United States Patent [19]

Someya et al.

[11] **3,715,612**

[45] **Feb. 6, 1973**

[54] **LOW PRESSURE MERCURY VAPOR DISCHARGE LAMP RADIATING GERMICIDAL AND ERYTHEMAL RAYS IN RATIO OF LESS THAN 1.5**

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[21] Appl. No.: **149,437**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 812,264, April 1, 1969, abandoned.

[52] **U.S. Cl.** **313/109,** 313/112, 313/221

[51] **Int. Cl.**.....**H01j 61/30,** H01j 61/44

[58] **Field of Search**.....313/109, 221, 112

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Primary Examiner—Palmer C. Demeo

Attorney—Flynn & Frishauf

[57] **ABSTRACT**

A low pressure mercury vapor discharge lamp emitting erythemal rays and germicidal rays includes an envelope on the inner surface of which there is coated with an erythemal ray emitting film for transmitting to the outside of said envelope visible straight light beams within the range of 45 to 75 percent.

2 Claims, 5 Drawing Figures

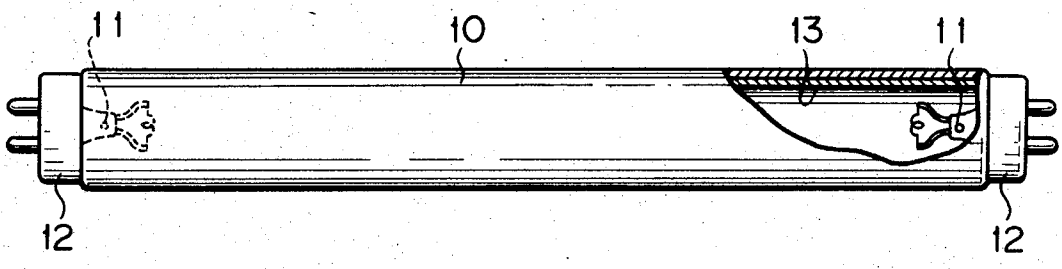


FIG. 1

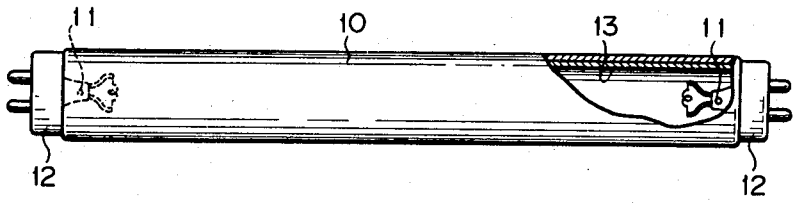


FIG. 2

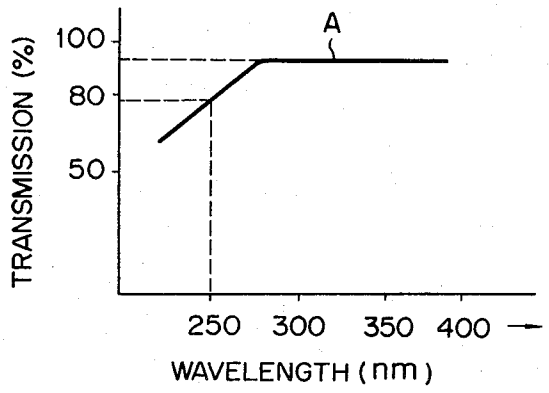


FIG. 3

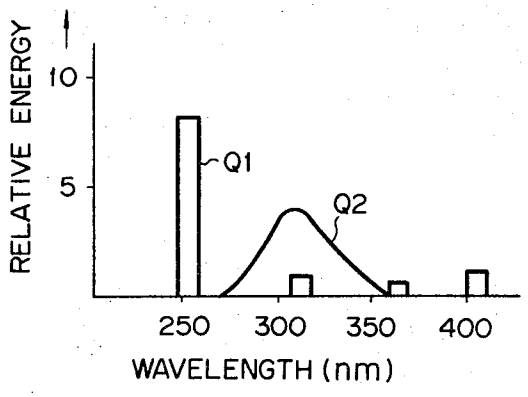


FIG. 4

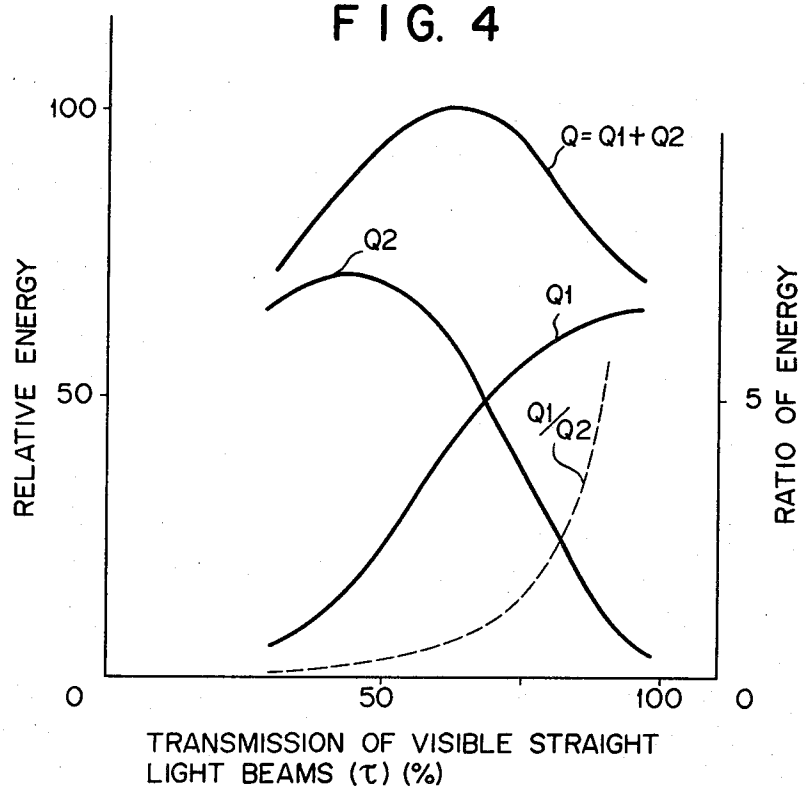
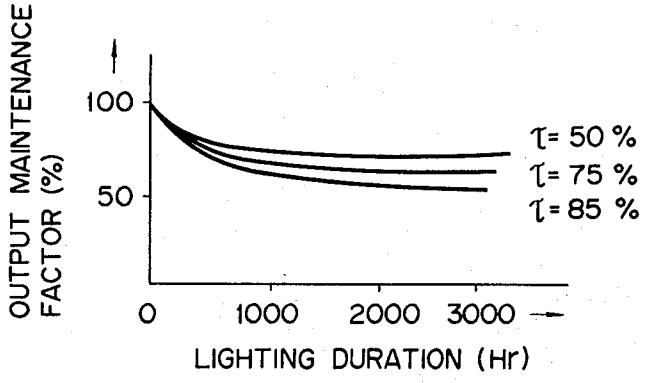

100
50
0
RELATIVE ENERGY
Q= Q1+ Q2
Q2
Q1
Q1/Q2
5
0
RATIO OF ENERGY
50
100
TRANSMISSION OF VISIBLE STRAIGHT LIGHT BEAMS (τ) (%)

FIG. 5


OUTPUT MAINTENANCE FACTOR (%)
100
50
τ= 50 %
τ= 75 %
τ= 85 %
0
1000
2000
3000
LIGHTING DURATION (Hr)

LOW PRESSURE MERCURY VAPOR DISCHARGE LAMP RADIATING GERMICIDAL AND ERYTHEMAL RAYS IN RATIO OF LESS THAN 1.5

CROSS-REFERENCE TO RELATED APPLICATION

This is Continuation-in-part of the U.S. Pat. application Ser. No. 812,264, filed on Apr. 1, 1969, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates a low pressure mercury vapor discharge lamp and more particularly to a lamp capable of irradiating ultraviolet rays and erythemal rays.

A discharge lamp capable of emitting germicidal and erythemal rays at the same time has been made public, for example, in the U.S. Pat. No. 2,445,692. Though originally designed for simultaneous realization of the effect of both rays, such prior art lamp had a low luminescence efficiency and a relatively short life, and was not adapted particularly for livestock breeding for which both rays should be generated in a prescribed ratio.

SUMMARY OF THE INVENTION

It is accordingly the primary object of this invention to provide a low pressure mercury discharge lamp capable of efficiently generating germicidal and erythemal rays at the same time and having its life prominently extended.

Another object on the invention is to provide a low pressure mercury discharge lamp adapted to breed livestock, particularly chickens and pigs.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevation, with part broken away, of a low pressure mercury vapor discharge lamp according to an embodiment of the present invention;

FIG. 2 is a diagram of the spectro-transmission curve associated with an envelope used in said mercury vapor discharge lamp;

FIG. 3 is a diagram of the spectral energy distribution of the germicidal and erythemal rays projected by said mercury vapor discharge lamp;

FIG. 4 is a diagram showing the percentage radiation of the respective germicidal and erythemal rays and the total percentage radiation of both rays as a function of the transmission of visible straight light beams of the fluorescent layer; and

FIG. 5 is a diagram of the relationship between the output maintenance factor and transmission of visible straight light beams associated with said mercury vapor discharge lamp.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Irradiation of ultraviolet rays (253.7 nm) to livestock, for example, pigs or chickens has generally been supposed to have a harmful effect, because such rays are likely to injure the cellular tissues of these creatures. However, the inventors' study and experiments of long years show that the aforesaid view is wrong, namely, that application of ultraviolet rays (253.7 nm) together with erythemal rays (280.0 to 340.0 nm) in the suitable ratio to livestock, particularly to chickens at the rate of several hours per day produced the undermentioned effect.

The parts of the chicken body or surroundings exposed to a combination of germicidal and erythemal rays were directly sterilized. Since the air in the chicken house was disinfected every day, disease germs were exterminated, though they might temporarily intrude therein. The occurrence of diseases, for example, the Newcastle disease, was reduced, proving the preventative effect of said rays. Various germs prevailing in the chicken house were substantially stamped out, so that the bad smell peculiar to the chicken house was appreciably eliminated, contributing to the prevention of a public nuisance.

Application of combined sterilizing and erythemal rays had a further advantageous effect of promoting the health of chickens, elevating the rate of laying eggs, reducing their death rate, minimizing the possibility of soft or broken eggs being laid and accelerating the growth of chickens. Furthermore, there was observed no harmful effect of, for example, destroying the cellular tissues of chickens which application of said rays was expected to give. Based on the aforementioned experiments, the inventors have developed a low pressure mercury vapor discharge lamp capable of giving forth both sterilizing and erythemal rays at the same time.

A discharge lamp according to this invention uses fluorescent materials such as calcium zinc phosphate and/or lead activated calcium silicate and is so designed as to cause 45 to 75 percent of visible straight light beams to be transmitted to the outside of an envelope, so that the germicidal and erythemal rays may be radiated in the ratio less than 1.5. Where applied to livestock breeding, the discharge lamp of this invention displays the aforementioned effect. For example, chickens should receive erythemal rays at the rate of 0.2 to 1.0 E-viton hr/cm^2 per day, where the discharge lamp of the invention generates said amounts of erythemal rays, the ultraviolet rays emitted at the same time will not have a harmful effect on chickens. In contrast, the discharge lamp set forth in the aforesaid U.S. Pat. No. 2,445,692 projects ultraviolet and erythemal rays in the ratio of 1.5 to 9, that is, the ultraviolet rays accounting for considerable percentage. Therefore, where erythemal rays are emitted at the above-mentioned rate of 0.2 to 1.0 E-viton hr/cm^2 per day, the amounts of ultraviolet rays radiated at the same time prominently exceeds the allowable limit, causing cocks to present parched crest and hens to lay a decreased number of eggs, that is, fowls as a whole to be undergrown.

There will now be described by reference to FIG. 1 a low pressure mercury vapor discharge lamp according to an embodiment of the present invention. An envelope or bulb **10** assumes a narrow cylindrical form and has a pair of electrodes **11** and corresponding bases **12** sealed to both ends. The envelope **10** is formed of ordinary ultraviolet-ray transmissible glass or germicidal glass which allows more than 70 per cent of ultraviolet rays (253.7 nm) and less than about 20 per cent of mercury resonant lines (185.0 nm) generating health-injuring ozone to be transmitted. The inner surface of the envelope **10** is coated with a health-promoting fluorescent layer **13** consisting of calcium zinc phosphate in a suitable thickness (for example, 0.003 gr/cm^2) or preferably to such extent that the transmission τ of visible straight light beams attains 45 to 75 per cent. The term "transmission of visible straight light

beams" as used herein, means the rate at which visible light beams are allowed to pass through a fluorescent layer applied on the inner surface of the envelope to the outside thereof. In the envelope **10** there are filled small amounts of mercury and rare gases. The ratio of the filled amount of mercury to that of rare gases may be the same as in a known low pressure mercury vapor discharge lamp. For example, the mercury is only required to have a vapor pressure of 10^{-2} to 10^{-3} mm Hg.

The fluorescent layer is not limited to the aforementioned material, but may be formed of any material, for example, lead activated calcium silicate which can mainly give forth erythemal rays (280.0 to 340.0 nm).

There will now be given the reason why the thickness of the fluorescent layer is limited preferably to the range of $\tau = 45$ to 75 per cent. As apparent from FIG. **2**, the germicidal glass or boron silicate glass used in the aforementioned embodiment has the transmission-wavelength characteristics of allowing approximately 80 per cent of ultra-violet rays (253.7 nm) to be transmitted to the outside of a lamp. Referring to FIG. **2** the ordinate represents transmission (percent) and the abscissa wavelength (nm), transmission at the respective wavelengths being denoted by curve A.

A lamp using an envelope prepared from boron silicate glass presents such a distribution of spectro-energies as shown in FIG. **3**. In FIG. **3**, the ordinate represents relative energies, the abscissa wavelengths (nm), Q_1 the radiated energy of ultraviolet rays (253.7 nm) and Q_2 the energy of erythemal rays (peak value: 310.0 nm) radiated from a fluorescent layer **13**. As seen from FIG. **3**, substantially 100 per cent of the erythemal rays emitted from the fluorescent layer **13** are allowed to pass to the outside of the envelope.

FIG. **4** presents the values measured, when the thickness of the fluorescent layer is varied, of the per cent energy Q_1 of germicidal rays radiated to the outside of the lamp, the per cent energy Q_2 of erythemal rays similarly radiated to the outside, the total per cent energy Q of both rays thus radiated and ratio of Q_1 to Q_2. In FIG. **4** the left ordinate designates the amount of energy released to the outside of the lamp, the right ordinate the ratio of Q_1 to Q_2 and the abscissa the transmission of visible straight light beams. Since the transmission of visible straight light beams through the fluorescent layer is in inverse proportions to the thickness of the layer, said thickness is expressed by the transmission of visible straight light beams. In this case, the kind, particle size and distribution of the comminuted material forming the fluorescent layer may be deemed constant. The results of measurement show that the total amount of radiated energy attains a maximum when the transmission τ of visible straight light beams account for 55 to 65 per cent, namely, that if the transmission τ of visible straight light beams is so regulated as to fall within the range of 45 to 80 per cent then the amount of energy actually radiated outside of the envelope can be elevated to more than 90 per cent of the maximum radiation of energy. FIGS. **4** and **5** illustrate that a range of substantially half way between the optimum values of the relative energy and maintenance factor is 60 to 65 percent. The maintenance factor is discussed below.

However, the inventors' experiments disclose that the larger the transmission τ of visible straight light beams, the more reduced the output maintenance factor of rays released to the outside of the envelope. The results of measurement associated with this fact are presented in FIG. **5**. In this figure, the ordinate represents the output maintenance (percent) and the abscissa the duration of lighting the lamp (hr). The experiments also indicate that there is obtained a preferable maintenance factor when τ stands at below 75 per cent. Preparation of a fluorescent layer whose thickness is sufficiently thin to allow τ to rise above 75 per cent is appreciably difficult from the practical standpoint. Moreover, where the thickness of the fluorescent layer is so reduced as to cause τ to rise higher than 75 per cent, there will be the disadvantage that the energy of erythemal rays is released outside of the envelope in smaller proportions than that of sterilizing rays. On the other hand, if τ falls below 45 per cent, the proportions of energy of sterilizing rays emitted outside of the lamp will, of course, be far more reduced than those of erythemal rays. Accordingly, if the thickness of the fluorescent layer is so regulated as to cause τ to fall within the range of 45 to 75 per cent, it will be possible effectively to radiate the respective sterilizing and erythemal rays without decreasing the total amount of released energy.

A low pressure mercury vapor discharge lamp according to the present invention of 15 W rated capacity formed of an envelope about 25 mm in outer diameter and about 436 mm long, the inner surface of which was coated with a fluorescent layer having such thickness as allowing the transmission of visible straight light beams to stand at 60 per cent, radiated sterilizing rays (257.3 nm) at the rate equal to about 60 per cent of that obtained by the 15 W sterilizing ray lamp and erythemal rays (280.0 to 340.0 nm) at the rate corresponding to about 80 per cent of that realized with the conventional 20 W fluorecent sun ray lamp. The mercury vapor discharge lamp of the invention indicated about 2 to 2.5μW/cmintensity of sterilizing rays and about 0.1 E-viton/cm^2 intensity of erythemal rays at a point 2.5 meters distant.

The aforementioned mercury vapor discharge lamp of the invention was switched on three times per day (morning, noon, and evening), each time 1 to 1.5 hours totalling 3 to 4.5 hours. The sterilizing and erythemal rays projected from the lamp were applied to grow chickens and the chicken house. As a result it was confirmed that the lamp effectively disinfected the air in the chicken house, substantially removed the objectionable odor characteristic of said house, prevented chickens from suffering infections diseases and moreover promoted their physical strength. Needless to say, the rate of laying eggs by hens was noticeably improved.

For reference, there will now be described the experimental method used.

EXPERIMENTAL METHOD

Lamp used and their arrangement (Three-tiered chicken house)

Six lamps were employed at a height of 2.5 meters above the floor, the shortest distance from the chicken head being about 1 meter.

Time of irradiation

Morning and evening	Each time 1.5 hours, totalling 3 hours per day.

Division of tested objects

Item	Group Irradiated	Not irradiated
Total number of chickens	93752	96457
Floor space	85.8 m²	85.8 m²
Number of lamps fitted	6	0

Results

group	month	Item Average egg weight per hen (gr)	Death rate	Number elected out	Number of soft or broken eggs
Irradiated	Sept. 1967	39.4	11	40	57
	Oct.	41.4	2	41	41
	Nov.	40.4	0	57	40
	Dec.	39.1	0	47	15
	Jan. 1968	38.4	0	54	23
	Feb.	41.6	0	32	11
Not Irradiated	Sept. 1967	39.0	4	48	101
	Oct.	41.1	4	48	78
	Nov.	38.2	0	69	76
	Dec.	38.3	1	51	37
	Jan. 1968	36.6	4	51	52
	Feb.	39.6	2	32	23

As seen from above table, increase in the weight of laid eggs per month averaged 38 gr per hen, and attained 60 gr (even equal to the weight of about one egg) three months after the initial irradiation.

Though it ran high in September, the death rate sharply decreased later. Particularly, reduction in the number of soft or broken eggs is deemed due to the powerful effect exerted by the description and precipitation of calcium in the chicken body which was promoted by mineral metabolizn.

The foregoing description relates to a low pressure mercury vapor discharge lamp of the present invention capable of giving forth both sterilizing and erythemal rays at the same time.

What we claim is:

1. A low pressure mercury vapor discharge lamp radiating germicidal and erythemal rays in the ratio of less than 1.5, comprising:

an envelope made of germicidal ray transmissible glass, said envelope having a transmissivity to ultraviolet rays of more than about 70 percent and to mercury resonant lines generating health injuring ozone of less than about 20 percent;

mercury and rare gas filled in said envelope;

a pair of electrodes sealed to both ends thereof; and

a fluorescent layer formed of at least one material selected from the group consisting of calcium zinc phosphate and lead activated calcium silicate, deposited on the inner surface of said envelope, said envelope and deposited fluorescent layer having a transmissivity of 45 to 75 percent of visible straight light beams.

2. A low pressure mercury vapor discharge lamp according to claim 1 wherein said envelope and deposited fluorescent layer has a transmissivity of 55 to 65 per cent of visible straight light beams.

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