORMANCE

The present commutator has a maximum of 256 segments (128 conductors) but can accommodate one more two-track disk, with a resultant increase in resolution to one part in 1024. The

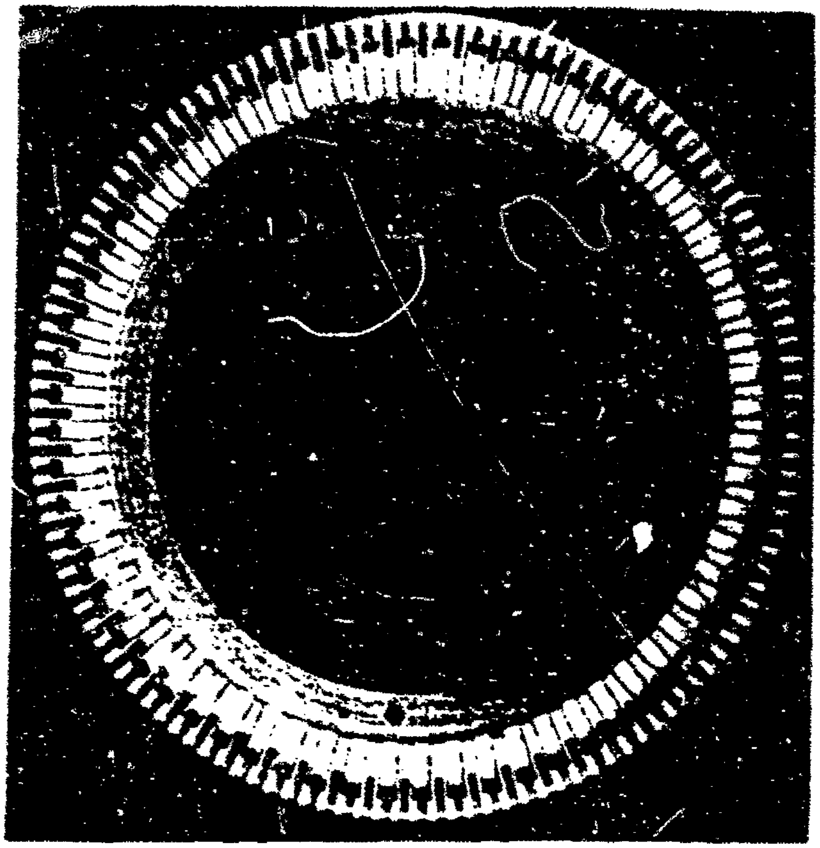

Fig. 7.--Top view, 256- and 128-segment track disk.

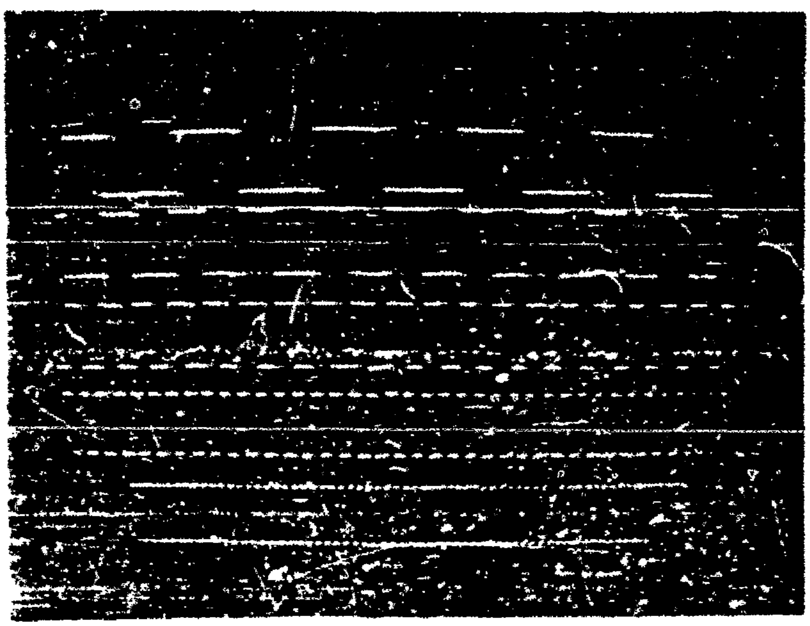

Fig. 8.--Binary code commutator signals, (4.5V, 100 μamp) on 8-, 16-, 32-, 64-, and 128-segment tracks.

present commutator is limited to a maximum speed of approximately 100 rpm. Figure 8 illustrates the clean square-wave output of five of the brushes.

Preliminary tests indicate the desirability of using a suitable lubricant on the commutator tracks to minimize wear and reduce noise. A life of several million cycles has been achieved with low current. Because of the contact design chosen, the device is limited to applications where no more than .25 milliamperes of current must be broken. A higher current will reduce life. The current-carrying capacity might be raised by increasing the number of brushes per track to two or more but it would be difficult to maintain simultaneous operation of the parallel contacts.

SUPPLEMENTARY

INFORMATION

DEPARTMENT OF THE AIR FORCE
PHILLIPS LABORATORY (AFSC)
HANSCOM AIR FORCE BASE, MASSACHUSETTS 01731-5000

ERRATA AD-23659

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8 September 1992

SUBJECT: Approval for Downgrading Technical Report to Statement A

TO: Defense Technical Information Center
Cameron Station
Alexandria, VA 22304

The following reports have been approved for downgrading to Statement A:

A Commutating Device for Transforming Shaft Position Into Binary Digit Information - AFCRC-TR-53-41 (AD23659)

Miniature Shaft-Position Coder in 8-Digit Cyclic Binary System - AFCRC-TR-53-40 (AD23672)

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