March 6, 1962 C. L. JOHNSON 3,024,329

VACUUM SWITCH

Filed Nov. 9, 1959

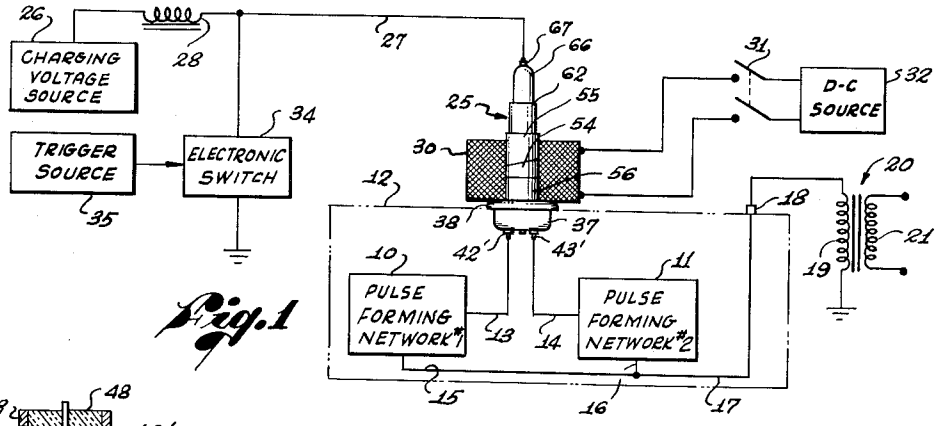


Fig. 1

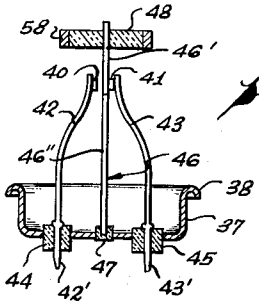


Fig. 2

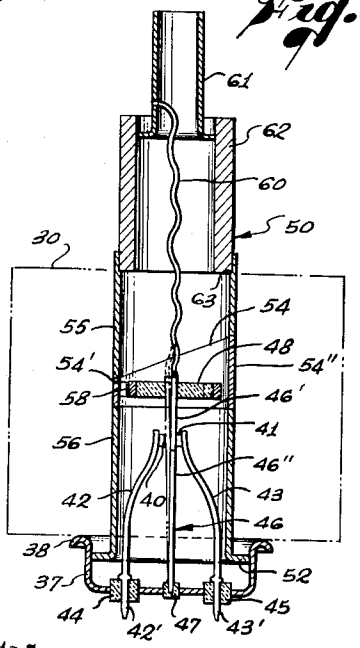


Fig. 3

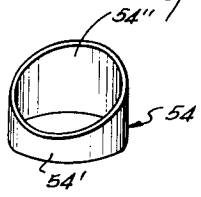


Fig. 4

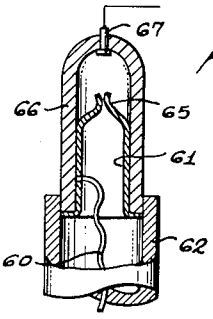


Fig. 5

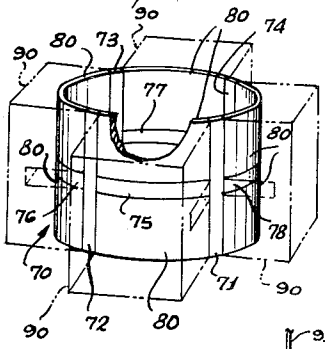


Fig. 6

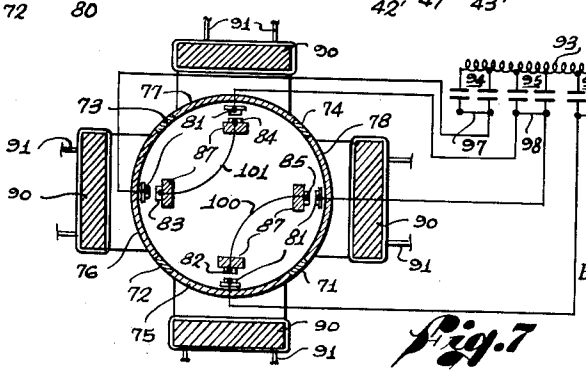


Fig. 7

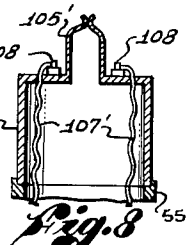


Fig. 8

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United States Patent Office 3,024,329 Patented Mar. 6, 1962

3,024,329

VACUUM SWITCH

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Filed Nov. 9, 1959, Ser. No. 851,764
5 Claims. (Cl. 200—87)

This invention relates to switching devices, and more particularly to an improved vacuum switch.

More specifically, this invention relates to vacuum switches of the type employing a movable armature and a pair of fixed contacts within an evacuated envelope. In this type of switch, the armature, which carries a contact element therewith, is normally positioned with the contact carried thereby being in engagement with one of the fixed contacts. The armature is adapted to be moved to a position wherein the contact carried thereby engages the other contact within the envelope. Such movement is effected magnetically as by energizing a toroidal coil placed over the envelope to set up a magnetic field to attract the armature to the desired position.

In prior art high-vacuum switches, it is a common practice to assemble the armature and contact elements in a glass envelope. In thus assembling these elements, it is necessary to position them so that the contact carried by the armature will, in the normal position of the armature, engage one fixed contact with sufficient firmness to maintain such engagement during vibration. Also, it must be possible with a predetermined magnetic field strength, i.e., a predetermined current in the toroidal coil, to attract the armature to its other position, and in such other position to insure that engagement of its contact with the other fixed contact will be maintained during vibration.

To properly orient and secure the elements in a glass envelope requires the services of a highly skilled worker. Not only is this objectionable because of the high cost of production, reliance on the particular worker makes quantity production impossible. Further, many assembled switches have to be rejected because of errors made in assembly, all of which makes the cost unduly high.

Prior art vacuum switches have numerous other disadvantages. One such disadvantage resides in the fragility of glass, and in the inherent variations in the wall thickness of the glass envelope. These characteristics contribute to breakage or rupture of the envelope, particularly when it is subjected to extreme vibration and shock.

Another disadvantage of prior art vacuum switches is that they cannot be made with as high a vacuum as is desired. This is for the reason that the glass envelope cannot be heated to a high temperature while it is evacuated. Due to the relatively low melting temperature of glass, heating during vacuum processing must be kept to relatively low temperatures. Accordingly, when the envelope is sealed off, there is still considerable gas trapped within it. The "getter" technique eliminates some of this residual gas, but an undesirable amount still remains within the envelope.

Further disadvantages of prior art vacuum switches using glass envelopes are revealed in mounting them onto a support. For example, where the switch is to be mounted on a metal casing, a metal band is secured to the glass envelope. This band is then secured to the metal casing, as by soldering. Such operations require the application of heat in the vicinity of the envelope which adversely affects the glass. The seal between the metal ring and the envelope may be broken, and the envelope itself may be melted. Thus, although a satisfactory vacuum switch may be constructed, the effectiveness of the switch may be destroyed in mounting it onto a support.

It is an object of this invention to provide a unique vacuum switch which utilizes no parts, such as glass or the like, having low melting points.

It is another object of this invention to provide an improved vacuum switch construction with which a higher vacuum can be obtained in assembly than is possible with prior art vacuum switches.

A further object of this invention is to provide a vacuum switch wherein stationary and movable contacts to be located within an evacuated housing or envelope can be selectively positioned and adjusted prior to enclosing them in the envelope.

A still further object of this invention is to provide a vacuum switch structure which can be assembled in a minimum of time by relatively unskilled laborers.

It is yet another object of this invention to provide a vacuum switch structure having a minimum number of component parts of simple design and rugged construction, capable of quantity production and having uniform characteristics.

The above and other objects and advantages of this invention will become apparent from the following description taken in conjunction with the accompanying drawing of illustrative embodiments thereof, in which:

FIGURE 1 is a combined schematic illustration of my vacuum switch and a block diagram of circuits controlled therewith;

FIGURE 2 is a partial sectional view of the cup element of the switch, showing the arrangement of a pair of fixed contacts and an armature carrying a movable contact;

FIGURE 3 is a longitudinal sectional view of the contact and armature elements disposed in a sleeve housing, showing the parts arranged preparatory to evacuating the housing;

FIGURE 4 is a perspective view of a non-magnetic insert which forms part of the housing, such insert being shaped to insure movement of the armature in a predetermined direction under the influence of a magnetic field;

FIGURE 5 is a partial sectional view of the upper portion of the housing after it has been evacuated, showing how the terminal connection is made thereto;

FIGURE 6 is a perspective view of a modified insert adapted for use in the housing of my switch;

FIGURE 7 is a schematic diagram illustrating the switch utilizing the insert of FIGURE 6 for selectively controlling the positions of one or more of a plurality of movable armatures toward respective stationary contacts, and illustrating schematically its use for selectively utilizing one or more portions of a circuit; and

FIGURE 8 is a sectional view of the upper portion of an envelope for the contacts shown in FIGURE 7, showing a non-magnetic closure element supporting terminal posts connected to respective movable contacts.

Referring to FIGURE 1, the switch of my invention is shown in use for controlling the operation of one or the other of a pair of pulse forming networks **10**, **11**, which are shown schematically as enclosed in a casing **12**. The pulse forming networks **10**, **11** have respective input leads **13**, **14** to conventional charging coils (not shown), and common connections **15**, **16** to groups of capacitors spaced along the coils.

The connections **15**, **16** form the output leads of the pulse forming networks **10**, **11**, and are connected, as at **17**, to a terminal post **18** supported on the casing **12**. The terminal post **18** is connected as shown, to one end of the primary winding **19** of a pulse transformer **20**; the other end of the primary winding **19** is grounded, as shown. The secondary winding **21** of the pulse transformer **20** is adapted for connection to means (not shown) operable in response to pulses developed across

such secondary windings, e.g., a magnetron oscillator which has a frequency of operation dependent upon the shape and duration of such pulses.

In order to effect operation of one or the other of the pulse forming networks **10**, **11**, a switch **25** is provided for connecting one or the other of the input leads **13**, **14** to the output of a charging voltage source **26**. To this end, the switch **21** is provided with a terminal lead **27** which is coupled to the source **26** through a choke **28**.

As will be described in greater detail hereinafter, the switch **25** is provided with a pair of fixed contacts connected to the leads **13**, **14**, and a movable contact connected to the terminal lead **27**. The movable contact is adapted to be selectively moved so as to connect one or the other of the leads **13**, **14** to the terminal leads **27**. To effect such movement of the movable contact a toroidal coil **30** is provided which is adapted to be connected through a switch **31** to an energizing source **32**. With the switch **31** open, the movable contact is in a normal position wherein one of the leads **13**, **14** is connected to the source **26**. When the switch **31** is closed, the coil **30** is energized by the source **32** to effect movement of the movable contact to a position wherein the other of the leads **13**, **14** is connected to the charging source **26**. In this manner, the pulse transformer **20** can be selectively coupled to one or the other of the pulse forming networks **10**, **11**, to thereby develop across the secondary winding **21** pulses having a waveform and duration determined by the characteristics of the particular pulse forming network connected to the primary winding **19**.

The development of pulses is effected by periodically connecting the terminal leads **27** to ground, and to this end an electronic switch **34** is connected between the terminal lead **27** and ground. A trigger source **35** is provided which develops trigger pulses of a predetermined repetition rate. Upon the occurrence of each trigger pulse, the electronic switch **34** conductively connects the terminal lead **27** to ground, thereby allowing the discharge of the capacitors in the pulse forming network connected to the terminal lead **27** through the switch **25**.

The construction of my switch **25** will now be explained with reference to FIGURES 2–5, along with FIGURE 1. As shown, the lower end of the envelope of the switch **25** comprises a flanged cup or bowl shaped element **37**. The cup **37** extends into the interior of the casing **12**, with the rim **38** thereof abutting the top surface of the casing. Preferably, the cup **37** is formed of a high temperature metal, such as cold rolled steel. Preferably, the rim **38** of the cup **37** is curved over (see FIGURES 2 and 3) so that the edge thereof is located below the upper portion of the cup. The edge of the cup is secured to the casing **12**, as by silver soldering it in place.

The fixed contacts previously mentioned are shown in FIGURES 2 and 3 at **40** and **41**. As shown, the contacts **40**, **41** are disposed at the upper ends of respective lengths of conductive metal rods **42**, **43** which extend at their upper ends through beads **44**, **45** of ceramic tubing which are secured in the lower end of the cup **37**, preferably by silver soldering. The ends **42'**, **43'** of the rods **42**, **43** extending below the beads **44**, **45** are connected to the leads **13**, **14** to the pulse forming networks **10**, **11** whereby to connect the fixed contacts **40**, **41** to the respective leads **13**, **14**. Disposed between the rods **42**, **43** is a thin rod **46** which at its lower end is secured in a ceramic bead **47** fixed in the bottom of the cup **37**. At least the upper end of the rod **46** is a conductive contact portion **46'** which extends between and above the contacts **40**, **41**, and an insulating element, illustrated as a ceramic disc **48**, is secured to the contact **46'** at a point intermediate its upper end and the portion thereof which is disposed between the contacts **40**, **41**. The rod **46** may be a length of conductive spring wire, or it may be comprised of conductive and non-conductive elements brazed together.

As shown in FIGURES 2 and 3, the conductive rods **42**, **43** are shaped so that the rod **46** has a normal position wherein the contact **46'** engages the contact **41** on the rod **43**, and is spaced from the contact **40**.

Referring to FIGURE 3, the rods **42**, **43**, **46**, and the disc **48** are surrounded by a sleeve **50**, the lower end of which extends into the cup **37** and is secured thereto. The lower end of the sleeve **50** is shown to be of smaller diameter than the inner diameter of the cup **37**, and is outwardly flared, as at **52**. The periphery or rim of the flared portion **52** is secured to the inner wall of the cup **37**, as by silver soldering or copper brazing.

The portion of the sleeve **50** that is surrounded by the coil **30** is formed of a tube of magnetic material which contains a non-magnetic insert **54**. The insert **54** separates magnetic sections, indicated at **55** and **56**, and is positioned so as to surround the disc **48** mounted adjacent the upper end of the rod **46**. The insert **54** and the magnetic sections **55**, **56** are made of high-temperature materials; for example, the insert **54** may be formed of copper and the magnetic sections **55**, **56** formed of steel tubing.

Secured to the ceramic disc **48**, as by copper brazing, is a ring **58** of magnetic material, such as iron. The iron ring **48** constitutes an armature element which is to be attracted, upon energization of the coil **30**, in a direction to separate the contact **46'** from the contact **41** and to bring the contact **46'** into engagement with the contact **40**. The insert **54** is so shaped and positioned as to insure this result, as will now be explained.

As shown, the insert **54** is in the form of a cylinder which at one end has been cut diagonally (see FIGURE 4 along with FIGURES 1 and 3) so as to provide a tubular element having diametrically opposed portions **54'**, **54''** of minimum and maximum length. The insert **54** is positioned intermediate the sections **55**, **56** so that the portion **54'** of minimum length is located at the portion of the sleeve nearest the contact **40**. This position of the insert **54** insures that, upon energizing the coil **30**, the armature **58** will be attracted toward the portion **54'** of minimum length to effect the desired engagement of the contact **46'** and the contact **40**.

As will be apparent, the magnetic lines of force established by the coil **30** pass between the magnetic sections **55**, **56** through the insert **54**. However, that half of the insert **54** on the left-hand side of FIGURE 3 offers less reluctance to the lines of force than does the right-hand half of the insert. Accordingly, there is a greater concentration of the magnetic lines of force immediately adjacent the portion **54'** of minimum length, thereby causing the armature **58** to be attracted in the direction of such portion **54'** and causing the contact **46'** to engage the contact **40**.

In order to connect the movable contact **46'** to an output connection, such as the terminal lead **27** in FIGURE 1, an elongated conductive element **60**, such as a length of copper ribbon, is connected at one end to the upper end of the movable contact **46'**. The conductive element **60** is connected to a short tube **61** of conductive material at the top of the envelope **50**. The tube **61** is secured in the upper end of a tubular element or sleeve **62** of insulating material which is secured at its lower end, as by copper brazing, to the upper end of the magnetic section **55**. The lower end of the tube **61** is flared outwardly and has the peripheral surface of the rim secured, as by copper brazing, to the interior of the insulating element **62**.

Preferably, the insulating element **62** is formed of material capable of withstanding rather high temperatures. For this purpose the element **62** may be made of alumina, an aluminum oxide compound capable of withstanding temperatures in the neighborhood of 2000° F. The lower end of the element **62** is supported within the upper end of the section **55** of the envelope as on a shoulder **63**. As with the connections between various elements as previously described, the insulating element **62** is secured to the section **55** with material capable of withstanding extremely high temperatures, e.g., silver soldering or copper brazing.

With the parts arranged as shown in FIGURE 3, I place the assembly in an oven and connect the open end of the tube **61** to a vacuum system. Since all of the parts are capable of withstanding rather high temperatures, evacuation can be carried out with at temperatures well above the melting temperature of glass, e.g., vacuum processing at 1000° F. to 2000° F. Accordingly, my switch structure is such that it can be substantially completely evacuated, and to a degree not obtainable with glass envelopes even with the use of the "getter" technique.

When the desired vacuum has been obtained, the upper end of the tube **61** is pinched (see FIGURE 5), as at **65**, thereby sealing off the interior of the envelope. Thereafter, I place over the tube **61** a tight fitting cup **66** of conductive material which is secured at its lower end, as by copper brazing, to the interior of the insulating element **62**. The cup **66** is closed at its upper end, and it has embedded therein a terminal post element **67**.

Thus, with the terminal post **67** connected to the terminal lead **27** in FIGURE 1, it will be seen that the source **26** is connected to one of the pulse forming networks **10**, **11** through the terminal post **67**, the cup **66**, the tube **61**, the conductive element **60**, and thence through the contact **46'** and the one of the contacts **40**, **41** engaged thereby.

Not only does my vacuum switch constitute a much more rugged structure than switches employing glass envelopes, but it can be assembled in a minimum of time by relatively unskilled workers. Unlike the procedure with prior art vacuum switches, the contacts **40**, **41** and **46** are positioned properly while freely accessible, i.e., before placing the sleeve **50** over them.

The rods **42**, **43** are characterized in that they can be bent, but they will retain their shapes. For this purpose, the rods **42**, **43** may be made of nickel tubing. The rod **46** preferably is a relatively stiff, spring metal member. Initially, the rod **43** is bent so that the contact **41** thereon abuts the contact **46'** of the rod **46**. In this connection the rod **46** is not straight when the contact **46'** thereon engages the contact **41**. Instead, the position of the rod **43** prevents the rod **46** from assuming a straight position, i.e., the rod is slightly flexed in its normal position of engagement with the contact **41**. This means that, due to the spring characteristic of the rod **46**, it bears against the stationary contact **41**. The degree of flex of the rod **46** determines the amount of force with which the contact **46'** bears against the contact **41**.

Both of the rods **42**, **43** are bent by the worker as necessary to adjust their positions so that, in the normal position of the rod **46**, the contact **46'** bears against the contact **41** with the force necessary to withstand vibrations and shock of predetermined magnitudes, and so that the contact **46'** is held against the contact **40** under a predetermined force of attraction of the armature **58**, as above described, despite vibrations and shock. Regarding vibrations and shock, the proper position of the contact **41** can be determined by controllably vibrating the cup **37** to the extent it is desired to maintain the contact between the contacts **46'**, **41**.

To determine the force needed to cause the contact **46'** to move from the contact **41** to the contact **40**, an initial determination is made of the mechanical force which is the equivalent of the force of attraction of the armature that is **58** needed to so move the contact **46'**. A simple strain gauge is then attached to the upper end of the rod **46**, and adjustments are made as necessary (by adjustably bending one or more of the rods **42**, **43**, **46**) to obtain the proper reading on the strain gauge.

Once the proper positions of the contact elements are obtained, the rest of the assembly is completed. Unlike prior art vacuum switches, there is no concern about whether the assembly of the rest of the switch will have any effect upon the settings of the contact elements. No further manipulation of the contacts is needed, so that upon completing the assembly one is assured that they are properly positioned, and that they will operate properly.

FIGURES 6–8 illustrate means for employing my switch to actuate a plurality of contacts. In such a switch, the insert **54** previously described is replaced with an insert **70** (see FIGURE 6) of cylindrical construction. In the embodiment shown, a cylindrical insert **70** comprises four spaced bars **71–74** of non-magnetic material, the adjacent bars **71—72**, **72—73**, **73—74**, and **74—71** having their mid-portions joined by curved band elements **75**, **78** of non-magnetic material. Filling the remaining spaces between the bars **71—72**, **72—73**, **73—74**, **74—71** are curved segments **80** of magnetic material.

With the insert constructed as shown in FIGURE 6, I utilize in my switch four spaced stationery contacts **81** which are positioned midway between the respective pairs of adjacent bars **71—72**, **72—73**, **73—74**, **74—71**. Also, I utilize four spaced movable contacts **82–85**, each of which is located adjacent a respective fixed contact **81**.

It will be apparent that where I employ a plurality of fixed contacts **81**, such contacts are supported in the cup **37** in the same manner as the fixed contacts previously described. Similarly, the movable contacts **82–85** are the upper ends of respective rods extending from the base cup. Adjacent the tops of the movable contacts **82–85** are mounted respective armature elements **87**, which are centered between the respective pairs of parallel bars **71—72**, **72—73**, **73—74**, **74—71**. Also, the armature elements **87** are located in the same plane as the non-magnetic elements **75**, **76**, **77**, **78**.

The insert structure **70** is shaped to permit the armatures **87** to be individually attracted to effect engagement between the associated movable and fixed contacts. To this end, I provide a plurality of generally U-shaped magnetic core elements **90**. As shown in phantom in FIGURE 6, the core elements **90** are arranged between the respective pairs of parallel bars **71—72**, **72—73**, **73—74**, **74—71**, with the ends of the legs thereof confronting the magnetic elements **80** above and below the horizontal non-magnetic elements **75—78**. As shown, the space between the legs of the core elements **90** span the non-magnetic elements **75—78**.

To establish a magnetic field, respective coils **91** (see FIGURE 7) are wound around the core elements **90** intermediate their legs. Due to the arrangement of the non-magnetic elements of the insert **70**, energization of any coil **91** causes only the armature **87** immediately adjacent thereto to be attracted. This will be apparent upon study of one of the sections; for example, if a magnetic field is established in the core element **90** located between the bars **71**, **72**, the magnetic lines of force are concentrated between the faces of the coil element **90** and the armature **87** immediately adjacent thereto. Accordingly, a strong attractive force exists to pull the adjacent armature **87** so that its contact **82** engages the fixed contact **81**. The side bars **71**, **72** of non-magnetic material prevent the lines of force from threading into the adjacent magnetic elements.

One use of the multi-contact switch arrangement is shown in FIGURE 7. A pulse-forming network is shown having a charging coil **93** and a plurality of spaced capacitive means connected along the coil, such capacitor means being arranged in pairs **94**, **95**, **96**, as by having the capacitor means of each pair connected together as at **97**, **98**, and **99**. The output of the network is coupled to the primary winding **19** of the pulse transformer **20**.

It is desired to operate the network so that (*a*) only the pair **96** is operative to develop pulses across the primary winding **19**, or (*b*) the pair **95** is operative with the pair **96** to develop pulses, or (*c*) all three pairs **94**, **95**, **96** are operative to develop pulses. My switch is adapted to effect the necessary switching to connect the pairs in any of these combinations.

As shown schematically in FIGURE 7, the connection 99 is connected to one of the fixed contacts 81, the connection 98 is connected to a pair of the fixed contacts 81, and the connection 97 is connected to the remaining fixed contacts 81. The movable contacts 82, 85, are directly connected, as at 100, so that when these movable contacts are simultaneously in engagement with their respective fixed contacts 81, the connections 91, 98 will be connected together, i.e., the capacitive section 95 is operatively connected with the pair 96 between the coil 93 and the transformer 20.

The movable contacts 83, 84 are also directly connected, as at 101, so that when they simultaneously engage their respective fixed contacts 81, the connections 97, 98 are connected together. When none of the movable contacts 82, 85 engages its respective fixed contact 81, only the connection 99, i.e., to the capacitive pair 96, is coupled to the transformer 20.

To connect the capacitors, pairs 95, 96 together, the coils 91 of the cores 90 immediately adjacent the movable contact 82, 85 are simultaneously energized. This causes the movable contacts 82, 85 to engage their respective fixed contacts, thereby to connect both capacitors sections 95, 96 to the pulse transformer 20.

When it is desired to make all three capacitor pairs 94–96 operative, all of the coils 91 are energized, thereby to simultaneously connect all of the movable contacts 82–85 to their respective fixed contacts 81. In this manner, the pulse transformer 20 can be supplied with pulses of any of three durations.

FIGURE 8 illustrates an arrangement of the top portion of my multi-contact switch for connecting the movable contacts to respective terminals. The upper portion of the housing is formed by a non-magnetic tubular element 105 which has a small diameter tube portion 105′ at its upper end. This tube portion 105′ is pinched after evacuating to seal off the housing, in the same manner as the tube 61 of FIGURES 3 and 5. Respective elongated conductive elements 107 are led from the movable contacts to respective terminal posts 108 embedded in the element 105.

While I have described my invention with reference to particular embodiments thereof, it will be apparent that various modifications can be made without departing from the spirit and scope of my invention. Accordingly, I do not intend that my invention be limited, except as by the appended claims.

I claim:

1. A switching device comprising: an evacuated housing including magnetic sections separated by a non-magnetic section, said non-magnetic section being shaped to permit magnetic lines of force to pass into the housing and around said non-magnetic section from one magnetic section to the other; a pair of normally disengaged contact elements in said housing, one being fixed and the other movable, said fixed contact being located between said non-magnetic section and said movable contact, said movable contact being attracted by said magnetic lines of force to move toward said non-magnetic section and engage said fixed contact.

2. A switching device comprising: a pair of spaced stationary contacts and a movable contact therebetween, said movable contact normally engaging one of said stationary contacts; a magnetic element connected to said movable contact; an evacuated housing enclosing said contacts and elements, said housing having a pair of sections of magnetic material separated by a section of non-magnetic material, said non-magnetic section being located adjacent the stationary contact that is not engaged by said movable contact; and means to establish a magnetic field between said magnetic sections to thread past said non-magnetic section and through said magnetic element, whereby said magnetic element is attracted in a direction to move said movable contact from engagement with said one stationary contact and into engagement with the other stationary contact.

3. A vacuum switch comprising: a cup element; a pair of spaced conductive elements extending into said cup element and each having one end secured in and extending through the bottom of said cup element, said conductive elements having respective contacts at their upper ends; an elongated element of conductive spring material secured at one end in the bottom of said cup element and extending at its upper end past the upper ends of said conductive elements, said elongated element being disposed between said conductive elements, said elongated element normally engaging one of said contacts; a magnetic armature element supported on the upper end of said elongated element; an elongated, evacuated housing having a sleeve surrounding said conductive and elongated elements, one end of said sleeve extending into said cup element and being secured to the interior thereof, said sleeve including a pair of sections of magnetic material separated by a section of non-magnetic material, said non-magnetic section surrounding said armature element, the lateral surface of said non-magnetic section varying in length, the portion of shortest length being positioned so that the other of said contacts is intermediate said elongated element and said portion of shortest length; a tubular element of non-magnetic material secured at one end to the upper magnetic section of said sleeve; a tubular element of conductive material secured in the upper end of said non-magnetic tubular element, said conductive tubular element being closed at its upper end; a conductive element connecting the upper end of said elongated element to said conductive tubular element; and a cap element of conductive material covering said conductive tubular element and being secured thereto, said cap element having a terminal post extending from its upper end.

4. A vacuum switch comprising: a cup element; a plurality of lengths of conductive elements extending into said cup element and each having one end secured in and extending through the bottom of said cup element to provide external terminals, said conductive elements having their upper ends arranged in a circle, said conductive elements at their upper ends being provided with contact surfaces facing the axis of the circle; a respective elongated element of conductive material extending past each contact surface and located between said surface and said axis, each being secured at one end in the bottom of said cup element, the upper ends of said elongated elements extending above the upper ends of said conductive elements, each elongated element having a contact portion spaced from and confronting a respective contact surface; a respective magnetic armature element supported on the upper end of each elongated element; an elongated, evacuated housing having a sleeve surrounding said conductive and elongated elements, one end of said sleeve being secured to the interior of said cup element, said sleeve including a pair of sections of magnetic material separated by a section of non-magnetic material, said section of non-magnetic material being in the form of a cage having a plurality of axially extending parallel ribs connected by a central band, said cage being positioned with said armature elements confronting said band; a tubular element of non-magnetic material secured at one end to the upper magnetic section of said sleeve, said tubular element being closed at its upper end, said tubular element supporting a plurality of terminal posts; and a conductive element connected between the upper end of each elongated element and a respective terminal post.

5. A vacuum switch comprising: a stationary contact and a movable contact, a magnetic element; means securing said movable contact and said magnetic element in fixed spaced relation; and an evacuated housing enclosing said contacts and magnetic element, said housing having two magnetic portions and a non-magnetic portion therebetween, said non-magnetic portion being positioned ad-

jacent said magnetic element, whereby a magnetic field can be set up between said magnetic portions to pass around said non-magnetic portion and through said magnetic element, thereby to move said movable contact to an operative position with respect to said fixed contact.

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