Aug. 22, 1967 J. S. HAWKINS 3,336,664

METHOD OF ASSEMBLING ELECTROMAGNETIC HIGH-CURRENT-CARRYING CAPACITY VACUUM RELAY

Original Filed Oct. 15, 1962 3 Sheets-Sheet 1

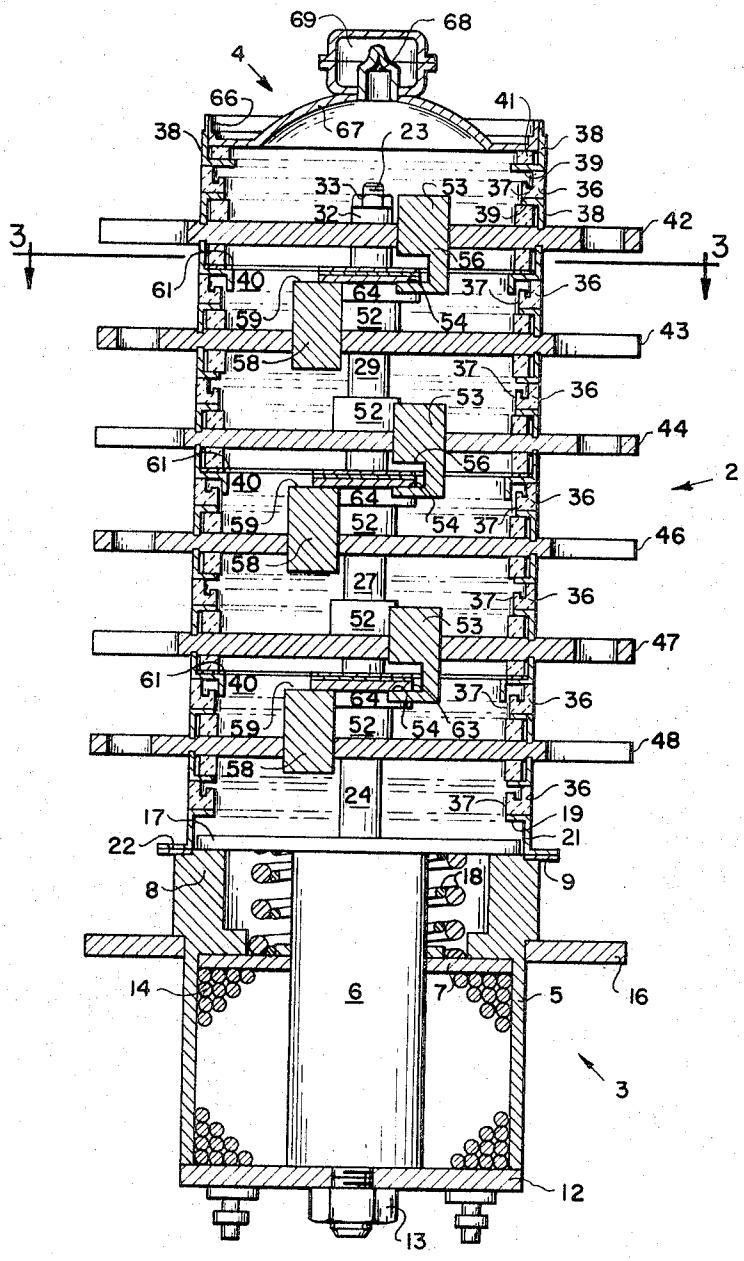


Fig 1

INVENTOR.
JACK S. HAWKINS
BY
John J. Leavitt

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Original Filed Oct. 15, 1962 3 Sheets-Sheet 2

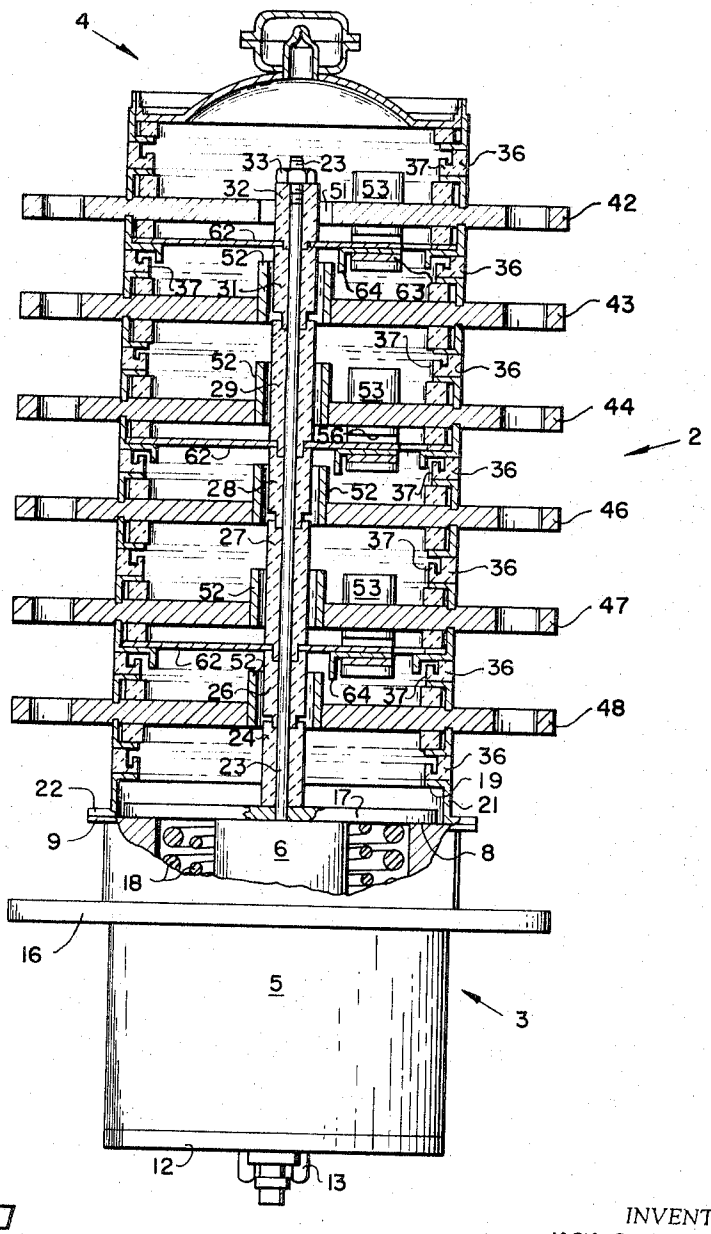


Fig 2

INVENTOR.
JACK S. HAWKINS

BY

John J. Leavitt

Aug. 22, 1967 J. S. HAWKINS 3,336,664

METHOD OF ASSEMBLING ELECTROMAGNETIC HIGH-CURRENT-CARRYING CAPACITY VACUUM RELAY

Original Filed Oct. 15, 1962 3 Sheets-Sheet 3

Fig 3

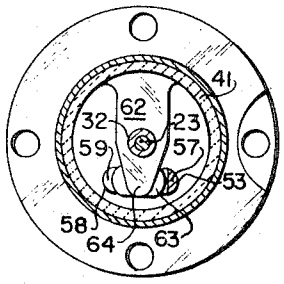
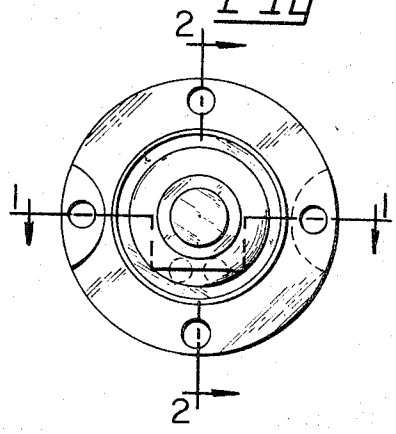


Fig 4



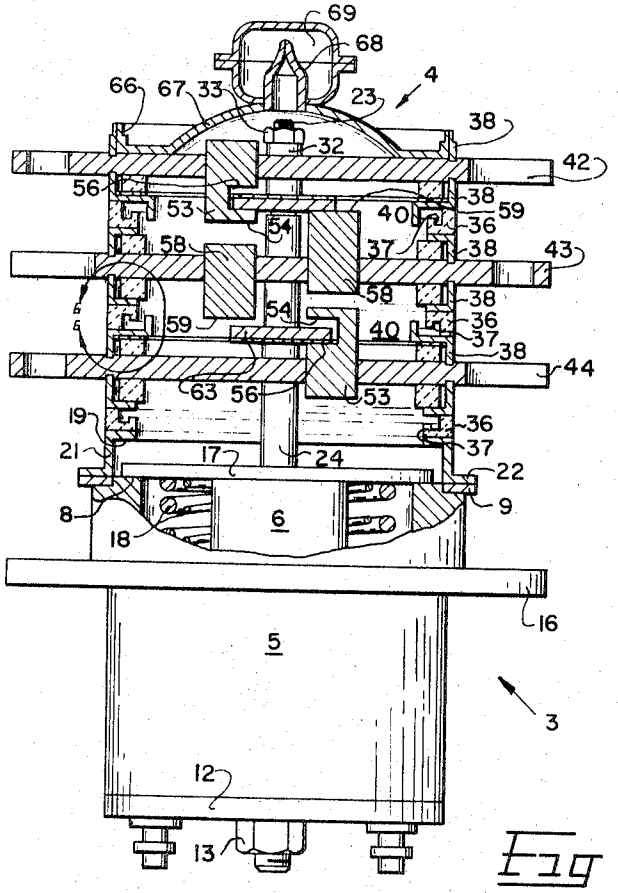
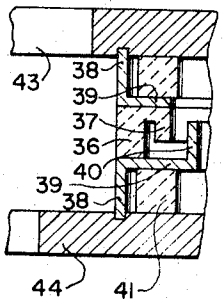


Fig 5

Fig 6



INVENTOR.
JACK S. HAWKINS

BY

John J. Leavitt

United States Patent Office 3,336,664
Patented Aug. 22, 1967

3,336,664

METHOD OF ASSEMBLING ELECTROMAGNETIC HIGH-CURRENT-CARRYING CAPACITY VACUUM RELAY

Jack S. Hawkins, San Jose, Calif., assignor to Jennings Radio Manufacturing Corporation, San Jose, Calif., a corporation of Delaware

Original application Oct. 15, 1962, Ser. No. 230,343, now Patent No. 3,200,222, dated Aug. 10, 1965. Divided and this application Nov. 4, 1964, Ser. No. 409,017
4 Claims. (Cl. 29—622)

This is a division of application Ser. No. 230,343, filed Oct. 15, 1962 (now Patent No. 3,200,222). This invention relates to transfer relays, and particularly to an electromagnetically operated multiple-contact relay of the parallel leaf spring type.

High current electromagnetically operated transfer relays have in the past been plagued by the inability to withstand impact shock and vibration characteristics imposed by contemporary environments such as jet planes and missiles. It is therefore one of the principal objects of the present invention to provide a high-current-carrying transfer relay having a multiple-contact configuration capable of withstanding vibration up to about 10 G's at about one thousand cycles per second.

Reliability of a relay has been another quality demanded by military applications in which failure of a relay because of its inability to carry high electric currents could be disastrous. It is therefore another object of the present invention to provide a transfer relay designed to carry continuously at least 200 amps of direct current without harmful effects due to the generation of heat by the passage of such large amounts of current.

Another factor important in determining whether a transfer relay possesses the requisite reliability for use in systems which do not permit of failure is the necessity of various difficult-to-achieve adjustments to provide proper gap spacing and voltage standoff between contacts during operation, and the necessity of additional adjustments required to be made after the unit is assembled so as to maintain the relay in operation. Accordingly, it is a still further object of the present invention to provide a transfer relay in which all adjustments are made during fabrication and in which no adjustments are necessary after the unit is sealed.

Although reliability of the unit is an extremely important factor in determining whether a relay is suitable in a particular environment, another important factor is the cost of the unit. Cost is often determined by the complexity of the design and a requirement for skilled labor in fabricating the parts and assembling the unit. It is therefore a still further object of the present invention to provide an electromagnetically operated high-current-carrying transfer relay in which the individual parts can be mass produced and assembled by relatively unskilled labor, thus reducing the initial cost of the relay.

It has been found that one way in which high-current-carrying capabilities is achieved is to separate the phases in a three-phase circuit and interrupt each phase separately. It is accordingly another object of the invention to provide a three-phase high-current-carrying transfer relay.

At the high currents at which the relay of this invention is designed to operate, one of the problems required to be solved is the isolation of each phase from the other phases in the three-phase relay. It is therefore another object of the invention to provide adequate phase shielding between the three phases of the relay.

A still further object of the invention is the provision

of a transfer relay in which different configurations such as single-pole single-throw, or single-pole double-throw, or three-pole single-throw may be arranged simply and effectively using many of the same parts common to all configurations and utilizing the same methods of assembly.

Still another object of the invention is the provision of a novel method of assembling a transfer relay so that the contact parts after assembly and final seal are in finally adjusted position and require no further adjustment after the unit is sealed.

Still another object of the invention is the provision of an hermetically-sealed envelope for a high-current-carrying transfer relay in which shield means are provided to prevent formation of a conductive coating of vaporized contact metal on the inner non-conducting surfaces of the envelope.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be apparent from the following description and the drawings. It is to be understood however that the invention is not limited to the showing made by the said description and the drawings, as it may be incorporated in various forms within the scope of the appended claims.

Broadly considered, the transfer relay of the invention comprises a generally cylindrical hermetically sealed envelope fabricated from a multiplicity of stacked and alternately arranged dielectric and metal parts hermetically brazed one to the other, and having appropriately interposed therealong a multiplicity of radially extending terminal plates or contact flanges of heavy cross-section and having a portion projecting outside the envelope as thermal radiating elements, and a portion extending into the envelope to provide a solid and vibration-free support for the current-carrying contact assembly. Each of the annular contact flanges supports adjacent its inner periphery a heavy tungsten contact extending in a direction parallel to the axis of the envelope and having an appropriate contacting surface adapted to be engaged by a movable or floating contact plate suitably supported on the envelope and actuated by a central actuating stem. Each of the movable contacts includes a metallic ring, preferably of molybdenum, having a radially extending resilient finger extending past the central axis of the envelope and having brazed on the free end thereof a heavy floating contact plate or shorting bar adapted to short circuit spaced and fixed contact points within the envelope. The actuating stem is supported on a floating armature adapted to be energized by a suitable solenoid assembly hermetically closing one end of the envelope. In one aspect of the invention the relay is adapted to separately interrupt the phases of a three-phase circuit so as to prevent interference between the phases when a circuit is broken therethrough. Each phase is provided with a pair of contacts isolated within a separate contact chamber from adjacent contacts. In another aspect of the invention the relay comprises a single-pole double-throw relay utilizing a common contact flange isolating the two switches.

Referring to the drawings:

FIG. 1 is a vertical cross-sectional view of a three-phase relay, the plane of section being indicated by the line 1—1 in FIG. 4.

FIG. 2 is a vertical cross-sectional view taken in the plane indicated by the line 2—2 in FIG. 4.

FIG. 3 is a horizontal cross-sectional view taken in the plane indicated by the line 3—3 in FIG. 1.

FIG. 4 is a plan view of the embodiment illustrated in FIG. 1.

FIG. 5 is a vertical cross-sectional view of a different embodiment of the invention in a single-pole double-throw relay.

FIG. 6 is a fragmentary cross-sectional view taken through a portion of the wall as indicated by the line 6—6 in FIG. 5.

FIGS. 1, 2 and 5 are shown twice actual size, FIGS. 3 and 4 are shown actual size, and FIG. 6 is shown four times actual size for clarity.

In terms of greater detail, the transfer relay in the embodiment disclosed in FIGS. 1, 2, 3 and 4 comprises an hermetically sealed generally cylindrical envelope portion designated generally by the number **2**, closed at one end by a solenoid assembly **3** and at the other end closed by a domed end cap assembly **4**.

The electromagnetic solenoid assembly comprises a generally tubular housing portion **5** having a coaxially arranged core member **6** therein supported on the housing **5** by an integral and transversely extending hermetic wall **7**. The wall is spaced intermediate opposite ends of the housing, the inner end portion **8** of the housing being provided with a radially extending seal flange **9**. The other end of the housing is provided with a detachable closure plate **12** secured to the open end of the housing by a suitable screw or bolt **13**, the closure plate serving to enclose a magnetic coil **14** within the housing and complete the magnetic circuit around this end of the housing. A radially extending flange **16** is provided brazed about the outer periphery of the housing to serve as a mounting means for the relay. An armature **17** is provided adjacent the inner end **8** of the housing and is adapted to move axially toward and away from the housing upon energization and de-energization of the solenoid. Suitable spring means **18** are interposed between the wall **7** and the armature.

In FIGS. 1, 2 and 5, the armature is shown in core-energized position. Inasmuch as similar electromagnetic solenoid means are utilized for the separate embodiments illustrated in FIGS. 1 and 5, corresponding parts have been indicated by corresponding reference numbers. In both embodiments axial movement of the armature is restricted in one direction by the inner end **8** of the housing, and in the other direction by a radially extending flange **19** formed on one end of a cylindrical metallic shell portion **21**, the other end of which is provided with an integral and radially outwardly extending flange portion **22** abutting against and having its outer peripheral edge coincident with the outer peripheral edge of sealing flange **9**.

The coincident edges of flanges **22** and **9** are adapted to be hermetically and integrally united as by heliarc welding. As clearly shown in the drawings, the shell member **21** and the inner end portion **8** of the housing, together with the inner end of the core and wall **7**, cooperate to form a part of the hermetically sealed envelope. Housing and core, together with closure plate **12**, are fabricated from low reluctance magnetic material, while shell member **21** and hermetic wall **7** are fabricated from non-magnetic material. The armature **17** is of course fabricated from a magnetic material of a thickness and diameter suitable to form a low reluctance path across the inner end of the housing.

Fixedly secured centrally in the armature **17** is an axially extending metallic support rod **23**, serving to support a multiplicity of axially aligned dielectric segments **24, 26, 27, 28, 29, 31** and **32**. The dielectric segments are preferably short tubular ceramic segments stacked one above the other in abutting relation as shown and secured in place by a suitable nut **33** engaging the threaded free end of rod **23**. Selected ones of the dielectric segments are provided with reduced diameter portions seated within complementarily recessed portions in adjacent dielectric portions.

As clearly shown in FIGS. 1, 2 and 5, the armature and its attached, centrally disposed rod **23** are coaxially arranged with respect to the envelope assembly **2**, the rod or actuating stem extending substantially from one end of the envelope assembly to the other. The alternate dielectric and metallic envelope assembly **2** is preferably fabricated from ceramic ring members **36** axially aligned and spaced one from the other, each being provided on its inner periphery with a re-entrant cylindrical flange portion **37** radially spaced inwardly from the inner periphery of the ring. The re-entrant flange portions on the ceramic rings serve to prevent the formation of a continuous conductive path between adjacent metallic portions of the envelope.

Each of the dielectric rings **36**, is appropriately metallized on each of its transverse surfaces, which surfaces are hermetically united as by brazing to an associated metallic ring member **38**, each metallic ring member being provided with a radially inwardly extending flange portion **39**. Selected ones of the ring members **38** are additionally provided with a cylindrically extending flange **40** integral with the inner periphery of the radially extending flange **39**. The radially inwardly extending flanges **39** are hermetically brazed to the adjacent ceramic rings. Where desirable or necessary, suitable dielectric backing members **41** are brazed to the opposite surface of radially inwardly extending flanges **39** from the ring **36** to equalize stresses on opposite surfaces of the flanges. As shown in the drawing, where the cylindrically extending flange **40** is provided on the ring members **38**, the flange is spaced radially inwardly an amount sufficient to provide clearance between the re-entrant flange **37** on ceramic member **36** and the cylindrical flange **40**. This construction is shown in enlarged cross-section in FIG. 6.

To hermetically unite each sub-assembly comprised of one ceramic ring **36** and two adjacent metallic rings **38** with adjacent envelope sub-assemblies, corresponding portions of ring members **38** extend toward each other and are hermetically brazed to heavy metallic annular plates **42, 43, 44, 46, 47**, and **48**, numbered consecutively from top to bottom as shown in FIGS. 1 and 2. In FIG. 5, since there are only three such heavy annular plates utilized, these plates are numbered consecutively **42, 43** and **44**. Each of the heavy contact flanges or plates is provided with a radially outwardly extending portion as shown in the drawings, and with a radially inwardly extending portion terminating at a central aperture **51** in each of the plates.

In the embodiment of the relay illustrated in FIGS. 1 and 2, plates **43** through **48** are provided with a centrally disposed coaxial metal shield cylinder **52** press-fitted and brazed within the central aperture **51**. Each of the shield cylinders **52** closely surrounds the central actuating stem **23**.

In the embodiment of the relay illustrated in FIGS. 1, 2 and 5 each of the plates **42, 44** and **47** support a heavy cylindrical contact member **53** having a longitudinal axis extending parallel to the axis of the envelope and provided intermediate its ends with a groove in the nature of a transversely extending kerf providing a contact surface **54** and an abutment surface or stop **56**. Each contact member is brazed in a suitable aperture formed in the associated contact flange at a point spaced from the central axis of the envelope. As shown best in FIG. 3, the remaining portion of contact **53** forming the bottom of the groove provides a vertical abutment or surface **57** for purposes which will hereafter be explained.

Comparing the relationship of contact members **53** in FIGS. 1 and 5, it will be seen that in FIG. 1 the contact members **53** all extend in the same direction, whereas in FIG. 5 the contact members extend in opposite directions. Thus, in FIG. 5, the groove in contact **53** in the uppermost contact illustrated is adjacent the lower end of the contact, whereas in the lowermost contact **53** illustrated in FIG. 5 the groove is adjacent the upper end of the contact. In FIG. 1 the grooves in contact members **53** are oriented adjacent the lower end of the contact member as shown.

On each of plates **43, 46** and **48** in FIGS. 1 and 2, and on plate **43** in FIG. 5, a contact member **58** is provided

brazed in a suitable aperture formed in the associated contact flange, and providing a contact surface **59** lying in a plane coincident with the contact surface **54** on contact member **53**. Each of the contact members **58** is cylindrical about a longitudinal axis parallel to the axis of the adjacent contact member **53** and the central axis of the envelope.

In the embodiment illustrated in FIG. 5, the contact flange **43** is provided with a pair of such contact members **58**, each extending on opposite sides of plate **43** so that corresponding surfaces **59** lie in parallel axially spaced planes also containing contact surfaces **54** of associated contact members **53**. In this embodiment the plate **43** and its associated contact members **58** provide a common conductive path associated with each of the contact members **53** lying on opposite sides of plate **43**.

In order to complete an electrical circuit between the contact members **53** and **58**, a mobile contact assembly is provided comprising an annular metallic member **61** sandwiched between one of the metallic envelope ring members **38** and a ceramic backing member **41**, and provided with a radially inwardly extending resilient finger portion **62** having a heavy contact member **63** of thick cross-section brazed on the free end of the finger **62**. A suitable baffle **64** is provided mounted adjacent the free end of the finger **62** in close proximity to the associated shield cylinder **52**. The baffle plate **64** and shield cylinder **52** cooperate to prevent vaporized contact material from migrating between the contact chambers associated with the separate pairs of cooperating contact members **53** and **58**. This cooperative relationship is adapted to further isolate the contact chambers from each other. This construction insures that there will be no interference between each phase of a three phase circuit.

In the embodiment illustrated in FIG. 5, it will be noted that the baffle plate **64** is omitted. The contact flange **43** in this embodiment functions to isolate separate pairs of contact members **53** and **58** from each other. Additionally, this embodiment is not a three-phase relay and separation of the phases is therefore not critical. Both of the embodiments however utilize members of relatively large cross-section suitable for interruptnig and carrying large currents in the order of about 200 amps. The heavy parts also function to draw heat from the contact assembly, thus enabling a much higher current to be carried continuously without generation of excessive heat.

In order to effect actuation of the relay, each of the movable and resilient contact fingers **62** is provided with an aperture through which a reduced diameter portion of the associated dielectric stem segment projects. Adjacent segments thus trap the finger therebetween. It will thus be seen that movement of the armature by means of energization and de-energization of the solenoid will displace the resilient arm and the floating contact thereon. The parts are preferably proportioned to provide a resilient bow in the arm **62** in both of its positions. Such a resilient bow imposes a direct resilient closing force on the contacts, thus preventing or diminishing bounce due to impact shock or vibration. It will also be seen that the dielectric portion of the stem associated with each of the resilient contact arms **62** functions to electrically insulate the contacts from the longitudinally extending rod **23** which, like the magnetic assembly, is at ground potential.

The end of the envelope assembly opposite the magnetic solenoid assembly is closed by the end cap assembly **4** as previously indicated, the end cap **4** being provided with a cylindrically extending seal flange **66** hermetically heliarc welded to the associated flange **38**. The central portion of the end cap assembly is provided with a dome **67** and a suitable tubulation **68** protected by a cap **69**.

In order that the contact surfaces **54** and **59** may be properly aligned for mating with the floating contact **63**, assembly of the relay proceeds in what is believed to be a novel method. As will be seen from the following description, adjustment of the cooperating contact surfaces is automatically effected during the final braze operation.

It has been found that an economical and effective method to accomplish this result is to pre-fabricate or pre-assemble separate sub-assemblies of the relay and braze the sub-assemblies in an initial braze operation, and subsequently hermetically join the composite sub-assemblies in a final braze operation. In this manner separate sub-assemblies may be fabricated and leak-checked before assembly into a completed unit. One of the first sub-assemblies to be assembled and brazed is the solenoid assembly **3**, including housing **5**, flange **16**, wall **7**, flange **9** and core **6**. These elements are assembled with suitable jigs and braze rings and passed through a brazing furnace so as to hermetically unite the members one to the other to form a composite rigid and vibration free sub-assembly.

Another sub-assembly that is initially assembled and brazed is the end cap assembly **4**, with a portion of protective cap **69** thereon, and tubulation **68** in open condition. The separate parts making up this sub-assembly are suitably brazed in a single operation. It will of course be understood that appropriate brazing jigs are utilized to maintain the parts in proper alignment.

A third sub-assembly that is pre-fabricated or pre-assembled and initially brazed is the annular plate or contact ring **61** having the integral radially extending finger **62** thereon, floating contact **63**, and baffle plate **64** brazed thereon. The contact ring **61** is conveniently stamped from .010" molybdenum sheet while the contact member **63** is fabricated from a thick piece of tungsten. Baffle plate **64** may conveniently be fabricated from .005" molybdenum.

The separate sub-assemblies are assembled and the initial braze operation are conducted as follows: Referring to FIG. 1, metallic envelope ring **21** is placed on a suitable jig having a center guide or alignment post of tungsten upon which are appropriately stacked in proper sequence the separate ceramic spacer members **24** through **32**, respectively. Stacked on the radially inwardly extending flange **19** of the ring **21** is a ceramic ring **36**, appropriately metalized. A braze ring (not shown) is interposed between the rings **21** and **36**. Superposed on ring **36** is metallic envelope ring **38** having radially inwardly extending flange **39** adapted to be brazed to the adjacent metalized surface of ceramic ring **36**. Seated within ring **38** on flange **39** is a backing member **41**, preferably of ceramic, also brazed to flange **39**. Suitable braze rings are interposed between these members so that when the sub-assembly is passed through the brazing furnace the parts will be hermetically united. It will of course be understood that appropriate jigs surround these parts during the stacking operation to maintain them in axial alignment.

The heavy copper contact flange **48** is next stacked on the ring **38** so as to cause seating of the member **38** in an appropriate groove machined in the contact flange **48**. At this point it should be understood that all the sub-assmblies are brazed at one time and that the flange **48** is not brazed to the member **38** upon which it rests in this initial braze operation. The plate or flange **48** merely rests on the cylindrical member **38**, the groove in the flange **48** acting as a guide to coaxially align the contact flange with the remaining elements of the combination. On the other hand, each of the contact flanges is brazed in this initial brazing operation to the envelope ring **38** next above the contact flange. With the contact flange in place, a suitable jig is dropped into the aperture occupied by the contact member **59** in FIG. 1 to provide an abutment against which finger **62** may abut for proper alignment when this element of the combination is stacked. The assembly of the relay proceeds by sequential stacking of elements **41**, **38** and **36** between contact flanges **48** and **47**, and thereabove between succeeding pairs of contact flanges **47–46**; **46–44**; **44–43**; **43–42**; and contact flange **42** and envelope ring **38** next adjacent end cap assembly **4**.

As the stacking progresses, appropriate jigs are inserted in the apertures in the contact flanges in place of the contact members **58** and **53** which will ultimately be brazed in these apertures and which are shown in FIG. 1. Placement of these jigs is for purpose of ensuring proper positioning of the contacts with the resilient contact finger **62** upon final braze. From the foregoing it will be apparent that each contact flange **42** through **48** forms the base for the next-above assembly of metallic and ceramic rings, including backing rings **41**, and each of these sub-assemblies is brazed in a single operation by passing the multiplicity of stacked sub-assemblies through the brazing furnace at once. Upon extraction of the stacked sub-assemblies from the furnace, each of the sub-assemblies in the stack will be united in a composite rigid unit, but the units will not be brazed to each other. At this point this composite sub-assembly may be leak-checked to make sure that the unit is vacuum tight. Sub-assemblies that are not vacuum tight are discarded and replaced by tight sub-assemblies.

After the separate sub-assemblies are brazed into composite units, the sub-assemblies are hermetically brazed to each other in the following manner. Whereas stacking of the parts comprising each sub-assembly as explained thus far proceeded from the end of the relay next adjacent the solenoid assembly toward the end-cap assembly **4**, stacking of the unitized sub-assemblies is accomplished in reverse order by inverting the composite sub-assemblies and stacking them one upon the other commencing with the sub-assembly including contact flange **42**. As before, an appropriate jig having a center guide pin or post is provided upon which the sub-assemblies are stacked for final brazing.

In this operation one sub-assembly acts as a jig for the next superposed sub-assembly. After the first or lowermost composite sub-assembly is stacked on the jig in inverted position so that contact flange **42** forms the uppermost element, contact member **53** is dropped into the aperture in the contact flange adapted to receive it. The contact member is temporarily supported on the contact flange by placing a split spring ring of brazing wire about the contact member. Placement of the split spring ring of brazing wire is gauged so that the grooved end of the contact member extends above the contact flange an appropriate distance.

At this point, ceramic stem segment **32** is dropped over the center post or guide pin so that its reduced diameter end portion extends upwardly. The second composite sub-assembly including contact flange **43** is now stacked on the first sub-assembly so that an end portion of cylindrical ring member **38** indexes in the groove formed in contact plate **42**. This ensures coaxial alignment of the two sub-assemblies. It should be noted however that the second sub-assembly includes resilient contact arm **62**, the free end of which must lie within the groove formed in contact member **53**. This requires that the two sub-assemblies be brought into axial alignment while the resilient contact arm is laterally offset from the contact member **53**. This places floating contact plate **63** at the proper height so that subsequent rotation of the second sub-assembly swings the floating contact into the groove in contact member **53**. Rotation continues until the floating contact abuts the stop **57**, whereupon it is turned in the opposite direction a small amount to provide operating clearance between the edge of floating contact **63** and stop surface **57**.

With the second sub-assembly in position as just described, a contact member **58** is dropped through the aperture in contact flange **43** adapted to receive it. The contact member **58** will pass downwardly until its contact surface **59** rests on the floating contact **63**. A split spring brazing ring is placed about the contact member **58** so that before the final braze operation it lies closely adjacent the upper surface of contact flange **43** when in inverted position.

As the stacking of the sub-assemblies progresses, the actuating stem ceramic sections are also stacked about the center guide pin of the jig so as to appropriately engage the radially extending contact arm **62**. The lengths of the ceramic sections **24** through **32** making up the actuating stem are proportioned so that upon final assembly and brazing, the relationship of each floating contact **63** with the associated contact members **53** and **58** is such that upon actuation of the relay to either a make or break position, the floating contact will be resiliently pressed against at least one abutment. Such resilient pressure is provided by gauging the travel of the solenoid and therefore the stem so that overtravel is provided in either direction, thus producing a bow in the resilient arm **62** when the actuating stem is at either extremity of its travel. It has been found that in a relay having the proportions of the relay illustrated a .020" overtravel will bow the resilient arm **62** enough to cause resilient impingement of the floating contact with sufficient force to withstand vibration to 10 G's at 1000 cycles per second.

After the sub-assemblies are all stacked and the resilient contact arms properly oriented horizontally by appropriate rotation of each sub-assembly, the floating contacts are oriented vertically without regard to contact surfaces **54** and **59** by placing the stacked ceramic sections **24** through **32** under compression so that the vertical height of each floating contact above the jig is fixed. It should be understood that at this stage of the assembly contact surfaces **54** and **59** on contact members **53** and **58** have not been oriented in a fixed relationship with respect to the floating contact **63**. It will be remembered that both these contact members are temporarily supported on the associated contact flange by the split spring rings of brazing material.

The loosely stacked sub-assemblies are now ready for final braze, which proceeds with the parts held in inverted position. Suitable braze material associated with each envelope ring **38** which loosely abuts an adjacent contact flange, upon melting, hermetically unites the sub-assemblies into a composite envelope portion **2**. In the same braze operation the split spring brazing rings supporting contact members **53** and **58** are melted, and upon melting release the contact members, which sink downwardly until contact surfaces **54** and **59** rest on the floating contact. The braze material flows by capillary action between the contact members and the associated contact flange to braze each contact member rigidly in position. The contact surfaces **54** and **59** are now properly oriented with respect to each other and with respect to the mobile or floating contact.

It will of course be apparent from the foregoing that the sequence of assembly of the parts, and the sequence of brazing operations may be varied to accord with different configurations. Thus, in the embodiment illustrated in FIG. 5, the lowermost contact members **53** and **58** are vertically oriented and brazed in one operation with the relay in an upright position as shown. Then the uppermost contact members are vertically oriented and brazed with the assembly inverted. Upon completion of the two braze operations each set of contact members is properly oriented with the associated floating contact.

It has been found that this method of assembly materially increases the reliability of the relay in that substantially perfect orientation of the mating contact surfaces is obtained. This contributes to simultaneous make or break as between a plurality of separate contact elements as in the two embodiments disclosed.

I claim:

1. In an electrical relay having an envelope portion comprised of a plurality of separate initially brazed composite sub-assemblies including a plurality of transversely extending contact flanges defining contact chambers within each of which fixed contact members provide a plurality of spaced fixed contact surfaces in planar alignment adapted

to be simultaneously engaged and disengaged by a mobile contact, said separate initially brazed composite sub-assemblies being adapted to be hermetically united in a final braze operation, the method of effecting planar alignment of the fixed contact surfaces in each contact chamber and cooperative correlation thereof with the contact surface of the associated mobile contact comprising the steps of stacking said sub-assemblies one upon another in association with braze material positioned so that the sub-assemblies are bonded one to the other when the braze material is raised to brazing temperature then cooled, fixing the vertical position of each mobile contact with respect to a common reference plane, releasably suspending the normally fixed contact members on said contact flanges in association with each mobile contact in a manner whereupon being heated to brazing temperature said normally fixed contact members are released and sink into final position, heating said stack of sub-assemblies to hermetically unite the sub-assemblies and effect release of said normally fixed contacts, and cooling of the assembly to hermetically unite the sub-assemblies and braze the fixed contact members when in final position to the associated contact flange.

2. The method according to claim 1, wherein the heating of said stack of sub-assemblies is effected while the stack is inverted in position.

3. The method according to claim 1, wherein said fixed contact members are initially releasably suspended by means responsive to heat to effect release thereof, and after the application of heat said fixed contact members sink by gravity into abutting relation with the contact surface of the mobile contact.

4. The method according to claim 1, wherein said fixed contacts after release are held by gravity in abutting relation with the contact surface of the associated mobile contact while the stacked assembly is cooled to effect brazing of the fixed contacts to the contact flanges.

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JOHN F. CAMPBELL, *Primary Examiner.*

J. C. CLINE, *Assistant Examiner.*