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METHOD OF EXHAUSTING AND COLD WELD SEALING

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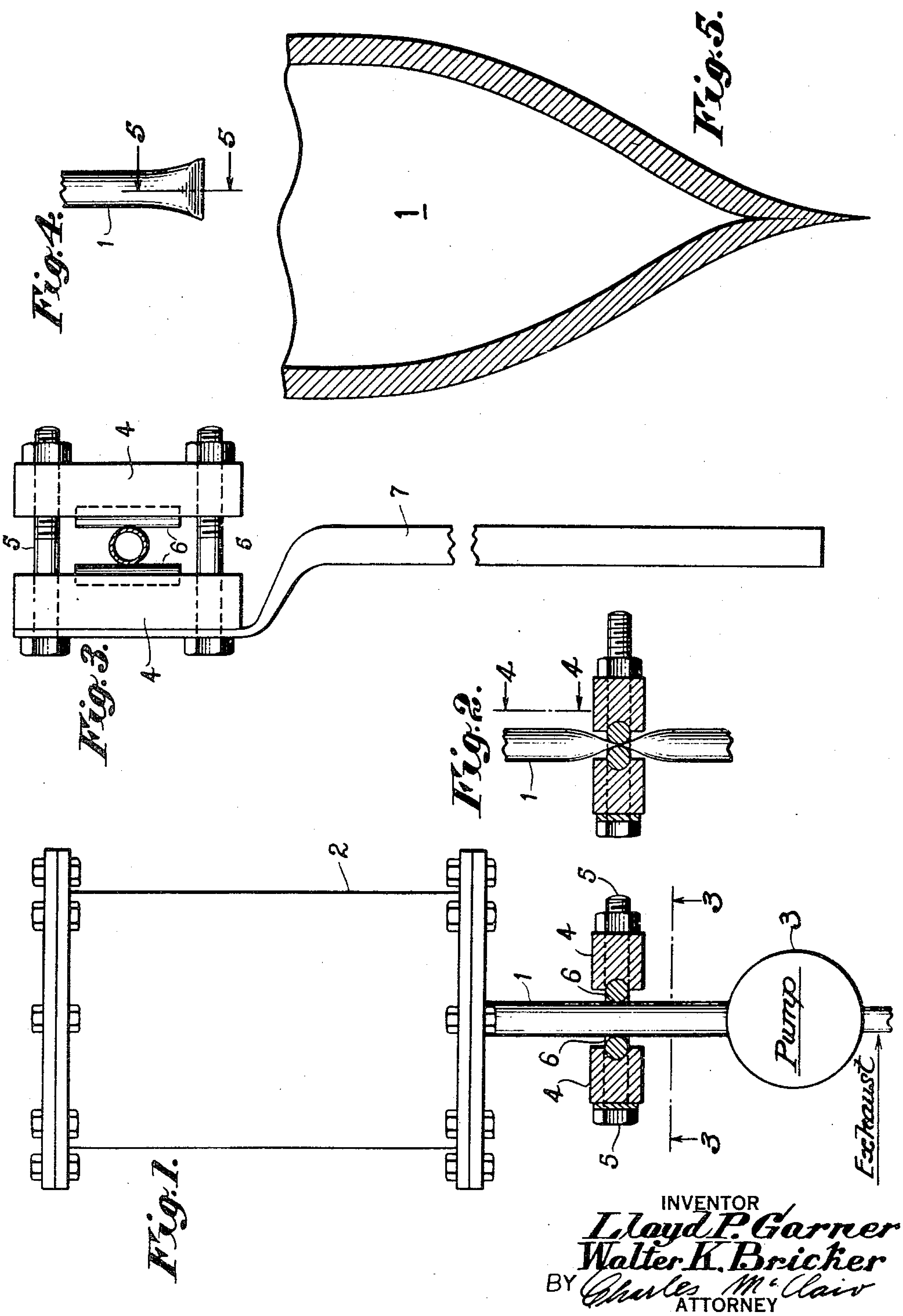

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METHOD OF EXHAUSTING AND COLD WELD SEALING

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Our invention relates to seals for evacuated or gas-filled envelopes of the type used for radio tubes, lamps or the like, and to methods and means for making the seals.

The final step in sealing the envelope of a radio tube and disconnecting it from its exhaust pump consists in heating and pinching the exhaust tube. The exhaust tube is limited in size because, as found in practice, if it is too large the wall of the tube may suck in or collapse prematurely and cause an imperfect seal. According to common practice the glass or metal exhaust tube must be heated to a fusing or welding temperature and at the instant of seal off a cloud of gas is driven from the seal region. After the exhaust tube is closed any gas liberated in the envelope is permanently trapped and of course cannot be removed by the pump.

An object of our invention is an improved exhaust tube seal that is vacuum-tight and that will not liberate gas from the seal region.

Another object of our invention is an improved exhaust tube seal which does not limit the size of the exhaust tube.

A still further and more specific object of our invention is improved means and methods of sealing metal exhaust tubes.

The characteristic features of our invention are defined in the appended claims and one embodiment thereof is described in the following specification and shown in the accompanying drawing in which Figure 1 shows an envelope and one device for sealing off a metal exhaust tube envelope according to our invention; Figure 2 is a view of the seal region of the exhaust tube after sealing; Figure 3 is a side view, taken along line 3—3 of Figure 1, of one sealing device; Figure 4 is a side view of the sealed tube of Figure 2, taken along line 4—4; and Figure 5 is an enlarged sectional view, taken along line 5—5 of Figure 4, of our improved seal.

The exhaust tube 1, connected at one end to the envelope 2 to be exhausted and at the other end to the exhaust pump 3, is of ductile metal such as copper, or brass. After the desired degree of vacuum or gas pressure has been obtained in the envelope, the exhaust tube is sealed off adjacent the envelope. According to our invention two round parallel jaws, of a metal harder than the metal of the exhaust tube, are pressed against opposite sides of the exhaust tube. The cold side walls of the exhaust tube may be collapsed and pressed together with comparative ease. According to the characteristic features of our invention the pressure applied by the rods is then

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gradually increased until the metal of the exhaust tube begins to flow between the rods. A simple lever of high mechanical advantage may consist of two metal blocks 4 on opposite sides of the rods drawn together by two heavy draw bolts 5 with nuts or stud bolts. The faces of the jaws may conveniently be hardened steel shafts 6, such as drill rods, embedded in the blocks. As the nuts are tightened the rods proceed toward each other, causing the metal in the walls of the exhaust tube to flow lengthwise of the tube and outwardly from the plane through the rod centers. However, the metal in or very near to this plane of the jaw centers can flow in neither direction and the pressure perpendicular to the interfaces of the contacting sealing surfaces is limited only by the strength and ruggedness of the pressure applying means. Microphotographs indicate that as the pressure increases the grains of one wall can be forced into interleaved relation with the grains of the other wall, and that the line of demarcation between the two walls disappears into the laminae of the cold drawn walls. When a cross section of the seal is optically amplified so that the grains can be easily seen, it becomes evident that the line of demarcation in the seal region becomes indistinguishable from the grain boundaries. The grains, of course, in the seal region are considerably elongated compared to the grains in the unworked portions of the wall. The wall thickness of the exhaust tube and the radius of curvature of the jaws may be large or small. The greater the radius of curvature is, the greater is the amount of metal caught between the jaws, and of course the greater is the pressure necessary to force an actual hermetic seal. The minimum radius of curvature of the pinching jaws, compared to the wall thickness, will of course be determined by the cutting action of the jaws and by the coefficient of friction between the rounded jaws and the tube. The drill rods 6, for example, must not be so small that they will sever or cut into the exhaust tube before welding pressure is applied to the seal region.

Good results have been obtained in sealing and pinching off copper exhaust tubes one-half inch in outside diameter and having a wall thickness of .050 inch with drill rods one-quarter inch in diameter. Commercial machine bolts one-half inch in diameter with conventional V-cut threads were found sufficiently strong to apply the welding and pinch-off pressure for this one-half inch copper exhaust tube.

The particular pressure applying means shown in Figures 1 and 3 comprise jaws 4 attached to a long handle 7 that is used to hold the jaws while the nuts on the draw bolts are turned with a wrench. By holding the jaws with the handle 7 while the nuts are tightened, the brazed or soldered connection of the exhaust tube at the envelope may be relieved of twisting or bending stresses. A hydraulic press may in some cases be used to advantage in applying the pressure to rods 6 necessary to pinch and close the exhaust tube.

It now becomes apparent, with our novel method of making a hermetic seal by high pressures and cold welding, that the principle may be applied to envelope shells and tubes of various shapes. A header plate or cap, for example, may be pressed against the flanged end of an exhaust tube or against the end of a tubular envelope. In this case the pressure applying means would consist of a hardened steel ring fitted over the tube or envelope to be closed and laid against its flange. The flat side of the header could be backed up with either a flat anvil or a second annulus of the same size as the first. A hydraulic press could in this case be used to advantage. Likewise, two radial flanges or lips of two portions of an envelope shell could be sealed by cold welding between two hardened steel rings pressed against the outer surfaces of the contacting flanges to cold weld them together. Where the size of the seal is large and where it may be impractical to apply sufficient pressure for making the entire seal at one time, the seal may be pressed in sections or may be made by rolling the two pieces to be welded between high pressure rolls in a manner similar to rolling the crimped edge of fruit cans.

We are not prepared to state just what may be the actual condition of the metal in the seal region or to state what degree of diffusion there may be between the two wall sections at the seal, but it is certain that the seal, when made with clean inner wall surfaces, is vacuum-tight and is mechanically strong. Microscopic examination of carefully acid-etched and polished sections of the seal, with magnifications as high as 1000 diameters, shows that the interface does not extend to the edge of the tipped off tube. Liquid hydrostatic pressures increased to the rupture point of the tube showed in all cases that the metal fractured across and through the wall inward a considerable distance from the edge of the seal, thus indicating that the junction of the two walls is mechanically stronger than the wall itself removed from the seal.

The improved exhaust tube seal of our invention is vacuum tight, will not liberate gas from the seal region during sealing, may be used on metal exhaust tubes of any desired size and is easy and inexpensive to make.

We claim:

1. The method of exhausting and sealing vacuum-tight a highly evacuated envelope having an exhaust tube of ductile metal with a copper inner surface which consists in exhausting said envelope through said exhaust tube, pressing the walls of said exhaust tube together between two parallel hardened steel jaws having proximate surfaces curved on a radius at least great enough to avoid cutting said walls to force the walls of the tube into contact and form a flattened seal region between said jaws, to bring the copper inner surfaces into contact throughout a seal region intermediate the ends of said exhaust tube without evolution of gas from the metal in

said seal region and solely by cold welding said walls together without application of heat to said walls and solely by applying sufficient pressure to said jaws to cause the metal in the walls of said exhaust tube in said seal region to flow, and increasing the presure perpendicular to the interface of the contacting wall surfaces in the zone of pressure to consolidate the copper surfaces in contact in the seal region into a vacuum tight pressure weld consisting of a homogeneous mass of copper which has a greater resistance to rupture by internal hydrostatic pressure in the exhaust tube than the walls of said tube and in which the interface and line of demarcation between the contacting copper surfaces is indistinguishable from the grain boundaries and the grains of one surface are interleaved with the grains of the other surface.

2. The method of sealing vacuum-tight a thin-walled copper tube without evolution of gas from the metal of said tube during sealing, which comprises cold welding the walls of said tube together by flattening said walls between two parallel hardened steel jaws having proximate surfaces curved on a radius at least great enough to avoid cutting said walls to force the walls of the tube into contact and form a flattened seal region between said jaws, and then increasing the pressure between said jaws gradually and continuously without the application of heat to said seal region until the metal of the tube begins to flow between said jaws and the faces of said jaws are substantially together and the pressure perpendicular to the interfaces of the contacting sealing surfaces is sufficient to cause the grains of said surfaces to be forced into interleaved relation in the seal regions solely by cold pressing and without the application of heat until the line of demarcation in the seal region is indistinguishable from the grain boundaries and the metal in the seal region is a homogeneous mass of metal constituting a vacuum-tight pressure weld in which the grains of the metal in the weld are interleaved and are considerably elongated compared to the grains in the unworked portions of the tube walls.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,697,881	Petty	Jan. 8, 1929
368,837	Kenny	Aug. 23, 1887
1,655,156	Muir	Jan. 3, 1928
501,547	Thomson	July 18, 1893
1,935,423	Wayringer	Nov. 14, 1933
2,056,035	Beggs	Sept. 29, 1936
2,154,542	Swanson	Apr. 18, 1939
1,424,180	Pritchard	Aug. 1, 1922
9,989	Hunt	Sept. 6, 1853
1,914,634	Eden	June 20, 1933
1,388,248	Fate	Aug. 23, 1921
178,501	Appert	June 13, 1876

FOREIGN PATENTS

Number	Country	Date
10,262	Great Britain	July, 1888
505,014	Germany	Aug. 12, 1930
512,557	Great Britain	Sept. 20, 1939