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A BUOY-LIGHT FLASHER WITH SCINTILLATING XENON LAMP

W. WYSLOUZIL

OTTAWA

DECEMBER 1966

ABSTRACT

In buoy-light service a xenon flash tube promises to be a more reliable light source than the conventional filament lamp, particularly under conditions of shock and vibration. The unit described is built with solid state devices, and generates bursts of flashes whose effective intensity is somewhat greater than that of a filament lamp consuming the same power.

CONTENTS

FIGURES

A BUOY-LIGHT FLASHER WITH SCINTILLATING XENON LAMP

- W. Wyslouzil -

SPECIFICATIONS

Input voltage range:	+7 to +15 volts dc
Input current (with 11-volt supply):	During burst: 440 ma During eclipse: 5 ma
Output energy:	0.35 ws/flash or 0.52 cds/flash
Over-all electrical efficiency:	72%
Flash tube type:	FX-6A (E.G. and G.)
Flash character:	0.4 second flash, comprising 5 discharges of xenon lamp; 3.6 second eclipse
Operating temperature range:	-30°C to +60°C

INTRODUCTION

The unit to be described was designed to be at least equivalent in effective light intensity to an incandescent lamp with the same power consumption. Since no particular intensity was specified, a 12-volt 0.55-ampere incandescent lamp was chosen as a reference. As will be shown, the over-all electrical efficiency of the flasher need only be approximately 53% to achieve an equivalent light intensity.

Generally, the Department of Transport "Specification for Solid State Flasher with Scintillating Xenon Lamp" was taken as a guide in the design of the unit. The requirement that the flash intensity be constant for supply voltages from 9.6 to 12 volts implies some sort of regulation which would decrease the over-all efficiency, while adding to the complexity of the circuit, and was not incorporated in the unit at this time.

CONDITIONS FOR EQUIVALENT LIGHT INTENSITY

To determine the over-all electrical efficiency of the flasher to provide a light intensity equivalent to that of an incandescent lamp consuming the same power, some basic assumptions have to be made:

1) The filament lamp constitutes an isotropic source so that $I = \frac{L}{4\pi}$,

where I = candlepower
L = total flux emitted

2) The effective candlepower of an incandescent lamp flashed for 0.5 second is

$I_{eff} = 1.3 \times \text{cds}$, where I_{eff} = effective candlepower
cds = candlepower-seconds in flash
1.3 = Blondel-Rey Merit Factor

3) The effective candlepower of a flash tube is given by $I_{eff} = 5 \times \text{cds}$

4) The conversion efficiency of a flash tube is such that 1 watt-second yields 1.5 candlepower-seconds

5) The effective intensity of a burst of 5 flashes is 1.5 times the effective intensity of one of the component flashes isolated from the others, according to T.H. Projector (private communication).

Now consider a 12-volt 0.55-ampere (6.6 watt) filament lamp. According to a Wallace and Tiernan catalogue, L = 75 lumens and $I = \frac{75}{4\pi} = 6$ candlepower.

Therefore, the candlepower-seconds in a 0.5-second flash is $6 \times 0.5 = 3$ cds and $I_{eff} = 3 \times 1.3 = 3.9$ candlepower.

For the flash tube, $I_{eff} = 5 \times \text{cds}$, so that the light energy required for a single equivalent flash is $\frac{3.9}{5} = 0.78$ cds. The electrical energy required to yield this light energy is $\frac{0.78}{1.5} = 0.52$ watt-seconds. However, a burst of pulses is to be used; this reduces the energy required per pulse by 1.5, so that the energy per pulse in the burst is $\frac{0.52}{1.5} = 0.35$ watt-seconds.

The average power delivered to the flash tube during the burst — assuming a scintillating rate of 10 pps — is $0.35 \times 10 = 3.5$ watts.

The power consumed by the filament lamp while it is turned on is 6.6 watts. Therefore, the over-all electrical efficiency required of the xenon flasher for the same effective light intensity as the filament lamp consuming the same power is $\frac{3.5}{6.6} = 53\%$.

DESCRIPTION OF CIRCUITRY (Fig. 1)

The flasher comprises a dc-to-dc converter followed by a dc resonant charging circuit, a flash tube high-voltage trigger supply, and timing circuits to switch the converter and determine the flash character.

1) DC-to-DC Converter

The converter is of the conventional push-pull configuration, with the exception of the R-C network (470 ohms, 0.22 μF) which provides reliable starting without wasting power during operation. The 470-ohm resistor limits the power the converter can deliver to the load and should be as large as possible for maximum efficiency. The converter output is rectified and filtered.

DC resonant charging is employed to transfer energy to the storage capacitors supplying the flash tube (Figs. 2 and 3). If the capacitors were charged through a resistor, half the energy would be dissipated by the resistor, regardless of its value.

2) Flash Tube High-voltage Trigger

A high-voltage (4 to 7 kv) low-energy pulse is required to trigger the flash tube and initiate ionization of the gas. A silicon controlled rectifier (S3) is used to discharge a capacitor through the primary of a pulse transformer. This produces a high-voltage pulse across the secondary which is coupled to the firing electrodes of the flash tube through six small capacitors. The rectifier is turned on by a unijunction relaxation oscillator (UJ3) operating at 10 pps, gated by the timing circuit to generate the proper flash character (Fig. 4).

3) Timing Circuits

The timing circuit comprises two silicon controlled switches (S1, S2) and two unijunction transistor relaxation oscillators (UJ1, UJ2), as shown. One of the unijunction transistors, UJ1, operates continuously, and is adjusted by means of R1 to provide a positive pulse every 4 seconds, the specified period of the flash character. This pulse turns on S1, applying voltage to the second unijunction oscillator UJ2 which is adjusted to generate a pulse approximately one-half second after the voltage is applied. This triggers on S2 to turn off S1 by commutation through the 0.01 μF capacitor. Thus, a timing pulse with individually adjustable repetition rate and width is generated at the cathode of S1 and applied to the base of Q3.

The output at the emitter of Q3 energizes the trigger circuit of the flash tube, which then generates trigger pulses at a rate of 10 pps for the duration of the timing pulse. The timing-pulse width is adjusted so that a burst of only 5 pulses is generated. The output at the collector of Q3 saturates Q4, connecting the converter biasing resistor to the supply. Owing to a small delay between the leading edge of the timing pulse and the first trigger pulse of the flash tube, the converter is allowed to start under no-load conditions.

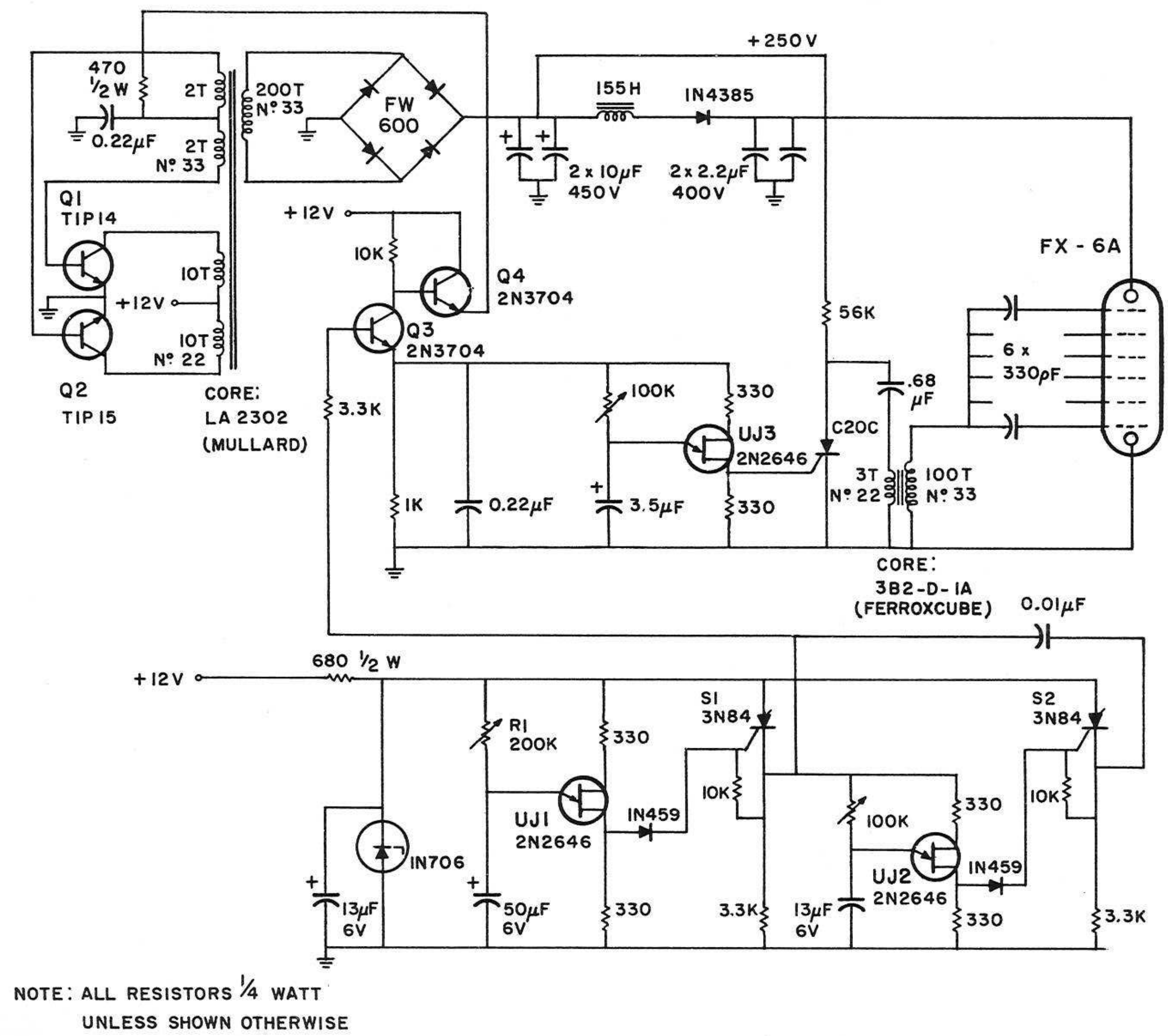
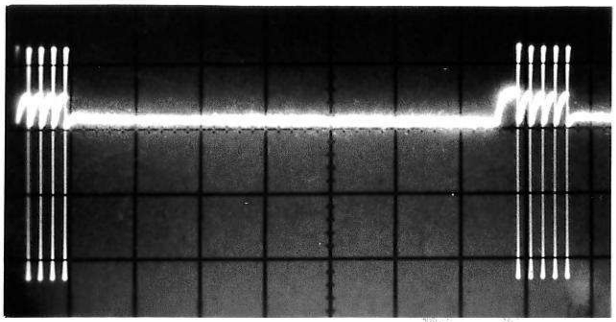
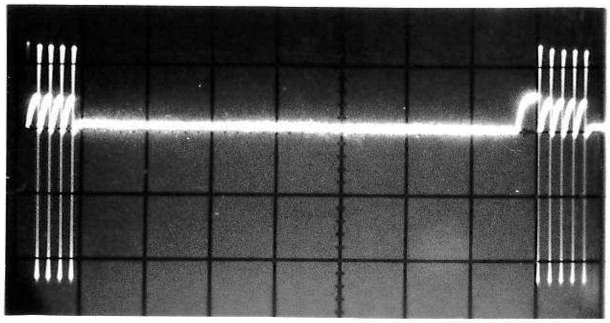


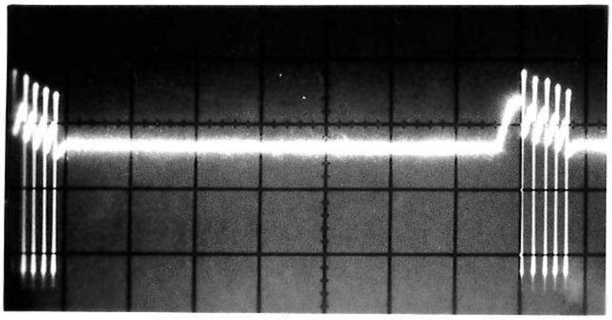
Fig. 1 Circuit diagram of buoy-light flasher



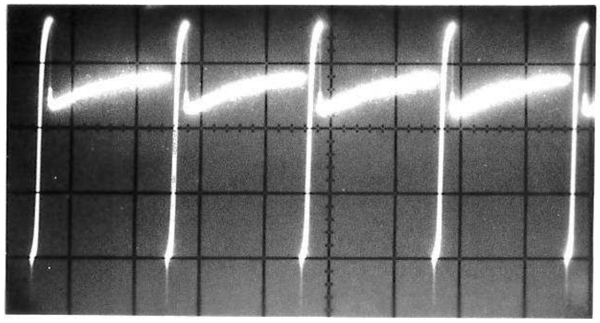
(a) Horizontal: 0.5 second/cm
Vertical: 100 volts/cm +60°C



(b) Horizontal: 0.5 second/cm
Vertical: 100 volts/cm +30°C



(c) Horizontal: 0.5 second/cm
Vertical: 100 volts/cm -30°C



(d) Horizontal: 0.05 second/cm
Vertical: 100 volts/cm +30°C

Fig. 2 Output waveforms at charging choke at various temperatures (note timing stability)

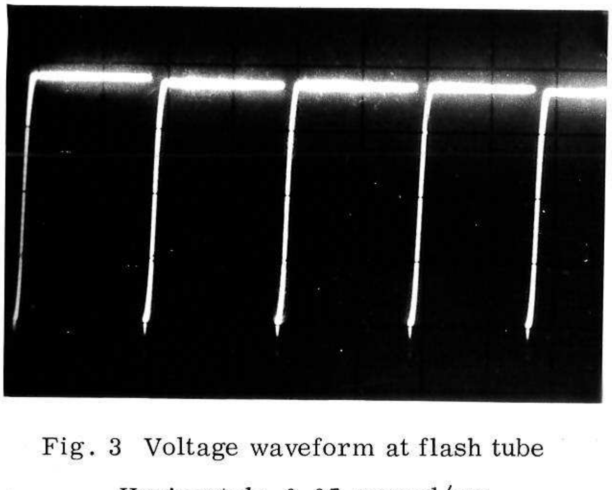


Fig. 3 Voltage waveform at flash tube
Horizontal: 0.05 second/cm
Vertical: 100 volts/cm

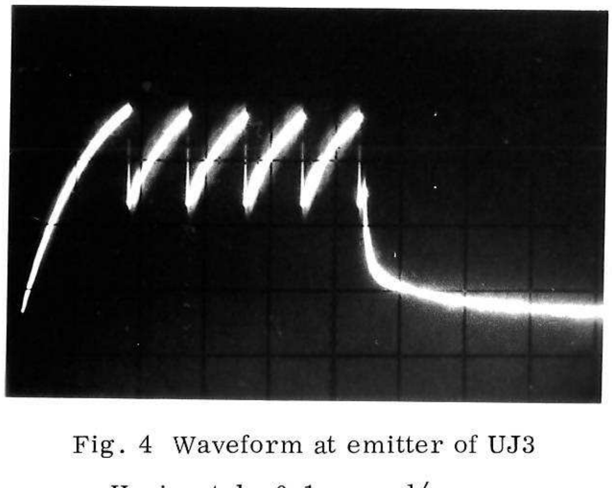


Fig. 4 Waveform at emitter of UJ3
Horizontal: 0.1 second/cm
Vertical: 1.0 volt/cm