July 9, 1940. J. FODOR 2,207,217

ELECTRIC DISCHARGE DEVICE

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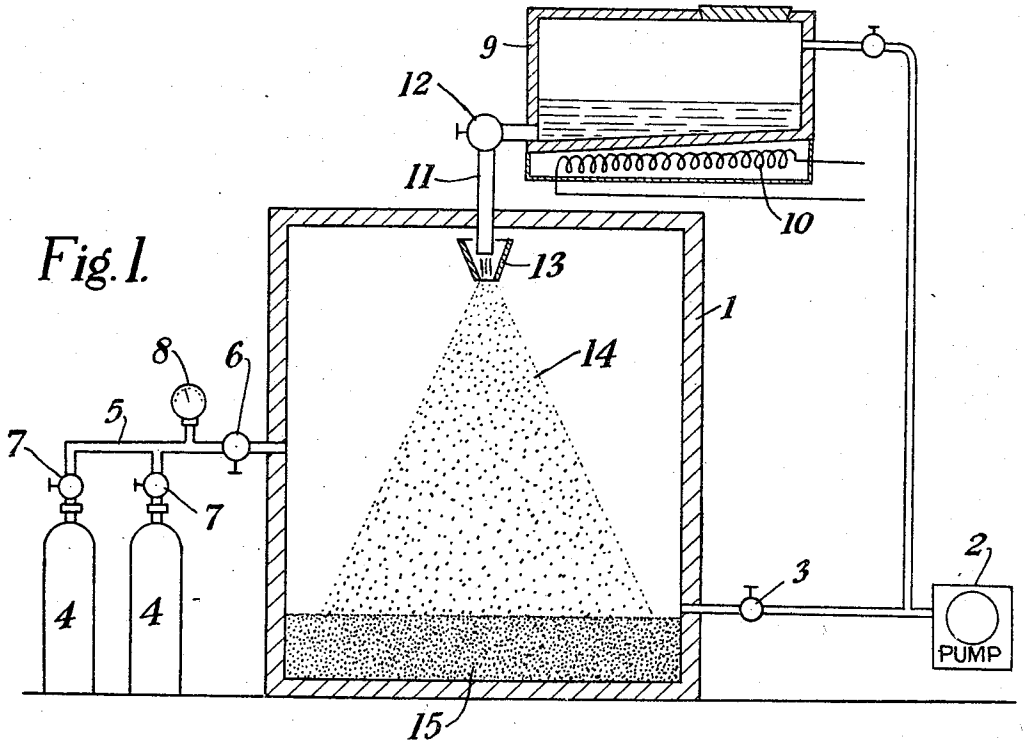



Fig. 1.

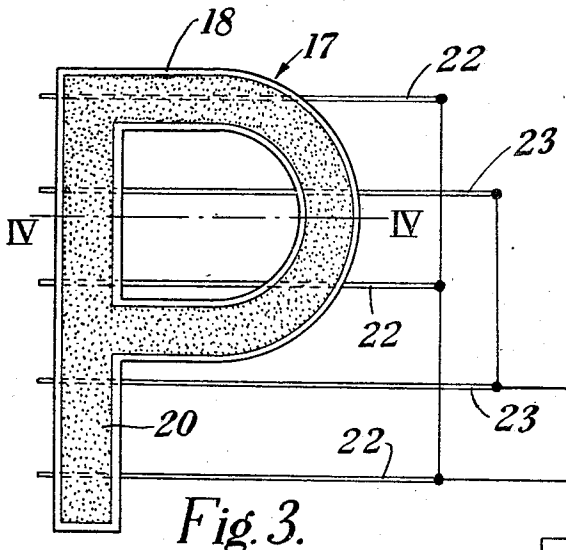



Fig. 3.

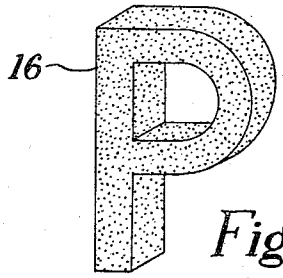



Fig. 2.

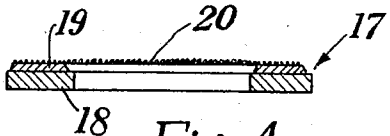



Fig. 4.

HIGH FREQUENCY GENERATOR 21

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## ELECTRIC DISCHARGE DEVICE

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In Great Britain May 18, 1938

17 Claims. (Cl. 176—122)

Gas or vapour discharge devices are known in which a gas or vapour, such as air, neon, argon, mercury vapour or sodium vapour, is contained under reduced, atmospheric or super-atmospheric pressure in a glass envelope and which when submitted to low or high tension current or energised by a high frequency current, can be caused to glow to produce light. Such discharge devices may either have internal or external electrodes.

Difficulties are experienced, however, in the manufacture and use of such discharge devices. In manufacture, the handling of the glass or other material of the envelope is complex; the necessary cleaning, evacuating, filling and shaping the envelope into the desired form involving considerable time and expense. The possible shapes of the envelope are limited by technical considerations, which consequently limit, in use, the practical applications of such luminous discharge devices; moreover, if the envelope is broken the device is rendered useless.

The present invention consists in a gas or vapour discharge device which is very small, lighting devices of any desired shape being built up of a number of these small discharge devices. The individual discharge devices may comprise small spheres or beads of other external shape comprising an envelope made wholly or partly of translucent material and containing the gas or vapour, and may be of any size up to about 1 centimetre diameter, or they may even be larger than this if the total area to be illuminated is large (e. g. a large advertising sign) and is possibly arranged at some considerable distance from the observer. Preferably, however, the discharge devices are made as small as possible, and a feature of the invention is to provide gas or vapour discharge devices of a size corresponding to that of small grains or powder whereby (if necessary by mixing them with an adnesive) they may be painted or sprayed onto a surface in any desired pattern, or moulded or bound together to form any desired shape of lighting device.

The method of producing the small gas discharge devices consists in intermixing or bringing together the translucent material of the envelope, either in a finely subdivided or a fluid or semi-fluid state, with the gas or vapour (or the basic material of the vapour), and in then uniting the subdivided material or solidifying the fluid or semi-fluid material, the gas or vapour thereby being incorporated in the material. If the material of the envelope is in the finely subdivided form, for example glass powder, the particles may be united together by heating to cause the surface of the glass to melt.

In this way, the gas or vapour is occluded or enveloped in the body of the translucent material. The glass or translucent material thus contains millions of very small bubbles each constituting a discharge device.

It will be appreciated that by the method according to this invention, there is no need for the separate evacuating, filling and sealing-off operations as is at present practised. Moreover, no separate evacuation and filling of each individual discharge device is necessary.

A feature of the invention therefore resides in the method of manufacturing a gas or vapour discharge device which consists in forming, filling and sealing the envelope in an atmosphere of the gas or vapour with which the discharge device is to be filled.

A further feature of the invention consists in making a plurality of discharge devices in a chamber which has been evacuated and filled with the gas or vapour whereby the separate evacuation and filling operations of each individual discharge device are dispensed with.

The unifying or solidifying of the translucent material may be effected in moulds or the like, whereby lighting devices of any desired shape may be cast. Or it may solidify into a block of any shape, which block is then broken up into smaller units or may be ground into a powder.

It is possible to make the size of the individual discharge devices in the block of treated translucent material of the order of micro-metres so that if the glass is ground up to a powder of a grain size of the order of 10 micrometres each grain will contain a large number of separate discharge devices, so that even if further broken it will still comprise a discharge device which can be illuminated when energised.

The gas or gas mixture or vapour or vapour mixture occluded or enveloped in the translucent material may be selected to give any desired colour when illuminated, and/or the translucent material may be coloured.

The powder may be mixed with an adhesive and painted on to any surface in any desired pattern, or a complete surface, such as a ceiling, may be painted with a powder. Or the area to be treated may have an adhesive applied thereto (if desired through a stencil or set of stencils), the powder then being sprayed or otherwise applied to the adhesive. The powder being translucent, and preferably transparent, may also be

painted over the glass of a window so that during daytime the daylight can penetrate in the usual way, whilst when artificial illumination is necessary the powder may be energised and produce illumination from the same area as the illumination is produced during daytime. Or the window glass may be manufactured incorporating the discharge devices.

The powder may also be moulded to form any desired shape, or may be painted or sprayed on to a base of glass or other translucent material to form a lighting device.

The powders producing different colours may be selectively used to produce any multi-coloured pattern. Or the powders producing different colours may be mixed together or applied overlapping one another to produce a composite colour. By combining the primary colours in this way, a light radiation with nearly the sun's spectrum may be produced.

The treated translucent material may also be drawn in the form of a fine thread, which may be flexible and similar to glass silk. This thread can be used in a similar manner to the powder.

With regard to the manufacture of the treated translucent material, the gas may be occluded or enveloped in the material in many ways. For example, if glass is used this may be fed or sprayed in molten form in very small drops into a chamber containing the gas under reduced pressure. The various drops falling on to one another form a layer at the bottom of the container with a small quantity of gas between each drop. When the glass solidifies the gas is incorporated therein.

The material from which the envelopes of the discharge devices are made may consist of glass or any other suitable material, such as cellulosic material as used in the manufacture of artificial silk, a translucent resinous condensation product or thermo-plastic material, particularly thermoplastic material of the heat-hardening type. A further feature of the invention therefore consists in a luminous electric discharge device having an envelope of non-vitreous materials.

Since the discharge devices according to this invention are so minute, they may be energised by a very small potential, which leads to the possibility of energising them in many ways. For example they may be energised in the following manners:

(1) By placing them in an electrical field created by an alternating electric current, for example a high tension current or ordinary lighting current. The conductor carrying the current is arranged in the vicinity of the discharge devices or may be embedded in the lighting device, and many consist of metal, graphite or other conducting material. The impedance of the conductor system should be matched to the applied current. The conductor system may comprise a conducting paint or the like which may be painted or sprayed on to the lighting device or the surface to which the discharge devices are applied.

(2) By placing them in an electric field created by high frequency current, that is current with a frequency from about 1000 cycles per second up to ultra-short wave radio frequencies. Conductors for the high frequency current may be arranged as in the previous example, and be fed with the high frequency current. The conductor system may be aperiodic or tuned to the high frequency current or a harmonic thereof. By tuning the conductor systems associated with different lighting devices to different frequencies, the lighting devices may be selectively operated by the selection of the applied high frequency. Or the lighting device itself may be constructed in such a way that it, or certain parts thereof, resonate at a desired frequency.

(3) By feeding the discharge device by an electric field created by electromagnetic waves (of the order of radio waves). Also in this case a conductor system may be associated with the discharge devices as in the previous examples, and in this case serves as an "antenna" system. The system may be aperiodic or tuned to the wavelength of the electromagnetic waves, modifications being possible as in the case when feeding with high frequency current. By so constructing the lighting device that it resonates to the transmitted wavelength, the "antenna" conductor system may be dispensed with. The electromagnetic waves may be produced locally or at a central transmitting station for a certain area. In this case, the lighting devices may be controlled by varying the resonance conditions of the conductor system associated with the lighting device.

(4) By the action of electromagnetic waves, such as light radiation (visible or invisible) heat radiation, X- or Gamma-rays or chemical rays, upon the discharge devices.

(5) By the action of electron radiation, such as cathode rays and beta-rays, upon the discharge devices.

(6) By the action of natural radiation, such as cosmic rays, upon the discharge devices.

Since a large proportion of the discharge in a gas or vapour discharge device comprises invisible rays (in the region of ultra-violet or infra-red rays), the efficiency of the illumination may be increased by causing these rays to act upon fluorescent material. To this end, the fluorescent material may be incorporated in the translucent material at some stage in the production of the discharge or lighting devices, or the translucent material itself may consist of a fluorescent material. The fluorescent material could also be coated upon the grains of or mixed with the powder, and painted or sprayed therewith on to a surface, or molded therewith in a lighting device. Further, a surface treated with powder could be coated with fluorescent material, which could, in turn, be coated with another layer of powder; further similar alternate layers of fluorescent material and powder could be applied if desired. Different fluorescent materials or mixtures thereof could be used in the same discharge or lighting device. The translucent material may be such as to permit the transmission of the invisible rays although, due to the minute thickness of the envelope of a discharge device, the absorption thereby is extremely small.

It will be appreciated that these methods of employing fluorescent material possess distinct advantages over the methods at present employed, where it is necessary to coat the inner surface of a discharge tube with the fluorescent material by a complex process. Furthermore, by the use of minute discharge devices according to this invention, the efficiency is enormously increased since nearly all the invisible radiation is usefully employed for acting on fluorescent material, whereas in previous devices, due to the size of the discharge device relative to the amount of fluorescent material it is possible to apply thereto, a considerable excess of invisible radiation is wasted.

A feature of the invention therefore resides in the method of building up a lighting device of a plurality of very small gas or vapour discharge devices each of which acts separately on a proportion of fluorescent material located in close proximity thereto.

It will be understood that the invention is not limited to gas or vapour discharge devices emitting visible rays, but that it also applies to discharge devices emitting only invisible rays. In this latter case, visible illumination may be produced by the use of fluorescent material as above described.

This invention is applicable to the production of screens for oscillographs or for electrical picture and image transmission systems, such as television systems, and to this end according to a further feature of the invention a screen for television and like purposes is made from a large number of small discharge devices which are excited in sequence. The screen may be cast as above described but is preferably made from the powder which is coated on to a sheet of material (which may be translucent or opaque) or the whole screen may be built up of a plurality of sections each of which is constructed in this manner. The discharge devices may be excited by rays or waves which are directed to each of the discharge devices in sequence and in synchronism with the transmitted picture signals. For example, the discharge devices may be excited by a beam of electro-magnetic waves controlled by an electromagnetic or electrostatic field or by a mechanical controlling device, such as by mechanically swinging a directional radiator of electromagnetic waves. Or the directional beam may be swung electrically by phase displacement.

The discharge devices may also be excited by electronic rays, such as cathode rays, and according to a further feature of the invention an existing cathode ray tube may be coated with the powder according to this invention and energised by the cathode rays created therein. The screen may be used for television or oscillograph work.

By making the screen of discharge devices which illuminate with different colours it is possible to obtain a multi-colour television. The discharge devices emitting the different colours may be selectively excited by different rays or waves, such as waves of different intensity or wavelength.

In the accompanying drawing:

Fig. 1 illustrates diagrammatically one method of producing the new gas discharge devices,

Fig. 2 indicates a cast letter according to the invention,

Fig. 3 illustrates one form of lighting system incorporating the novel discharge devices, and

Fig. 4 is a section on the line IV—IV of Fig. 3.

Referring to Fig. 1, a chamber 1, into which the translucent material, e. g. glass, and the desired gas or vapour are introduced, is initially evacuated by a pump 2, after which the valve 3 is closed. Gas or vapour is then introduced into the chamber at the required low pressure from a container 4 through pipe 5, under control of the valves 6 and 7. A plurality of gas containers may be provided, as illustrated, containing different gases so that desired gas mixtures can be introduced into the chamber. A pressure gauge is indicated at 8. In the example represented, glass is fused in a tank 9 by a suitable source of heat, for instance electrically, indicated at 10. The tank 9 is also evacuated of air by the pump 2. Molten glass passes from the tank, by way of pipe 11 under control of valve 12, into the chamber 1 where a suitable atomising device 13 breaks up the glass into a fine spray of drops 14 which settle at the bottom of the chamber in a mass as indicated at 15. The finely-divided glass, while passing through the atmosphere of gas and settling, is intermixed with the gas, so that the mass 15, on solidifying, has trapped and incorporated therein a quantity of the gas distributed minutely through the mass. Powdered instead of molten material may be fed into the chamber in a similar manner and consolidated by heat.

The material may be consolidated by casting in moulds in the chamber 6, to form it into various shapes such as a letter 16 as shown in Fig. 2. Such a cast letter is composed of a multitude of very small discrete gas or vapour discharge devices.

As an alternative to casting, after consolidation the mass 15 may be crushed, and the granular material or powder so formed applied by means of adhesive to a base of any suitable shape or material. Figs. 3 and 4 illustrate a sign 17, in the shape of a letter, formed in this manner from a base 18 to which is applied a coating of adhesive 19 securing a layer 20 of the granular or powder material, so that the base is coated with a multitude of very small gas discharge devices.

Fig. 3 also illustrates one manner of energising the small gas discharge devices. A generator 21 supplies high frequency current to conductors 22 and 23 by means of which a high frequency electric field is created in which the lighting device such as a sign 16 or 17 is placed. The conductors may form supports for the device.

I claim:

1. Method of producing electric discharge devices comprising a translucent envelope containing a gas or vapour which produces light in response to electric excitation, which method comprises bringing into intimate contact with the said gas or vapour a quantity of the translucent material of the envelope in divided or attenuated condition presenting a large surface to volume ratio, and consolidating said material while in the presence of said gas or vapour whereby to incorporate a quantity thereof in the consolidated product.

2. Method as defined in claim 1 and comprising the step of subsequently comminuting the consolidated product.

3. Method as defined in claim 1 wherein said translucent material is consolidated to predetermined shape.

4. Method as defined in claim 1 wherein fluorescent material is incorporated in the translucent material prior to the consolidation thereof.

5. Method as defined in claim 1 wherein the translucent material after consolidation is drawn into filamentary form.

6. Method of producing electric discharge devices comprising a translucent envelope containing a gas or vapour which produces light in response to electric excitation, which method comprises consolidating in the presence of the said gas or vapour a quantity of the translucent material of the envelope in solid comminuted condition, whereby to incorporate a quantity of said gas or vapour within the consolidated body of said translucent material.

7. Method of producing electric discharge devices comprising a translucent envelope containing a gas or vapour which produces light in response to electric excitation, which method

comprises solidifying in the presence of the said gas or vapour a quantity of the translucent material of the envelope in subdivided fluid condition, whereby to incorporate a quantity of said gas or vapour within the solidified body of said translucent material.

8. Method of producing electric discharge devices comprising an envelope of translucent material containing a gas or vapour which produces light in response to electric excitation, which method comprises projecting particles of said translucent material in an atmosphere of said gas or vapour, collecting said particles in a mass thereof and consolidating said mass into a solid body all while in said atmosphere, whereby to incorporate in said body a quantity of said gas or vapour.

9. A luminous electric discharge device comprising a body of translucent material having a quantity of a gas or vapour which produces light in response to electric excitation dispersed discretely throughout said body.

10. A luminous electric discharge device comprising a mass of particles of translucent material each enveloping a minute quantity of a gas or vapour which produces light in response to electric excitation.

11. A luminous electric discharge device comprising a mass of discrete particles of translucent material agglomerated with an adhesive, said particles each enveloping a minute quantity of a gas or vapour which produces light in response to electric excitation.

12. A luminous electric discharge device comprising a mass incorporating translucent material and small bubbles of a gas or vapour which produces light in response to electric excitation enveloped by said material, and fluorescent material distributed throughout said mass whereby each bubble of gas or vapour is individually associated with a portion of said fluorescent material located in close proximity thereto.

13. A luminous electric discharge device comprising a mass of translucent material and a quantity of a gas or vapour which produces light in response to electric excitation in discrete bubbles each enveloped by a portion of said material, and fluorescent material associated with said mass such that each gas or vapour bubble when energised by an electric discharge separately excites a proportion of said fluorescent material located in close proximity thereto.

14. A luminous electric discharge device comprising a mass of translucent material incorporating discrete bubbles of a gas or vapour which produces light in response to electric excitation each enveloped by a portion of said material, said mass including a quantity of fluorescent material.

15. A luminous electric discharge device as defined in claim 14 wherein said mass is incoherent.

16. An electrodeless gas or vapour electric discharge device comprising a support and a layer applied thereto comprising particles of translucent material each enveloping a minute quantity of a gas or vapour which produces light in response to electric excitation.

17. An electrodeless gas or vapour electric discharge device comprising a moulded body of translucent material having a quantity of a gas or vapour which produces light in response to electric excitation dispersed in minute bubbles throughout said body.

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