AMENDED SPECIFICATION

Reprinted as amended in accordance with the decision of the Assistant Comptroller, acting for the Comptroller-General, dated the eleventh day of April, 1939, under Section 21 of the Patents and Designs Acts, 1907 to 1938.

(The Amendments are shown in erased and italic type and in the drawings.)

PATENT SPECIFICATION

Application Date: Jan. 19, 1937. No. 1594/37.
" " April 8, 1937. No. 10027/37.

486,138*

One Complete Specification Left: Nov. 5, 1937.
(Under Section 16 of the Patents and Designs Acts, 1907 to 1932).
Specification Accepted: May 31, 1938.

PROVISIONAL SPECIFICATION
No. 1594 A.D. 1937.

Improvements in Electrodes for High-pressure Metal Vapour Electric Discharge Devices

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

This invention relates to electrodes for high-pressure metal vapour electric discharge devices.

It has been proposed in such devices to provide two pairs of electrodes (other than auxiliary electrodes for initiating the discharge), namely a pair of starting electrodes provided with a store of thermionically active material and a pair of refractory running electrodes. The discharge starts on the starting electrodes; the running electrodes are arranged relatively to them so that, during the " run up " when the vapour pressure of the metal increases, the discharge transfers itself to the running electrodes. The starting and running electrodes may be part of the same body.

The object of this invention is to provide improved electrodes of this general type. The improvements sought are (1) a small size, so that the electrodes can be fitted into narrow tubes, (2) regularity of transfer of the discharge from the starting to the running electrodes, (3) ease of construction and degassing, (4) maintenance of the high thermionic activity of the starting electrodes. Further it is particularly important that the electrodes should operate satisfactorily at high vapour pressures, i.e. those of 10 atmospheres or more; but the invention is applicable even at pressures as low as 1 atmosphere.

According to the invention an electrode for a high-pressure metal vapour discharge device comprises a shaft, preferably of refractory metal such as tungsten, a head of refractory metal usually expanded on the end of the said shaft, serving as the running electrode, and a sleeve carrying thermionically active material on the said shaft behind the said head.

The invention will now be further explained with reference to the accompanying drawings in which Figures 1, 2, 3, 4, 5 each show by way of example a different embodiment.

In each figure, 1 is the shaft of tungsten wire, 2 the expanded head, 3 the sleeve. This sleeve in these examples is always a tungsten spiral, of wire finer than that of the shaft, coated with alkaline earths; but geometrically similar sleeves constructed in other known manners might be substituted. The embodiments differ mainly in the nature of the heads and in the relation between head and sleeve. Each figure is approximately correct in relative scale.

In Figure 1, the head 2 is a block of tungsten 3 mm. long and the sleeve 3 is separated from it by a gap. The electrode is suitable for a 300 watt quartz lamp with a distance of 1 cm. and a voltage of 100 volts between the electrodes.

In Figure 2 the head is a flat spiral 2.5 mm. in diameter wound of the wire constituting the shaft. The sleeve is adjacent to the head. The electrode is

suitable for a 125 watt quartz lamp, with a distance of 3 cm. and voltage of 120 volts between the electrodes.

In Figure 3 the head is a helix 1½ mm. long co-axial with the shaft with which it is continuous. The sleeve is adjacent to the head.

In Figure 4 the head is a fused blob 1½ mm. in diameter on the end of the shaft; the sleeve is again adjacent to the head. The electrode is suitable for an 80 watt quartz lamp with a distance of 2 cm. and a voltage of 120 between the electrodes.

In Figure 5 the part of the shaft between the head and the sleeve in Figure 1 is covered by a helix 4 of tungsten wire stouter than that of the sleeve and nearly equal in diameter to the head.

The differences between the heads are determined mainly by constructional convenience; the massiveness of the head is determined by the consideration that the head should run as hot as possible consistently with there being no appreciable evaporation from it. If the currents are small and the pressure high, this consideration may not require that the head should be more massive than the shaft. Accordingly in extreme cases the head may be an unexpanded end of the shaft; but this is not usual.

The distance between the sleeve and the head is determined by two conflicting considerations. First it is desirable that the starting electrode should be as near as possible to the running electrode, in order that the transfer of the discharge during the run up should be delayed as long as possible; second it is undesirable that an appreciable amount of active material should be able to diffuse continually during operation from the starting to the running electrode. A third consideration that sometimes enters is the preservation of the activity of the starting electrode. If it is too cold during operation it may pick up impurities from the gas which will render starting difficult; on this account it should be near the running electrode, so that it is kept warm but not, of course, so hot as to evaporate or emit thermionically. The correct balance between these considerations must be determined in each case.

If the vapour pressure and therefore the volts per cm. of the discharge path are relatively low, the discharge may tend to terminate on the shaft behind the head. For it may be able to heat the shaft so hot that the increased thermionic emission more than counterbalances the greater length of the discharge. The helix 4 in Figure 5 tends to prevent this; since this helix does not heat up much more easily than the head. But this device will not be necessary at high pressures.

Dated the 18th day of January, 1937.
For the Applicants,
NORMAN R. CAMPBELL.

PROVISIONAL SPECIFICATION

No. 10027 A.D. 1937.

Improvements in Electrodes for High-pressure Metal Vapour Electric Discharge Devices

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

This invention relates to electrodes for high-pressure metal vapour electric discharge devices.

It has been proposed in such devices to provide two pairs of electrodes (other than auxiliary electrodes for initiating the discharge), namely a pair of starting electrodes provided with a store of thermionically active material and a pair of refractory running electrodes. The discharge starts on the starting electrodes; the running electrodes are arranged relatively to them so that, during the "run up" when the vapour pressure of the metal increases, the discharge transfers itself to the running electrodes. The starting and running electrodes may be part of the same body.

The object of this invention is to provide improved electrodes of this general type. The improvements sought are (1) a small size, so that the electrodes can be fitted into narrow tubes, (2) regularity of transfer of the discharge from the starting to the running electrodes, (3) ease of construction and degassing, (4) maintenance of the high thermionic activity of the starting electrodes. Further it is particularly important that the electrodes should operate satisfactorily at high

vapour pressures, i.e. those of 10 atmospheres or more; but the invention is applicable even at pressures as low as 1 atmosphere.

According to the invention the desired properties are attained by uniting a running electrode with its corresponding starting electrode into a self-supporting, substantially cylindrical structure, the running electrode, being of refractory metal such as tungsten, being a head at one end of the structure and the starting electrode, of thermionically active material supported by a metal, lying behind the head. Cylindrical does not necessarily imply that the cross section perpendicular to the axis is circular; but it does imply that the structure has a considerable degree of symmetry about a straight axis and that the length parallel to this axis considerably exceeds the width perpendicular to it. The head is preferably, but not necessarily, wider than the rest of the structure and, particularly, wider than the part where the thermionically active material lies, which will be termed the body.

The body may be a straight shaft of refractory metal integral with the head, carrying a sleeve coated with or otherwise supporting the thermionically active material. Five examples of this construction are described in co-pending application No. 1594/37 and illustrated in Figures 1—5 of the drawings accompanying it.

Alternatively the body may be a helix of refractory metal. It may carry a sleeve or support within it a rod-like member provided with thermionically active material at least on its surface. Thus the rod may be composed throughout of the material, or it may be porous and saturated with the material, or it may be merely coated with the material; in this last case it may be another helix. Alternatively the body may be of porous conducting material saturated with the thermionically active material, for example a sintered mass of tungsten powder and alkaline earth oxides; such material is able both to support the head and to carry current to it.

Any of the heads shown in the aforesaid figures may be used with these alternative constructions; the nature of the head, and the distance between the body and the head, and the nature of the part (if any) intervening between the body and the head are to be determined by the considerations presented in the said co-pending application.

In order that the best results should be obtained from electrodes according to the invention it is necessary that, during the pumping of the devices in which they are used, all the usual precautions should be taken to remove adherent and absorbed gas.

Dated the 8th day of April, 1937.

For the Applicants,
NORMAN R. CAMPBELL.

COMPLETE SPECIFICATION (AMENDED)

Improvements in Electrodes for High-pressure Metal Vapour Electric Discharge Devices

We, THE GENERAL ELECTRIC COMPANY LIMITED, of Magnet House, Kingsway, London, W.C.2, a British company, and VICTOR JAMES FRANCIS, of Research Laboratories of The General Electric Company Limited, Wembley, Middlesex, a British subject, 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 electrodes for high-pressure metal-vapour electric discharge devices of the type in which the metal is so heated by the discharge that its vapour pressure in full operation exceeds 1.5 atmospheres, and more especially to those in which it is at least 5 atmospheres.

It has been proposed in high pressure metal-vapour discharge devices to provide two pairs of electrodes (other than auxiliary electrodes for initiating the discharge), namely a pair of starting electrodes provided with a store of thermionically active material, and a pair of refractory running electrodes. The discharge starts on the starting electrodes; the running electrodes are arranged relatively to them so that, during the "run up" when the vapour pressure of the metal increases, the discharge transfers itself to the running electrodes.

If the device is to be operated on D.C., the said two pairs may have a common member, which must be the anode, and need not have a store of active material. But, since operation on A.C. is much more common than operation on D.C., it alone will be considered explicitly in what follows. However it is to be noted that electrodes according to the invention may

be used as the cathodes of devices operated on D.C.; of course they may also be used as the anodes, but then they have no special advantage.

The object of this invention is to provide improved combinations of starting and running electrodes, the improvement consisting especially in the small size of the electrodes, so that they can be fitted into narrow tubes, and in the case of making and degassing them.

In Patent Specification No. 444,545 and again in Patent Specification No. 472,658, it is proposed to use as starting and running electrodes different parts of the same body of refractory material, the part acting as starting electrode being provided with thermionically active material and the part acting as running electrode being free from it. In Specification No. 444,545 it is suggested that the body should taper towards the discharge, the narrow end being the running electrode; one preferred construction is a conical helix of tungsten wire, the bore of which is filled with the active material.

At the date of this specification, all commercial high-pressure mercury-vapour discharge lamps operated at a vapour pressure below, or at any rate but very slightly above, atmospheric pressure, the said suggestion was therefore probably made with reference to such lamps. But, as explained in said Patent Specification No. 472,658 (not published at the date of this application), the higher pressures characteristic of the devices to which the present invention relates, and the resulting greater potential gradient in the discharge, modifies profoundly the relation between running and starting electrodes. One discovery on which the invention is based is that, at these higher pressures, it is not desirable that a single body, forming both running and starting electrodes, should taper towards the discharge; if it tapers at all, it should taper away from the discharge.

According to the invention, in a high-pressure metal-vapour electric discharge device of the type specified and having at least one pair of cooperating starting and running electrodes, the said pair of electrodes form together a self-supporting, substantially cylindrical structure, wherein the running electrode, being of refractory metal such as tungsten, is a head at one end of the structure and the starting electrode, of thermionically active material supported by a metal, lies behind the head and forms part or the whole of a shaft terminating in the said head. Cylindrical does not necessarily imply that the cross section perpendicular to the axis is circular; but it does imply that the structure has an axis, not necessarily straight, and that the length parallel to this axis considerably exceeds the width perpendicular to it. As already indicated, the head is usually wider than the rest of the structure and, in particular, wider than the part where the thermionically active material lies. This may not always be necessary, especially if the shaft is sufficiently stout; but it must not be substantially narrower than the shaft.

The shaft may be a straight rod of refractory metal integral with the head, carrying a sleeve coated with or otherwise supporting the thermionically active material. Alternatively the shaft may be a helix of refractory metal and the thermionically active material may be within it, supported on a rod-like member. Thus the rod-like member may be composed throughout of the material, or it may be porous and saturated with the material, or it may be merely coated with the material; in this last case it may be another helix. Alternatively again the shaft, or part of it, may be of porous conducting material saturated with the thermionically active material, for example a sintered mass of tungsten powder and alkaline earth oxides; such material is able both to support the head and to carry current to it.

Certain embodiments of the invention will now be described with reference to the drawings accompanying Provisional Specification No. 1594/37, in which Figures 1, 2, 3, 4, 5 each shows by way of example a different embodiment.

In each figure, 1 is a straight tungsten wire, 2 an expanded head on one end of it, which is the running electrode; 3 is a sleeve on it, which is the starting electrode. This sleeve in these examples is always a tungsten spiral, of wire finer than that of the shaft, coated with alkaline earths; but geometrically similar sleeves constructed in other known manners might be substituted. The wire 1 and sleeve 3 constitute the shaft in Figures 1, 2, 3, 4, and the greater part of the shaft in Figure 5. The embodiments differ mainly in the nature of the heads and in the relation between head and sleeve. Each figure is approximately correct in relative scale.

In Figure 1, the head 2 is a block of tungsten 3 mm. long and the sleeve 3 is separated from it by a gap.

In Figure 2 the head is a flat spiral 2.5 mm. in diameter wound of a continuation of the wire 1. The sleeve is adjacent to the head. The flat spiral may be replaced by a conical helix.

In Figure 3 the head is a helix 1½ mm.

long threaded on the wire 1. The sleeve is adjacent to the head.

In Figure 4 the head is a fused blob 1½ mm. in diameter on the end of the wire 1; the sleeve is again adjacent to the head.

In Figure 5 the part of the wire 1 between the head 2 (similar to that of Figure 1) and the sleeve 3 is covered by a helix 4 of tungsten wire stouter than that of the sleeve and nearly equal in diameter to the head; this helix 4 is not coated with active material.

If the vapour pressure and therefore the volts per cm. of the discharge path are relatively low, the discharge may tend to terminate on the shaft behind the head. For it may be able to heat the shaft so hot that the increased thermionic emission more than counterbalances the greater length of the discharge. The helix 4 tends to prevent this, since this helix does not heat up much more easily than the head; it also helps to prevent the starting electrode acting as cathode while the running electrode acts as anode. But this device will not be necessary if the vapour pressure is sufficiently high.

The proportions of the parts shown in the aforesaid embodiments must be chosen with reference to the characteristics of the device in which the electrodes are to be used. It will be evident to those skilled in the art that it is impossible to give instructions whereby the electrode most suitable for any given characteristic can be designed without trial. On the other hand, if the conditions are borne in mind that electrodes must satisfy in order that the advantage derived from the use of cooperating starting and running electrodes may be obtained, and if the examples given below are studied, no great amount of trial will be necessary in designing electrodes suitable for any normal characteristic. Accordingly it is desirable to set forth the aforesaid conditions somewhat fully.

(1) The thermionically active material must be so volatile that, if the discharge terminated on the starting electrode in full operation, it would evaporate appreciably.

(2) The distance between the starting and running electrodes must exceed some limit d_1 (a) because the active material must not be heated by the discharge terminating on the running electrode to a temperature at which it evaporates appreciably, (b) because diffusion of the active material to the running electrode must be hindered, (c) because the discharge in running up must transfer itself from the starting to the running electrode. Here it may be noted that it is possible to find conditions in which the discharge transfers itself partially, but not wholly; the starting electrode continues during full operation to act as the cathode during one half of the cycle, but the associated running electrode acts as anode, during the other half. This condition is not consistent with there being true starting and running electrodes; any electrodes which necessarily bring about this condition are outside the scope of the invention.

(3) The distance between the starting and running electrodes must be below some other limit d_2, (a) in order that the discharge should start under the applied voltage required to maintain the full discharge, sometimes (b) in order that active material on the starting electrode should not be so cold during operation that noxious impurities condense on it and make it inactive, and sometimes (c) in order that there should not be so large a dead space behind the electrodes that the vapour pressure cannot be maintained.

(4) The running electrode must not become so hot in operation that it evaporates appreciably in spite of being refractory. This condition requires that the running electrode should be of a certain size and massiveness. On the other hand it must, of course, attain a temperature giving copious thermionic emission; accordingly it must not be too large or massive.

It will be observed that requirements (2) and (3) might have proved contradictory, because d_1 was greater than d_2, so that no distance greater than d_1 but less than d_2 could be found. A great part of the discovery on which the invention rests is that there is no such contradiction, and that a value of d can be found between d_1 and d_2 so as to attain the object of the invention.

Any of the aforesaid embodiments may be modified, as indicated above, by placing the thermionically active material inside the shaft instead of on its surface, or making part of the shaft of porous conducting material saturated with the active material. The part of the shaft that should be altered in any such modification is, of course, the part occupied by the sleeve.

~~One example of such a modification is shown in Figure 6 of the accompanying drawings, which also illustrates the possibility that the head should be no wider than the shaft.~~

~~In this figure, 5 is a tungsten rod 1.4 mm. in diameter, 6 a rod of thermionically active material of the same diameter. These rods are held together by the uncoated helix 7 of wire 0.4 mm. in diameter which extends~~

~~to the end of the rod 5. The end of the rod 5 remote from the rod 6 and the helix surrounding that end form the running electrode, the helix 7 where it encloses the rod 6 is the starting electrode. The rod 6 may be replaced by a smaller rod inside another uncoated helix, so that two helices intervene between the thermionically active material and the discharge path. Such an electrode is suitable for a lamp having a tubular quartz envelope of 10 mm. bore, the distance between the running electrodes being 30 mm., designed to operate with its length vertical and to consume 250 watts with 160 volts between the electrodes. The upper and lower electrodes should then be slightly different, because the vapour density is greater below than above. For the upper electrode the dimension indicated by a, b, c, in the figure should be respectively 4.5, 3, and 4 mm.; for the lower electrode, they should be respectively 3, 3, 4 mm.~~

It remains to state for what types of lamp these remaining embodiments are suitable and how the dimensions of the parts should be adapted to the type.

One type of lamp is shown in Figure 6 7 of the accompanying drawings, where (a) and (b) represent sections in perpendicular planes. The envelope 1 is of quartz. 2, 3 are electrodes according to the invention supported by leading-in-wires issuing through the extensions 4, 5. The distances represented in the figure by *a*, *b*, *c*, *d* are respectively 21, 7, 28, 23 mm. The gap between the running electrodes is 3 mm.; the lamp is adapted to consume 250 watts with 60 volts between the electrodes. The electrodes described with reference to the aforesaid Figure 1 or Figure 5 are suitable for use in this lamp. In particular, if an electrode according to Figure 5 is used, the tungsten head 2 may be 3 mm. long and 2 mm. in diameter; the wire 1 may be 0.6 mm. in diameter; the sleeve 3 may consist of an inner and an outer helix, both coated with oxide material and both wound of wire 0.2 mm. in diameter on mandrels respectively 0.6 and 1.1 mm. in diameter; the length of either may be 4 mm. The uncoated helix 4 may also be double, the outer helix being wound of 0.3 mm. wire on a 1 mm. mandrel and the inner helix of 0.2 mm. wire on a 0.6 mm. mandrel.

Another type of lamp is shown in Figure 7 8 of the accompanying drawings. Here the quartz envelope 1 is tubular; the bore is 8 mm.; the distance between adjacent ends of the running electrodes 2, 3 is 30 mm.; these ends are some 5 mm. from the end of the envelope. The lamp is adapted to consume 125 watts with 120 volts between the electrodes. The electrodes described with reference to the aforesaid Figure 2 are suitable for this lamp. In particular, the wire 1 may be 0.3 mm. in diameter; the head 2 may be a conical helix 1½ mm. long wound of 5 turns of this wire, the bore towards the sleeve 3 being 3 mm. in diameter. The sleeve 3 may again consist of an inner and an outer helix, the inner being wound of 0.15 mm. wire on a 0.3 mm. mandrel with 150% pitch, the outer of 0.2 mm. wire on a 0.7 mm. mandrel with 150% pitch. Both helices are coated and extend within the conical helix 2. The distance of the apex of 2 to the further end of 3 is 4 mm. Electrodes similar to those shown in Figures 3 and 4 are also suitable for ~~similar~~ lamps of similar type.

The lamps shown in Figures 6 7 and 7 8 may have auxiliary electrodes, as usual, for initiating the discharge. It must be understood that the use of electrodes according to the invention implies neither the presence nor the absence of such auxiliary electrodes.

In order that the best results may be obtained from electrodes according to the invention, it is desirable to take known precautions to prevent oxidisation of the electrodes during sealing in, and during the pumping of the device in which they are to be used, to remove adherent and absorbed gas. But as indicated above, one of the advantages of such electrodes is that no exceptional steps are required during pumping in order that the gas may be fully removed.

We are aware that Figure 4 of the drawings accompanying Patent Specification No. 425,597 (on which no patent was granted) shows an electrode consisting of a shaft of tungsten ending in a spherical head free of thermionically active material, and carrying behind the head a helix of tungsten wire coated with active material. But it is there proposed to use this electrode in a device comprising a " bulb " containing a quantity of vaporisable metal and a heater in the bulb adjacent to the vaporisable metal. It appears that the heater is an element separate from the envelope, the gaseous medium contained in it, and the electrodes, for example, a resistance in series with one of the electrodes having a covering of refractory insulating material extending through the vaporisable metal.

The present invention does not relate to devices comprising such a separate heater for the metal; for the problem to which starting and running electrodes are directed does not arise in them. The exclusion of such devices is to be understood to be implied by the provision, in the specification of the type, that the metal is heated by the discharge.

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 high-pressure metal-vapour electric discharge device of the type specified, having starting and running electrodes satisfying all of conditions (1), (2), (3), (4) aforesaid, wherein the said starting and running electrodes form together a self-supporting, substantially cylindrical structure, wherein the running electrode, being of refractory metal such as tungsten, is a head at one end of the structure and the starting electrode, of thermionically active material supported by a metal, lies behind the head and forms part or the whole of a shaft, not substantially wider than the said head and terminating in it.

2. A device according to Claim 1 wherein the said starting electrode is a sleeve, coated with or otherwise supporting the thermionically active material, on a substantially straight rod of refractory metal integral with the head.

3. A device according to Claim 1 wherein the said shaft is a helix enclosing the thermionically active material supported on a rod-like member.

4. A device according to Claim 1 wherein the said shaft or part of it is of porous conducting material saturated with thermionically active material.

5. A device according to Claim 2 wherein a sleeve uncoated with active material intervenes between the head and the said sleeve carrying the thermionically active material.

6. A high-pressure metal-vapour electric discharge device having at least one electrode substantially as hereinbefore described with reference to Figures 1, 2, 3, 4 or 5 of the drawings accompanying provisional specification No. 1594/37 ~~or in Figure 6 of the accompanying drawings~~.

7. A high-pressure metal-vapour electric discharge lamp substantially as hereinbefore described with reference to Figures *6 7* or *7 8* of the accompanying drawings.

Dated the 5th day of November, 1937.

For the Applicants,

NORMAN R. CAMPBELL.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1939.

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 high-pressure metal-vapour electric discharge device of the type specified, having starting and running electrodes satisfying all of conditions (1), (2), (3), (4) aforesaid, wherein the said starting and running electrodes form together a self-supporting, substantially cylindrical structure, wherein the running electrode, being of refractory metal such as tungsten, is a head at one end of the structure and the starting electrode, of thermionically active material supported by a metal, lies behind the head and forms part or the whole of a shaft, not substantially wider than the said head and terminating in it.

2. A device according to Claim 1 wherein the said starting electrode is a sleeve, coated with or otherwise supporting the thermionically active material, on a substantially straight rod of refractory metal integral with the head.

3. A device according to Claim 1 wherein the said shaft is a helix enclosing the thermionically active material supported on a rod-like member.

4. A device according to Claim 1 wherein the said shaft or part of it is of porous conducting material saturated with thermionically active material.

5. A device according to Claim 2 wherein a sleeve uncoated with active material intervenes between the head and the said sleeve carrying the thermionically active material.

6. A high-pressure metal-vapour electric discharge device having at least one electrode substantially as hereinbefore described with reference to Figures 1, 2, 3, 4 or 5 of the drawings accompanying provisional specification No. 1594/37 ~~or in Figure 6 of the accompanying drawings~~.

7. A high-pressure metal-vapour electric discharge lamp substantially as hereinbefore described with reference to Figures *6 7* or *7 8* of the accompanying drawings.

Dated the 5th day of November, 1937.
For the Applicants,
NORMAN R. CAMPBELL.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1939.

* C L M S *