PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION
No. 1760 A.D. 1939.

Improvements in Gas-tight Seals wherein Electric Conductors pass through Quartz or like Vitreous material

We, THE GENERAL ELECTRIC COMPANY LIMITED, of Magnet House, Kingsway, London, W.C.2, a British company, and KARL GUSTAV SCHNETZLER, of Research Laboratories of The General Electric Company Limited, Wembley, Middlesex, a German citizen, do hereby declare the nature of this invention to be as follows:—

This invention relates to gas-tight seals wherein electric conductors pass through quartz or like vitreous material; the term "like" means having a coefficient of thermal expansion much less than that of the conductor.

The well-known strip seal, made by collapsing a quartz tube onto a sufficiently thin metal strip, is highly satisfactory so long as the conductor has to carry a current no greater than one or two amperes. But if currents of ten or more amperes have to be carried, either an inconveniently wide single strip has to be used or a plurality of narrow strips have to be combined into a multiple seal. The object of this invention is to provide strip seals in which, though the strip is conveniently narrow (say not more than 10 mm. wide), it will carry much larger currents than can be carried by known single strip seals in which the strip is also conveniently narrow.

According to the invention in a strip seal conductors are connected to the strip so that, when the strip is carrying current, the stream lines are highly inclined to the length of the strip. The thickness of the strip is the narrowest dimension. The width is then the least dimension of the strip perpendicular to its thickness; the length is the greatest dimension perpendicular to its thickness.

The invention will now be explained further with reference to the accompanying drawing, which shows, by way of example, one embodiment of the invention.

In the figure, 1 is a strip of molybdenum about 0.015 mm. thick; 2, 3 are the said conductors welded to it being also of molybdenum, 4 is the quartz into which the strip is sealed in the usual manner. The conductors have, as usual, a cross section much greater than the cross section of the strip containing its width and thickness.

In the figure, there is shown at (*a*) a plan viewed along the thickness of the seal, at (*b*) a section by a plane perpendicular to the plan (*a*). Here the conductors 2, 3, lie along the centre of the strip on opposite sides of it, overlapping where they meet; they are welded to the strip along this overlapping portion, but preferably not elsewhere. The stream lines pass along the thickness of the strip; the area of the cross section perpendicular to the stream lines is the area of the welded portion and is independent of the thickness of the strip.

The invention is not limited to narrow strips or single seals. The advantages obtained, relative to known methods, are independent of the width of the strip or the multiplicity of the seal. But of course the advantages are greatest when narrow strips and single seals are adopted for ~~each~~ of construction.

Dated the 18th day of January, 1939.

NORMAN R. CAMPBELL,
For the Applicants.

[Price 1/-] PRICE 2/-

PROVISIONAL SPECIFICATION
No. 2022 A.D. 1939.

Improvements in Gas-tight Seals wherein Electric Conductors pass through Quartz or like Vitreous material

We, THE GENERAL ELECTRIC COMPANY LIMITED, of Magnet House, Kingsway, London, W.C.2, a British company, and KARL GUSTAV SCHNETZLER, of Research Laboratories of The General Electric Company Limited, Wembley, Middlesex, a German citizen, do hereby declare the nature of this invention to be as follows:—

This invention relates to gas-tight seals of the type wherein electric conductors pass through quartz or like material from the exterior to the interior of an hermetically sealed vessel. Material like quartz means highly siliceous vitreous material whose thermal expansion (measured by a method that gives to quartz the accepted value, 0.55×10^{-6} per °C.) is less than 2×10^{-6} per °C. and is therefore too small to permit any but very thin conductors of tungsten to be sealed through it.

One well known form of such seals is that in which the conductor embedded in the quartz, and forming a gas-tight junction with it, is a strip of metal (usually molybdenum) less than 0.02 mm. thick, to whose ends are attached stouter conductors which, though they are also embedded in the quartz near the strip, do not form a gas-tight junction with the quartz. The seal is made by collapsing a quartz tube onto the strip.

In such seals the minimum area of the cross-section of the conductor perpendicular to the stream lines of the current passing through it is the product of the width and the thickness of the strip. (Stream lines mean, as usual, lines whose tangents are everywhere parallel to the direction of the current at the point where they are drawn). If, as is usual, the strip is flat, its width, and therefore the said area, is limited by the bore of the tube that can be conveniently collapsed onto the strip, although (as is known) the strip may be bent so that its width exceeds the bore. But the said area determines the greatest current that the strip will carry without damage to the seal. Accordingly single strip seals of this kind cannot easily be made to carry more than about 10 amp.

The object of this invention is to increase the current that can be carried by a strip seal, that is to say, one in which the conductor forms an air-tight junction with the quartz in virtue of its thinness.

According to the invention a gas-tight seal of the type specified comprises a thin sheet of suitable metal and a pair of conductors each attached to a part of the said sheet, one said part being on one side of the said sheet and the other on the other, so that, when current flows from one said conductor to the other, the stream lines in the sheet are substantially parallel to the thickness of the sheet, and parts of the sheet around the said parts to which the conductors are attached are so embedded in the quartz or like material that the said sheet, together with the said quartz or like material, forms the barrier separating the region around one said conductor from the region around the other. The said minimum cross-section can then always be as great as the area over which the said conductors make contact with the sheet.

The terms " thin " and " suitable " in the foregoing statement are to be interpreted with reference to the known art of making strip seals. A suitable metal is one known to be suitable for making quartz strip seals, particularly molybdenum or tungsten. A thin sheet is one that could be used for making a strip seal, for example not more than 0.02 mm. thick if the metal is molybdenum, of course the sheet must be impenetrable to gas wherever it is part of the said barrier. Either member of the pair of conductors, the stream lines between which are substantially parallel to the thickness of the sheet, may be composed of a plurality of wires or strips, all attached to the same side of the thin sheet.

In order that the sheet may form the barrier as aforesaid, a sufficient condition is that the edge of the sheet is everywhere embedded in the quartz. But, as will be explained with reference to the second embodiment of the invention described hereinafter, this condition is not always necessary.

We are aware that gas-tight seals are known in which the stream lines are substantially parallel to the thickness of a metal sheet sealed at its edges to vitreous material of much higher thermal expansion than the metal; but in previous proposals the vitreous material has had a thermal expansion much greater than that of quartz.

Two embodiments of the invention will now be described, by way of example,

with reference to the accompanying drawing in which Figures 1 and 2 show two stages in the manufacture of the first embodiment, and Figures 3, 4, 5, 6 show various sections through the second embodiment.

In Figures 1 and 2, 1 is a disc of molybdenum, 30 mm. in diameter and 0.015 mm. thick, which is the said sheet. 2 and 2^1 are the said conductors being each a molybdenum strip, 3 mm. wide and 0.35 mm. thick, bent back on itself so as to form a central portion, 3 or 3^1, 4 mm. long, perpendicular to the greater part of their length. These central portions are attached (in a manner described more fully below) opposite each other to opposite sides of the disc 1.

4 and 4^1 are two quartz tubes of 4 mm. bore, each flanged at one end 5 or 5^1; the quartz wall is about 1 mm. thick. The conductors 2, 2^1 are placed in the bores, preferably fitting tightly into them, with the disc between the flanges as shown in Figure 1. The flanges are then heated and pressed together, so that they form a gas-tight junction with each other. In order to avoid oxidation of the disc during the joining of the flanges, nitrogen is passed down the tubes 4, 4^1 until the edges of the flanges are joined. The region around the disc 1 is evacuated through the tubes 4 and 4^1, and the quartz heated so that it collapses onto the disc; for in seals according to the invention, as in the known strip seals, it is preferable that the junction between the quartz and the sheets should be made in a vacuum. The completed seal is shown in Figure 2.

Figure 3 is a longitudinal section of the second embodiment perpendicular to the width of the sheet; it is not to scale; the widths of the gaps between the conductors and the quartz are exaggerated in order that their presence may be clearly shown. 1 is the sheet of molybdenum 0.015 mm. thick and about 8 mm. wide; 2, 2^1 are the conductors, being molybdenum wires about 0.7 mm. in diameter, 7 is the quartz. The wires 2, 2^1, entering the seal from either side, overlap where they meet and these are attached to opposite sides of the central part 8 of the sheet. It is to be noted that the diameter of the conductors 2, 2^1 is much less than the width of the sheet; this is always desirable in seals according to the invention in which the conductors lie along the strip; for if the conductors are too wide, the seal will crack. In the formation of the seal, the quartz tube is collapsed onto the sheet and conductors, as in the known methods of making strip seals, and will adhere to the sheet where a conductor does not lie between the wall of the tube and the sheet; where a conductor does so lie, the quartz will not adhere to the sheet.

The result is illustrated in Figures 4, 5, 6 which are cross-sections of the seal by the planes AA, BB, CC in Figure 3 respectively distorted, in the same manner as Figure 3. It will be seen that a longitudinal tunnel extends into the seal from either end, each tunnel tapering to a closed end; but the tunnels are always separated by the sheet, so that gas cannot pass from one to the other. The end edges 9, 9^1 of the sheet are not embedded in the quartz where they lie under the conductors 2, 2^1; here the quartz contacts with one side only of the sheet. But, as shown in Figures 4, 5, 6, the side edges of the sheet are embedded in the quartz.

It remains to be considered how, in either example, the conductors are to be attached to the sheet. We have found that, if the conductors are nickel-plated, the nickel will act as a solder during the collapse of the quartz onto the sheet; the plating must not be so thick that the nickel eats holes in the sheet.

In the second example the wires 2, 2^1 are nickel-plated and first spot-welded to the sheet at one or two points only. This assembly is placed in the quartz tube which is then collapsed onto it.

In the first example the central portions 3, 3^1 of the strips are each spot-welded to a molybdenum disc, 6 or 6^1, 9 mm. in diameter and 0.1 mm. thick. These discs 6, 6^1 are then lightly nickel-plated and placed one on either side of the disc 1. When the metal is heated during the collapse of the quartz onto the disc 1, the discs 6 and 6^1 are soldered to the disc 1 by the nickel-plating.

Dated the 20th day of January, 1939.
NORMAN R. CAMPBELL,
For the Applicants.

COMPLETE SPECIFICATION

Improvements in Gas-tight Seals wherein Electric Conductors pass through Quartz or like Vitreous material

We, THE GENERAL ELECTRIC COMPANY LIMITED, of Magnet House, Kingsway, London, W.C.2, a British company, and KARL GUSTAV SCHNETZLER, of Research Laboratories of The General Electric Company Limited, Wembley, Middlesex,

a German citizen, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to gas-tight seals of the type wherein electric conductors pass through quartz or like material from the exterior to the interior of an hermetically sealed vessel. Material like quartz means highly siliceous vitreous material whose thermal expansion (measured by a method that gives to quartz the accepted value, 0.55×10^{-6} per °C.) is less than 2×10^{-6} per °C. and is therefore too small to permit any but very thin conductors of tungsten to be sealed through it.

One well known form of such seals is that in which the conductor embedded in the quartz, and forming a gas-tight junction with it, is a strip of metal (usually molybdenum) less than 0.02 mm. thick, to whose ends are attached stouter conductors which, though they are also embedded in the quartz near the strip, do not form a gas-tight junction with the quartz. The seal is made by collapsing a quartz tube onto the strip.

In such seals the minimum area of the cross-section of the conductor perpendicular to the stream lines of the current passing through it is the product of the width and the thickness of the strip. (Stream lines mean, as usual, lines whose tangents are everywhere parallel to the direction of the current at the point where they are drawn). If, as is usual, the strip is flat, its width, and therefore the said area, is limited by the bore of the tube that can be conveniently collapsed onto the strip, although (as is known) the strip may be bent so that its width exceeds the bore. But the said area determines the greatest current that the strip will carry without damage to the seal. Accordingly single strip seals of this kind cannot easily be made to carry more than about 10 amp.

The object of this invention is to increase the current that can be carried by a strip seal, that is to say, one in which the conductor forms an air-tight junction with the quartz in virtue of its thinness.

According to the invention a gas-tight seal of the type specified comprises a thin sheet of suitable metal and a pair of conductors each attached to a part of the said sheet, one said part being on one side of the sheet and the other on the other, so that, when current flows from one said conductor to the other, the stream lines in the sheet are substantially parallel to the thickness of the sheet, and parts of the sheet around the said parts to which the conductors are attached are so embedded in the quartz or like material that the said sheet, together with the said quartz or like material, forms the barrier separating the region around one said conductor from the region around the other. The said minimum cross-section can then always be as great as the area over which the said conductors make contact with the sheet.

The terms "thin" and "suitable" in the foregoing statement are to be interpreted with reference to the known art of making strip seals. A suitable metal is one known to be suitable for making quartz strip seals, particularly molybdenum or tungsten. A thin sheet is one whose thickness is such that it could be used for making a strip seal, for example not more than 0.02 mm. thick, if the metal is molybdenum: of course the sheet must be impenetrable to gas wherever it is part of the said barrier. Either member of the pair of conductors, the stream lines between which are substantially parallel to the thickness of the sheet, may be composed of a plurality of wires or strips, all attached to the same side of the thin sheet.

In order that the sheet may form the barrier as aforesaid, a sufficient condition is that the edge of the sheet is everywhere embedded in the quartz. But, as will be explained with reference to the second embodiment of the invention described hereinafter, this condition is not always necessary.

We are aware that gas-tight seals are known in which the stream lines are substantially parallel to the thickness of a metal sheet sealed at its edges to vitreous material of much higher thermal expansion than the metal. Proposals to make such seals are made, for example, in Patent Specifications Nos. 196,231, 198,322, 205,784; but we are not aware that in ~~many~~ any of these proposals it was suggested that the vitreous material should have a thermal expansion less than 2×10^{-6} per °C.

Two embodiments of the invention will now be described, by way of example, with reference to the drawing accompanying Provisional Specification No. 2022/39 in which Figures 1 and 2 show two stages in the manufacture of the first embodiment and Figures 3, 4, 5, 6 show various sections through the second embodiment.

In Figures 1 and 2, 1 is a disc of molybdenum, 30 mm. in diameter and 0.015 mm. thick, which is the said thin sheet. 2 and 2^1 are the said conductors, being each a molybdenum strip, 3 mm. wide and 0.35 mm. thick, bent back on itself so as to form a central portion, 3 or

3^1, 4 mm. long, perpendicular to the greater part of their length. These central portions are attached (in a manner described more fully below) opposite each other to opposite sides of the disc 1.

4 and 4^1 are two quartz tubes of 4 mm. bore, each flanged at one end 5 or 5^1; the quartz wall is about 1 mm. thick. The conductors 2, 2^1 are placed in the bores, preferably fitting tightly into them, with the disc between the flanges as shown in Figure 1. The flanges are then heated and pressed together, so that they form a gas-tight junction with each other. In order to avoid oxidation of the disc during the joining of the flanges, nitrogen is passed down the tubes 4, 4^1 until the edges of the flanges are joined. The region around the disc 1 is evacuated through the tubes 4 and 4^1, and the quartz heated so that it collapses onto the disc; for in seals according to the invention, as in the known strip seals, it is preferable that the junction between the quartz and the ~~sheets~~ should be made in a vacuum. The completed seal is shown in Figure 2.

Figure 3 is a longitudinal section of the second embodiment perpendicular to the width of the sheet; it is not to scale; the widths of the gaps between the conductors and the quartz are exaggerated in order that their presence may be clearly shown. 1 is the sheet of molybdenum 0.015 mm. thick and about 8 mm. wide; 2, 2^1 are the conductors, being molybdenum wires about 0.7 mm. in diameter, 7 is the quartz. The wires 2, 2^1, entering the seal from either side, overlap where they meet and are attached to opposite sides of the central part 8 of the sheet. It is to be noted that the diameter of the conductors 2, 2^1 is much less than the width of the sheet; this is always desirable in seals according to the invention in which the conductors lie along the strip; for if the conductors are too wide. the seal will crack. In the formation of the seal, the quartz tube is collapsed onto the sheet and conductors, as in the known methods of making strip seals, and will adhere to the sheet where a conductor does not lie between the wall of the tube and the sheet; where a conductor does so lie, the quartz will not adhere to the sheet.

The result is illustrated in Figures 4, 5, 6 which are cross-sections of the seal by the planes AA, BB, CC in Figure 3 respectively, distorted in the same manner as Figure 3. It will be seen that a longitudinal tunnel extends into the seal from either end, each tunnel tapering to a closed end; but the tunnels are always separated by the sheet, so that gas cannot pass from one to the other. The end edges 9, 9^1 of the sheet are not embedded in the quartz where they lie under the conductors 2, 2^1; here the quartz contacts with one side only of the sheet. But, as shown in Figures 4, 5, 6, the side edges of the sheet are embedded in the quartz.

It remains to be considered how, in either example, the conductors are to be attached to the sheet. We have found that, if the conductors are nickel-plated, the nickel will act as a solder during the collapse of the quartz onto the sheet; the plating must not be so thick that the nickel eats holes in the sheet.

In the second example the wires 2, 2^1 are nickel-plated and first spot-welded to the sheet at one or two points only. This assembly is placed in the quartz tube which is then collapsed onto it.

In the first example the central portions 3, 3^1 of the strips are each spot-welded to a molybdenum disc, 6 or 6^1, 9 mm. in diameter and 0.1 mm. thick. These discs 6, 6^1 are then lightly nickel-plated and placed one on either side of the disc 1. When the metal is heated during the collapse of the quartz onto the disc 1, the discs 6 and 6^1 are soldered to the disc 1 by the nickel-plating.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A gas-tight seal of the type specified comprising a thin sheet of suitable metal and a pair of conductors each attached to a part of the said sheet, one said part being on one side of the sheet and the other on the other, so that, when current flows from one said conductor to the other, the stream lines in the sheet are substantially parallel to the thickness of the sheet, wherein parts of the sheet around the said parts to which the conductors are attached are so embedded in the quartz or like material that the said sheet, together with the said quartz or like material, forms the barrier separating the region around one said conductor from the region around the other.

2. A gas-tight seal according to Claim 1 wherein the edges of the said sheet are everywhere embedded in the quartz and each of the said conductors is substantially perpendicular to the said sheet.

3. A gas-tight seal according to Claim 2 wherein the conductors and the sheet are arranged in relation to the quartz substantially as hereinbefore described with reference to Figures 1 and 2 of the drawing accompanying provisional specification No. 2022/39.

4. A gas-tight seal according to Claim

3^1, 4 mm. long, perpendicular to the greater part of their length. These central portions are attached (in a manner described more fully below) opposite each other to opposite sides of the disc 1.

4 and 4^1 are two quartz tubes of 4 mm. bore, each flanged at one end 5 or 5^1; the quartz wall is about 1 mm. thick. The conductors 2, 2^1 are placed in the bores, preferably fitting tightly into them, with the disc between the flanges as shown in Figure 1. The flanges are then heated and pressed together, so that they form a gas-tight junction with each other. In order to avoid oxidation of the disc during the joining of the flanges, nitrogen is passed down the tubes 4, 4^1 until the edges of the flanges are joined. The region around the disc 1 is evacuated through the tubes 4 and 4^1, and the quartz heated so that it collapses onto the disc; for in seals according to the invention, as in the known strip seals, it is preferable that the junction between the quartz and the ~~sheets~~ should be made in a vacuum. The completed seal is shown in Figure 2.

Figure 3 is a longitudinal section of the second embodiment perpendicular to the width of the sheet; it is not to scale; the widths of the gaps between the conductors and the quartz are exaggerated in order that their presence may be clearly shown. 1 is the sheet of molybdenum 0.015 mm. thick and about 8 mm. wide; 2, 2^1 are the conductors, being molybdenum wires about 0.7 mm. in diameter, 7 is the quartz. The wires 2, 2^1, entering the seal from either side, overlap where they meet and are attached to opposite sides of the central part 8 of the sheet. It is to be noted that the diameter of the conductors 2, 2^1 is much less than the width of the sheet; this is always desirable in seals according to the invention in which the conductors lie along the strip; for if the conductors are too wide. the seal will crack. In the formation of the seal, the quartz tube is collapsed onto the sheet and conductors, as in the known methods of making strip seals, and will adhere to the sheet where a conductor does not lie between the wall of the tube and the sheet; where a conductor does so lie, the quartz will not adhere to the sheet.

The result is illustrated in Figures 4, 5, 6 which are cross-sections of the seal by the planes AA, BB, CC in Figure 3 respectively, distorted in the same manner as Figure 3. It will be seen that a longitudinal tunnel extends into the seal from either end, each tunnel tapering to a closed end; but the tunnels are always separated by the sheet, so that gas cannot pass from one to the other. The end edges 9, 9^1 of the sheet are not embedded in the quartz where they lie under the conductors 2, 2^1; here the quartz contacts with one side only of the sheet. But, as shown in Figures 4, 5, 6, the side edges of the sheet are embedded in the quartz.

It remains to be considered how, in either example, the conductors are to be attached to the sheet. We have found that, if the conductors are nickel-plated, the nickel will act as a solder during the collapse of the quartz onto the sheet; the plating must not be so thick that the nickel eats holes in the sheet.

In the second example the wires 2, 2^1 are nickel-plated and first spot-welded to the sheet at one or two points only. This assembly is placed in the quartz tube which is then collapsed onto it.

In the first example the central portions 3, 3^1 of the strips are each spot-welded to a molybdenum disc, 6 or 6^1, 9 mm. in diameter and 0.1 mm. thick. These discs 6, 6^1 are then lightly nickel-plated and placed one on either side of the disc 1. When the metal is heated during the collapse of the quartz onto the disc 1, the discs 6 and 6^1 are soldered to the disc 1 by the nickel-plating.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A gas-tight seal of the type specified comprising a thin sheet of suitable metal and a pair of conductors each attached to a part of the said sheet, one said part being on one side of the sheet and the other on the other, so that, when current flows from one said conductor to the other, the stream lines in the sheet are substantially parallel to the thickness of the sheet, wherein parts of the sheet around the said parts to which the conductors are attached are so embedded in the quartz or like material that the said sheet, together with the said quartz or like material, forms the barrier separating the region around one said conductor from the region around the other.

2. A gas-tight seal according to Claim 1 wherein the edges of the said sheet are everywhere embedded in the quartz and each of the said conductors is substantially perpendicular to the said sheet.

3. A gas-tight seal according to Claim 2 wherein the conductors and the sheet are arranged in relation to the quartz substantially as hereinbefore described with reference to Figures 1 and 2 of the drawing accompanying provisional specification No. 2022/39.

4. A gas-tight seal according to Claim

1 wherein each of the said conductors is substantially parallel to the said sheet and the part of the edges of the said sheet underlying the said conductors is not embedded in the quartz.

5. A gas-tight seal according to Claim 4 wherein the conductors and the sheet are arranged in relation to the quartz substantially as hereinbefore described with reference to Figures 3, 4, 5, 6 of the drawings accompanying provisional specification No. 2022/39.

6. The method of manufacturing a gas-tight seal according to any preceding claim wherein the conductors are nickel-plated where they are to be attached to the sheet before they are so attached.

Dated the 24th day of January, 1939.

NORMAN R. CAMPBELL,
For the Applicants.

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