DEVICE OF LUMINESCENT LIGHT BULBS WITH DEFECTED FILAMENTS

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Abstract. In contradiction to the already known electrical lighting device which contains voltage duplicator and in the output of which through the ballast resistor one luminescent light bulb with the filament of end electrode being burned out is attached, in the offered device from repeatedly increased capacity condensers and proportionally lesser resistor semiconductor diodes a voltage fourfold of symmetrical scheme is made at the output of which several in a chain joined luminescent light bulbs with electrode filaments being burned out are attached. On the cylindrical corpus of bulbs metallic surface electrodes are equipped which simultaneously serve as improving elements of their running circumstances and over-commutable shunting links. Fail-self performance conjecture of scheme elements estimated in the valuation of the device's safety additionally characterises exploitation advantages for the new device.

Keywords: luminescent light bulbs, voltage fourfold, defected filaments, system safety.

Introduction

The device [1], which contains a chain connection, made of ballast incandescent bulb and voltage duplicator at the output of which one luminescent light bulb with burned out electrode is attached is well-known. The device is characterized by the following shortages. It is possible to exploit only one defected bulb with reduced and unregulated light yield. The output voltage (600 V) does not secure stable scheme performance in all possible regimes of exploitation. Lack of scheme protection against the possible overload and short circuit regimes.

In the development of the new device the following aims are set: to increase the common light yield, to carry out variously adjustable local lighting, to increase the degree of exploitation safety, to reduce the prime cost and gain the economy of electrical energy.

Materials and Methods

The set aims are achieved by forming voltage fourfold, at the output of which several in a chain joined luminescent light bulbs are attached with burned out filaments of the end electrodes, of repeatedly increased capacity condensers and proportionally lesser resistor (increased nominal current) semiconducting diodes. It is well known that in the lighting devices of voltage multipliers, in the case of increase of condenser capacity, also the working voltage [2] and current [3] of the energized luminescent light bulb increases. It is used in the offered technical solution [4] by creating this symmetrical scheme voltage fourfold of improved parameters (Figure 1) which in the attached defected luminescent light bulbs fully secures the necessary ionization of gas blow for the loading of voltaic ark for their successful burning and exploitation in such a way highly increasing the power efficiency of the device.

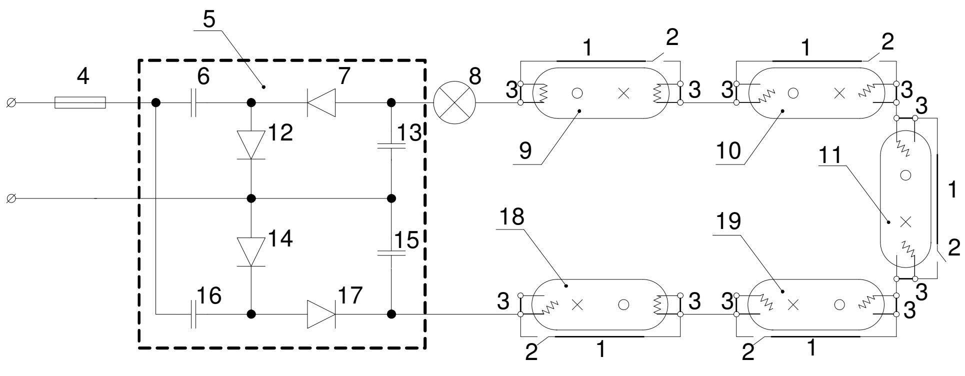

Fig. 1. **The device of the luminescent light bulbs with defected filaments**

On the cylindrical corpus of bulbs metallic surface electrodes 1 are set, which simultaneously serve as improving elements of their running circumstances and over-commuting shunting links. The outputs of the bulb electrodes are linked with little metallic plates 3 in such a way stabilizing emission of electrons from burned out filaments. The safety fuse 4 protects the elements of rectifier 5 against possible overloads and short circuits in the chain of luminescent light bulbs thus greatly increasing the device's degree of exploitation safety.

Figure 1 shows experimentally inspected accordingly defected luminescent light bulb joining where: bulb of trademark 9-20 W "Pila" with intact electrodes, bulb of trademark 10-20 W "Pila" with both end electrodes burned out, bulbs of trademark 11, 19-16 W "Narva" with both end electrodes burned out, bulb of trademark 18-16 W "Narva" with one electrode burned out.

Circuitry performs as follows. When connecting the device to 220 V alternating current, in the odd half-cycles, the condenser 16 through the diode 14 charges up to the value (≈300 V) of feeding wiring range becoming a source of current. Therefore, during the half-cycles of the couples when the net has opposite polarity condenser 15 through the diode 17 charges up to the double value (≈600 V) of the net's current range. This current corresponds to the sum of the feeding net voltage maximum value and the voltage of the condenser 16. Taking into account the scheme's symmetry analogically the condenser 6 through the diode 12 charges up to the net voltage amplitude in the same way. Whereas the condenser 13 charges up to the double voltage maximum value which consists of the condenser 6 and the sum of the net amplitude voltage (600 V). Since the condensers 13 and 15 are joined in a chain their voltages summarize reaching fourfold value of feeding alternating current net amplitude (≈1200 V). To this pulsing direct voltage several in a chain connected luminescent light bulbs are joined with the filaments of defected end electrodes. May also be exploited luminescent light bulbs with filaments of intact or damaged both electrode ends (Figure 1). During the exploitation the condensers 13 and 15 obtain functions of ballast resistance thus increasing stability of bulb performance.

When manipulating with switches 2 electrical feeding may be delivered to any bulb group thus carrying out their locally modifiable exploitation and relieving the device's running circumstances in total. For example, in order to burn bulbs 18 and 19, shunting switches 2 for bulbs 9, 10 and 11 should be switched off. The total amount of joined bulbs depends on their nominal circuit voltage, level of voltage ignition and nature of electrode defects.

The incandescent bulb 8 at the device's joining to the net serves as the restrictor of running current but after the burning of luminescent light bulbs it may be used as an additional light source. The incandescent bulbs rated capacity may be changed according to the demanded current intensity by the luminescent bulbs chain in each concrete case.

Results and Discussion

Calculations of main safety indices of the device's exploitation [5].

Variant 1. The impulse-mode ignition scheme (Figure 2) consists of the start-up (starter) S5, throttle d2, condenser C3 and bulb L4. The start-up S5 is a small neon bulb with two electrodes – rigid and moving (bimetallic) which curves when being heated and closes electric circuit with rigid contact [6].

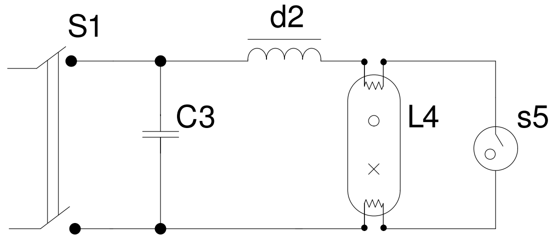

Fig. 2. **Classical scheme of luminescent light bulb running**

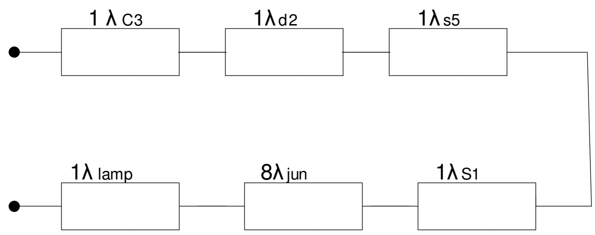

Fig. 3. **The logical scheme of the safety of computerized scheme**

Since the exponential safety rule is in full force and effect the system total failure intensity may be calculated by the formula:

$$\lambda s = \sum_{j=1}^{k} n_j \lambda_j \tag{1}$$

where n_j – number of elements in j-ing group,
λ_j – failure intensity of j-ing group elements,
k – number of homogenous elements.

The calculation data on the failure intensity λ_s (Figure 3) and the results are given in the Table 1. The main system safety indices $P(t)$, $Q(t)$ and $A(t)$ (Table 3 and Figures 6-8) are set using the calculated λ_s.

Table 1

The calculation of scheme failure intensity λs for classic luminescent bulb running

Designation	**Amount**	λ_{nom}, $10^{-6}\cdot h^{-1}$	λ_{nom}, group $10^{-6}\cdot h^{-1}$	*Ks*	*α* (θ=20 °C)	**Group failure intensity, $10^{-6}\cdot h^{-1}$**
Condenser C3	1	0.330	0.330	0.5	0.045	0.01485
Throttle d2	1	0.250	0.250	0.5	0.450	0.11250
Lamp L4	1	0.200	0.200	0.5	0.600	0.12000
Starter s5	1	0.950	0.950	0.5	0.600	0.57000
Automatic switch S1	1	0.550	0.550	0.7	0.600	0.33000
Junction	8	0.001	0.008	1.0	1.000	0.00800
					Total:	**1.15535**

Then the system average fail-self performance time may be expressed by the total failure intensity:

$$Tv = \frac{1}{\lambda_s} = \left(\frac{1}{1.16}\right)\cdot 10^6 h = 8.6\cdot 10^4 h\,. \tag{2}$$

System gamma – proportional resource:

$$ty = -8.6\cdot 10^4 \ln 0.9 = 9061h\,. \tag{3}$$

Variant 2. Device prototype of luminescent light bulbs with defected filaments (Figure 4).

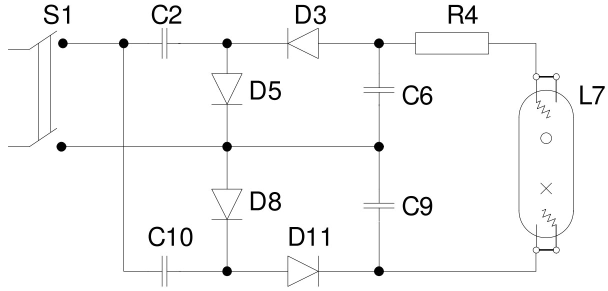

Fig. 4. **The scheme of the defected filament luminescent light bulb running**

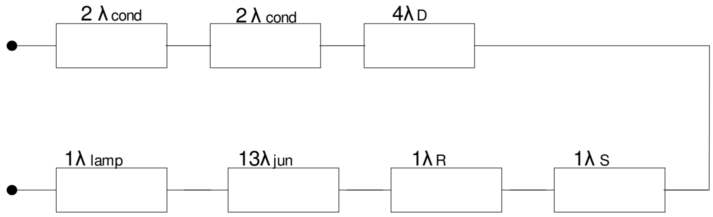

Fig. 5. **The logical scheme of the defected filament luminescent light bulb running safety**

The total failure intensity of the system may be calculated by the formula (1).

The calculation data for the failure intensity λ_s (Figure 4) and the results are given in Table 2. The main system safety indices $P(t)$, $Q(t)$ and $A(t)$ (Table 4 and Figures 6-8) are defined by using the calculated λ_s.

Table 2

The calculation of the failure intensity λs for defected filament luminescent light bulb running scheme

Designation	**Amount**	λ_{nom}, $10^{-6}\cdot h^{-1}$	λ_{nom}, group $10^{-6}\cdot h^{-1}$	*Ks*	**α** (θ=20 °C)	**Group failure intensity, $10^{-6}\cdot h^{-1}$**
Condenser C2;C10	2	0.330	0.660	0.3	0.045	0.0297
Condenser C6;C9	2	0.300	0.600	0.3	0.045	0.0297
Diode D3;D5;D8;D11.	4	0.105	0.420	0.5	0.200	0.0840
Resistor R4	1	0.220	0.220	0.4	0.200	0.0440
Lamp L7	1	0.100	0.100	0.7	0.600	0.0600
Automatic switch S1	1	0.550	0.550	0.7	0.600	0.3300
Junction	13	0.001	0.013	1.0	1.000	0.0130
					Total:	**0.5904**

The average fail-self performance time of this system may be expressed by the total failure intensity:

$$Tv = \frac{1}{\lambda_s} = \left(\frac{1}{0.59}\right)\cdot 10^6 h = 16.9\cdot 10^4 h \tag{2a}$$

System gamma – proportional resource:

$$ty = -16.9\cdot 10^4 \ln 0.9 = 17805h \tag{3a}$$

Table 3

Safety indices for variant 1

Safety indices (*h*)	5000	10000	15000	20000	25000	30000
$P(t)$	0.994	0.988	0.983	0.977	0.971	0.966
$Q(t)$	0.006	0.012	0.017	0.023	0.029	0.034
$A(t)$	1.153	1.147	1.140	1.133	1.127	1.120

Table 4

Safety indices for variant 2

Safety indices (*h*)	5000	10000	15000	20000	25000	30000
$P(t)$	0.997	0.994	0.991	0.988	0.985	0.982
$Q(t)$	0.003	0.006	0.009	0.012	0.015	0.018
$A(t)$	0.588	0.587	0.585	0.583	0.581	0.580

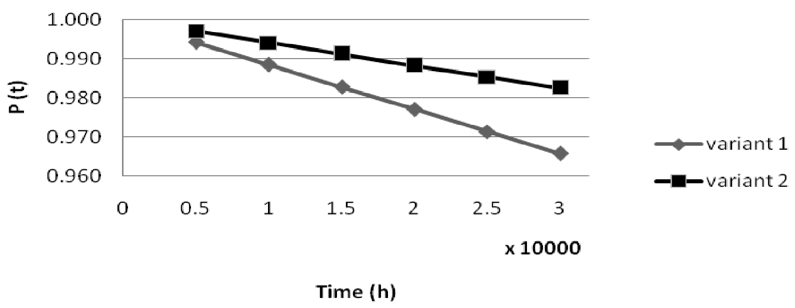

Fig. 6. **Fail-safe performance probability for variants 1 and 2**

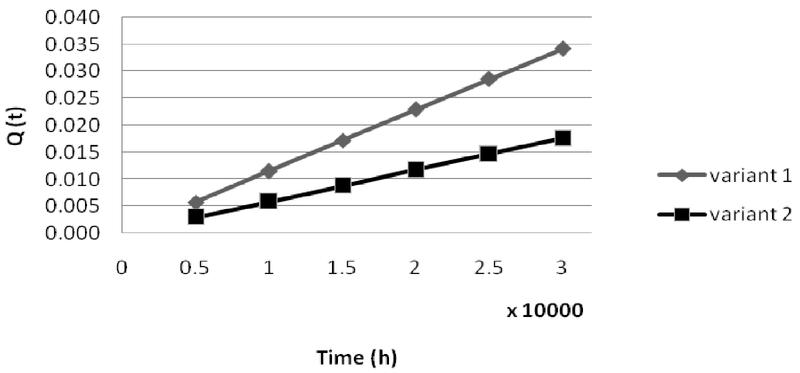

Fig. 7. **Failure probability for variants 1 and 2**

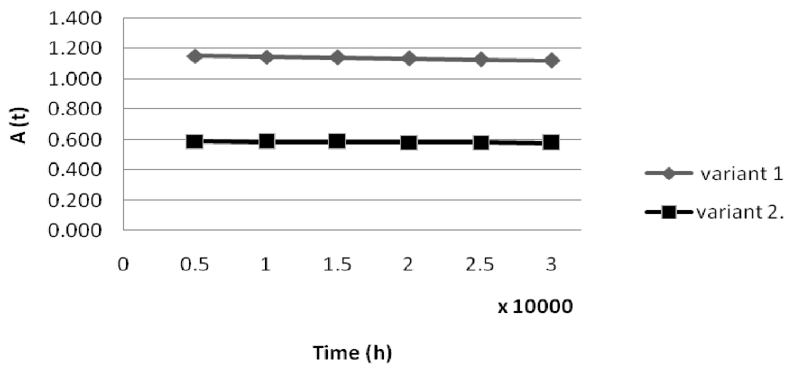

Fig. 8. **Failure frequency for variants 1 and 2**

The calculation of the comparable device costs [7]. In Table 5 there are listed the amount and price of elements of both comparative devices. In the result there the price of the installation for one device is calculated.

Table 5

The table of device cost calculation

Variant 1	**amount**	**LVL on 1 unity**	**LVL total**	**EUR**
Condenser	1	0.56	0.56	0.80
Throttle	1	3.00	3.00	4.29
Starter	1	0.20	0.20	0.29
		Total:	**3.76**	**5.38**
Variant 1	**amount**	**LVL on 1 unity**	**LVL total**	**EUR**
Condenser	4	0.56	2.24	3.20
Diode	4	0.03	0.12	0.17
Resistor	1	0.50	0.50	0.71
		Total:	**2.86**	**4.08**

Conclusions

The economic effectiveness of the device shows as follows: simultaneous exploitation of several defected filament luminescent light bulbs increases the device's light yield for ≈500 %, the actual cost is reduced for four times and the economy of electric energy is gained up to 30 %. The use of shunting links easies bulb running and secures their variable exploitation accordingly to the needs of local lighting which increases the energy effectiveness of exploitation for 25 %; and the use of safety fuse increases the device's safety for 20 %.

The safety calculation for the scheme elements demonstrates the reduction of the offered device's failure probability in comparison with the standard luminescent bulb devices.

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