July 16, 1963 G. J. LYNCH ETAL 3,098,129

SWITCHING MECHANISMS

Filed Sept. 23, 1958

FIG. 1.

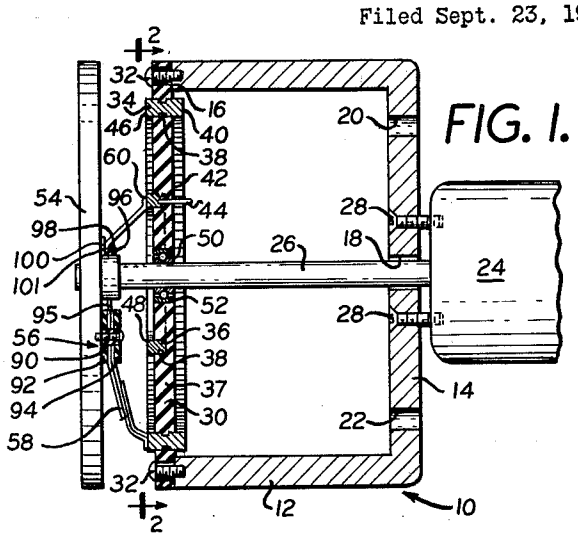


FIG. 3.

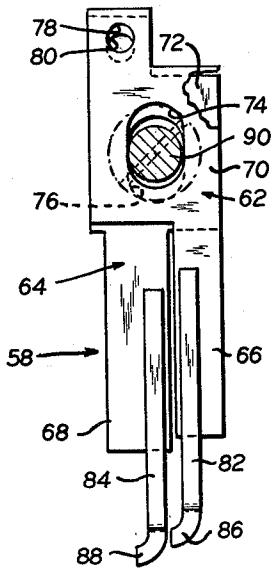


FIG. 2.

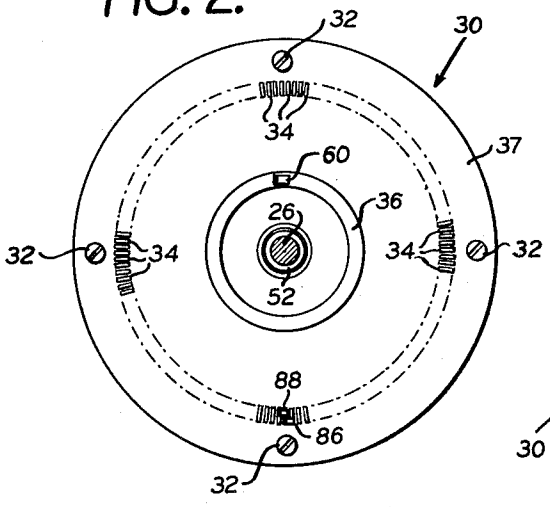


FIG. 4.

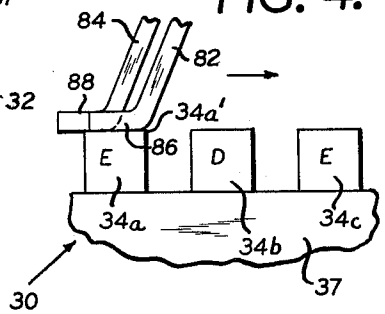


FIG. 5.

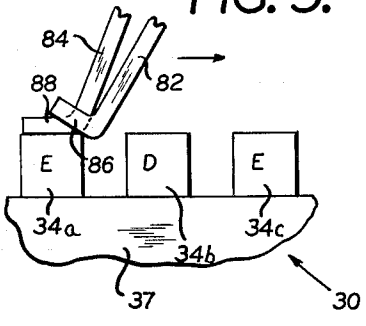
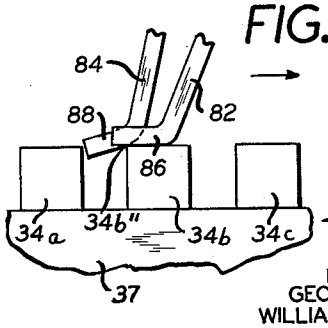


FIG. 6.



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SWITCHING MECHANISMS

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4 Claims. (Cl. 200—11)

This invention relates to switching mechanisms and particularly to high speed switching mechanisms for use in telemetering systems in which a large number of continuous switching operations must be carried out.

In telemetering systems, it is a common expedient to employ a high speed switching mechanism as a "multiplixing" switch for sequentially closing circuits from data supplying devices to a transmitting means so that the data will be sequentially supplied to receiving apparatus remote from the source of the data. Such an expedient is commonly used in airborne telemetering systems such as systems for metering the performance of rockets, missiles and aircraft. In such systems reliability and minimization of weight and bulk are of paramount importance.

In standard commutation switches there is provided at least one circular ring of spaced contacts and a continuous slip ring. At least some of the contacts are connnected to the data supplying devices referred to above. A rotating brush assembly is adapted to engage the contacts in the row of contacts and further to engage the slip ring whereby to sequentially close the circuits between said contacts and said slip ring in order to supply in sequence the data from the data supplying devices to a suitable transmitting means.

There are two common arrangements for connecting the data supplying devices to the commutation switch contacts. In one of the arrangements each of the contacts is connected to a data supplying device. In such an arrangement, assuming the brush to be larger than the spacing between contacts, it will be obvious that as a brush moves from one contact to the next contact, it will engage the next contact before it disengages from said one contact whereby to give a "make-before-break" system. That is, if one circuit is closed, the next adjacent circuit will become closed as the brush progresses around the ring of contacts before said one circuit is open.

Another common ararngement is to have data supplying devices connected to alternate contacts with the contacts in between being completely de-energized. Assuming the brush engaging the contacts is not of sufficient longitudinal extent to bridge two contacts then clearly one circuit will be open before the next circuit will be closed as the brush moves around the ring of contacts. Such an arrangement is commonly known as a "break-before-make" arrangement.

Different telemetering systems require different periods of time during which a signal is supplied to transmitting means. The period during which a signal is supplied is generally known as the "on-time" and the period during which no signal is supplied is commonly known as the "off-time". Assuming a circular row of contacts which are all spaced equidistant from one another and with alternate contacts energized the on-time is equal to the percentage of time that a circuit is closed as a brush moves from one position on an energized contact to a corresponding position on the next energized contact. The on-time can be stated quantitatively by the following expression.

$$\text{on-time} = \frac{\text{length of energized contact} + \text{length of brush}}{\text{length of energized contact} + \text{length of de-energized contact} + 2 \times \text{spacing between contacts}}$$

Analyzing the above equation it will be seen that the

on-time can be varied by varying either the length of the contacts, the spacing between adjacent contacts or the length of the brush. The possibilities of varying the length of the contacts are limited by practical production considerations. First of all, it is often desirable to have a large number of relatively short contacts in one row so as to minimize the amount of space taken up by the commutation switch. Accordingly, there is a constant pressure for making a commutator plate with smaller and smaller contacts, thereby greatly restricting the possibility of varying the length of the contacts. Moreover, it is possible to vary the on-time by having the energized contacts of a different dimension than the de-energized contacts. This can and has been done in the past. However, there is a wide variety of on-times required for the wide variety of telemetering systems employing switches of the type described herein. Therefore, if the commutator plate is to be a molded article, which is preferred, there will have to be a wide variety of costly tools, thereby rendering the cost of each plate almost prohibitive. The spacing between contacts can also theoretically be varied to vary on-time but this is also greatly restricted. First of all, there is a minimum spacing between contacts for any given commutator plate since the insulation resistance between adjacent contacts must be above a predetermined value. As for increasing the spacing between contacts above the minimum this will cause the circular row to have a relatively large diameter and thereby be wasteful of space. Accordingly, the opportunities for varying on-time by varying contact spacing are extremely limited.

The remaining means for varying the on-time is by varying the brush length. However, in United States patent application Serial No. 649,150, now Patent No. 2,975,246, filed by George J. Lynch and George Golik, on March 28, 1957, for Switching Mechanisms, which application is assigned to the assignee hereof, it is disclosed that for optimum commutation the length of the brush which moves over the contacts is limited to a definite relationship to the spacing between contacts. Particularly, the longitudinal extent of the brush, that is the length of the brush, should be between 1.4 and 2.5 times the contact spacing and preferably 1.85 times the contact spacing. With brushes of such proportion a superior signal is achieved particularly in metal-to-metal brush and contact assemblies due to the inherent ability of such brushes to clean themselves and to maintain good surface-to-surface engagement with the contacts. Accordingly, there is very limited possibility for varying the on-time by changing the length of a single brush and if the length of the brush is substantially changed from the optimum, the quality of the signals commutated by the switch is not good enough for the reliability sought. When a single brush made in accordance with the preferred proportioning of Lynch and Golik is employed to engage a series of identical contacts in a break-before-make system, it has been found that the on-time is about 60%.

There is further described in said aforementioned Lynch and Golik application a brush assembly wherein two electrically connected brushes are aligned with respect to their path of movement and are spaced from one another along said path. With such a multiple brush arrangement in a break-before-make system and with the same relationship between the brush lengths and the contact spacing, it has been found that an on-time of about 99% or more can be achieved. However, on-times between about 60% and about 99% are not achievable with the commutator plate configuration described.

The main object of the present invention is to provide a new and improved switching mechanism having provision for a continuous adjustment of the on-time.

Another object of the present invention is the provision of a new and improved commutation switch having a ring

of substantially identical contacts and provision for varying the on-time over a continuous range.

A further object of the present invention is the provision of a new and improved brush assembly for a commutation switch having provision for a continuous adjustment of the on-time for a switch associated with said brush assembly.

A still further object of the present invention is the provision of a new and improved commutation switch having a plurality of contacts arranged in a circular row, which contacts have linear leading and trailing edges, and a brush assembly adapted to cooperate with said ring of contacts, the brush assembly having provision for continuous adjustment of the on-time.

The above and other objects, characteristics and features of the present invention will be more fully understood from the following description taken in connection with the accompanying illustrative drawing.

In the drawing:

FIG. 1 is a vertical view partly in section and partly in elevation of a switching mechanism embodying the present invention;

FIG. 2 is a sectional view taken along the line 2—2 of FIG. 1;

FIG. 3 is a plan view of the brush assembly with some parts deleted to more adequately illustrate other parts of the invention;

FIG. 4 is a diagrammatic fragmentary side elevational view illustrating the engagement of the brushes with the contacts;

FIG. 5 is a view similar to FIG. 4 showing another condition; and

FIG. 6 is a view similar to FIGS. 4 and 5 showing still another condition.

Referring now to the drawing in detail, a commutation switch embodying the present invention is generally designated by the reference numeral **10**. Switch **10** includes a cylindrical support member **12** having integrally formed thereon an end piece **14**, the other end **16** being open. End piece **14** is provided with a central aperture **18** and two oppositely disposed apertures **20** and **22** for reasons which will appear hereinafter. Secured to the end piece **14** by suitable securing elements such as screws **28** is a motor means **24** which may be a simple electric motor or a motor together with a gear train, as may be desired. Motor **24** includes output shaft **26** which extends through aperture **18** in end piece **14** with clearance.

Overlying the open end **16** of cylindrical member **12** is a commutator plate **30**. Commutator plate **30** is here shown as being of substantially the same peripheral extent as cylindrical member **12** and lies in abutting relation therewith. To secure plate **30** to member **12** a plurality of securing elements such as screws **32** are employed. Commutator plate **30** is preferably a molded article having a ring of closely spaced contacts **34** adjacent the periphery thereof and a continuous slip ring disposed inwardly of said circular row of contacts **34** and concentric therewith. The circular row of contacts **34** and the slip ring **36** are all held in fixed relation by a suitable electrical insulating material **37**. Preferably the insulating material in commutator plate **30** is a vitreo-micaceous material such as glass-bonded mica or a ceramoplastic and plate **30** is most preferably manufactured by injection molding techniques. By employing an injection molded commutator plate of vitreo-micaceous material the plate **30** will have excellent dimensional stability, resistance to deterioration under high temperature conditions and the contacts **34** in the slip ring **36** will be rigidly held against displacement in use. To assure against the displacement of the contacts and slip ring they are preferably all provided with re-entrant portions **38** to mechanically lock them relative to the vitreo-micaceous insulat-

provided with a terminal **40** disposed opposite the rear

ing material. As shown herein each of the contacts **34** is surface **42** of plate **30** and the slip ring is provided with

one or more terminals **44** extending beyond the rear surface **42** of plate **30**. The front surface **46** of the contacts **34** are all flush relative to one another and are preferably flush with the front surface **48** of the slip ring **36**.

Although a wide variety of materials may be employed for the contacts **34** and the slip ring **36** we have found that these contacts and slip ring are most preferably made from coin silver, and to provide proper electrical and mechanical properties they are preferably plated with a gold alloy, although rhodium or other suitable plating materials may be employed.

Commutator plate **30** is provided centrally with an aperture **50** in which is disposed a bearing **52** to support output shaft **26** which extends therethrough. Mounted on the end of shaft **26** is a disc-like rotor **54** on which is mounted the brush assembly **56**. Brush assembly **56** includes brush means **58** which is adapted to sequentially engage the contacts **34** and a brush means **60** which is adapted to ride in surface-to-surface relation with the slip ring **36**. With such an arrangement it will be seen that when motor **24** is energized to rotate shaft **26** the brush assembly **56** will move over the contacts **34** and the slip ring **36** to sequentially close electrical circuits between the contacts and the slip ring to supply information to suitable transmitting means (not shown). In this connection it will be understood that the terminals **40** and **44** of the contacts **34** and the slip ring **36**, respectively, are adapted to have connected thereto suitable conducting means such as wires (not shown) which wires can pass out of cylindrical member **12** through the openings **20** and **22**.

In accordance with the present invention each of the contacts **34** is preferably an elongated rectangle having its major axis extending in a radial direction on said commutating plate **30**. In lieu of the rectangular configuration of contacts **34**, wedge shaped contacts may be employed. In this connection it will be understood that wedge shaped contacts would have their edges extending along radii of commutator plate **30**. The reason for the inclusion of rectangular or wedge shaped contacts will become clear as this description proceeds. Brush means **58** which engages in sequence the contacts **34** comprises a pair of plate-like brush holders **62** and **64** having offset arms **66** and **68**, respectively, and, superposed main support portions **70** and **72**, respectively. The support portions **70** and **72** are each provided with an elongated aperture **74** and **76**, respectively, and a small circular aperture **78** and **80**, respectively, for reasons which will appear hereinafter. Preferably the brush holders **62** and **64** are made of a suitable resilient electrically conducting material such as, for instance, beryllium copper, although Phosphor-bronze or other suitable material may be employed.

Secured to each of the offset portions **66** and **68** of support means **62** and **64** are brush members **82** and **84**, respectively. The brush members **82** and **84** may be made of any suitable material, but we prefer to use metallic materials such as a palladium, platinum, gold, silver, copper alloy of undisclosed proportions as sold under the trade designation Paliney #7 by John M. Ney Co., or an alloy of silver, cadmium, nickel and copper as sold by P. R. Malloy Co. under the trade name Elkonium. Of course, other suitable brush materials may be employed and in this connection silver graphite would be a satisfactory although not preferred material. The brush members **82** and **84** are connected to the offset portions **66** and **68** in any suitable manner as by spot welding.

At the free end of each of the brush members **82** and **84** is a brush **86** and **88**, respectively, which brushes are proportioned to have a longitudinal extent (length) of between 1.4 and 2.5 times the spacing between adjacent rectangular contacts. Most preferably the brushes **86** and **88** have a longitudinal extent of about 1.85 times the spacing between adjacent contacts. It will be seen that brushes **86** and **88** are displaced (offset) trans-

versally of one another relative to their projected path of movement over the contacts **34**. Moreover, it will be seen that the brushes **86** and **88** are offset relative to one another in the direction of their path of movement. This second offset, that is the offset in the longitudinal direction, is adjustable since the brush means **58** is secured to the rotor by means of a screw **90** which extends through the elongated apertures **74** and **76**. When screw **90** is loosened the longitudinal displacement of brushes **86** and **88** may be adjusted merely by sliding the brush support means **62** and **64** relative to one another as permitted by the elongated apertures **74** and **76**. When they are properly adjusted for position, screw **90** is tightened which will cause the insulating wafers **92** and **94** overlying and underlying respectively the brush means **58** to clamp said brush means in fixed position.

The advantage of a brush assembly as described above may be best illustrated by describing a specific commutator plate with specific proportions. In a commutator plate now being produced the rectangular contacts have a radial extent of .125 inch and a length in the direction of the circular row of .028 inch. The spacing between adjacent contacts at the center line is about .0165 inch. Assuming a brush moving over said contacts is made in accordance with the preferred embodiment of this invention so that it has a longitudinal dimension of 1.85 times the contact spacing the longitudinal extent of the contact will be .031 inch. However, due to irregularities along the leading and trailing edges of the brushes the actual electrical engagement will be equivalent to a brush approximately 80% as long as the mechanical dimension given above or .025 inch. In a break-before-make system, that is in a system in which every other contact is energized and the remainder de-energized, with each contact the same size as described above, the on-time for a single brush of the dimensions stated above can be calculated as follows:

$$\text{On time}=\frac{.028+.025}{2(.028+.0165)}$$

$$\text{On time}=\frac{.053}{.089}$$

$$\text{On time}=60\%$$

Now, if two such brushes are offset longitudinally but are not transversely offset and assuming for purposes of mechanical expediency that the trailing edge of the forward brush cannot be closer than .010 inch to the leading edge of the rearward brush, then the on-time for such an arrangement would be calculated as follows:

$$\text{On time}=\frac{.028+2\times.025+.010}{2(.028+.0165)}$$

$$\text{On time}=\frac{.088}{.089}$$

$$\text{On time}=99\%$$

From the foregoing calculations it will be seen that for any given contact arrangement and for a specified longitudinal dimension of any brush element engaging said contacts there is a gap in the achievable on-time between a value of around 60% and a value around 100%. While, as was stated hereinbefore, such intermediate on-times can be achieved by modifying the plate this would be undesirable due to the necessity of having a wide variety of different plates. As stated hereinbefore, the dimension of the brushes is fixed due to the fact that optimum commutation is achieved only with a brush having the desired relationship to the contact spacing.

However, by offsetting the brushes laterally any on-time between 60% and 100% can be achieved merely by adjusting the extent of longitudinal offset between the two associated brushes which adjustment is permitted only because the brushes have been laterally offset.

With the provision of laterally offset brushes a problem arises. If circular contacts are employed neither brush will be able to ride along the circle defining the centers of the contacts. Accordingly, each brush will engage the leading contact edge of each circular contact at an angle which will tend to twist the brush. Over a substantial period of time this will have a deleterious effect. Furthermore, the gap between circular contacts over which each of the laterally spaced brushes pass may vary considerably which will affect the on-time that is so critical. To overcome this we prefer to employ contacts which have linear leading and trailing edges so as to eliminate the shortcomings described above. Moreover, with rectangular or wedge shaped contacts there is more space in the radial direction to accommodate the laterally offset brushes thereby facilitating manufacture.

Naturally, the brushes **86** and **88** are electrically connected. The electrical connection between them is affected by means of the surface-to-surface contact between the brush supports **70** and **72**. Moreover, the brush means **58** is electrically connected to the brush means **60** which engages slip ring **36**. This connection is effected by connecting a wire **95** to the brush assembly **58** through the registered apertures **78** and **80** and to any suitable portion of the brush holder for brush **60**. As shown herein, brush **60** is mounted on rotor **54** by means of a screw **96** extending through insulating wafers **98** and **100** and the brush holder **101** for brush **60**.

The operation of the commutation switch is illustrated in FIGS. 4, 5 and 6. With the motor **24** rotating and with the brushes **86** and **88** engaging a contact **34***a* which contact will be assumed to be an energized (E) contact a circuit will be closed between the contact **34***a* and the slip ring **36**. As rotor **54** continues to rotate under the driving of motor **24** the leading edge **86***a* of brush **86** will pass over the trailing edge **34***a'* of contact **34** and will tend to dip down into the space between the contact **34***a* and the contact **34***b* due to the self bias of brush member **82** whereby to cause a scraping of the bottom surface of brush **86** along the upper corner of the controlling edge of the contact **34***a*. At the same time brush **88** will remain in full engagement with the contact **34***a* and the circuit will remain established as heretofore described (FIG. 5). Thereafter, brush **86** will engage the leading edge **34***b''* of de-energized (D) contact **34***b* and will be wiped thereby and will then move into surface-to-surface relation with that contact and brush **88** will become disengaged from the contact **34***a* in the same manner as brush **86** previously became disengaged, and will thereafter engage the leading edge **34***b''* of contact **34***b* and scrape along said leading edge as brush **86** previously did to complete the disengagement of the brush means **58** from the contact **34***a* to open the circuit between contact **34***a* and the slip ring (FIG. 6). This will be the off-time period. The subsequent disengagement from contact **34***b* and engagement of contact **34***c* will establish a new circuit to commence a new duty cycle.

While we have herein shown and described the preferred form of the present invention and have suggested various changes and modifications therein, other changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of the invention.

What we claim is:

1. In a commutation switch, a commutation plate having a circular row of equi-spaced substantially identical raised contacts and a slip ring concentric with said circular row of contacts, alternate contacts in said circular row being adapted to be connected to electrical devices and the remaining of said contacts being unconnected, and rotatable brush means engageable with said contacts and slip ring for sequentially electrically connecting said contacts to said slip ring, said brush means

including a brush engaging said slip ring and a pair of laterally and longitudinally offset brushes both engaging in sequence each of said contacts in said circular row of contacts, and resilient means biasing said pair of brushes into engagement with said circular row of contacts.

2. In a commutation switch, a commutation plate having a circular row of equi-spaced substantially identical raised contacts and a slip ring concentric with said circular row of contacts, alternate contacts in said circular row being adapted to be connected to electrical devices and the remaining contacts being adapted to be unconnected, alternate contacts in said circular row being adapted to be connected to electrical devices and the remaining of said contacts being unconnected, and rotatable brush means engageable with said contacts and slip ring for sequentially electrically connecting said contacts to said slip ring, said brush means including a brush engaging said slip ring and a pair of laterally and longitudinally offset brushes both engaging in sequence each of said contacts in said circular row of contacts, resilient means biasing said pair of brushes into engagement with said circular row of contacts, and means for permitting the adjustment of the extent of longitudinal offset between said offset brushes.

3. In a commutation switch, a commutation plate having a circular row of equi-spaced substantially identical raised contacts and a slip ring concentric with said circular row of contacts, alternate contacts in said circular row being adapted to be connected to electrical devices and the remaining of said contacts being unconnected, and rotatable brush means engageable with said contacts and slip ring for sequentially electrically connecting said contacts to said slip ring, said brush means including a brush engaging said slip ring and a pair of laterally and longitudinally offset brushes both engaging in sequence each of said contacts in said circular row of contacts, and resilient means biasing said pair of brushes into engagement with said circular row of contacts, both of said offset brushes having a longitudinal dimension between about 1.4 and 2.5 times the space between adjacent contacts.

4. In a commutation switch, a commutation plate having a circular row of equi-spaced substantially identical raised contacts and a slip ring concentric with said circular row of contacts, alternate contacts in said circular row being adapted to be connected to electrical devices and the remaining of said contacts being unconnected, and rotatable brush means engageable with said contacts and slip ring for sequentially electrically connecting said contacts to said slip rings, said brush means including a brush engaging said slip ring and a pair of laterally and longitudinally offset brushes both engaging in sequence each of said contacts in said circular row of contacts, and resilient means biasing said pair of brushes into engagement with said circular row of contacts, both of said offset brushes having a longitudinal dimension of about 1.85 times the space between adjacent contacts, and means for permitting the adjustment of the extent of longitudinal offset between said offset brushes.

References Cited in the file of this patent

UNITED STATES PATENTS

1,835,788	Knoop	Dec. 8, 1931
2,402,736	Davis	June 25, 1946
2,634,342	Baechler	Apr. 7, 1953
2,678,985	Smith	May 18, 1954
2,848,567	Estoppey	Aug. 19, 1958
2,866,861	Lynch	Dec. 30, 1958
2,894,096	Schacht	July 7, 1959
2,975,246	Lynch et al.	Mar. 14, 1961