Dec. 16, 1958 A. D. JOHNSON ET AL 2,864,935

APPARATUS FOR SPACING AND UNITING PARTS

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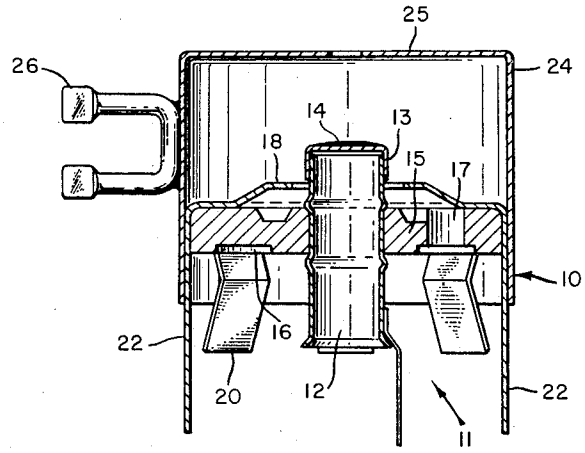



FIG-1

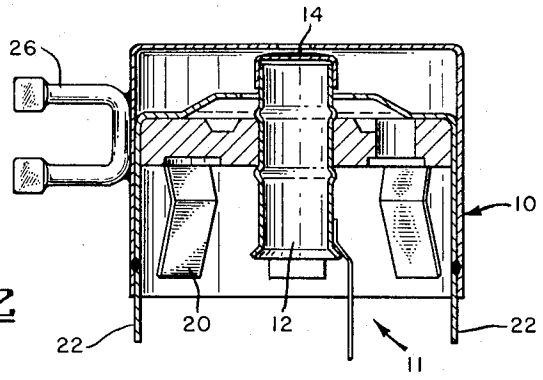



FIG-2

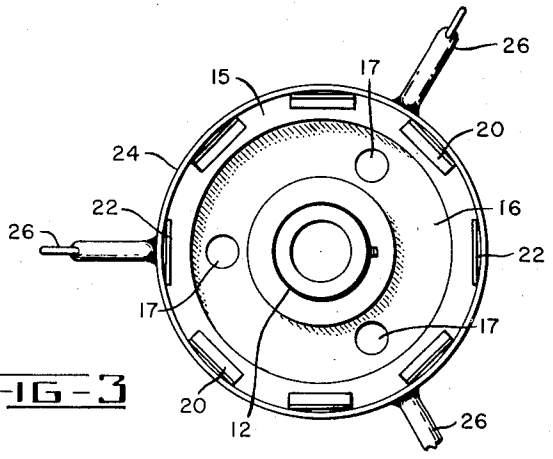



FIG-3

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APPARATUS FOR SPACING AND UNITING PARTS

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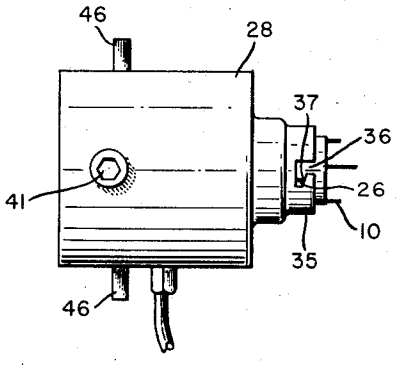



FIG-4

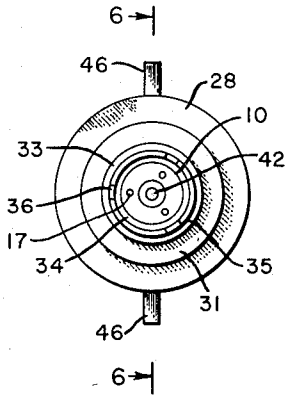



FIG-5

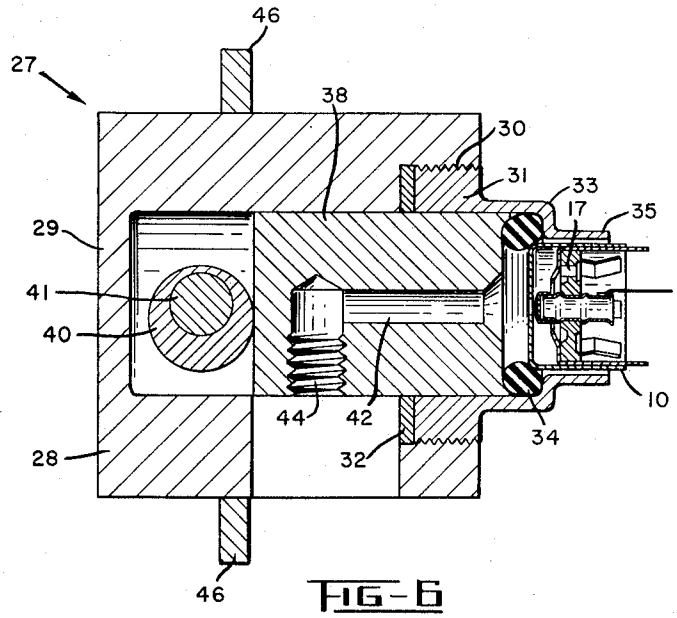



FIG-6

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APPARATUS FOR SPACING AND UNITING PARTS

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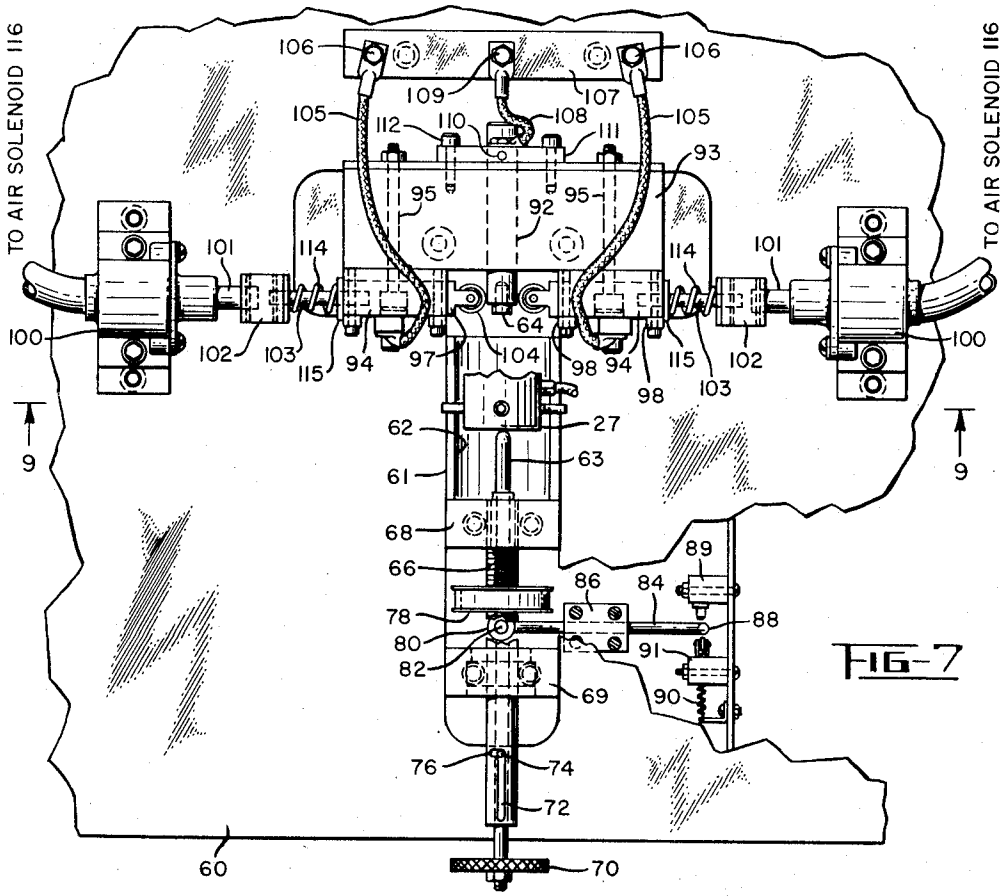



FIG-7

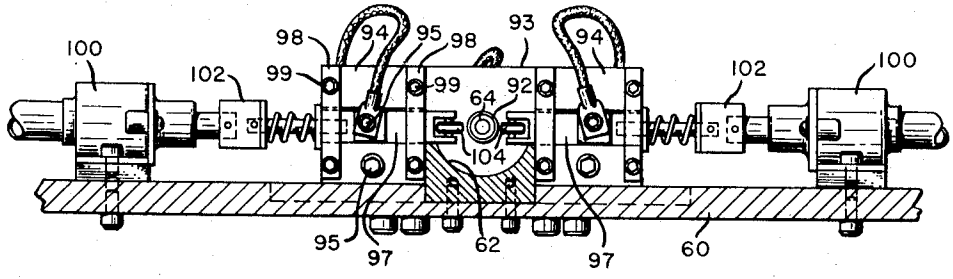



FIG-9

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APPARATUS FOR SPACING AND UNITING PARTS

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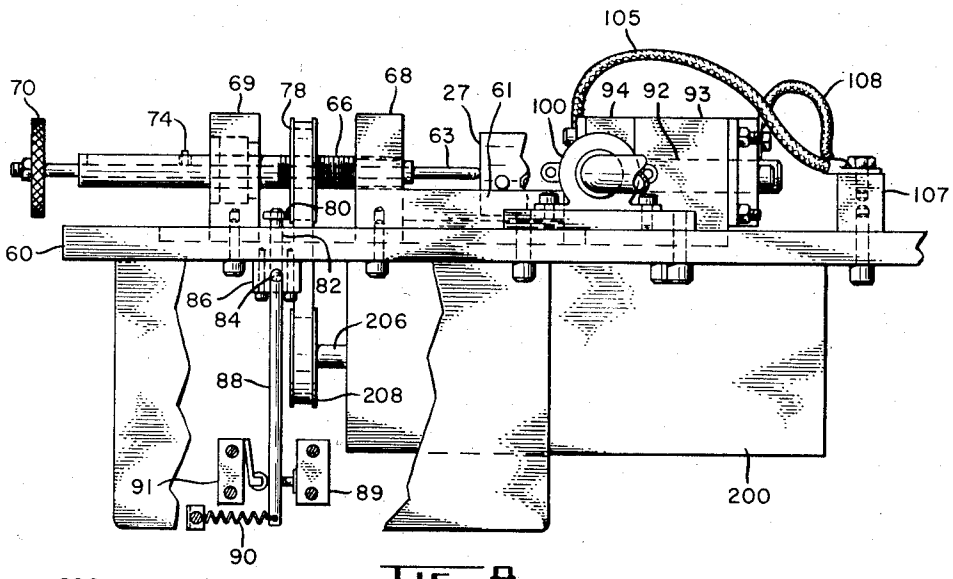



FIG-8

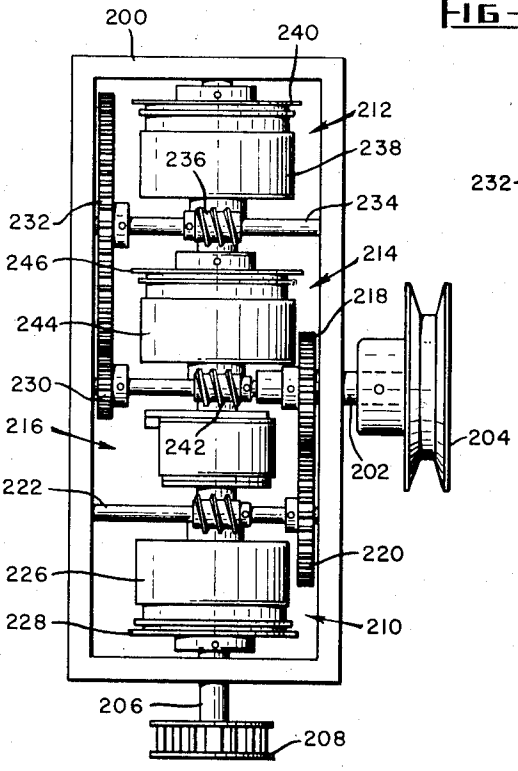



FIG-12

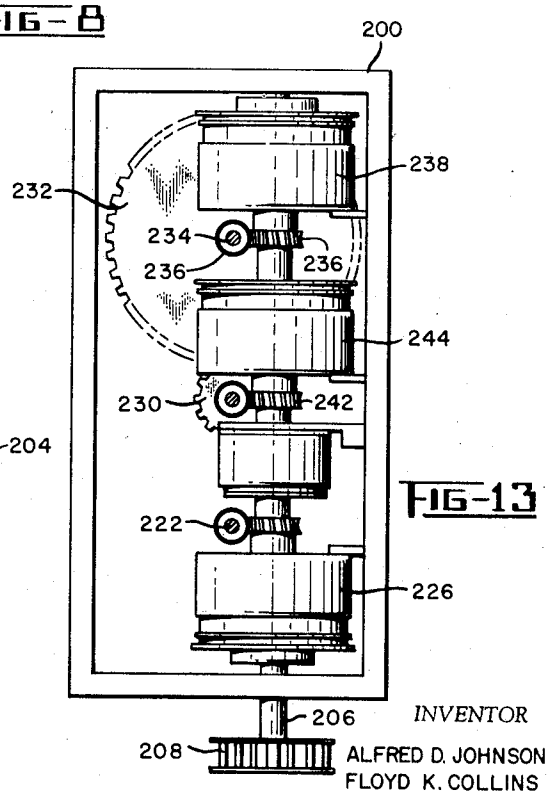



FIG-13

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APPARATUS FOR SPACING AND UNITING PARTS

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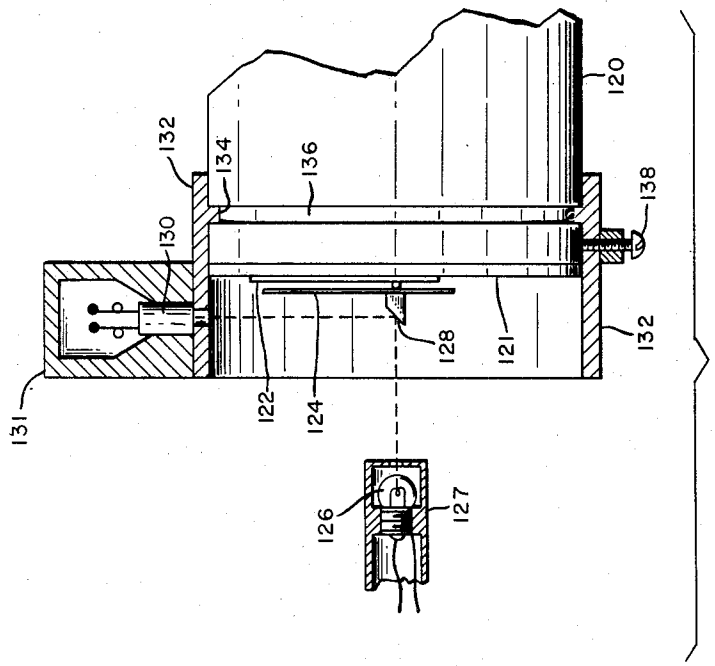



FIG-11

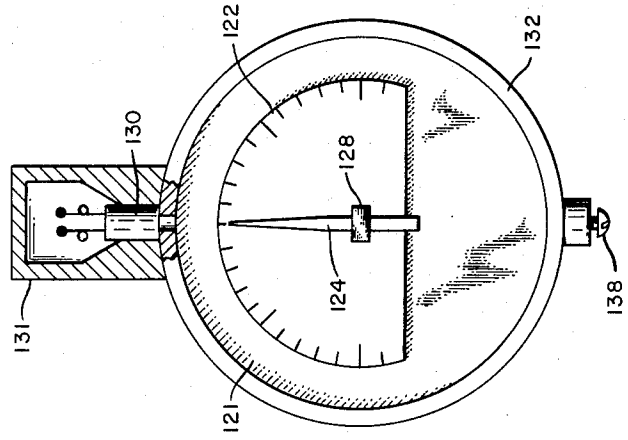



FIG-10

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APPARATUS FOR SPACING AND UNITING PARTS

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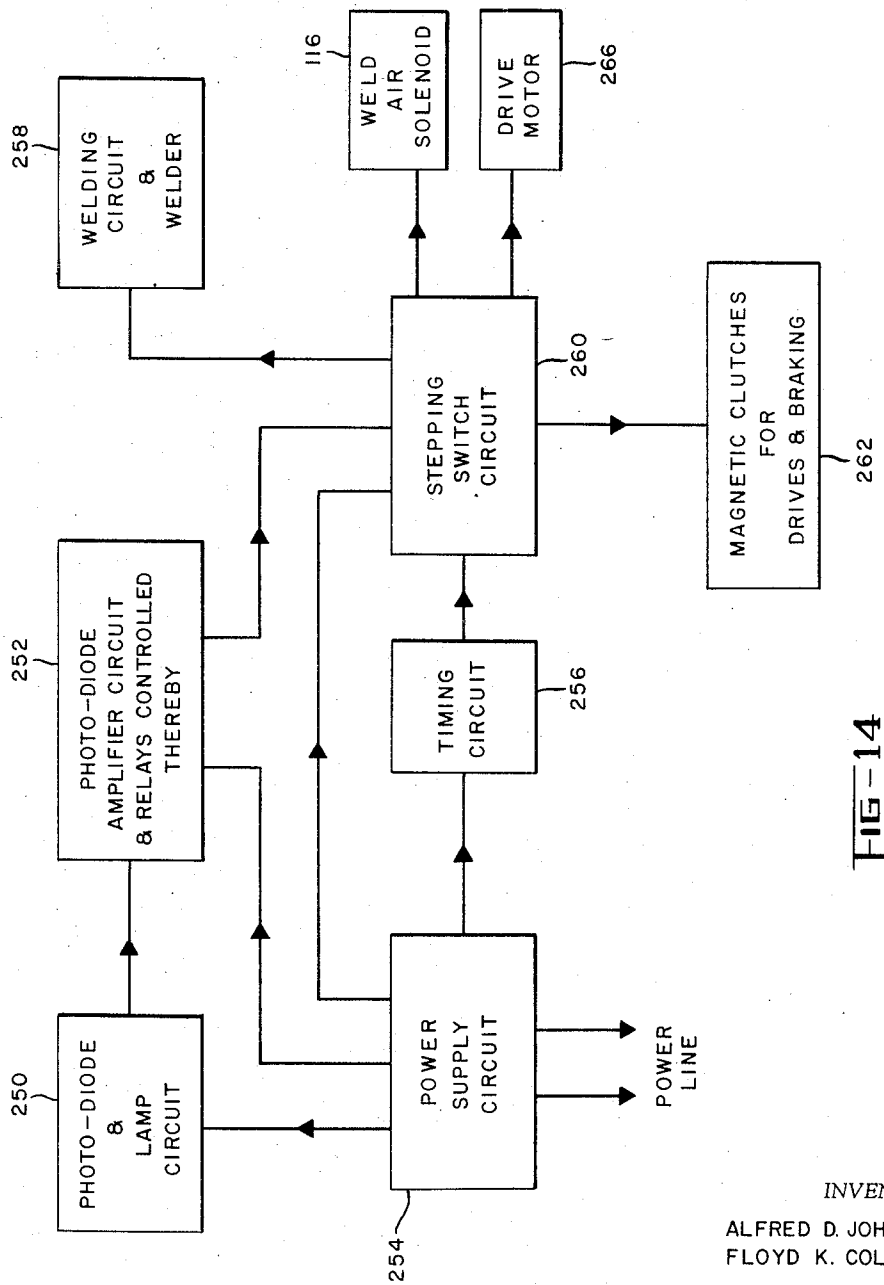



FIG-14

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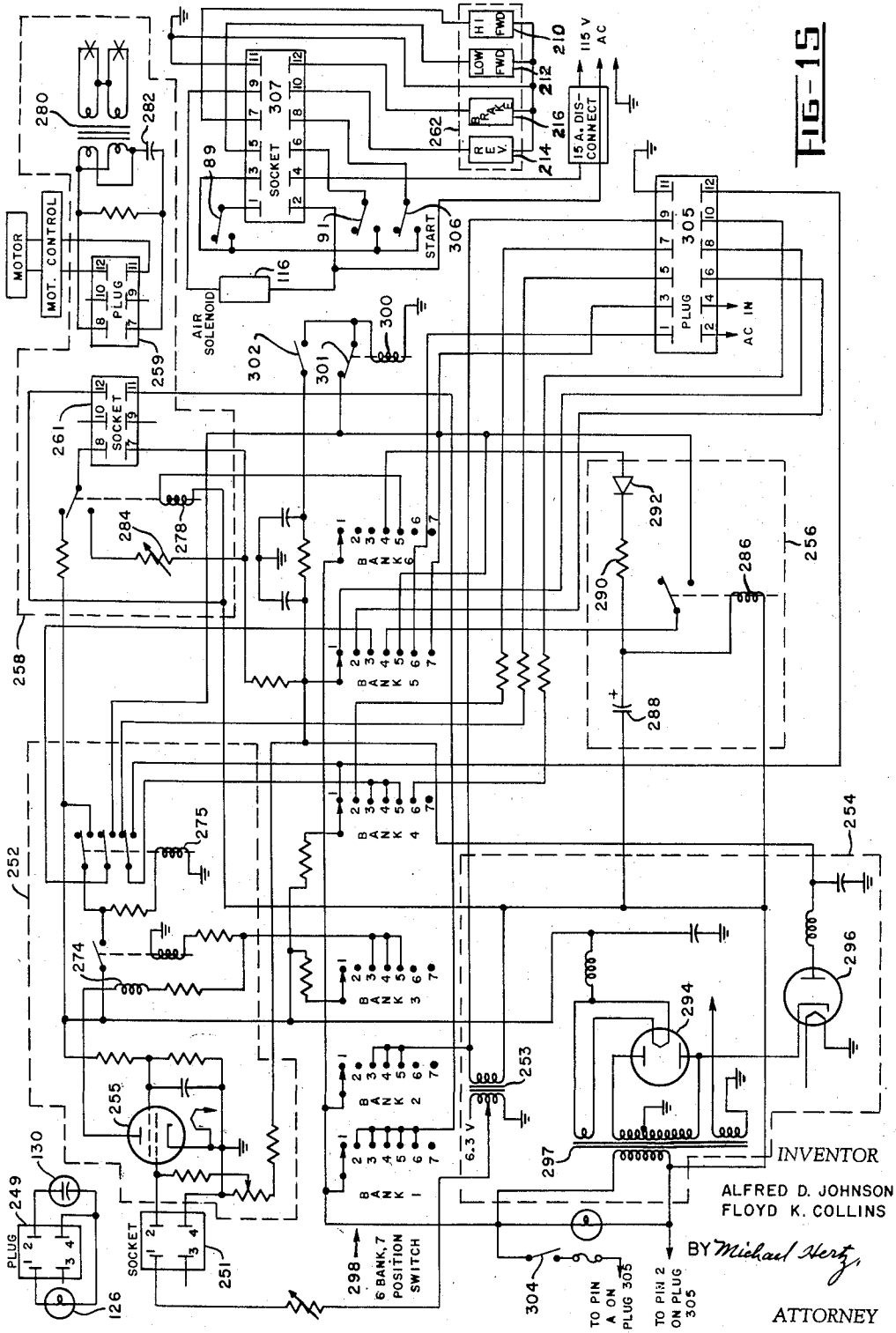
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Dec. 16, 1958 A. D. JOHNSON ET AL 2,864,935

APPARATUS FOR SPACING AND UNITING PARTS

Filed July 1, 1957 7 Sheets-Sheet 7

FIG-15



United States Patent Office 2,864,935 Patented Dec. 16, 1958



2,864,935

# APPARATUS FOR SPACING AND UNITING PARTS

Alfred D. Johnson and Floyd K. Collins, Seneca Falls, N. Y., assignors to Sylvania Electric Products Inc., a corporation of Massachusetts

Application July 1, 1957, Serial No. 669,311

14 Claims. (Cl. 219—78)

This invention relates to apparatus for positioning parts relative to one another and affixing said parts to each other when so positioned. More specifically, this invention concerns itself with apparatus used to position and weld the parts of an electron gun.

It is well known to those skilled in the art of electron discharge devices that great care must be exercised during manufacture of such devices to space certain of the electrodes relative to one another in order that an acceptable product be obtained. In the case of cathode ray tubes, it is necessary to closely control the spacing between the first grid and cathode in order that the cutoff characteristic of such tubes be maintained within certain desirable limits.

It will therefore be appreciated that in order to manufacture tubes whose cutoff characteristic will fall within certain desirable limits, a very close check must be kept on all parts which could in any way affect the distance between the control grid and the cathode. It will further be appreciated that a check of the grid-cathode spacing on each grid-cathode assembly after it is assembled and welded together, but before incorporation within a tube, will result in a great saving in labor and materials by not incorporating improperly spaced grid-cathode assemblies into otherwise good tubes. For this reason, each and every grid-cathode assembly is checked for spacing before the gun assembly operation.

In a prior method of making the grid-cathode assembly, a circular metal spacer ring of L-shaped cross section is dropped into a cylindrical metal grid cup with the flange end away from the bottom of the disc. Because of variations in the flatness of the bottom of the grid cup, a reading is then made on a dial gauge to check the distance between the inside bottom of the grid cup and the outermost surface of the flange of the spacer. Those parts showing improper dimensions are discarded. The cathode assembly, which comprises a nickel cathode sleeve provided with an emissively coated top cap mounted in a substantially flat circular ceramic, is next measured for the height of the emissive coating above the ceramic. The cathode assembly is then inserted into the grid cup. The aforementioned spacer serves to space the cathode coating a proper distance from the grid. A retainer ring having a peripheral flange is then machine pressed into the cup against the ceramic and welded thereto to thereby hold the cathode as embly rigid in the grid cup. A spacing check is then made by an air senser known as an air comparator to weed out any assemblies having an unacceptable spacing between the grid and the cathode coating.

The above steps describe a method of manufacturing and space checking grid-cathode assemblies which involves an undesirable number of handling operations and often produces a condition wherein assemblies are out of specification. This condition cannot be accurately determined before the welding operation.

It is an object of this invention to produce a method and apparatus for manufacturing grid-cathode assemblies



which will assure that the assembly is in accordance with specifications at the time and after the cathode assembly is fixed in position within the grid cup.

It is another object of this invention to continuously keep check on the grid-cathode spacing by means of a sensing device, so that a welder which fixes the cathode relative to the grid will be energized only when said spacing is within certain limits.

It is a further object of this invention to eliminate checking of the grid-cathode assemblies for spacing, as a separate step.

It is another object of this invention to incorporate spacing, checking and welding of said assemblies in one continuous operation.

It is a still further object of this invention to provide a method and a machine to eliminate handling of the cathode-grid assemblies between the assembling of parts and the manufactured checked product.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood, however, by reference to the following description taken in connection with the accompanying drawings, in the several figures of which like reference numerals indicate like elements, and in which:

Fig. 1 shows, in enlarged cross-section, the grid-cathode assembly as it appears when inserted into an air senser adapter head ready to be spaced and welded by the apparatus herein described.

Fig. 2 shows in enlarged cross-section the finished grid-cathode assembly manufactured by the present apparatus,

Fig. 3 is a plan view of the grid-cathode assembly shown in Fig. 2,

Fig. 4 is a plan view of a jig or adapter head holding the grid-cathode assembly in place as it would appear during spacing and welding operations.

Fig. 5 is an end view of the adapter head looking into the assembly receiving end,

Fig. 6 is a section on the line 6—6 of Fig. 5.

Fig. 7 is a plan view of the adapter head receiving channel, a screw driving mechanism for advancing the adapter head toward a hollow cylindrical stop, and welder electrode actuating means, a portion of the adapter head being shown in the channel.

Fig. 8 is a side view of Fig. 7.

Fig. 9 is an end view of Fig. 7 taken along the line 9—9.

Fig. 10 is a front view of the space checking air senser device showing a photo-diode in section, that operates in conjunction with the indicator of the device to trigger welding, motor stop and reverse circuits,

Fig. 11 is a fragmental side view of the mechanism shown in Fig. 10 and also showing photo-diode illuminating means,

Fig. 12 is a plan view of a three speed electrically controlled transmission drive unit for advancing the lead screw mechanism shown in Figs. 7 and 8,

Fig. 13 is a side view of a portion of Fig. 12,

Fig. 14 shows a block diagram of the various circuits used to carry out the objects of the invention, and

Fig. 15 is a schematic diagram of the circuits shown in block form in Fig. 14.

The apparatus by which the objectives set forth above are carried out consists in its most elemental form of a grid-cathode assembly holding device, means for advancing at a high forward speed the holding device, with respect to a stop in order to effect a preliminary spacing of the assembly, means for subsequently advancing the holding device at a slower speed to effect a slower rate of change of the assembly spacing, sensing means

to stop the change of spacing at a proper time, welding means to unite the grid and cathode at the proper spacing as determined by the sensing means, and means to return the mechanism to the starting point.

*Description of the device*

Now referring to the drawings with greater particularity, Fig. 1 shows a grid-cathode assembly. The grid member **10** of this assembly is to be accurately spaced from, and welded in spaced relationship to, the cathode **11**. The cathode comprises a metallic sleeve **12**, preferably of nickel, and having a cylindrical nickel cap **13** affixed to one end thereof. The top flat surface of the cap carries an electron emissive coating **14**. The cathode is secured within a central opening of a circular ceramic member **15** having a recessed annular portion **16**, and a plurality of apertures **17** through said annular portion. The member **15** is mounted within a spider retainer comprising an annulus **18** having resilient fingers **20** projecting from the annulus. Also projecting from the annulus is a pair of diametrically opposed securing fingers **22** which are to be welded to the wall of the grid cup **10**. The grid comprises a metal cup having cylindrical walls **24** and a centrally perforated bottom **25**, the exterior of the cup having wings **26** or the equivalent for later securement to other parts of the electron gun structure. The spider retainer, which holds the ceramic mounted cathode, is slidably, frictionally engaged by the inner surface of the cylindrical metal wall **24** of grid cup **10** as clearly shown in Fig. 1. The grid-cathode assembly, with the cathode thus in adjustable relationship within the grid cup, is then ready to be inserted into a holding device and to be operated on by a sensing, spacing and welding mechanism.

During the spacing and welding operations the grid-cathode assembly is held by the specially designed adapter head holding mechanism shown in Figs. 4 to 6. The outer member of the adapter head **27**, is made of a metal block **28**, which is preferably cylindrical in shape to ride in a semi-cylindrical channel guideway, as will later appear. The block **28** is closed at one end **29**, the other end being threaded at **30** to receive a cylindrical flanged end member **31**. A washer **32** is seated between adjoining faces of the block **28** and member **31**. The member **31** is provided with an in-turned lip **33**, having a recess therebeneath. Seated in the recess is an O ring **34**, preferably of neoprene, and to effect an air tight seal around the curved edge of the grid cup **10**.

At one end of the flanged member **31** and further outward from the O ring is a collar **35**, having a number of bayonet slots **36**, of which there are at least two and preferably three. These slots receive or grasp the wings **26** which are disposed on the periphery of the grid cup **10**. The slots have tapered walls **37** which assist in making an air tight seal between the neoprene O ring and the grid cylinder by rotating the grid cylinder whose wings **26** rest on the tapered walls **37**, to thus press the curved edge of the grid cup against the O ring.

Disposed coaxially within the cylindrical piece **28** and in axially slidable relation therewith is a compression cylinder **38**, Fig. 6. One end of this cylinder serves as a seat for the O ring **34**. The other end rests against the surface of a cam **40** which is affixed to a shaft **41**, the latter being held by member **28**. The axis of this shaft is also transverse to the cylinders **28** and **38** and suitable means is provided at one end of the shaft to receive a wrench or other device in order to turn cam **40** and thereby shift cylinder **38** with respect to cylinder **28**. This action will compress the O ring **34** between cylinders **38** and lip **33** thus compressing it against the outside of grid cup **10** to effect an air tight seal around its periphery.

The central part of cylinder **38** is provided with a bore **42** which communicates with the end of the cylinder in contact with the O ring and with a port **44**, the latter being threaded to receive an air hose connection. At diametrically opposed points on the periphery of the outer cylinder **28** are guide pins **46** to maintain it in non-rotatable position when resting in the channel to be described.



Referring now to Figs. 7, 8 and 9, means are shown for reducing the grid-cathode spacing of the grid-cathode assembly and welding the assembly when said spacing is reduced to the desired dimension as indicated by appropriate sensing means. The numeral **60** indicates a base plate upon which is mounted a guideway channel **61** having a way **62**, preferably half-cylindrical in cross-section, that will allow the adapter head to be conveniently received and advanced axially thereon between an advancing push-rod shaft **63** and a positioner or stop member **64** at one end of the guideway channel.

A hollow cylindrical shaft lead screw **66** is threaded into a stationary threaded support portion **68** of the guideway channel **61** and an unthreaded portion finds bearing in a support **69**. The thread must have a large number of turns per inch, 80 being desirable, so that the axial movement of the screw shaft will be slow. This is necessary since the grid-cathode spacing is of the order of several thousandths of an inch; the inertia of the various rotating driving members could easily overshoot the correct spacing if a much smaller number of threads per inch were used.

The push-rod or shaft **63** is disposed concentrically within the lead screw shaft **66** and extends beyond both ends thereof. One end of the rod **63** is adapted to engage the end **29** of the adapter head holding means **27** and is a part of the moving means which urges the adapter head along the guideway channel **61**. The other end of the rod **63** is fitted with a knurled knob **70** so as to be easily grasped. The push rod is axially movable along the length of a slot **72** in the lead screw shaft wall and can move only the length of the slot due to a protruding pin **74** on the rod. An offset bayonet type slot portion **76** is also provided in order to hold the push rod in its most forward position at which point the forward end of the push rod will either be in contact with or close to the end wall **29** of the adapter head **27** as it rests in channel way **62**. The sliding feature of the push rod is manual and its purpose is to provide for quick axial travel of the push rod to thereby enable immediate removal of the adapter head from the way **62** without waiting for the relatively slow axial travel of the lead screw assembly. A similar time saving is realized between insertion of the adapter head and the subsequent operations.

At an intermediate point on the lead screw **66** there is affixed a pulley **78**. A roller **80** rides on one side of the pulley and is attached to one end of a crank arm **82**. The arm **82** is fixed on an oscillatable shaft **84** pivoted in a bearing **86**, the shaft having a second crank arm **88**. A simple lever arrangement also might be employed instead of the foregoing mechanism. Attached to the free end of arm **88** is a tension spring **90**, which holds the roller **80** against one side of pulley **78**. Backward axial travel of the lead screw and pulley forces arm **88** to actuate a limit switch **89** and forward travel allows the spring **90** to pull arm **88** against the arm of another limit switch **91** to thereby actuate the same.

At one end of the channel member **61**, and fixed to the base plate **60**, is a rectangular block **93**. Held within this block and extending therethrough is a cylindrical metal tube **92**. The end **64** of this tube is of smaller diameter than the main portion and is adapted to engage the annular recess **16** of the cathode ceramic **15** to thus act as a stop member. Said stop member cooperates with the advance of lead screw **66** to reduce the grid-cathode spacing to the desired value. As the spacing between grid and cathode is decreased, the grid cup slips over the large diameter portion of tube **92**.

The block **93** has fixed to one side thereof two rectangular blocks **94**, by means of bolts **95**. These blocks are recessed to receive the horizontally disposed and oppositely actuated sliding members **97**, which are electrically conductive. These members are confined to the blocks **94**, which are electrically non-conductive, by means of straps **98**, and screws **99**, allowing movement only along the longitudinal axis of said members. The outer ends of the sliding members **97** are positively connected to air cylinders **100** by means of connecting members **101**, **102** and **103**. The member **102** is of insulating material to isolate the welding current from traveling into undesired paths. Affixed to the inner ends of sliding members **97** are rollers **104** which serve as welding contacts.

Cable means **105** connect the sliding members **97** to terminals **106** on a terminal block **107** mounted on the base plate **60**.

Another cable **108** is connected from a central terminal **109** on terminal block **107** to one end of tube **92**. Through the tube at this end is also provided a pin **110** to prevent axial movement of the tube when it serves as a stop for the cathode portion of the grid-cathode assembly. The pin **110** also extends through member **111** which is secured to block **93** by machine bolts **112**. The tube **92** is of course insulated in suitable fashions, such as by means of an insulating sleeve, not shown, or by making the block **93** of an insulating material, so that the welding current will be routed through the proper conductors. The terminals on terminal block **107** are connected to a suitable welding power transformer **280**, Fig. 15.

At the proper time for welding, air pressure will be applied to cylinders **100** from a suitable air line, not shown, as will later appear. This will force rollers **104** against the wall **24** of the grid cup **10** which is to be welded to the securing fingers **22**. During welding, the current will travel from the secondary of the welding transformer **280**, Fig. 15, to terminal **106** on the terminal block **107**, through cables **105**, through sliding members **97**, through rollers **104**, through the wall **24** of the grid cup **10** and the securing fingers **22**, thereby welding said wall and said fingers together, through tube **92**, through cable **108** to terminal **109** and thence returning to the secondary of the welding transformer.

At some later time when the air to cylinders **100** is cut off, the springs **114**, compressed against stops **115** and members **102**, will retract the sliding members **97** and rollers **104** away from the welded grid-cathode assembly.

The air cylinders **100** are connected to any air line of suitable pressure, for example 25–30 pounds per square inch, through a weld air solenoid **116**, Fig. 15. This solenoid is actuated by the electrical control circuit to feed air pressure to the air cylinders at the proper time before welding.

The sensing device by means of which the proper grid-cathode spacing is determined is shown in Figs. 10 and 11. The basic mechanism consists of a standard "air comparator." This air senser is well known in the tube manufacturing industry for reading grid-cathode spacing of cathode ray tube assemblies by means of changes in air pressure. The unit is, however, modified as shown in Figs. 10 and 11 to adapt it to carry out the purposes of this invention. The standard "air comparator" comprises a casing **120** carrying a face plate **121** with a scale **122** and a movable indicating pointer **124**; to assist in carrying forth the objects of the invention, a light source, mirror and photo-diode are added. The light source **126** is mounted in a housing **127** and disposed forward of and in line with the axis of the pointer **124**. The mirror **128** is affixed to the pointer at its axis of rotation and is disposed at an angle of 45° to the plane of the pointer so that the beam from the light source **126** will be reflected onto the photo-diode **130** mounted in a housing **131** on a ring **132** on the periphery of the



casing **120**. The peripheral location of photo-diode **130** will depend upon the desired grid-cathode spacing. Accordingly, ring **132** may be made rotationally adjustable about the casing by means of a tongue **134** and slot **136** arrangement to allow location of the photo-diode at different points with respect to the dial. A set screw **138** is provided to fix the location of the photo-diode at any point. Thus the photo-diode may be rendered conductive by impingement of light thereon at any desired reading of the pointer. In this way the mechanism may be employed to weld different electron gun type assemblies at their own particular grid-cathode spacings.

In order for the air senser to sense the decrease in spacing between the cathode coating **14** and the grid cup **10**, an air line is provided between the air senser and the adapter head. The air senser operates on a pressure of about 5 pounds per square inch but it may be connected to a standard air line of higher pressure, through an appropriate pressure reduction valve, not shown. The air flow through the system will then be as follows: first through the air senser, secondly through a flexible hose connection and into the bore **42** of the adapter head, thirdly passing through the aperture in the bottom **25** of the grid cup **10**, through the spacing between the cathode coating and the grid, and finally through the three holes **17** in the cathode ceramic **15**, into the atmosphere. The neoprene O ring **34** in the adapter head prevents any leakage of air past the outside of the grid cup and thus insures that the entire air flow passes through the grid-cathode spacing. As this spacing is decreased, the impedance to the flow of air through the system will be increased and this increase will be sensed by the well known air senser mechanism and will actuate the pointer **124** thereon. At some predetermined position of the pointer, the light beam from the light source **126** will be reflected into the photo-diode **130** by means of the mirror **128**, to actuate various circuits as will later appear. The scale **122** of the senser may be calibrated in thousandths of an inch for direct reading of grid-cathode spacing.

In order to drive the lead screw shaft **66** at the proper speed in the forward and reverse directions, a special three speed transmission drive assembly, see Figs. 12 and 13, is employed. The assembly is enclosed in a housing **200**. The input shaft **202** extends from one side of the housing through the opposite side and is fitted with a pulley **204** for belt connection to another pulley, not shown, on a suitable driving means, as for example, an electric motor. The output shaft **206** is disposed at right angles to the input shaft and on a different level. It extends from one end of the housing, through the opposite end and is fitted with a pulley **208**. This pulley has teeth as does pulley **78** on the lead screw for positive driving action by means of a toothed belt between them.

Associated with the output shaft **206** are standard magnetic clutch drive mechanisms **210**, **212** and **214** and a magnetic brake **216**. The clutches **210** and **212** when actuated through energization of appropriate circuits allow a gear arrangement to turn the lead screw shaft **66** at fast forward and slow forward speeds, respectively, of 48 and 16 revolutions per minute. The clutch **214** allows for a reverse speed of 64 revolutions per minute. The gear trains which produce these speeds are: (1) fast forward—input shaft **202** via a spur gear **218** which drives a spur gear **220** fixed on a shaft **222** on which a worm **224** is also fixed, to drive a clutch body **226**; (2) slow forward—input shaft **202** via a spur gear **230** which drives a spur gear **232** fixed on a shaft **234** on which a worm gear **236** is also fixed, to drive a clutch body **238**; (3) reverse—input shaft **202** via a worm **242** which drives a clutch body **244**. The clutch bodies **226**, **238** and **244** continuously rotate in close proximity to their mating elements **228**, **240**, and **246**

respectively, which latter elements are fixed to output shaft **206**. Various circuits actuate the various standard clutches at different times to cause the appropriate clutch body to drive its mating portion. The circuit arrangement is so designed that if one clutch be actuated, no other can be actuated unless and until that one clutch has been deenergized, thus avoiding damage to the assembly unit. The magnetic brake arresting means likewise cannot be actuated if any other clutch be energized.

The circuit for automatically carrying out the steps of the invention is shown in block form in Fig. 14. The photo-diode **130** and its cooperating light source **126** is shown in conventional circuit arrangement in Fig. 15. The photo-diode **130** is connected by a plug **249** and socket **251** and a cable to the input circuit of photo-diode amplifier **252**; by this means the lamp **126** is also connected to a low voltage power transformer **253**. A sensitive relay **274** is connected in the output circuit of tube **255** and controls the action of relay **275**.

A welding circuit in block **258**, is of the condenser discharge type. The welder, located on the base plate **60**, receives its power from the control circuit by means of a plug **259**, socket **261** and cable arrangement, Fig. 15. When relay **278**, is actuated, the circuit comprising the primary of the welding transformer **280** in series with power storage condenser **282** and heat control resistor **284** is complete, thus discharging condenser **282**.

The various magnetic clutches on the transmission drive assembly are connected by a plug **305**, socket **307** and cable arrangement, to the control circuit of Fig. 15. This means also affords connection to limit switches **89** and **91**, push button start switch **306** and the weld air solenoid **116**.

A timing circuit **256** includes a relay **286**, capacitor **288**, resistor **290** and a rectifier **292**. This timer assists in actuating the welder at the proper time.

To operate the various circuits a power supply having a full wave rectifier **294** and a half wave rectifier **296** is employed to supply direct current. The circuit includes a conventional high voltage transformer **297** and filter circuits.

The operation of the system is made possible by means of a magnetically actuated stepping switch **298** having seven positions and six circuits or banks, four shorting and two non-shorting. Counting from the left, the first three banks are shorting, four and five are non-shorting, and six is shorting. The various circuits actuated by the advancement of the switch contacts will be described under the description of operation to follow. A relay coil **300** is provided as a part of the switch, with an interrupting contact **301**, to actuate the switch to subsequent positions. A push-button **302** is provided, however, to manually advance the step switch when desired. Main power to the entire circuit is controlled by a single pole single throw switch **304**.

*Operation of the device*

Operation of the apparatus is as follows: A ceramic mounted cathode, held within the spider **18**, is inserted a short distance into grid cup **10**, see Fig. 1. This grid-cathode assembly is next inserted into the recess of the adapter head **27** against the neoprene O ring **34**, see Figs. 4, 5 and 6. Turning the assembly several degrees will engage the wings **26** on the grid cup with the tapered walls **37** of slots **36** on the adapter head, thus holding the assembly firmly in position. Turning cam **40** via a suitable wrench applied to the end of the shaft **41** then effects an air tight seal between the O ring and the outside of grid cup **10**.

The assembly must be inserted in such a position that the securing fingers **22** on the spider retainer **18** are in line with the guide pins **46** on the adapter head, so that said fingers will be under the weld rollers **104** for the welding operation. The adapter head is next laid in the semicylindrical adapter head channel way **62**, see Figs. 7, 8 and 9, so that the annular recess **16** of cathode ceramic **15** either engages or is in close proximity to stop **64** at one end of the channel way. The push rod **63** is then advanced and turned manually until its pin **74** engages the offset slot **76** in lead screw **66**. The push rod is thus fixed against axial movement with respect to the lead screw.

The switch **304**, Fig. 15, having been previously thrown, the circuits are energized for automatic operation. It will be assumed that an assembly has just been spaced and welded and the step switch will therefore be in position #1, the brake clutch **216** thus being energized. Also, the limit switch **89** will be in closed position and limit switch **91** will be open, by reason of the reverse travel of lead screw shaft **66**. Details of the operation of the device are best understood with reference to the various step switch positions.

*Step switch position #1.*—The series of automatic operations is now started by operating the push button switch **306**. This energizes the step switch coil **300** which advances the step switch to position #2.

*Step switch position #2.*—In this position, bank #1 of the step switch feeds power to the motor which drives the three speed transmission unit; it remains energized for all positions of the step switch from position 2 to position 6 inclusive. Bank #4 energizes the magnetic clutch **210** which allows the motor to drive the lead screw shaft at the fast forward speed of 48 R. P. M. This will advance the grid-cathode assembly in the adapter head traveling along the guideway **62**, toward stop **64**. After the cathode ceramic abuts said stop, the grid-cathode spacing will uniformly decrease.

Bank #5 establishes a circuit path to the step switch coil **300** through limit switch **91**, Figs. 7 and 8, so that when the lead screw shaft **66** actuates said limit switch by means of the pulley and oscillatable shaft arrangement **78**, **80**, **82**, **84** and **88**, said coil will advance the step switch to position #3.

*Step switch position #3.*—Bank #2 energizes the primary of transformer **253** which supplies current to photo-diode lamp **126**. It also connects power to the weld air solenoid **116** which supplies air pressure to air cylinders **100** thus forcing weld rollers **104** into contact with the grid cup, or with tube **92** if the cup wall **24** has not yet advanced far enough to be between the rollers and the tube. These conditions are maintained for positions 3, 4 and 5 of the step switch. Bank 3 connects B+ power to the output circuit of the photo-diode amplifier tube **255**; this condition also remains for positions 3, 4 and 5 of the step switch. Bank 4 connects power to the low forward magnetic clutch **212** on the three speed transmission, through the relay **275**, allowing the lead screw shaft **66** to now be driven at the slow forward speed of 16 R. P. M. The high speed forward clutch is deenergized when the step switch leaves #2 position, thus preventing damage to the transmission assembly. Bank #5 establishes an open circuit to the step switch coil **300**, through the open contacts on relay **275**; the step switch will not be advanced to the next position until relay **275** is actuated.

At this point the lead screw **66** continues to be advanced at the slow forward rate of 16 R. P. M., continuously decreasing the grid-cathode spacing. The air flowing through the grid aperture will therefore be increasingly impeded as the cathode moves closer to the aperture. This will alter the pressure and rate of air flow through the air senser. As the grid-cathode spacing approaches the desired value, which is previously determined by the setting of photo-diode **130** on the periphery of the air senser, see Figs. 10 and 11, the pointer **124** will begin to move. When the pointer reads the proper spacing, the light from lamp **126** will, as previously described, be reflected from the mirror **128** into the photo-diode, thus activating the latter. This will change the grid bias on tube **255**, increasing its current flow and

actuating relay **274** and in turn closing relay **275**. The closing of relay **275** accomplishes the following: (*a*) relay contactor #1 applies B+ to the welding circuit, thus charging the welding discharge condenser **282**, (*b*) relay contactor #2 disconnects the low forward speed magnetic clutch **212**, and connects the brake magnetic clutch **216**, thus arresting the change in spacing between grid and cathode at this point, and (*c*) relay contactor #3 actuates step switch coil **300** to advance the step switch to position #4.

*Step switch position #4.*—With the grid-cathode spacing at the proper value and the brake on, the parts are ready to be welded. However, since the required charging time of the welding discharge condenser **282** is longer than the step motion of the step switch, a timing circuit is provided to delay the step switch a short time before the step switch is advanced to the #5 weld firing position. Bank #5 connects power to the timing circuit and bank #4 establishes a circuit, through open relay **286** to the step switch coil **300**. The condenser **288** of the timing circuit comprising relay **286**, condenser **288**, resistor **290** and rectifier **292** acts as a short circuit when power is first applied to the circuit by bank #5, and relay **286**, therefore, which is in parallel with the condenser **288** cannot close. In a short time, however, the condenser charges, there is now a voltage drop across it and the relay closes. This applies the voltage from bank #4 to the step switch coil **300** to advance it to position #5. The short delay achieved by means of a condenser of the order of 300–400 microfarads is all that is needed to delay the switch advance the desired time.

*Step switch position #5.*—In this position, bank #6 applies A. C. voltage to relay **278**, closing it and thereby discharging the weld storage condenser through the grid-cathode assembly. The fingers **22** of the retainer ring **18** are now firmly welded to the wall **24** of grid cup **10** at the proper grid cathode spacing. Bank #5 energizes the step actuating coil **300**, advancing the step switch to position #6.

*Step switch position #6.*—In this position the photo-diode light **126** and the weld air solenoid **116** are cut out by bank #2. The rollers **104** are therefore retracted from grid-cathode assembly. Bank #3 deenergizes the photo-diode amplifier tube **255**. The brake is now off since the relay **275**, now open, deenergizes the magnetic brake clutch **216**.

Bank #4 energizes the reverse magnetic clutch **214** and the lead screw shaft is now driven in reverse speed at 64 R. P. M.

Bank #5 establishes a circuit through open limit switch **89** so that when the lead screw shaft **66** has traveled far enough in the reverse direction to close it, see Fig. 8, a voltage will be again applied to step switch coil **300** to advance the step switch to position #7. In its reverse travel, the lead screw **66** first opens limit switch **91** and then, a short distance further, closes limit switch **89**, thus advancing the step switch to position #7.

Position #7 merely returns the step switch to position #1 ready to repeat the sequence of operations.

The push-rod **63**, Figs. 7 and 8, may now be retracted, the completed grid-cathode assembly removed from the adapter head, and a new assembly loaded therein for the next operation.

Thus is disclosed a novel apparatus and method for manufacturing and space checking grid-cathode assemblies which eliminates a great number of disadvantages of the prior art. While certain aspects of the invention have been described with particularity, it is apparent that various changes and modifications may be made without departing from the spirit of the invention or the scope of the appended claims.

Having thus described the invention, what is claimed as new is:

1. Apparatus for automatically positioning two parts of an electron gun with respect to each other comprising means for holding said parts, a positioner engaged by one of said parts to restrain it against motion, means for engaging the second part and moving it with respect to the first part, means for sensing the relative displacement between said parts, and means under control of the sensing means for arresting the motion of said moving means.

2. Apparatus for automatically positioning two parts of an electron gun with respect to each other comprising means for holding one of said parts, means for moving the second part with respect to the first part at a relatively fast rate of speed, means under control of said moving means for changing the rate of speed from said fast rate to a slower rate, sensing means for sensing the relative displacement of said parts, and means under control of the sensing means for disabling the forward motion of said moving means.

3. Apparatus for automatically positioning two parts of an electron gun with respect to each other comprising means for holding one of said parts, means for moving the second part with respect to the first part at a relatively fast rate of speed, means under control of said moving means for changing the rate of speed from said fast rate to a slower rate, sensing means for sensing the relative displacement of said parts, means under control of the sensing means for disabling the forward motion of said moving means, and means also under control of the sensing means for effecting a rapid reverse movement of the moving means.

4. Apparatus for automatically positioning two parts of an electron gun with respect to each other comprising means for holding one of said parts, means for moving the second part with respect to the first part at a relatively fast rate of speed, means under control of said moving means for changing the rate of speed from said fast rate to a slower rate, sensing means for sensing the relative displacement of said parts, means under control of the sensing means for disabling the forward motion of said moving means, and means for manually moving that portion of the moving means which is engageable with the holding means.

5. Apparatus for automatically positioning two parts of an electron gun with respect to each other comprising means for holding one of said parts, means for moving the second part with respect to the first part at a relatively fast rate of speed, means under control of said moving means for changing the rate of speed from said fast rate to a slower rate, sensing means for sensing the relative displacement of said parts, means under control of the sensing means for disabling the forward motion of said moving means, and means for manually advancing and retracting at least a portion of the moving means respectively toward and away from the holding means.

6. Apparatus for automatically positioning two parts of an electron gun with respect to each other comprising means for holding one of said parts, means for moving the second part with respect to the first part at a relatively fast rate of speed, means under control of said moving means for changing the rate of speed from said fast rate to a slower rate, sensing means for sensing the relative displacement of said parts, means under control of the sensing means for disabling the forward motion of said moving means, and means also under control of said sensing means for arresting the forward motion of said moving means.

7. Apparatus for automatically positioning and welding two parts of an electron gun with respect to each other comprising means for holding and advancing both of said parts, a positioner engaged by one of said parts to restrain it against further motion, means for moving the holding means for continuing to advance the second part thereby varying the spacing between said parts, means for sensing said variation in spacing, and means under control of said sensing means when said spacing attains a predetermined value for arresting the relative motion of the parts and for welding said parts to each other.

8. Apparatus for automatically positioning and welding two parts of an electron gun with respect to each other comprising means for holding and advancing both of said parts, a positioner engaged by one of said parts to restrain it against further motion, means for moving the holding means for continuing to advance the second part thereby varying the spacing between said parts, means for sensing the relative displacement between said parts, means under control of the sensing means for arresting the motion of said moving means, and a movable welder electrode also under control of said sensing means mounted to move toward and away from said parts to thereby weld said parts together.

9. Apparatus for automatically positioning and welding two parts of an electron gun with respect to each other comprising, a guideway, means for holding said parts in said guideway and for advancing both of said parts therealong, a positioner at one end of said guideway and engageable by one of said parts to restrain it against motion, means for moving the second part with respect to the first part to vary the spacing between said parts, means for sensing said variation in spacing between said parts, and means under control of said sensing means when said spacing reaches a predetermined value for arresting the relative motion of said parts, for welding said parts to each other, and for reversing the movement of said moving means.

10. Apparatus for automatically positioning and welding two parts of an electron gun with respect to each other comprising a guideway, means for holding said parts in said guideway and for advancing both of said parts therealong, means for moving said holding means along said guideway, a positioning means at one end of said guideway engageable by one of said parts to restrain it against motion to thereby effect a change in spacing between said engageable part and said other part, means for changing the rate of advance of said holding means and one of said parts, means for sensing the change of spacing between said parts, and means under control of said sensing means for disabling and arresting the motion of said moving means, for welding said parts to one another, and also for effecting a direction of movement of said moving means away from said positioning means.

11. Apparatus for automatically positioning and welding two parts of an electron gun with respect to each other comprising means for holding and advancing both of said parts, a positioner engaged by one of said parts to restrain it against further motion, means for moving the holding means for continuing to advance the second part thereby varying the spacing between said parts, means for sensing said variation in spacing, and means under control of said sensing means when said spacing attains a predetermined value for disabling and for arresting the forward motion of said moving means, for welding said parts to one another, and also for causing said moving means to travel in a direction opposite to said forward motion.

12. Apparatus for automatically positioning two parts of an electron gun with respect to each other comprising means for holding said parts, a positioner engaged by one of said parts to restrain it against motion, means for moving the second part with respect to the first part, said moving means including a first axially movable hollow shaft having a first slot in an axial direction in the wall of said shaft and a second slot portion at one end of said first slot portion at an angle thereto and communicating therewith, a second shaft disposed coaxially within said first shaft and extending beyond both ends of said first shaft and movable therein, said second shaft having a pin extending above the surface thereof and adapted to ride in said first and second slots of said first shaft, and means to drive said first and second shafts in an axial direction.



13. Apparatus for automatically positioning two parts of an electron gun with respect to each other and one of which parts is perforated and for determining the spacing therebetween comprising a positioner engaged by one of said parts to restrain it against motion, means for moving the second part with respect to the first part, a holding means for said parts including a first member having an inturned flange portion, and grasping means exterior of said flange portion for holding said parts, with the perforated part within the flange portion, a second member within the first member and in telescopic relation therewith, a compressible ring between an end of said second member and said flange, means for longitudinally moving said second member with respect to said first member to compress said ring and form an air tight seal around said perforated part, a passageway extending longitudinally through the second member and terminating in an air outlet at the said end of said second member, said passageway extending to an air inlet port near the other end of said second member, air pressure sensing means, and an air line between said sensing means and said air inlet port.

14. Apparatus for automatically positioning two parts of an electron gun with respect to each other comprising holding means for said parts, a positioner engaged by one of said parts to restrain it against motion, means for moving the second part with respect to the first part, including a rotatable shaft connected to drive said holding means and having a helical screw surface adapted to engage a mating screw surface in a fixed member to thereby impart a component of axial travel to the shaft, a pulley secured to said shaft, means to drive said pulley, a lever having a roller mounted on one arm thereof and riding on a side of said pulley, means acting on said lever to hold said roller in contact with said pulley, and a switch in the path of movement of the other arm of said lever to be actuated thereby to control the movement of the pulley driving means.

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