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MAGNETIC SWITCHES

Filed Feb. 21, 1961

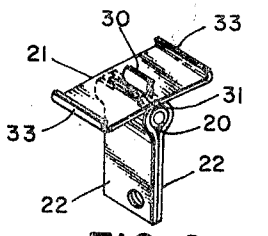


FIG. 9.

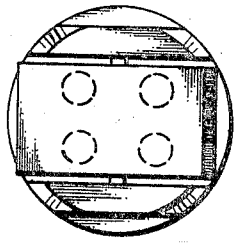


FIG. 4.

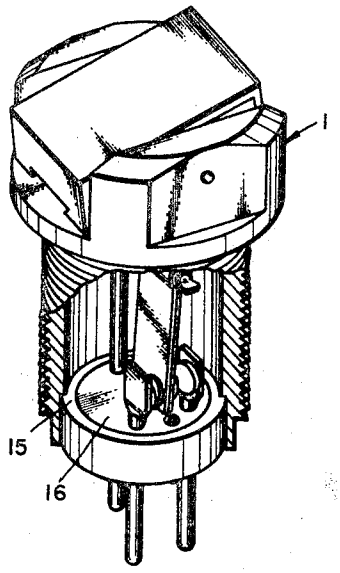


FIG. 1.

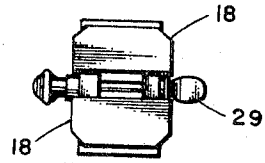


FIG. 7.

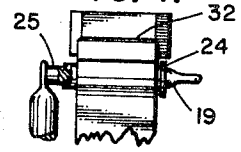


FIG. 8.

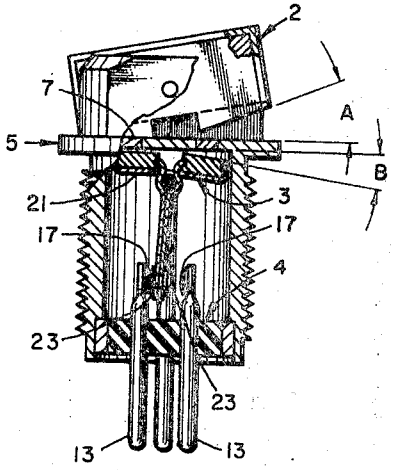


FIG. 2.

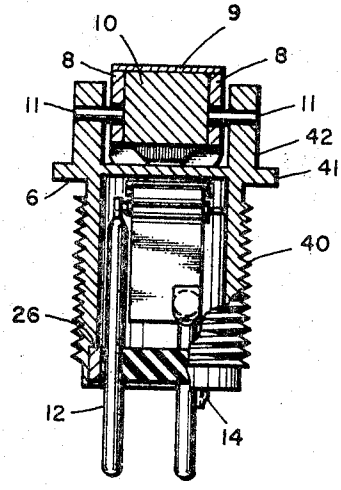


FIG. 3.

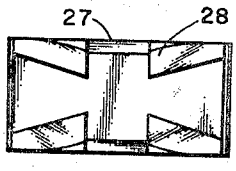


FIG. 5.

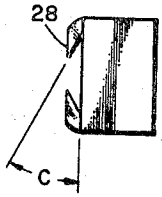


FIG. 6.

INVENTORS

DONALD E. REED

STANLEY F. REED

EMMETT F. DEADY

EDWARD R. FAIRBANKS

BY

ATTORNEY

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MAGNETIC SWITCHES

Donald E. Reed, Kensington, Md., Stanley F. Reed, McLean, and Emmett F. Deady, Arlington, Va., and Edward R. Fairbanks, Silver Spring, Md., assignors to Space Components Inc., Washington, D.C., a corporation of the District of Columbia

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This invention is concerned with the art of electric switches, particularly magnetic switches having a snap-action.

Whenever switch contacts in an electrical circuit carrying a substantial load are moved to make or break the circuit, there occurs a certain amount of arcing across the contacts. This burns the contacts, deforms their original optimum surface contour, and eventually changes the operating characteristics of the switch to an extent that it becomes inoperative for its intended purpose. Various expedients have been developed for actuating such switches in a manner to cause a substantial snap-action to minimize this arcing. Most attempts to solve the arcing problem, and thereby extend the useful life of these switches, have utilized spring-loaded elements and these elements have created secondary problems due to their susceptibility to fatigue and the difficulties encountered in maintaining consistent contact alignment and pressure under such conditions.

Accordingly, it is an object of this invention to provide an improved and simplified magnetic switch having a snap-action.

Furthermore, it is an object of this invention to provide such a switch which has no components under substantial compression or tension, thereby eliminating most fatigue malfunctioning thereof.

It is another object of this invention to provide an improved structural arrangement for a switch whereby a magnetic actuator on one side of a rugged hermetically sealed wall will control switch contacts within a hermetically sealed compartment on the other side of said wall.

Still another object of this invention is to provide an improved structural arrangement for a very small switch for all types of load requirements, and specifically adapted for loads in the 10 to 20 ampere range.

A more specific object of this invention is to provide an electric switch incorporating a pivotable permanent magnet on one side of a barrier to control a pivotable armature on the other side of this barrier.

A further specific object of this invention is to provide a switch with a rugged hermetically sealed non-corrosive contact chamber without organic contaminants therein to facilitate the provision of the optimum atmosphere therewithin for the reduction of arcing, and thereby maintain predetermined operational characteristics at temperatures up to 500° F. for periods substantially longer than other prior art switch structures.

These, together with other objects and advantages which will become subsequently apparent, reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

FIG. 1 is a partially sectional perspective view of a switch incorporating the principles of this invention;

FIG. 2 is a partially sectional side elevational view thereof;

FIG. 3 is a partially sectional front elevational view thereof;

FIG. 4 is a top plan view thereof;

FIG. 5 is a bottom plan view of the actuator assembly thereof;

FIG. 6 is an end elevational view of the actuator assembly shown in FIG. 5;

FIG. 7 is a top plan view of the armature assembly of the switch shown in FIGS. 1 to 3;

FIG. 8 is a fragmentary partially sectional side elevational view of the armature assembly shown in FIG. 7; and

FIG. 9 is a fragmentary perspective view of the actuator assembly shown in FIGS. 7 and 8, with the ferrite blocks and contacts removed to more clearly illustrate the interlocking of the actuator assembly support elements.

Referring now in greater particularity to the drawings, and first to FIGS. 1 to 4, there will be seen a switch constructed in accordance with the principles of this invention and designated generally by the numeral **1**. The switch **1** includes four unitary subassemblies; the actuator assembly **2**, the armature assembly **3**, the header assembly **4**, and the shell assembly **5**. The switch **1** shown is provided with threads **40**, annular shoulder **41**, and a pair of parallel flat surfaces **42** to facilitate the rigid moisture-proof installation thereof into larger assemblies. However, this particular mounting adaptation forms no part of this invention and those skilled in the art can provide switches constructed in accordance with this invention with various other mounting means.

The shell assembly **5** comprises a generally cup-shaped body **6** formed from easily machinable nonmagnetic stainless steel, such as Standard Type Number 303, and four flux buttons **7** hermetically sealed within four apertures provided at the closed end of cup-shaped body **6**. These apertures are arranged in the form of a rectangle, as best seen in FIG. 4. Buttons **7** are in the form of small cylinders of ferromagnetic stainless steel, such as Standard Type Number 416 of high permeability. Care must be exercised in assembling the buttons **7** with body **6** in order to insure a hermetic seal therebetween which can be indefinitely maintained at the wide temperature range for which these switches are intended. A convenient assembly process is to form the apertures in body **6** slightly larger than the diameter of buttons **7** and to silver braze buttons **7** in place utilizing the controlled clearance between buttons **7** and their respective apertures to form a hermetic seal by the capillary action inherent in such a method as is well known in the brazing art. It is significant to note that in order to preserve the corrosion resistance of body **6** and buttons **7**, a low melting temperature silver solder, such as a compound of 45% silver, 24% cadmium, 16% zinc, and 15% copper, and a low temperature brazing flux, such as that distributed under the trade name "Handy Flux," should be used. The above-described solder compound is solid at 1125° F. and liquid at 1145° F. The above-identified flux starts to liquify and become active at 800° F. and is entirely liquid and active at 1100° F. In this way, the silver brazing of buttons **7** into body **6** may be carried out by a very short application thereto of a minimum of heat, such as by RF induction heating at 1150° F. for 20 seconds. The corrosion resistance characteristics of the entirely stainless steel shell assembly are thereby retained. While body **6** and buttons **7** may be formed to size prior to brazing, it has been found expedient to leave excess metal on both sides of the body surfaces which receive buttons **7** which are over-length when assembled. Body **6** and buttons **7** are finished after brazing to provide smooth flux free surfaces on both the upper and lower surfaces of buttons **7** and the surfaces of body **6** flush therewith.

Referring further to FIGS. 1 to 4 and more specifically

to FIGS. 5 and 6, the finished actuator assembly **2** comprises; a permanent magnet **10** formed of a material such as distributed under the trade name "Alnico V," two mild steel pole pieces **8** formed into the configuration shown in FIGS. 5 and 6 and a non ferrous protecting strip or cover **9** which surrounds the top and both ends of magnet **10** and pole pieces **8** to protect them from inadvertent damage during handling and usage. This assembly is formed by forming oversize pole pieces **8** to have an interior angle "C plus 90°," as best seen in FIG. 5, between their flat side portions **27** and their depending actuating portions **28**; soft soldering polepieces **8** to magnet **10** at a temperature below 700° F. in such a manner as to insure that no substantial air gap exists between pole pieces **8** and surfaces of magnet **10** adjacent thereto; finishing the top and ends of this intermediate assembly to exact size; soft soldering protective cover **9** to these three finished surfaces at a temperature below 700° F.; finishing the remaining surfaces of pole pieces **8** to provide a central transverse channel and an angle A of approximately 20°; cleaning the finished assembly; bright chrome plating the entire assembly after copper and nickel undercoats; and thereafter magnetizing the magnet in the direction to provide a N pole at one pole piece **8** and a S pole at the other pole piece **8**. It should be noted, that at no time during the fabrication of the actuator assembly does the temperature of the magnet **10** exceed 700° F., thereby retaining the required operational characteristics thereof.

Referring further to FIGS. 1 to 3 and more specifically to portions of FIG. 8, the header assembly **4** comprises two conducting contact pins **13**, a center conducting pin **12**, and an exhaust tube **14** integrally bonded within a compressive-type glass insulator **16**. Insulator **16** is surrounded by a ring **15** also integrally bonded thereto. Conducting pins **12** and **13** are stainless steel clad upon a copper core, and exhaust tube **14** and ring **15** are stainless steel. The intermediate assembly comprising ring **15**, pins **12** and **13**, tube **14**, and insulator **16** hermetically bonded together may be procured commercially. However, to adapt this component for the purposes of this invention, the upper end of pin **12** is flattened and a center bearing pin **19** of stainless steel is resistance welded perpendicular thereto, as best shown in FIG. 8, and contact pins **13** are flattened on their upper end and silver-cadmium oxide-steel contact buttons **17** resistance welded thereto. It will be noted that pin **19** is upset to provide a larger diameter at the end **25** and thereby provide a bearing shoulder thereon.

Referring further to FIGS. 1 to 3 and more specifically to FIGS. 7 to 9, the armature assembly comprises two ferrite blocks **18**, two silver-cadmium oxide-steel contact buttons **23**, a silver-graphite bushing **20**, a bracket **21** of substantially rigid beryllium copper and two mirror image contact support leaves **22** also of substantially rigid beryllium copper interlocked together. Leaves **22** are resistance welded together to form a contact support arm and contact buttons **23** resistance welded to each other through an aperture in leaves **22**, thereby integrally locking these four elements together. The ferrite blocks **18** and bracket **21** are interlocked with leaves **22** by the insertion of bushing **20** between the ears **30** provided at the upper ends of leaves **22** when ears **30** are within a rectangular aperture **31** in bracket **21**. Ferrite blocks **18** are formed from a nickel-zinc ferrite selected for its characteristics of high resistivity of 10^9 ohm-centimeters, Curie point above 500° F., high permeability at low flux density, and low coercive force. Further, each side of ferrite blocks **18** is grooved at **32** to interlock with ears **30** of leaves **22** and the inwardly sloping retaining edges **33** of bracket **21** when assembled therewith. It will be noted that bushing **20** performs the function of a locking pin to retain the relative positions of the components of this assembly. Bushing **20** is formed of silver-graphite and has an internal diameter approximately .001 inch larger than the diameter of bearing pin **19** of header assembly **4** and will therefore freely pivot thereon with a substantial wiping action when in actual use. It will be noted that the flat upper surfaces of ferrite blocks **18** form an angle of "180° minus B." This angle is formed in practice by the natural bowing of bracket **21**, but may be formed by bending a bracket of more rigid material through a suitable angle or by using a flat rigid bracket and forming ferrite blocks **18** to have a top surface angled by one half of angle B.

Referring further to FIGS. 1 to 3, the final assembly of the four subassemblies described hereinabove will be set forth. Armature assembly **3** and header assembly **4** are cleaned; armature assembly **3** is slipped upon pin **19** of header assembly **4** with one end of bushing **20** in contact with the shoulder formed on pin **19** by upset end **25** thereof welded to center pin **12**; retaining washer **24** is placed on pin **19** in contact with the other end of bushing **20**; and the protruding end of pin **19** is deformed or crimped at **29** to maintain the desired alignment between these two assemblies. This results in the formation of an armature-header subassembly.

Further, it will be noted that body **6** has an internal shoulder **26** at the end thereof remote from buttons **7**, and that the distance from shoulder **26** to the internal flat surface of body **6** which includes the inner surfaces of buttons **7** must be carefully maintained.

The armature-header subassembly and shell assembly **5** are next carefully cleaned to remove any contaminants; the armature-header subassembly then is inserted within the generally cylindrical cavity of body **6** until the upper flat surface of ring **15** mates with internal shoulder **26** of body **6**; and this position is maintained while ring **15** is silver brazed to body **6** by any convenient process, the RF induction heating method described hereinabove with respect to the joining of body **6** and buttons **7** being satisfactory. It should be noted that no flux or other contaminants must be allowed to leak into the internal portions of the contact chamber thus formed. Following this assembly operation, this major assembly is placed in an evacuated chamber heated to approximately 400° F. for a period of several hours. It is to be noted that the internal contact chamber is still open to the external environment through exhaust tube **14**. This major assembly is then permitted to cool in a nitrogen atmosphere and is cycled several times between nitrogen at 10 p.s.i. gage and a vacuum. Individual assemblies are next pressurized to 10 p.s.i. gage with a 93% nitrogen–7% helium mixture and thereafter exhaust tube **14** is resistance welded closed and the excess tube removed; or alternatively crimped closed, cut, and capped with soft solder.

Following this, actuator assembly **2** is pivotally positioned upon this assembly with pins **11** inserted through holes in body **6** and pole pieces **8**, care being exercised so that no air gap exists between the top surface of buttons **7** and the actuating portions **28** of pole pieces **8** immediately adjacent to buttons **7**. It will be noted that while the holes in body **6** are substantially the same diameter as pins **11**, the holes in pole pieces **8** are approximately .002 inch larger in diameter than pins **11** to provide for the necessary pivotal action therebetween. Pins **11** are lightly staked in place at the end where they are substantially flush with the flat surfaces **42** of body **6**. It will be noted that while no air gap exists between pole pieces **8** and buttons **7** whenever the actuator is in either of the switch positions, there is always an air gap of approximately .003 inch between the top surface of the raised ferrite block **18** and the underside of buttons **7** substantially parallel thereto. This air gap is required in order that the contact pressure between contacts **23** and **17** may be maintained even though a slight deformation thereof occurs during the operational life of the switch.

It will be noted that in the assembled switch, the four buttons **7** are operatively divided into two pairs, each of these pairs operatively associated with a single ferrite

block 18 and the pair of depending actuating portions 28 of pole pieces 8 comprising one N pole and one S pole which are closest thereto. Further, it will be seen that magnet 10, pole pieces 8, buttons 7, and ferrite blocks 18 form two magnetic circuits.

The operation of switch 1 will be apparent from the following description. Whenever actuator assembly 2 is in contact with a first pair of buttons 7, the ferrite block 18 closest thereto and the entire armature assembly 3 will be strongly biased in a first direction toward said first pair of buttons 7 to minimize the small parallel air gap in this first magnetic circuit. At the same time, the other pair of buttons 7 are physically separated from the actuator assembly 2 by the angular configuration thereof and the other ferrite block 18 is separated from said other pair of buttons 7 by a relatively large angular air gap. This second magnetic circuit having these substantial air gaps biases said other ferrite block 18 and the entire armature assembly 3 toward said other pair of buttons 7 in a direction opposite to said first direction. From the above, it will be seen that one of these two magnetic circuits is always much stronger than the other whenever actuator assembly 2 is pivoted into direct contact with shell assembly 5, and therefore, armature assembly 3 will be rotated until a button 23 contacts a corresponding button 17 to complete an external circuit connected thereto, and thereafter retained in this contact position with a substantial contact pressure due to the stronger of said two magnetic circuits.

The operation of switches constructed in accordance with this invention is simplified since there are only two moving parts, actuator assembly 2 on one side of the closed end of shell assembly 5 and armature assembly 3 on the other side thereof.

Alternative structures within the scope of applicants' invention include an armature assembly similar to that described hereinabove, but with the following modifications: resilient conductive material substituted for the rigid material for leaves 22; soft iron blocks substituted for ferrite blocks 18; and non-conductive material substituted for the material for bracket 21 or the iron blocks insulated therefrom by other insulating means, such as coating the front, rear, and bottom of these iron blocks with a ceramic material. It will be seen that with this modification, the parallel air gap may be eliminated and the contact pressure maintained by the resiliency of the leaves.

Additional modifications of applicants' devices include the use of a spot of soft solder between bushing 20 and leaves 22 to improve the conductive characteristics of the armature assembly.

Further, it will be understood that the fabrication processes set forth hereinabove have been selected to minimize alignment problems. However, all the elements could be formed to exact size before assembly, provided that sufficient care is exercised to maintain the precise alignment of the component parts during assembly.

Although specific materials and fabrication processes have been set forth in describing an exemplary embodiment of applicants' invention, it is to be understood that this embodiment is given by way of illustration and not limitation; changes and modifications in the details of the apparatus can be made without departing from the spirit of the invention as defined in the appended claims.

We claim:

1. In an electrical switch, the combination comprising: a supporting housing, said housing comprising a sealed switching cavity and a rigid wall, said wall comprising a body portion of non-magnetic material with four apertures therein arranged in a generally quadrangular configuration and an insert of magnetic material sealed within each of said apertures; a magnetic actuator mounted on said housing externally of said cavity for movement between two switching positions, said actuator comprising a permanent magnet having N and S poles, each of said poles having a pair of actuating portions, said actuating portions aligned so that one actuating portion of each of said poles is in substantial contact with said wall whenever said actuator is in one of said switching positions, each of said actuating portions aligned with one of said inserts; an armature within said cavity supported by said housing for pivotal movement between two switching positions, said armature magnetically associated with said actuator so that said armature assumes a predetermined angular position for each of said two switch positions, said armature comprising two separate blocks of magnetic material, a non-magnetic supporting means for said blocks, and first contact means mounted thereon; and second contact means within said cavity supported by said housing, whereby one actuating portion of each of said poles of said magnet, two of said inserts, and one of said blocks form a strong magnetic circuit to maintain contact between said first and second contact means whenever said actuator is positioned in one of said switching positions.

2. The combination set forth in claim 1 wherein said blocks have the characteristics of high resistivity, high curie point, high permeability at low flux density, and low coercive force.

3. The combination set forth in claim 2, wherein said strong magnetic circuit comprises a small air gap between said two inserts and said block for every position of said armature.

4. The combination set forth in claim 1, wherein said blocks are mild steel.

5. The combination set forth in claim 1 wherein said strong magnetic circuit comprises a small air gap between said two inserts and said block for every position of said armature.

6. In an electrical switch, the combination comprising: a supporting housing, said housing comprising a hermetically sealed switching cavity and first and second rigid, walls, said first wall comprising a body portion of non-magnetic material with four apertures therein arranged in a generally rectangular configuration and an insert of magnetic material hermetically sealed within each of said apertures; a magnetic actuator supported on a first axle mounted on said housing externally of said cavity on one side of said first wall for pivotal movement between two switching positions, said first axle having an axis, said actuator comprising a permanent magnet having N and S poles and a magnetic axis aligned parallel to said axis of said first axle, said magnet having a pole piece integrally mounted on each of said N and S poles, each of said pole pieces having a pair of depending actuating portions, said actuating portions aligned so that one actuating portion of each of said pole pieces is in substantial contact with said one side of said first wall whenever said actuator is in one of said switching positions, each of said actuating portions aligned with one of said inserts; an armature within said cavity supported on a second axle for pivotal movement between two switching positions, said second axle having an axis aligned parallel to said axis of said first axle, said second axle mounted on a pin supported by said second wall, said armature comprising two separate blocks of magnetic material, a non-magnetic supporting means for said blocks, a first contact support means in contact with said second axle, and first contact means mounted on said first contact support means; and a second contact means mounted within said cavity on a second contact support means, said second contact support means supported by said second wall, whereby one actuating portion of each of said pole pieces, said magnet, two of said inserts, and one of said blocks form a strong magnetic circuit to maintain contact between said first and second contact means whenever said actuator is positioned in one of said switching positions.

7. The combination set forth in claim 6, wherein said blocks have the characteristics of high resistivity, high

Curie point, high permeability at low flux density, and low coercive force.

8. The combination set forth in claim 7, wherein said strong magnetic circuit comprises a small air gap between said two insets and said block for every position of said armature.

9. The combination set forth in claim 6, wherein said blocks are mild steel.

10. The combination set forth in claim 6, wherein said strong magnetic circuit comprises a small air gap between said two inserts and said block for every position of said armature.

11. In an electrical switch, the combination comprising: a supporting housing, said housing comprising a hermetically sealed switching cavity and first and second rigid walls, said first wall comprising a body portion of non-magnetic material with four apertures therein arranged in a generally rectangular configuration and an insert of magnetic material hermetically sealed within each of said apertures; a magnetic actuator supported on a first axle mounted on said housing externally of said cavity on one side of said first wall for pivotal movement between two switching position, said first axle having an axis, said actuator comprising a permanent magnet having N and S poles and a magnetic axis aligned parallel to said axis of said first axle, said magnetic having a pole piece integrally mounted on each of said N and S poles, each of said pole pieces having a pair of depending actuating portions, said actuating portions aligned so that one actuating portion of each of said pole pieces is in substantial contact with said one side of said first wall whenever said actuator is in one of said switching positions, each of said actuating portions aligned with one of said inserts; an armature within said cavity supported on an electrically conductive bearing for pivotal movement between two switching positions, said bearing having an axis aligned parallel to said axis of said first axle, said bearing mounted on an electrically conductive pin supported by said second wall, said armature comprising two separate blocks of magnetic material, a non-magnetic supporting means for said blocks, an electrically conductive bushing concentric with said bearing, a first contact support means in electrical contact with said bushing, and first contact means mounted on said first contact support means; and second contact means mounted within said cavity on a second contact support means, said second contact support means supported by said second wall, whereby one actuating portion of each of said pole pieces, said magnet, two of said inserts, and one of said blocks form a strong magnetic circuit to maintain contact between said first and second contact means whenever said actuator is pivoted into one of said switching positions, and the pivotal motion of said bushing on said bearing provides a substantial wiping action therebetween.

12. The combination set forth in claim 11 wherein said blocks have the characteristics of high resistivity, high Curie point, high permeability at low flux density and low coercive force.

13. The combination set forth in claim 12, wherein said strong magnetic circuit comprises a small air gap between said two inserts and said block for every position of said armature.

14. The combination set forth in claim 11, wherein said blocks are mild steel.

15. The combination set forth in claim 11, wherein said strong magnetic circuit comprises a small air gap between said two inserts and said block for every position of said armature.

References Cited in the file of this patent

UNITED STATES PATENTS

2,439,753	Reavis	Apr. 13, 1948
2,520,935	Hubbell	Sept. 5, 1950
2,770,697	Kellett	Nov. 13, 1956
2,896,043	Andrews	July 21, 1959
2,935,583	Howell	May 3, 1960
2,945,928	Houser	July 19, 1960
2,971,068	Wegner	Feb. 7, 1961
2,985,734	Howell et al.	May 23, 1961
3,025,372	Benson	Mar. 13, 1962
3,052,778	Kathe	Sept. 4, 1962

FOREIGN PATENTS

1,129,715	France	Jan. 24, 1957