

⑫

EUROPEAN PATENT APPLICATION

⑰ Application number: **85850298.2**

⑤① Int. Cl.⁴: **H 01 J 61/10, H 01 J 61/30**

⑰ Date of filing: **25.09.85**

③① Priority: **23.05.85 SE 8502562**

⑦① Applicant: **Lumalampan Aktiebolag, P.O. Box 508, S-371 23 Karlskrona (SE)**

④③ Date of publication of application: **03.12.86**
Bulletin 86/49

⑦② Inventor: **Björkman, Ake, Hortensvägen 26, S-371 45 Karlskrona (SE)**

⑧④ Designated Contracting States: **AT BE CH DE FR GB IT LI LU NL SE**

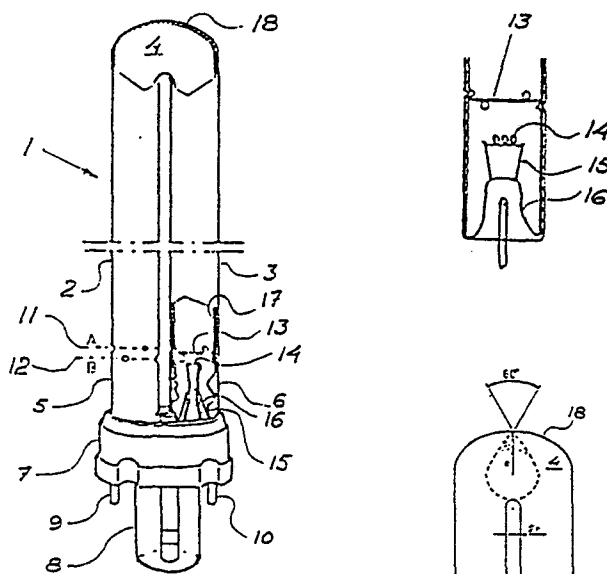
⑦④ Representative: **Erixon, Bo et al, Kooperativa Förbundet (KF) Patent Department Box 15200, S-104 65 Stockholm (SE)**

⑤④ **Compact low-pressure mercury vapour discharge lamp incorporating a mercury condensation chamber.**

⑤⑦ A compact low-pressure mercury vapour discharge lamp comprises two or more straight tubes which are connected together by arcuate connections (4), to form a discharge chamber between two electrodes (14). These electrodes are located in the outer ends (5, 6) of the lamp, these ends being gas-tight connected to a lamp socket (7) enclosing the necessary contact pins (9, 10) and conductors (15).

The connection (4) is provided with a spine (18) which extends along the connection (4). The spine (18) exhibits in cross-section an acute angle, to form a condensation space for mercury vapour used in the lamp. Because of the shape of the spine (18), condensation of the mercury will take place externally of the circular cross-section of the connection (4); when the lamp is energized the discharge current passes through this circular cross-sectional area of the connection and the positive column is formed therein.

The tubes (2, 3) are provided at a location downstream of the electrodes (14) in the discharge current direction with screening plates (13), in order to define around the electrodes (14) spaces in which ions released from the electrode emission substance are held concentrated, so as to fall back onto the electrode surface when the current changes phase.



An electrode conserving, compact low-pressure mercury vapour discharge lamp incorporating a mercury condensation chamber.

The present invention relates to a so-called compact low-pressure mercury vapour discharge lamp, i.e. a gas discharge lamp, comprising two or more mutually parallel tubes which are joined together in the proximity of their
5 ends to form a common discharge chamber between two electrodes placed in the mutually opposite, furthest ends of the discharge chamber. These ends are connected in a gas-tight manner to a common lamp base which incorporates a starter or ignition means and the requisite series impedance means, and is provided with contact pins for current
10 supply to the lamp.

Many kinds of compact low-pressure mercury vapour discharge lamps are known to the art. Of these many known
15 designs, there are two constructions which dominate in the case of lamps comprising solely two straight tubes. The first of these constructions can be most easily described as being of inverted U-shape, with the lamp electrodes located in the free ends of the tube, these
20 free ends being attached to a common lamp base. The second of these dominating lamps has a substantially H-shape, with the horizontal bridge placed at a very high location between the two verticals. In this lamp, the electrodes are arranged in the tube ends located furthest
25 from the bridge. The ends of the tubes in which the electrodes are located are also fitted to a common lamp base, which incorporates a starter or ignition means and series impedance means. The tubes of both these designs are coated internally with a luminous powder of any
30 desired composition. This luminous powder converts the ultraviolet light rays produced by a discharge into visible light.

Those compact low-pressure mercury discharge lamp variants which incorporate more than two straight tubes normally comprise four tubes. These tubes may be located in a single plane, or may be placed in the corners of a square, forming an imaginary cross-section at right angles to the symmetry axes of the tubes. Cross-coupling between the straight tubes is effected alternately between the tube ends located furthest away from the lamp base and the tube ends located nearest said base. Only the first and the last tubes, together with other tubes and the cross-coupling tubes forming a common discharge chamber, are connected to the lamp base, and it is in these ends of the base connected tubes that the electrodes are arranged. In this way there is formed a continuous discharge chamber through which the electric current passing between the electrodes flows when the lamp is energized. The fact that electric current is forced to change direction when passing from one straight tube to another straight tube, via an interconnected tube, has no essential significance with respect to luminous efficiency.

In compact low-pressure mercury vapour discharge lamps, as with other low-pressure gas discharge lamps, there is formed between the electrodes a positive column of light arc which passes through a rare gas mixed with mercury vapour. The gas pressure in a compact gas-discharge lamp is held beneath 500 Pascal (Pa), and at operating temperatures the mercury partial pressure constitutes less than 1 Pa of this value.

The function of the rare gas is to facilitate lamp ignition at a reasonable start voltage, and to increase the probability of collision between the electrons and mercury atoms when the lamp is energized. The low mercury vapour pressure prevailing at 40°C provides the optimum for producing the mercury resonance lines, which lie within the ultraviolet range, namely at 253.7 and 185 nanometers (nm). Of the light thus produced the longer

wavelength is responsible for 85 % of the intensity, whereas the shorter wavelength constitutes 15 %. If a low-pressure mercury vapour discharge lamp were to contain solely mercury vapour, the electrons would collide practically solely with the tube walls and mercury atoms, where-
5 with in the absence of luminous powder the electron energy would be converted into heat and not into light. Many of the collisions with mercury atoms would result in an elastic effect, causing the energy of the electrons to
10 be absorbed without exciting the photons.

A compact low-pressure mercury vapour discharge lamp of the aforescribed U-configuration is known from EP-A-2-0 061 758 (Application No. 82102636.6). It is stated in
15 this publication that the object of the invention described therein is to be provide a lamp in which the glass walls thereof have such a geometric configuration that certain parts thereof sustain a desirably low temperature during operation of the lamp, so that mercury is able to
20 condense in the vicinity of these parts. A balanced mercury vapour pressure is obtained in the lamp in this way.

The object of the present invention is to provide a
25 compact low-pressure mercury vapour discharge lamp in which the mercury partial pressure in the discharge chamber, during operation of the lamp, is maintained at the level which affords maximum power with respect to the formation of radiation by the discharge in the mercury
30 resonance lines.

A further object is to screen the lamp electrodes so as to limit the extent to which heat generated thereby propagates. It is ensured hereby that the temperature of
35 a major part of the straight tubes at the ends thereof located furthest from the lamp base will not exceed 40°C. This is of particular importance when such compact low-

pressure mercury vapour lamps are placed in lamp fittings provided with reflectors. When the lamps are housed in lamp fittings of this nature, the heat emitted by the lamps is not adequately dissipated and temperatures in excess of 40°C occur within the lamps. This causes the mercury vapour pressure in the lamp to rise, resulting in a lower intensity in the generation of radiation in the mercury resonance lines.

These objects are achieved by means of the invention defined and characterized in the following claims.

The invention is based on the concept that in a discharge chamber of the kind used in compact low-pressure mercury vapour lamps the negative space charge is concentrated to the tube walls and a positive column is formed between the electrodes with the space charge 0 along its axis. The discharge between the cathode and anode regions is unitary in the axial direction at each moment following ignition of the lamp. Positive ions and electrons are formed simultaneously with the discharge. These are concentrated at the tube walls by diffusion. Since the column is axially unitary, no particle losses are experienced in the axial direction. During this diffusion process, the electrons move much more rapidly than the positive ions, due to the smaller mass of the electrons, and hence a positive space charge is developed from the centre of the tube outwards. This improves conditions for discharge in the positive column, and therewith increases the power in the ultraviolet radiation.

In order to enable the discharge to propagate naturally in the lamp, this propagation wave being of circular cross-section, the novel compact low-pressure mercury vapour lamp is provided with a mercury condensation section which extends along a part of the positive column, without encroaching upon the column, either axially or radially. This prevents disturbances of the circular pro-

pagation wave of the positive column, which is a requisite for optimum radiation generation by the discharge. This condensation section is obtained in practice by giving the lamp discharge chamber a U-shape, wherewith the peripheral surface of the curved tube section between two straight tube members is drawn from its circular cross-sectional shape into a spine-like configuration in the region of the tube section of largest radius of curvature. This spine extends along substantially the whole of the curved tube section.

The spine extending along the U-bend of the lamp suitably has an angle of 90° or therebelow, when seen in cross-section. In this way there is formed in the tube bend a space which lies to one side of the positive column and in which the mercury condensation temperature can be held constant at the pressure prevailing in the lamp. Expressed differently it can be said that the length of the lamp at different wattages is chosen so that the temperature prevailing along the spine when the lamp operates at normal room temperatures is in the vicinity of 40°C , this temperature being liable to be in excess of 70°C in the region nearest the electrodes. Consequently, the mercury partial pressure will be beneath 1 Pa, or about 5×10^{-3} torr, which is the pressure at which the relative efficiency for the generation of resonance radiation in mercury vapour from a light arc culminates. At lower mercury partial pressures the mercury atoms are spaced too widely apart, resulting in fewer collisions between the atoms and electrons and hence also in fewer excited photons of a low intensity in the ultraviolet radiation. At higher mercury vapour partial pressures, the mercury atoms are so dense that the number of collisions becomes excessive and electrons rebound, which also results in fewer excited photons.

The method by which the thermal propagation from the electrodes is restricted in accordance with the invention

involves providing the straight tubes with screening elements downstream of the electrodes. It has been found that such an arrangement surprisingly increases the useful life span of the lamp manifold. It has been established
5 that this is because the reduction in the free area of the glass tubes downstream of the electrodes in the path of the discharge current causes the electron density to increase during the half period over which the electrode functions as an anode. Consequently, the anode drop is
10 reduced, resulting in a lower temperature of the emission substance with which the electrode is coated. This reduced temperature lowers the rate at which the emission substance vapourizes. This in turn results in an increase in the useful electrode life and therewith also in the
15 useful life span of the lamp.

An important contribution to the increase in the useful life span of the electrode is given by the reflection of vapourized emission substance taking place in the screened
20 space around the electrode, this space being defined by the screening element downstream thereof. Those emission substance ions released from the electrode surface during one half period have very limited possibility of moving in the axial direction of the positive column generated
25 in the lamp. The screening element causes the positive column to be compressed radially, whereby only a minimum negative space charge exists along the tube wall adjacent the actual screening element or plate. Consequently, the released ions remain in the constricted space nearest
30 the electrode, and fall back on the electrode surface during the next half period.

The ions released from the emission substance have a far greater mass than the electrons around the electrode
35 and consequently move much more slowly. As a result, the ions do not reach the tube wall to any appreciable extent before the discharge current changes direction, and do not therefore precipitate onto the glass wall, which would

otherwise be blackened.

In addition to this screening of the straight tubes downstream of the electrodes resulting in reflection of the emission substance, thereby greatly restricting its degradation, it also reduces the occurrence of emission substance ions in the discharge chamber. Since a part of this chamber can be maintained at a temperature of 40°C, the mercury vapour pressure will be beneath 1 Pa, or approximately 5×10^{-3} torr, which is the pressure at which the relative efficiency for the generation of resonance radiation in mercury vapour from a light arc culminates. At lower mercury partial pressures the mercury atoms are spaced too widely apart, resulting in fewer collisions between the atoms and electrons and hence also in fewer excited photons or a lower intensity in the ultraviolet radiation. At higher mercury partial pressures, the mercury atoms are so dense that the number of collisions becomes excessive and electrons will rebound, which also results in fewer excited photons. Consequently, the low ion content from the emission substance results in the loss of but very few electrons through collision with such ions. Thus, a large number of electrons collide with mercury atoms, resulting in high efficiency, i.e. a high luminous efficiency for each Watt applied. Measurements have shown that the luminous flux of a compact low-pressure mercury vapour discharge lamp according to the invention is 3.5 times per Watt greater than that achieved with prior art lamps of this kind.

A preferred embodiment of a compact low-pressure mercury vapour discharge lamp will now be described with reference to the accompanying drawings, in which

35

Figure 1 is a partly cut-away view of the compact low-pressure mercury vapour discharge lamp;

Figures 1A and 1B are cross-sectional views of the lamp on both sides of the screening element;

5 Figure 1C is a longitudinal sectional view of one electrode region in the lamp, illustrating the positioning of the screening element;

10 Figure 2 illustrates schematically the curved interconnecting part of the lamp, indicating a conceivable spine angle; and

15 Figure 3 is a diagram showing the relative efficiency for generating resonance radiation in mercury as a function of the lowest temperature within a discharge lamp (bottom scale) and a corresponding mercury vapour pressure (top scale).

20 The compact low-pressure mercury vapour discharge lamp 1 comprises two straight tubes 2,3, which are internally coated with a luminescent powder of the two or three band type, and which are interconnected by an arcuate tube 4 located at a distance from the ends 5,6 of the straight tubes 2,3. The ends 5,6 are connected in a gas-tight manner to a common lamp base 7. The lamp base is provided on the side thereof remote from the tubes 2,3 with a housing 8 which encloses a starter and series impedance means. Located on both sides of the housing 8 are contact pins 9,10 for supply of current to the lamp 1.

30 Formed in the glass walls of the tubes 2,3 at mutually different levels 11,12 adjacent the ends 5,6 of said tubes are depressions which extend towards the centre of the tubes with a height of less than 1 mm. Plates 13 made of an electrically non-conducting material are snapped into the depressions. The plates 13 may be made, for example, of mica and have a thickness varying between 0.10 and 0.20 mm.

The following description in respect of the Fig. 1 embodiment will be made solely with reference to the one straight tube 3. The plate 13 snapped into this tube has a centrally located orifice, which may have a diameter of from 4.0 to 8.0 mm, calculated in respect of an internal tube diameter of 10 mm. With a tube of this diameter, the plate 13 is located at a distance of 3-10 mm downstream of the electrode 14 located in the tube 3, as seen in the direction of the discharge current. The electrode 14 is carried by two conductors 15 fused into a glass stem 16. The glass stem is, in turn, fused gas-tight with the end 6 of the tube 3. The one conductor 16 is connected to the contact pin 10 and the other to the starter in the housing 8.

The lamp is normally filled with the rare gas argon to a pressure of approximately 3 torr. When the orifice in the plate 13 is smaller than 4 mm, the glow voltage of the lamp 1 will increase, which is not to be desired. It has been found that this can be counteracted by adding krypton to the rare gas filling. Since krypton is an extremely expensive gas, it is desirable to minimize the amount added. Although a krypton addition of between 70 and 90 % will afford an extraordinarily good effect, it does not mean that a high krypton content of the rare gas filling will enable the diameter of the orifice in the plate 13 to be further decreased.

The purpose of providing a small orifice in the plate 13 is to define a space around the electrode 14 in the best possible manner. There is provided in this way an isolated space for ions released from the emission substance with which the electrode 14 is coated. These ions are primarily barium ions which are thrown out in the region nearest the electrode 14 during operation of the lamp. The smaller the diameter of the orifice in the plate 13, the more concentrated in cross-section is the positive column formed between the lamp electrodes. Since ion

movement in the axial direction of the positive column is practically excluded, the possibility for ions released from the emission substance to leave the space around the electrode 14 is greatly impeded. Since the current changes phase in the next half period, practically all of these ions will fall back onto the surface of the electrode 14, which thereby retains sufficient emission substance to function satisfactorily for at least 15000 operational hours. No measurable degradation of the fluorescent layer 17 on the inner surfaces of the tube 2-4-3 takes place during this time. Neither is the rare gas filling affected during this long length of useful lamp life, irrespective of whether the filling is pure argon or argon admixed with other rare gases, for example 10-25% neon or 70-90% krypton. As will be seen from the diagram in Fig. 3, it is of supreme interest to maintain in the lamp a mercury vapour pressure of 5×10^{-3} torr. This corresponds to a temperature of close to 40°C . Thus, some part of the lamp must be heated to this temperature in order to obtain optimum radiation generation in the mercury resonance lines. Normally, the temperature in the electrode region of the lamp is in the order of 70°C . By providing the interconnecting tube 4 with a spine 18 which deviates from the circular cross-sectional shape of the tube and which extends along a substantial part of the outer curved surface of the interconnecting tube 4, there is obtained a space in which the temperature 40°C can be maintained constant while the lamp is energized. An extremely high concentration of negative space charge namely occurs along the spine 18. This means that the positive column between the lamp electrodes will in no way endeavour to depart from its natural circular cross-section. Since the light arc generated by the discharge current is therefore contained within the circular cross-section and heated ions are repelled radially from the negative space charge in the spine 18, it is possible to maintain the aforesaid temperature of 40°C within the spine. The spine 18 is given an acute angle, in order to

obtain an effect which can be likened to a cooling-fin effect. It has been found in practice that technical difficulties occur in production when attempting to produce a spine angle more acute than 60° . Neither is it
5 necessary to provide an angle more acute than 60° , since a spine angle of 90° affords a sufficiently low temperature in the space along the spine 18.

The compact low-pressure mercury vapour discharge lamp
10 has been described with reference to its simplest variant, i.e. a lamp comprising two mutually parallel tubes. A compact low-pressure mercury vapour discharge lamp according to the invention, however, can be produced with any number of straight tubes. In the case of lamps which
15 comprise more than two straight tubes, the tubes connecting the straight tubes and corresponding to the interconnecting tube 4 may all be provided with a spine 18, similar to said interconnecting tube. Despite this, however, it suffices to provide solely one of the interconnecting tubes with a spine 18 where mercury vapour condensation can occur, and thus maintain the desired mercury
20 vapour pressure in the lamp.

Since it is desirable to use only one lamp base with a
25 compact low-pressure mercury vapour discharge tube, the lamp suitably comprises a uniform number of mutually parallel straight tubes. In such cases the straight tubes are connected by couplings corresponding to the tube 4 alternately between the ends of two straight tubes located furthest from the lamp base 7 and the ends of the
30 tubes located nearest the lamp base. The straight tubes are given a length adapted to the wattage for which the lamp is intended.

CLAIMS

1. A compact low-pressure mercury vapour discharge lamp comprising two or more mutually parallel, straight tubes connected together at their ends to form a common discharge chamber between two electrodes located in the ends of the discharge chamber located furthest away from each other, said ends being connected to a common lamp base enclosing a starter and series impedance means, characterized in that the straight tubes (2,3) are provided at the ends thereof (5,6) connected to the lamp base (7) with perforated plates (13) of an electrically non-conductive material which partially define the spaces nearest the lamp electrodes (14) and which, through their orifices, concentrate radially the positive column present between said electrodes when the lamp is energized; and in that at least one of the interconnecting means (4) between two straight tubes (2,3) has a non-circular cross-section.
2. A lamp according to Claim 1, characterized in that the orifices in the plates (13) have a diameter equal to 30%-80% of the diameter of the straight tubes (2,3), preferably 40%-50% of said diameter.
3. A lamp according to Claim 1 or Claim 2, characterized in that the interconnection (4) between two straight tubes (2,3) is provided with a spine (18) which extends along said interconnection.
4. A lamp according to Claim 3, characterized in that the spine (18) exhibits in cross-section an acute angle of between 60° and 90° , preferably 70° - 80° .
5. A lamp according to any one of the preceding claims, characterized in that mica plates (13) are arranged downstream of the electrodes (14), seen in the discharge direction.

6. A lamp according to Claim 1 or Claim 5, characterized in that the plates (13) are held fixed at a distance downstream of the electrodes (14) of 0.3-1.0 times the diameters of the tubes (2,3), by snap-in connection
5 between depressions (11,12) in the glass walls of the straight tubes (2,3).

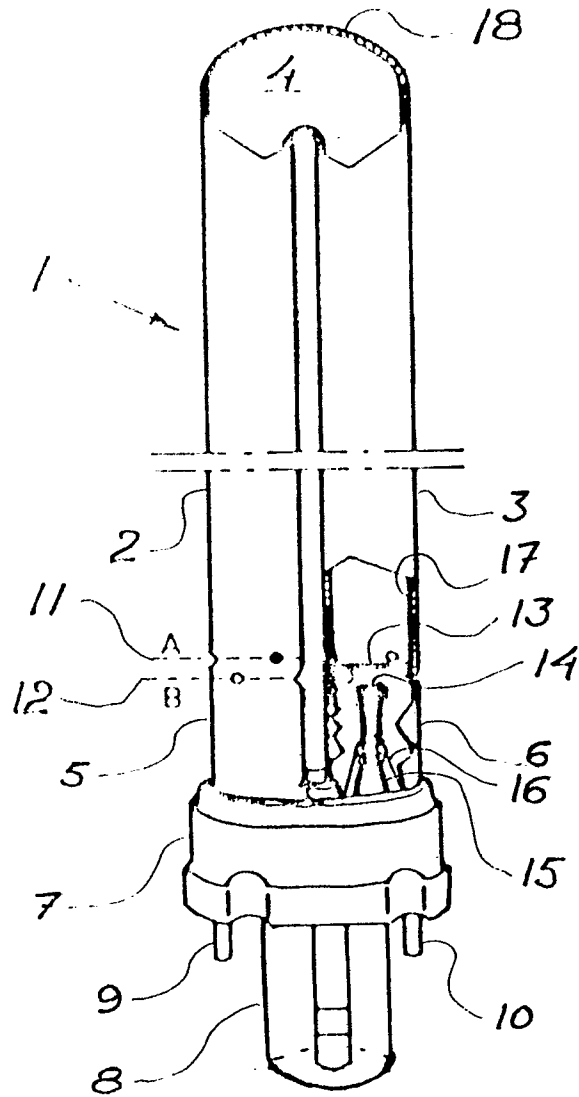
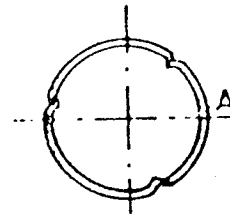
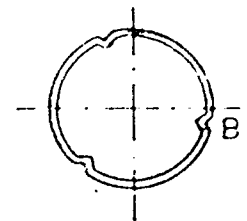
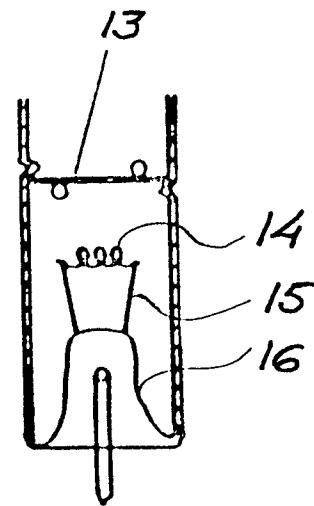
7. A lamp according to any one of the preceding claims, characterized in that the electrodes (14) are coated with
10 an emission substance from which barium ions are released when the lamp is energized.

8. A lamp according to any one of the preceding claims, characterized in that the lamp is filled with a rare gas
15 filling to approximately 500 Pa pressure, preferably pure argon.

9. A lamp according to any one of Claims 1-7, characterized in that the lamp has a rare gas filling comprising
20 at least 10% argon and at most 90% krypton.

10. A lamp according to any one of the preceding claims, characterized in that it contains mercury which, when the lamp is energized, vapourizes to a partial pressure
25 of between 4×10^{-3} torr and 7.5×10^{-3} torr.

1/2

*Fig. 1**Fig. 1A**Fig. 1B**Fig. 1C*

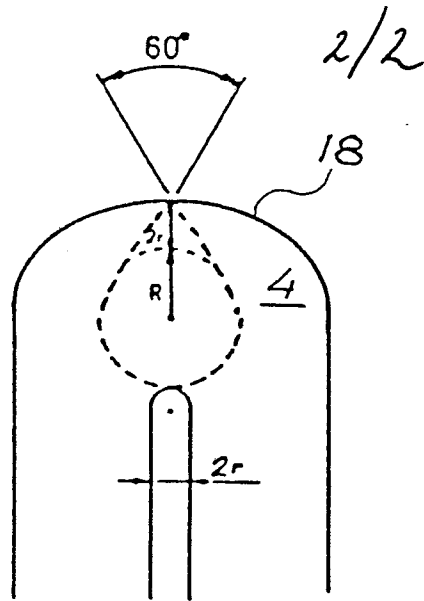


Fig. 2

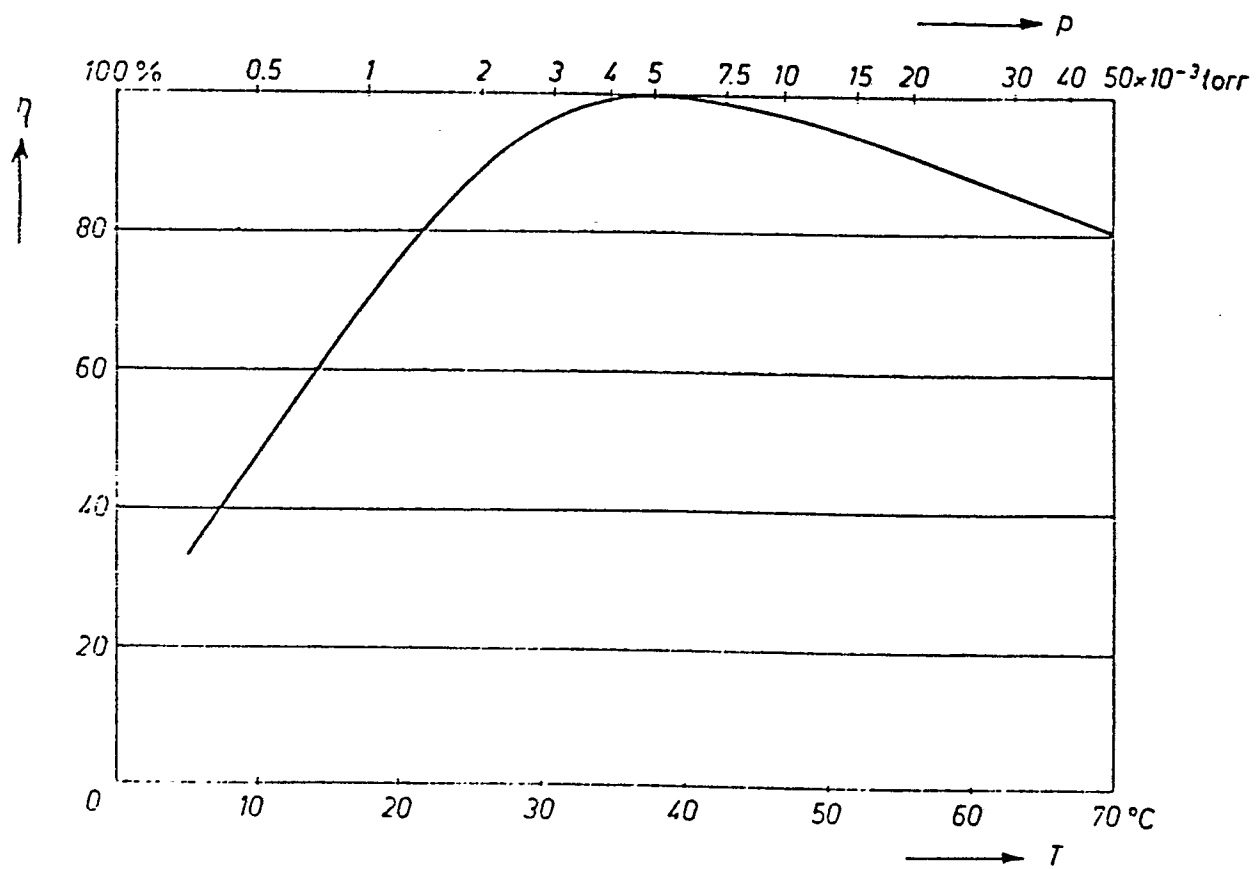


Fig. 3



European Patent
Office

EUROPEAN SEARCH REPORT

0203246

Application number

DOCUMENTS CONSIDERED TO BE RELEVANT			EP 85850298.2
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	US - A - 4 173 730 (YOUNG) * Fig. 3; abstract; column 4, lines 52-59 * --	1	H 01 J 61/10 H 01 J 61/30
A	DE - B2 - 1 539 504 (PHILIPS). * Fig. 3-4; column 3, lines 27-39; column 7, line 18 - column 8, line 2 * --	1	
A	GB - A - 398 799 (BRITISH THOMSON-HOUSTON) * Fig. * ----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			H 01 J 61/00 H 01 J 3/00 H 01 J 7/00 H 01 J 9/00 H 01 J 17/00
The present search report has been drawn up for all claims			
Place of search VIENNA		Date of completion of the search 01-09-1986	Examiner BRUNNER
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			