ABSTRACT OF THE DISCLOSURE

An electron gun, essentially complete except for its cathode, is supported by a workholder and a gauge is inserted into the gun in place of the cathode. The tip of the gauge rests on grid 1 and a setback shoulder or land of the gauge is established at the position to be occupied by the emitting surface of the cathode. A nitrogen gas line carrying nitrogen under pressure is threaded through the gun, discharging gas along the beam path within the gun. This line is advanced toward the gauge until a meter, monitoring the line, shows that a predetermined amount of back pressure has been created in the line as it approaches close enough to the gauge to have its free-flow condition disturbed by an interference or back pressure which increases as the line gets closer to the land of the gauge. The nitrogen line is then fixed in position and the gauge is removed. The cathode is now inserted into the gun and moved toward grid 1. The advance of the cathode continues until the same amount of back pressure is measured in the nitrogen line indicating that the cathode has reached its desired location. At this point, the cathode is secured in position by welding.

BACKGROUND OF THE INVENTION

The present invention is directed to an apparatus and process for making an electron gun and solves the very difficult problem of achieving precision in the relative spacing of the elements of the gun. While of general utility, the invention contributes its maximum benefit in establishing the cathode to grid spacing of the electron gun which is the most critical spacing encountered. Accordingly, the invention will be described in that environment.

Very frequently, the cathode is to be secured with in a cylindrical component of the gun which, in some instances, is a structural part of grid 1 and in other gun designs is simply a cylinder or sleeve which is coaxial with and surrounds a cylindrical cathode, being provided for the purpose of heat transfer. In either case a cylindrically shaped cathode must be inserted and positioned within such a cylinder and it is, therefore, appropriate to refer to the apparatus and process as one for effecting cathode insertion.

Obviously, cathode insertion is a problem with both monochrome and color picture tubes but it is far more significant in the latter where the tube generally has at least three electron guns arranged in a common mount. If color fidelity is to be obtained, and certainly that is a most important objective in the design of any color tube, it is essential that the characteristics of the several guns in the mount be as identical and uniform as possible. The cathode to grid 1 spacing is of paramount importance in determining the gun characteristics, and uniformity of guns in a gun cluster is most readily achieved through a fabricating apparatus and process which make possible identical cathode to grid 1 spacing in each of the guns of the mount. This difficult criterion is satisfied by the subject invention.

Previous approaches to the problem have, for the next part, relied on mechanical jiggling arrangements for locating the cathode at a particular distance from grid 1. It is found, however, that the tolerance variations cause such proposals to be relatively imprecise. In an effort to improve matters it has been suggested that the capacitance, presented between facing surfaces of grid 1 and the cathode, serve as one arm of a capacitance bridge which becomes balanced when the capacitance, which is a function of grid to cathode spacing, attains a specific value. In using this bridge technique, it is found that stray capacitances that are introduced by necessary leads used in the installation introduce an error or tolerance factor which is undesirable. It has also been found through experience that even where stray capacitance is sufficiently controlled to have this method acceptably accurate, it takes an undesirably long time to arrive at the very precise cathode to grid spacing that is required.

Accordingly, it is an object of the invention to provide a new and improved method and apparatus for precisely positioning two elements of an electron gun a given distance apart.

It is another object of the invention to provide a method and apparatus for accomplishing such spacing of contiguous gun elements with a high degree of precision and with a much reduced processing time.

It is a specific object of the invention to provide a new and improved method and apparatus for inserting the cathode of an electron gun quickly and with an accurate spacing from grid 1.

SUMMARY OF THE INVENTION

Broadly speaking, the method of the invention is for positioning a first solid disc-shaped element of an electron gun, such as the end of a cylindrically shaped cathode, a particular distance in a given direction from a second apertured disc-shaped element of the gun, for instance, apertured grid 1. In practicing the invention, a uniform rate of fluid of liquid, preferably as gas, is established from a conduit through the grid 1 in the direction that the cathode is to be spaced from that grid. The conduit terminates in an orifice that is small in cross-section compared to the area of the cathode and this orifice is secured in a reference position. The cathode is moved toward grid 1 in a direction generally opposed to the direction of fluid flow to constitute a barrier to free flow of fluid from the orifice when the cathode is at a known distance exceeding the particular distance that the cathode is to be positioned from grid 1. The advance of the cathode toward grid 1 is continued to create a back pressure or interference to free flow of the fluid from the orifice which varies as a function of the distance of the cathode from grid 1. The advance of the cathode is arrested when that back pressure has attained a predetermined value repre-
senting a spacing of the cathode from grid 1 corresponding to the aforesaid particular distance.

In order to have flexibility so that the method is equally useful in positioning the cathode within electron guns of different axial lengths, the method of the invention also contemplates a gauging process. In this aspect of the invention, a gauge is positioned in essentially the same geometrical arrangement within the gun as the cathode, differing in that the tip of the gauge rests against the facing surface of grid 1. A transverse shoulder of the gauge, offset from the tip, is disposed across the grid 1 aperture at the precise distance desired of the end surface of the cathode. With the gauge in position, the cathode is threaded through the gun in a direction opposite to the intended location of the cathode relative to grid 1 and as the fluid line approaches the gauge the free flow condition is disturbed because the shoulder of the gauge is across the fluid path. This results in back pressure and the conduit is advanced until the back pressure shows the orifice to have the precisely desired spacing from the shoulder of the gauge. Having thus determined the reference position of the orifice, the gauge is removed and the cathode inserted as previously described to locate it relative to the aperture of grid 1.

**BRIEF DESCRIPTION OF THE DRAWINGS**

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 by reference to the following description taken in conjunction with the accompanying drawings, in the several figures of which like reference numerals identify like elements, and in which:

**FIG. 1** represents the cathode inserting apparatus in accordance with the invention for carrying out the inventive process; FIG. 1a is a schematic representation of the fluid monitoring arrangement included in the apparatus of FIG. 1; FIG. 2 is a cross-sectional view taken as indicated by section lines 2—2 in FIG. 1 and illustrating the gauging process; FIG. 3 is a view taken along section lines 3—3 of FIG. 2 showing the workholder for holding and indexing a multiple gun mount; FIG. 4 is a view taken along section lines 4—4 of FIG. 2; FIG. 5 is a detail of the cathode supporting mandrel of the apparatus of FIG. 1; FIGS. 6 and 7 are partial views of the apparatus of FIG. 1 used in explaining the gauging process; FIGS. 8 and 9 are partial views of the apparatus used in explaining the cathode insertion process; and FIG. 9a is a fragmentary view used in describing a modified process for securing the cathode in position.

**DESCRIPTION OF THE PREFERRED EMBODIMENT**

For convenience, the description will proceed with a consideration of the gun mount, the gauging and cathode inserting apparatus, the gauging process and the cathode inserting process in the recited order.

**GUN MOUNT**

It will be assumed that the gun mount is a delta arrangement of three electron guns the structures of which are well known in the art and, per se, constitute no part of the present invention. In FIG. 3, the gun mount is shown as comprising electron guns 10, 11 and 12 each of which has an electrode system constituted of a number of electrode elements arranged in coaxial alignment to define the path of an electron beam and secured in such relation by the usual beads or insulating pillars 13 spaced 120 degrees apart and integrated into the mount by means of metallic tabs extending from electrodes of the guns and embedded in these beads. Referring to sheet 3 of the drawings and particularly to FIG. 8, each such gun, when completed, is comprised of a cylindrically shaped cathode 14 which is open at one end and closed at its opposite end by a solid disc-shaped end closure 14a which bears a coating of 14b of electron emissive material. The problem solved by the apparatus and method of the invention is the precise positioning of this cathode to achieve a spacing S of the cathode emitting surface 14b from the contiguous face of grid 1 which is designated 15. This grid is disc shaped and has a centrally located aperture 15a. Cathode 14 is surrounded by and welded to a cathode cylinder 16, which, in turn, is welded to a disc 17 having tabs (not shown) for attachment to beads 13.

The additional electrodes of the sun are positioned on the side of grid 15 opposite to cathode 14 and, as shown more completely in FIG. 6, include a further disc shaped electrode 18 having a central aperture 19a and a cylindrical electrode 19 with a reduced diameter section 19a facing electrode 18 and likewise having a central aperture 19b. Moreover, there is another cylindrical electrode 20 which is the final anode. This structure of electrode elements, suitably apertured and arranged in coaxial alignment, will be recognized as a well-known form of electron gun having a two element focusing lens constituted of electrodes 19 and 20. The structure, when completed with its cathode subassembly and suitably energized, issues a well-defined electron beam along a given beam path as required of each of the three guns of a color picture tube. Since no novelty is predicated on the structure of the gun itself, it is not necessary to consider its details or operation further.

**GAUGING AND INSERTING APPARATUS**

The apparatus, as shown in FIG. 1, has a bed 25 supporting a number of structural elements which individually are well known. Included in this category is a workholder 26 for retaining a gun mount designated by numeral 9. It includes three electron guns arranged in an assembly, as represented by beads 13 and the electrode system of one electron gun but with reference characters thereof omitted to avoid congestion in the figure. A larger sectional view of the workholder is contained in FIG. 2 which shows the electrodes of a single gun, except for the cathode, as described in the discussion of FIGS. 6 and 8.

The workholder has a principal base 26a which is supported from the bed of the machine through an arrangement of bearings 27 to the end that the workholder is rotatable about its axis either manually or through a power driven indexing system 38 that may be of conventional construction and for that reason has not been shown in detail. The workholder is provided with three mandrels 32, one to accommodate each of the guns of the three-gun mount. An enlarged view of one such mandrel 32 is included in FIG. 6 from which it is clear that each mandrel threads into base 26a of the workholder. Obviously, the mandrel is contoured to accommodate various of the electrodes of the electron gun and lend support so that the electrode alignment is not disturbed in either the gauging or cathode inserting processes carried out with the apparatus under consideration. Thus, section 32a has a diameter corresponding to the inside diameter of electrode 20 and section 32b corresponds in diameter to the inside diameter of electrode section 19a. The final section 32c is dimensioned to project through aperture 19b of electrode 19. Each mandrel is hollow to accommodate a fluid or nitrogen gas line 33. This line is segmented and presents a fluid passage of decreasing diameter, terminating in what is essentially a needle section 33e leading to an orifice 33f. The purpose of this
conduit or fluid line will be made clear hereafter and again it is noted that there are three such mandrels, each accommodating a similar fluid conduit.

The largest diameter section of line 33 is smaller than the bore of base 26c provided to accept mandrel 32. This gives space to accommodate a spring 34, see FIG. 2, which is compressed between the threaded end of mandrel 32 and a flared section 33c of the fluid line. The purpose of spring 34 is to seat fluid line section 33c finally against a fluid-line section 35a constructed within a member 35 which is arranged for movement in a vertical plane within a recess defined by a cylindrical extension 26b of base 26c of the workholder. While it is only required that member 35 be in alignment with the particular electrode gun of the mount that is being processed, it is convenient to have member 35 dimensioned to be aligned with all three guns of the mount in workholder 26 as indicated in FIG. 4. Fitting 37a provides a convenient means for connecting a fluid line 37 to the fluid conduit extending through member 35 and mandrel 32. Gears 38a shown within broken-line enclosure 38 indicate the manner in which an indexing mechanism may be associated with workholder 26 to present each of the three mandrels and the fluid lines provided therein in communication with line 35e, seriatim.

To load a gun mount into the workholder each of the three electrode assemblies is threaded over one of the three mandrels, respectively, protruding from the top surface of base member 26c. When in place, the free end of the final electrode 20 of each such gun rests essentially on the top surface of member 26c.

When the gun mount is positioned in the workholder, tabs 20a, see FIG. 3, which extend from the end of cylindrical electrode 20 are in position to be clamped by movable clamps 28 contained within the workholder. Since the gun mount includes three electron guns, there are three such clamps. Each clamp is rotatably supported but is biased by a spring 29, see FIG. 2, in a counter-clockwise direction to a rest position in which the clamp is clear of the electrode tab 20a. A collar 30 which threads on base 26 may be rotated by manipulation of handles 31 and, when moved in a clockwise direction as viewed in FIG. 3, causes a cam projection 30a to engage a finger 28a extending from clamp 28 to rotate the clamp also in a clockwise direction. This moves the clamp over tab 20a where it is releasably held by collar 30 and in this fashion anchors the gun mount by trapping the tip of the final anode electrode of each of the three guns by the three clamps of workholder 26.

The fluid or gas line is extended through member 35 and mandrel 32 for the purpose of accomplishing a gauging process to be described hereafter but this requires that the fluid line be displacable vertically relative to the electron gun supported by the mandrel. Accordingly, the structural components comprising the fluid conduit are dimensioned to permit vertical displacement, and compression spring 34 serves to have the entire conduit moved as a unit even though there are two separate component parts which meet at the seal 35b. Displacement of the fluid conduit is under the control of a cam 40, see FIG. 1, having a section 40a with a relatively steep slope and a contiguous section 40b of a much reduced slope. A cam follower 35c is rotatably supported within a bifurcation 35e, see FIG. 2, formed at one end of member 35. This portion of member 35 also accommodates an anchor pin 35e to which are attached springs 35f for biasing cam follower 35c into continuous engagement with cam 40. Relative movement of the cam and its follower is provided by a mounting block 40c which has a slot for slidably accommodating cam 40. Block 40c also has a bifurcated termination 40d that slidably receives the terminal part 35d of member 35 to complete the assembly. Slots 40e through which anchor pin 35c projects permits movement of member 35 vertically relative to block 40c under the control of cam 40. Of course, springs 35f may conveniently be anchored to block 40c.

An hydraulic system, see FIG. 1, including a cylinder 41 and enclosing a piston 41a which is coupled to cam 40, accomplishes the necessary displacement of cam 40. Cylinder 41 receives air or any other fluid under pressure through an input line 41b from a source (not shown) through solenoid actuated and series connected valves 41c, 41d. A line 41e extending from the opposite end of the cylinder returns the fluid to a reservoir and completes the system. Obviously, control of the fluid flow provides a control of both the direction and rate of displacement of piston 41a and cam 40. This mechanism is supported on a plate 25a suspended from bed 25 of the apparatus.

Valves 41c and 41d are electrically controlled by signals applied to their actuating mechanism over the leads shown in broken-construction line 41f and designated A, B. These leads return to a fluid pressure sensitive control system 45 which has as its principal function the monitoring of pressure in nitrogen conduit or line 37 to the end that control may be exercised on the fluid drive systems which actuate critical components of the apparatus when significant pressure readings are registered. It is a matter of concern, for example, in a gauging process that is the reason that valves 41c and 41d connect with unit 45 so that they may be actuated as certain particular pressures are recorded. As will be made clear presently, like connections attach to the control of the workholder by means of which a cathode is ultimately inserted into cylinder 16. Consequently system 45 has two control units designated 1 and 2.

Individually, these units are similar to the arrangement represented in FIG. 1A. As there indicated, a pair of bel lows type pressure sensitive devices 45a and 45b are tapped into nitrogen line 37 to respond to the back pressure established in that line when the normal free-flow condition is disturbed. A pair of contacts 45c and 45d are positioned over pressure sensitive elements 45a and 45b, respectively, to be closed as these bellows expand in response to the pressure line having achieved certain preselected values. Adjustment screws 45e permit convenient selection of the pressure levels in response to which contact actuation results. Each contact pair is included in one of the lines A and B which return to a suitable power source so that when a contact pair closes, the associated solenoid is energized to actuate its value in fluid line 41b. Unit 45 may also be conveniently coupled to a pressure regulator 37b for line 37 which extends from this regulator to a source of nitrogen under pressure (not shown).

It is convenient to include a pressure meter 45f which also registers the fluid pressure of line 37. Additionally, indicator lamps 45g may be controlled in response to the registration of particular values of fluid pressure to facilitate an operator's monitoring the operation of the apparatus in question. No claim of invention is here made to the structure or operation of control system 45, per se; it is a commercially available component and an acceptable form is marketed by the Bendix Corporation under the designation Modular Panel A.U. 125.

On the other side of bed 25 is a pedestal 25b supported within a hollow pillar 25c to guide movement of a platen 25d from which depends a cylinder 25e which slides upon pedestal 25b. Platen 25d is subject to vertical displacement under the control of another air cylinder 47 which is connected with a source of air under pressure through lines 47a and 47b. It is convenient to include a valve 47c in the line for the purpose of controlling the rate of displacement of platen 25d in response to displacement of the piston within air cylinder 47 which, in turn, is mechanically coupled to the platen.

Cylinder 25e is the support for both a gauge employed in the gauging process referred to above and a holder for retaining a cathode while it is being inserted into the gun under process. It further supports a welding system and
controls for these various components of the cathode insert apparatus.

Consider first the gauge and its support, there is a rod 48 which not only supports a gauge 49 but also makes possible control of the angular disposition of the gauge and its elevation relative to the gun being processed. The detail view of FIG. 2 shows an arm 48a extending transversely from the free end of the rod 48a which has a threaded end 48b which receives a compression spring 48c, a gauge 49 and a gauge retaining block 48d. The gauge, which normally rests against its retaining block under the influence of compression spring 48c, terminates in a tip 49a which shows most clearly in FIG. 7. During the gauging operation to be described, spring 48c is further compressed as shown in FIG. 2. Set back from the end of this tip is a shoulder or transverse land 49b and its offset is a critical dimension, specifically, it represents with precision the spacing S1 (FIG. 8) desired of the free end or emitting surface of the cathode cylinder from the facing surface of grid 15.

Gauge 49 has a rest position in which it is displaced away from the gun instantaneously in the processing station of workholder 26, and it is necessary, in carrying out the gauging process, first to bring the gauge into alignment with that electron gun and then permit it to descend into contact with a particular grid. For that purpose, rod 48 has a milled cam track 48b, see FIG. 1, into which projects a pin 48c which is attached to a lateral extension 25f of cylinder 25e. In other words, pin 48c is stationary during vertical displacement of rod 48, causing the pin to traverse cam track 48b and result in rotation of displacement arm 48a and gauge 49. Vertical movement of rod 48 is under the control of still another air cylinder 50 having a piston to which the rod connects. Fluid lines 50a and 50b connect with a source of air under pressure (not shown). Additional mechanical support for cylinder 50 is carried by a support member 25g which extends vertically from platen 25d. While cam 48b and pin 48c may easily rotate rod 48, they may not provide sufficient accuracy in the alignment of gauge 49 with the axis of the gun in process and, therefore, an additional position control is provided by means of a member 55c which is accurately positioned within member 25f in relation to the axis of the gun in process. It receives a pin 48d projecting downwardly from an arm 48e secured to rod 48. Suitable tapering of pin 48d, in conjunction with some free motion afforded by the relative dimensioning of cam 48b and pin 48c, permits the selection of pin 48d to accurately align gauge 49 with the electron gun being processed.

As will become apparent, after gauge 49 has been used in carrying out a gauging process, the next step is restoring the gauge to its rest position and inserting cathode 14 into cylinder 16 for precise positioning relative to grid 15. During this step, the cathode is retained by a holder 55 which comprises a cylindrically shaped member 55a extending through a passageway of extension member 25f for movement relative thereto so that the cathode holder may be moved upwardly and downwardly relative to cylinder 25e. The arrangement is generally similar to that described with reference to member 35 which is movable vertically relative to workholder 26 for the gauging process. More particularly, the upper end of member 55a serves as a cathode follower which engages a cam 56, being biased in engagement therewith by a compression spring 55b. At its opposite end, cathode holder 55, as shown in FIG. 6, carries a mandrel 55c having a duct 55d extending vertically therethrough in communication with a port 55e which connects with a vacuum line 55f, shown also in FIG. 1. As clear from the much enlarged view of FIG. 6, mandrel 55c is so constructed that described with reference to cathode 14 that when the mandrel is threaded over the mandrel the exhaust duct 55e is free to draw a vacuum in the holder, permitting the cathode to be releasably retained in position on the mandrel.

When a cathode is thus supported on mandrel 55c it is to be inserted into cylinder 16 by lowering the cathode the required amount. Obviously, cathode 15, being raised and lowered by movement of platen 25d and further independent, as well as precisely controlled, advance thereof is accomplished by cam 56 and air cylinder 57, see FIG. 1, which has lines 57a, 57b connecting the cylinider 16 to the high pressure air system. Line 57a also has solenoid controlled valves 57c and 57d which are connected with control unit 45 by means of the connections shown in broken-construction line and designated C, D. Cam 56 is accommodated and guided by a block 56a mounted on platen 25d.

Once the cathode has been inserted and properly positioned within cylinder 16 in a manner to be described, it is necessary to secure it and protect against any relative movement of the cathode and grid 15. This may be done by staking but, as shown, is accomplished by welding since the cathode cylinder as well as cylinder 16 are formed of conductive metal. Accordingly, there are three movable welding electrodes spaced approximately 120 degrees apart about cathode holder 55. Only one of these shows in FIG. 1 but all three are the same in construction and are well known devices.

Specifically, extension member 25f supports an air cylinder 60 which may also be coupled to the air system by lines 60a and 60b and a solenoid actuated valve 60c is provided to facilitate control of the fluid driving system. The piston of air cylinder 60 connects with a rod 60d which terminates in a cam member 60e having a cam track milled therein to receive a pin 60f carried on an electrode holder 60g which is mounted for slidable movement in a horizontal plane. A movable electrode 60g is carried by electrode holder 60h. When air under pressure is admitted to cylinder 60, causing its piston to descend, movement of cam track 60g replaces movable electrode 60g to its extreme left-hand position (to the left of that shown in FIG. 1) for the welding operation. This is true of all three welding units and they operate simultaneously.

The welding circuit for these units is completed through a common electrode 60h which supports mandrel 55c as illustrated in FIG. 5. Preferably, central electrode 60h is insulated from the structural components of the apparatus other than those required in completing the welding circuit such as conductor 60i which returns to the welding source (not shown). Timing of the welding operation may also be under the control of unit 45. For example, actuation of valve 60c from this control unit is made possible by the connection to the control circuit, as is the case for those labeled A-D, inclusive, is completed assuming that conductors having like letter designations are in circuit connection.

It is, of course, required that the various subsystems of the described cathode inserting apparatus operate in timed relation to one another. This is simply a matter of programming which is well within the knowledge of the art. For example, a series of cams may be relied upon to actuate switches in control circuits or microswitches positioned in the paths of moving parts may be operated by the movement of such parts to accomplish relative timing. Combinations of these controls are also useful. In any event, it would unnecessarily confuse the drawing to show the details of programming and since this is a matter within the knowledge of the art, it has been omitted.

**OPERATION**

To operate this apparatus and insert the cathode in each of the three electron guns characteristically included in the gun mount of a three gun color picture tube, it will be assumed that the movable major components of the apparatus are in their rest or loading positions. In short, air cylinder 41 will have moved cathode 14 to its extreme left-hand position (to the left of that shown in FIG. 1) causing member 35 and the fluid conduit sections 35a, 33
to be in their lowermost position. Air cylinder 47 will have raised plate 25c to its highest position, carrying cathode holder 55 away from workholder 26. Air cylinder 57 will have displaced cam 56 to its extreme left-hand position as shown in Fig. 1, raising cathode holder 55 to its highest position relative to plate 25d. Air cylinder 50 will have raised rod 48 and displaced gauge 49 totally away from the plane of workholder 26 and air cylinders 60 will have displaced movable welding electrodes 60c radially outwardly from mandrel 35c.

LOADING

The gun mount is first brought workholder 26. By counterclockwise rotation of handles 31, clamps 28 are moved to a loading position which clears the way so that each of the three electron guns of the mount may be threaded over each of the three mandrels 32 of workholder 26. When this has been accomplished, tabs 20a of electrodes 20 of the electron guns will rest upon the base of the workholder and clockwise rotation of handles 31 will accomplish a similar displacement of clamps 28. The workpiece in clamping relation to tabs 28c to hold each gun securely on its mandrel 32.

The cylindrically shaped cathode 14 is now threaded over mandrel 55c. This is simply accomplished through a tool which slips over the coated end of the cathode and releasably holds the cathode so that it may slide over mandrel 55c to be retained in place by the vacuum established by line 55f and duct 55d. The strength of the vacuum is adequate, not only to retain the cathode on the mandrel, but also to permit removing the tool used in placing the cathode in position. Having thus loaded the gun mount and one cathode, the operator will now actuate a start switch (not shown) to initiate programmed operation of the apparatus. The first principal operation is gauging in which the nitrogen fluid line 37 extending through duct 35c and the continuation of this duct through mandrel 32 of the gun being operated upon is positioned at the correct vertical height for precise location of cathode 14 within cylinder 16.

GAUGING PROCESS

The first manipulative step of the gauging process, which is timed by the programming arrangement, is the admission of air under pressure to cylinder 50. As the piston of that cylinder descends, pin 48c traveling along cam track 48b rotates gauge 49 to displace it from its rest position and bring it generally into alignment with the axis of the gun under process. Its final angular position will be made accurate by the reception of pin 45f within recess 25f. Continued descent of rod 48, permitted by the depth of recess 25b or by keying pin holder 48c to shaft 48, causes gauge 49 to be admitted into cylinder 16, assuming the operative position represented in Figs. 2 and 7. At this juncture, tip 49a of the gauge rests lightly against the upper surface of grid 15, being retained thereon by spring 48c and it is of no material consequence whether the air supplied to cylinder 50 continues or is terminated because the gauge has been placed in proper position for gauging.

With gauge 49 in position, the next program step is the admission of air to cylinder 41 and at this time both valves 41c and 41d are fully open. Also, at this time nitrogen under pressure will have been admitted to line 37 and a condition of free flow is established from this line through conduit 35e and through the conduit of mandrel 32 terminating in the needle section 33c and orifice 33c. The rate of flow will have been adjusted to the value desired by manipulation of regulator 37b in unit 45. As piston 41b of air cylinder 41 is displaced to the right in Fig. 1, cam section 40a in conjunction with cam follower 35c elevates member 35 and, because it abuts against conduit 33 within mandrel 32, elevates the entire fluid conduit in the direction of grid 15. The nitrogen line 33c-35c is elevated at a relatively rapid rate as cam section 40a passes under cam follower 35c and the rate is reduced as cam section 40b becomes effective. Throughout this entire interval, the flow of free flow of nitrogen is maintained and this will be the case as the conduit is advanced from its lowermost or rest position along the axis of the gun toward grid 15. Ultimately, since land 49b of the gauge is disposed across aperture 15a of grid 15 and is much larger in area than the terminating orifice 33b of the nitrogen line, the condition of free flow is disturbed and a back pressure is built up in fluid conduit 33, 35c, 37. Generally speaking, when orifice 33b gets so close to gauge land 49b that the exit defined by the facing surface of gauge line 49b and the perimeter of orifice 33b is less than the exit area represented by the orifice itself, a condition of interference with free flow sets in and back pressure is created in the nitrogen line in an amount which is a function of the distance of orifice 33b from land 49b. As soon as the free flow condition is disturbed and back pressure commences to build in the nitrogen line, pressure sensitive bellows 45c and 45b within unit 45 commences to expand. Bellows 45c is the first to produce a condition of decay and contact pair 45c to activate valve 41c which severely reduces the air supply to cylinder 41. Thereafter, the continued elevation of fluid conduit 33-35c is at an extremely slow rate, hardly perceptible to vision but it continues until pressure sensitive element 45e is in place by the vacuum established by line 45f to activate valve 41d and totally interrupt the supply of fluid to cylinder 41. This occurs when orifice 33b of the nitrogen line shall have attained a reference position at which the back pressure in the nitrogen line has a known predetermined value which, by calibration, denotes a most precise separation of orifice 33b from gauge land 49b. The described condition is that of Fig. 7, showing that in its final position conduit section 33c projects through grid aperture 15c and is spaced a distance S2 from gauge land 49b.

Where the indicator lights of control unit 45 are operable, one may be energized at the time the fluid is admitted to air cylinder 41 to be extinguished at the time valve 41c is energized to institute the creep advance of orifice 33b toward grid 15. The second indicator light may then be energized when the orifice attains its reference position of Fig. 7. The meter 45f responds at all times when back pressure is developed in the nitrogen line for further monitoring by the operator.

In any event, at this juncture, orifice 33b shall have been established in the desired reference position and the control signal employed to activate valve 41d may also be delivered, with delay if desired, to the fluid system controlling the cylinder 50. That system now elevates the piston of cylinder 50 withdrawing gauge 49 from cylinder 16 and thereupon rotating the gauge and its holder 48c back to its rest position.

CATHODE INSERTING PROCESS

As gauge 49 resumes its rest position, the program arrangement admits air to cylinder 47, and platen 25d as well as the components mounted thereon descend at a relatively rapid rate. Another component of the programming arrangement or a microswitch suitably positioned in the path of movement of the platen actuates valve 47c as cylinder 25e approaches pillar 25c so that in the final descent these two elements are brought together while their relative movement is very slow. In the lowermost position of platen 25d, cylinder 25e abuts against the top surface of pillar 25c.

Cathode holding member 55 is, of course, accurately aligned along the axis of the gun in process simply as a result of its location 41, the final position of platen 25d cathode 14 carried by mandrel 55c will have entered cylinder 16 but its precise position in relation to grid 15 will not as yet have been established. At this point in the process, the programming arrangement admits air to cylinder 57 and both valves 57c and
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The cathode continues its descent under the influence of cam 56 being moved to the right in FIG. 1 by the advance of piston in cylinder 57, the free flow condition continues until the cathode becomes a barrier to free flow. This is similar to the condition described in the gauging process and results because the end closure of cathode cylinder 14 is large in cross-section compared with orifice 33b of the nitrogen line and at some known distance which, although very close to grid 15, exceeds the spacing desired of the cathode from grid 15, causes interference with free flow of nitrogen in the fluid lines. At this point under number 2 of control 45, responding to the back pressure in nitrogen line 37, energizes valve 57c to decrease the fluid supply to cylinder 57 and greatly reduce the rate of advance of the cathode, instituting such a slow rate that it is termed a creeping condition. The advance of the cathode continues at this much reduced rate until the second pressure sensitive device in control number 2 of unit 45 records a predetermined back pressure; indeed, the same value of back pressure that was registered during the gauging process as orifice 33b arrived at its reduced reference position at this time. Unit 45 energizes valve 57d, and further advance of the cathode is arrested because now the cathode has been precisely positioned relative to grid 15.

With more particular reference to FIGS. 7 and 8, the reference position established for orifice 33b in the gauging process is at a distance $S_2$ from land 49b of gauge 49 as stated above. In the final position of cathode 14 it has the same spacing $S_2$ from orifice 33b. In short, gauging takes place with the land 49b of the gauge simulating the cathode to establish the desired and necessary reference position of orifice 33b. The cathode is inserted until the conditions encountered in gauging are duplicated, confirming that the cathode has been advanced to precisely the same position taken by land 49b with the gauge resting on grid 15. Since the distance from the tip 49a of the gauge to land 49b corresponds to the desired separation of the cathode from grid 15, the final spacing of cathode 14 has the identical value. In actual practice with the described apparatus this condition has been reproducibly achieved with a tolerance of 0.0005".

Having established the cathode precisely in the desired axial position within cylinder 16, it is now necessary to fix the cathode so that there can be no relative movement between the cathode and grid 15. The details of this part of the process will change somewhat in accordance with the cross-sectional configuration of cylinder 16.

Preferably cylinder 16 has the configuration of FIG. 9 in which angularly spaced sections thereof have previously been deformed to define three angularly spaced ribs 16a which are dimensioned relative to the external dimension of cathode 14 to have what is referred to as an interference fit. There is adequate force available in the cathode inserting mechanism to home cathode 14 within cylinder 16 even in the presence of an interference fit. Of course, this type of fit is advantageous in properly positioning cathode 14 transversely within cylinder 16 and retaining that position during welding. With cathode 16 in position, a control signal obtained from unit 45 to actuate valve 57d may be applied, after a suitable delay, to actuate valves 60c and admit air under pressure to each of the three cylinders 60. As these cylinders are actuated, the actuated elements 60a, 60b, 60c advance movable welding electrodes 60g concurrently to contact cylinder 16. At this juncture, the programming arrangement completes the welding circuit to weld these elements of the gun together.

When the welding shall have been accomplished, the programmer causes the sub systems carried by platen 15d to resume their rest positions. In particular, air cylinders 47, 57 and 60 are actuated to the end that platen 25d is elevated from 35d under the free flow condition and in the direction of grid 15.

If cylinder 16 has the cross-sectional configuration of FIG. 9A, the movable welding electrodes 60g may also be used to crimp local portions of cylinder 16 against cathode cylinder 14 simply by having the movable welding electrodes brought against cylinder 16 with sufficient force to deform it at three points of contact. This is to take place as platen 25d reaches its lowermost position and just prior to insertion of cathode 14 within cylinder 16. For this purpose, an adjustable switch actuator 70a is secured to cylinder 25e to actuate a program switch 70b as cylinder 25e arrives at its final position resting on pillar 25c. When actuated, switch 70b closes a control circuit (not shown) to operate valve 60c, causing electrodes 60g to advance against and deform three sections of cylinder 16. The deformation is only that which is required to provide the desired interference fit of cathode 14 within cylinder 16 and electrodes 60g return to their rest positions after having accomplished the step of deforming cylinder 16. The process from this point is as recited above. Cathode 14 is inserted and is then welded in position.

In one practical embodiment of the described apparatus which has been successfully employed in inserting the cathodes into gun mounts, the source pressure of nitrogen was 35 pounds per square inch and the orifice 33b had a diameter of 0.0018 inch. The grid to cathode spacing, determined by the offset land 49b from the tip 49a of gauge 49, was 0.0085 inch and was achieved with an accuracy of .5 mils. The condition of free flow in the nitrogen line became disturbed and the build up of back pressure instituted at a spacing of 3 mils of the orifice 33b from gauge land 49b or from the end surface of cathode 14. Nitrogen pressure is a parameter of importance because it is an inert gas which has no adverse effect on the emitting coating of the cathode. The machine carried out a complete process of gauging and cathode insertion in 55 seconds for the complete gun mount having 3 cathode arrangements.

The experience with the described apparatus and process has been most favorable compared with previous practices of cathode insertion in that a higher degree of precision has been attained and the process has been conducted in a much reduced period of time.

While a particular embodiment of the invention has been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

We claim:

1. The method of positioning a first solid disc-shaped element of an electron gun a particular distance in a given direction from a second apertured disc-shaped element of said gun which method comprises: establishing a uniform predetermined rate of flow of
gas through said second element in said given direction from a conduit terminating in an orifice which is small in cross section compared to the area of said first element and which is secured in a reference position;

moving said first element toward said second element in a direction generally opposite said first direction to constitute a barrier to the free flow of said gas from said orifice when said first element is at a known distance, exceeding said particular distance, from said second element;

continuing the advance of said first element toward said second element to create a back pressure or interference said gas in winding orifice which varies as a function of the distance of said first element from said second element;

and arresting the advance of said first element when said back pressure has attained a predetermined value representing a spacing of said first element from said second element corresponding to said particular distance.

2. The method as defined in claim 1 which includes the further step of fixing said first and second elements against relative movement when the advance of said first element has been arrested.

3. The method as defined in claim 1 in which a gauge, having a transversely disposed land surface set back from the tip of said gauge by said particular distance and having an area large compared with said orifice, is employed to conduct the following preliminary gauging steps:

resting said tip of said gauge on the side of said second element which faces said given direction with said land surface disposed across said aperture of said second element;

advancing said conduit from a rest position, at which said gas flows at said uniform rate, in said given direction along the axis of said aperture of said second element to said reference position at which said back pressure has said predetermined value;

stopping the advance of said conduit and fixing said orifice in said reference position;

and removing said gauge from the vicinity of said second element preparatory to the positioning of said first element.

4. The method as defined in claim 1 in which said first element is moved toward said second element at a first rate until it arrives at said known distance from said second element and in which said first element is then advanced at a much reduced rate until it moves a particular distance from said second element.

5. The method as defined in claim 1 in which said gas flow is directed along the path that is coaxial with the aperture of said second element and in which the movement of said first element is along said path.

6. The method as defined in claim 2 in which a cylindrical component of said electron gun surrounds the path of movement of said first element and is secured against movement relative to said second element, and including the step of attaching said first element to said cylindrical component to fix said first and second elements against relative movement and with a separation of said particular distance.

7. The method as defined in claim 6 in which said first element is the end closure of a cylindrically shaped cathode, in which said cylindrical component of said gun is deformed to define three angularly spaced ribs having a radial dimension to present an interference fit with said cathode, and including the step of welding said cathode cylindrically to said ribs to fix said first and second elements against said relative movement.

8. The method as defined in claim 6 in which said first element is the end closure of a cylindrically shaped cathode, in which said second element is the first grid of said electron gun, in which said gun includes additional electrodes positioned on the side of said first grid opposed to said cathode and structured to present an electron beam path coaxial with said first grid and including the step of threading said conduit through said electrodes to locate said orifice in said reference position.

9. The method as defined in claim 2 in which said first element is the end closure of a cylindrically shaped cathode and including the steps of threading said cathode over a mandrel that is movable to present said cathode tip said second element, securing said cathode to the supporting structure of said second element, securing said cathode to the supporting structure of said second element to fix said cathode and said second element against relative movement, and thereafter retracting said mandrel to strip said cathode therefrom.

10. The method as defined in claim 9 in which said mandrel has an exhaust line extending therethrough and including the step of establishing a vacuum in said line to releasably hold said cathode to said mandrel.

11. Apparatus for positioning a first solid disc-shaped element of an electron gun a particular distance in a given direction from a second disc-shaped element of said gun, which apparatus comprises:

means for establishing a uniform predetermined rate of flow of gas through said second element in said given direction from a conduit terminating in an orifice which is small in cross-section compared to the area of said first element and which is secured in a reference position;

means for advancing said first element toward said second element in a direction generally opposed to said first direction to constitute a barrier to the free flow of gas from said orifice when said first element is at a known distance exceeding said particular distance from said second element and for continuing the advance of said first element to create a back pressure to the flow of said gas which varies as a function of distance of said first element from said second element;

and means for arresting the advance of said first element when said back pressure has attained a predetermined value representing a spacing between said first and second elements corresponding to said particular distance.

12. Apparatus in accordance with claim 11 which further includes a gauge having a tip at its free end and a transverse shoulder set back from said tip by said particular distance;

means for moving said gauge between a rest position in which it is clear of an electron gun in process and a second position in which it has the location desired of said first element with its tip resting on a surface of and with its shoulder disposed across the aperture of, said second element; and

means for moving said conduit between a rest position in which said orifice is sufficiently far from said second element to establish a condition of free flow in said conduit and said reference position in which said orifice has advanced in the direction of said second element an amount such that said shoulder of said gauge interrupts the free flow condition of said conduit and creates back pressure of said predetermined value in said conduit.

13. Apparatus in accordance with claim 12 in which said first element is the end closure of a cylindrically shaped cathode, and in which said means for advancing said first element includes a mandrel over which said cathode may be threaded and a vacuum line within said mandrel for releasably holding said cathode in position on said mandrel.

14. Apparatus in accordance with claim 12 including means for securing said first element in position with a spacing of said particular distance from said second element.

15. Apparatus in accordance with claim 12 including
means for reducing the speed of movement of said conduit as said orifice approaches said reference position; and means for similarly reducing the speed of advance of said first element when its spacing from said second element is larger than but close to said particular distance.

16. Apparatus in accordance with claim 15 in which said means for reducing the speed of said conduit and said first element includes a pressure sensitive device monitoring said conduit to develop a control potential in response to back pressure in said conduit of a preselected amount which is less than said predetermined value.

17. The method as defined in claim 8 in which said gas is a neutral gas which has no reaction with the electron emissive material of said cathode.