Signalite
APPLICATION NEWS
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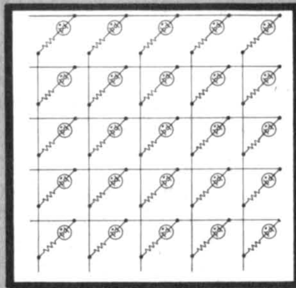


VOL. I, NO. 2

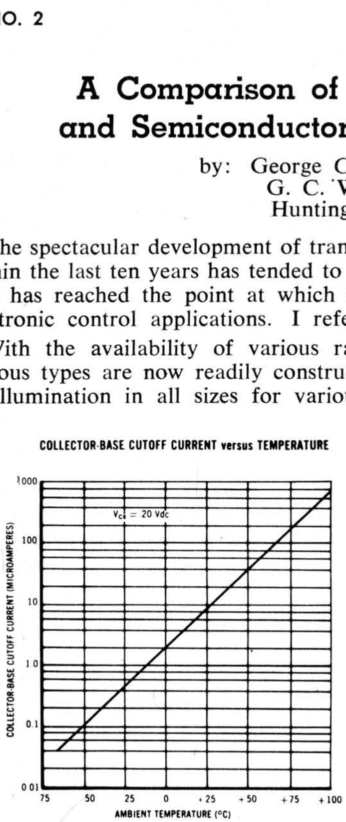
A Comparison of Cold Cathode Tubes and Semiconductors as Control Elements

by: George C. Wilson, President
G. C. Wilson & Co.
Huntington, W. Va.

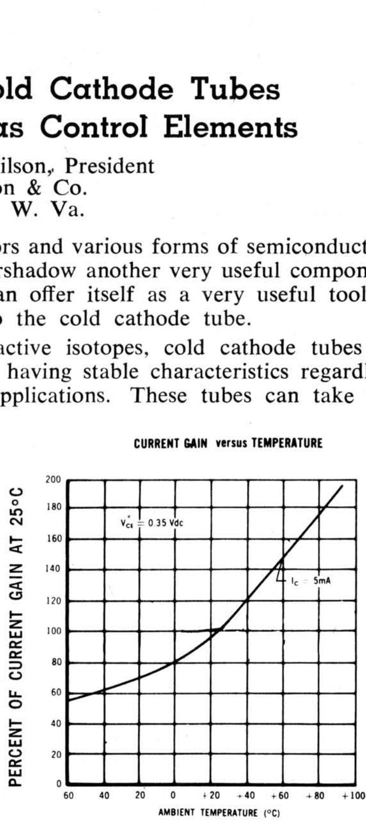
The spectacular development of transistors and various forms of semiconductors within the last ten years has tended to overshadow another very useful component that has reached the point at which it can offer itself as a very useful tool in electronic control applications. I refer to the cold cathode tube.

With the availability of various radioactive isotopes, cold cathode tubes of various types are now readily constructed having stable characteristics regardless of illumination in all sizes for various applications. These tubes can take the

COLLECTOR-BASE CUTOFF CURRENT versus TEMPERATURE



CURRENT GAIN versus TEMPERATURE



Stable operation of transistors requires that the operating point (quiescent point) not vary with changes in temperature. It can be seen from the Collector-Base Cutoff Current chart that a transistor which is reversed biased and cut off at + 25° can be turned on at + 75° if a 20 times increase in Icbo through the base input impedance overcomes the reverse bias. In timing circuits the change in base input resistance with temperature causes unstable time constants. Current gain change with temperature is shown in the second chart.

form of diodes for such applications as voltage regulation, trigger tubes, memory tubes, as well as indicators. Cold cathode triodes are available for control applications such as timers, electronic relays, level controls, wireless remote control, photo-electric controls, computers, temperature controllers and many other applications.

The circuit designer, using semiconductors, frequently finds that two serious short comings exist in such devices. One is because of the very low thermal mass in the barrier region, and the other is because of the very high voltage gradients which can exist in the barrier region.

The very low thermal mass causes semiconductor devices to be seriously damaged, in some cases resulting in complete failure due to current surges such as may occur when equipment is initially turned on. The surges can be of very short duration and still result in over heating of the barrier region.

The very high voltage gradients occurring at the barrier region can result in puncture in the reverse direction of semiconductors such as diodes by voltage transients occurring on the power lines resulting from the removal of power from power contactors, transformers and other devices having inductance. These transients can be as short as one microsecond and still result in puncture and total failure of the semiconductor device.

Protection against both these sources of premature failure can be provided in many cases. However, these protective devices do add to the cost as well as to the number of components involved for a given control application.

Neither of these shortcomings is evident in cold cathode devices. Neither voltage nor current surges of short duration cause failure or even damage to cold cathode tubes. As a consequence, for a given control, they are generally less expensive, less complex and require fewer auxiliary components than semiconductors.

Another big advantage of cold cathode tubes over semiconductor devices is their relative insensitivity to temperature changes. Temperatures normally encountered in industrial applications from zero to 120 Fahrenheit result in little or no change in the characteristics of cold cathode tubes.

The life of cold cathode tubes is generally determined by the amount of current load at which the tubes are operated. Failures are generally not of a catastrophic nature but occur gradually, making it more susceptible to maintenance than for semiconductor devices. In other words, when your control begins to malfunction occasionally you know it is time to check your cold cathode tubes. With semiconductors, generally the devices fail completely without previous warning.

Cold cathode circuits require minimum voltages of sixty to seventy volts DC for operation. They can readily be used on 115 volts AC or its rectified counterpart, 150 volts DC, which is readily obtainable from the normal power outlets available in industrial or commercial installations.

As with semiconductors no filaments are involved and no warm up time is required. However, semiconductor devices generally will require a step down transformer in order to reduce the supply voltage of 115 volts AC to voltages of the order of 25 to 50 volts. The low voltage aspects of semi-conductors are, of course, advantageous for portable equipment where batteries or low voltage DC generators are available. This, however, is not the case for most industrial applications which operate on 115 volts or 220 volts AC.

Cold cathode tubes tend to be more rugged from the standpoint of installation or maintenance than semiconductor devices. They are not effected by the temperatures normally encountered during the soldering of their electrodes or output leads to other components or terminals. With semiconductor devices it is generally necessary to use some sort of a heat sink to prevent the soldering temperatures from damaging the semiconductor device.

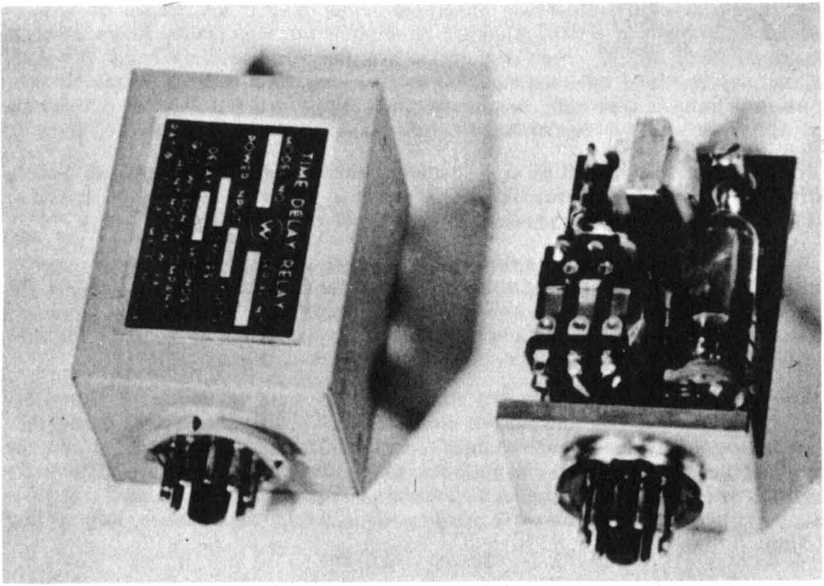


FIGURE 1

Electronic Time Delay Relay, Model 591, uses three Signalite RT2-32-1A cold cathode diodes and one cold cathode triode. The three diodes can be seen in the upper left section of the uncovered time delay unit. (See photo).

TYPICAL OPERATION

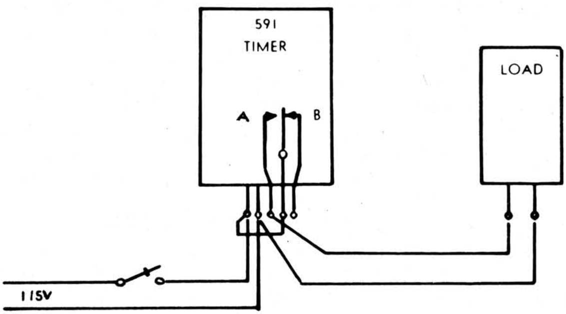


FIGURE 2

When 115 volts is switched on, Model 591 Time Delay begins. After preset time delay, relay in Model 591 operates and switches power to load. If contact B is used instead of A, Power is switched to load when 115 volts is switched on timer and disconnected from load at end of preset time delay.

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A condensation of the Arc-Suppressor story (Vol. I, No. 1) appeared in the July, 1963 issue of E E E Magazine.

A recent development which illustrates some of the advantages of a cold cathode assembly over a semiconductor assembly is the Time Delay Relay which is illustrated in Figure 1. This is a device designed for operation from 115 volts AC employing three cold cathode diodes and one cold cathode triode in conjunction with an output relay to provide time delays in a range from .02 seconds up to 300 seconds. A description of the circuit operation is given in Figure 2.

In view of the fact that cold cathode diodes can be constructed having extremely high leakage resistance, it is possible to use a very high resistance value with relatively small capacitors in order to obtain long time delays.

A similar semiconductor device would require a capacitance several tens of times greater than one microfarad because of the low impedance nature of the semiconductor device. The cost of such a capacitor for example having a capacitance of seventy microfarads would be several times as great as the cost of the one microfarad capacitor required in the cold cathode delay unit.

The accuracy or repeatability of the time delay unit, of course, is dependent entirely upon the voltage breakdown characteristic of the cold cathode diode. We have had extremely good results using a Type RT-2-32-1A tube produced by Signalite Inc., Neptune, N. J., which incorporates within the glass envelope a radioactive material which provides residual ionization so that stable, repeatable breakdown characteristics are available with varying light levels, and over a long period of time.

CIRCUIT DIAGRAM

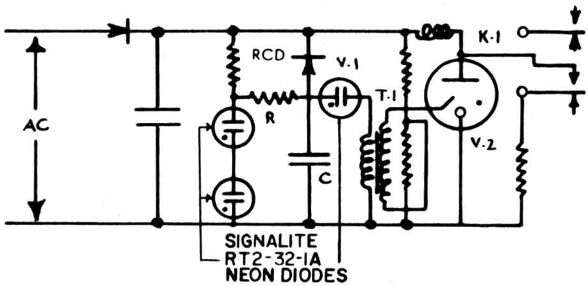


FIGURE 3

A simplified circuit diagram of the Electronic Time Delay Relay is shown. Operation is as follows: AC power applied as shown is rectified, filtered and regulated by the two Signalite RT2-32-1A cold cathode diodes and used to charge capacitor "C" through a resistance "R". When the charge on "C" reaches the ionization potential of cold cathode diode V-1, it discharges "C" through transformer "T-1" in a momentary impulse. This impulse is stepped up and used to ionize the cold cathode triode "V-2", which energizes relay "K-1". Time delay can be recycled before time out by momentarily shorting "C". It can be recycled after time out by removing AC and shorting "C", or by providing recycle diode "RCD" connected as shown. For remote time adjustment, resistor "R" is located outside of timer. When timer times out, contacts on relay K-1 remove load from output tube.

In order to insure that the timing will be independent of variation in the power supply voltage, a regulated charging voltage is established by using two cold cathode diodes in series as voltage regulation. (Figure 3) With this arrangement it is quite practical, at minimum expense, to obtain timing variations as low as two percent with line voltage variations as great as twenty percent.

Since all of the active elements in the time delay unit are cold cathode tubes, no heat is generated and it is quite practical to have the complete unit enclosed in a metal can, either hermetically sealed or as a dust tight enclosure.

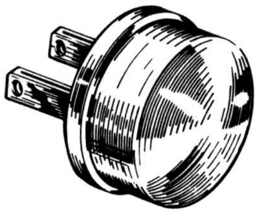
The Time Delay Relay is not affected by voltage transients, is not damaged by current surges caused by turning it off and on, is unaffected by temperatures in the range of 40 to 120 degrees Fahrenheit and provides time delays in the range of .02 to 300 seconds for a price of $20.00 or less.

In conclusion we believe serious consideration should be given to the use of cold cathode tubes for industrial applications operating from normal power sources, in view of the many advantages of these devices which have been stated.

About the author —

GEORGE C. WILSON

A former member of technical staff at Bell Telephone Laboratories and a graduate of Carnegie Institute of Technology. Mr. Wilson holds patents in the field of Timing Controls and is President of G. C. Wilson & Co. His company is one of the leading manufacturers of Electronic Timing Controls.



A Signalite Owl Eye Nite Lite for the home will be sent free to each person who sends a problem or solution.

Your Glow Lamp Application Forum

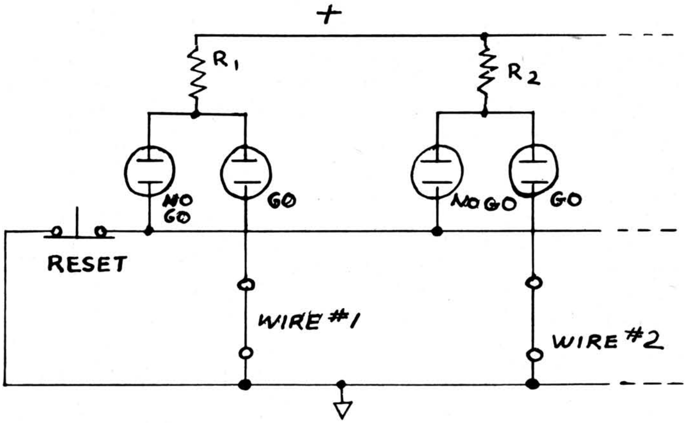
It is Signalite's policy to publish letters based on their intrinsic interest only. We do not necessarily agree with all comments and suggested uses and will upon occasion wait for your reaction before taking editorial space for ours.

Inexpensive harness tester

Dear Sirs:

The difference between the firing voltage and the extinguishing voltage of a glow lamp forms the basis of a compact, inexpensive harness tester. Unnecessary complexity and expense is avoided by using a neon-lamp flip-flop rather than a transistor or SCR system to continuously monitor each individual wire in a cable harness.

Environmental specifications on harnesses frequently require that wire continuity be checked while the harness is undergoing vibration or shock test. When the harness contains hundreds of wires, a considerable amount of electronic gear is required to monitor each wire individually and continuously. Some simplified test methods check only for the existence of failure but do not indicate which wire has failed. Others rely on a sampling (stepping) procedure, and will therefore overlook momentary failures.



Evidently, a method that monitors each wire individually for a momentary open circuit is to be preferred so long as the total complexity is not excessive.

The circuit shown in the figure performs the required flip-flop function. Each wire is associated with two glow lamps and resistor. One terminal of each wire is grounded; the other terminal completes the circuit for the GO glow lamp. Initially, the RESET button opens the circuit for the NO-GO glow lamps, extinguishing these lamps and causing the GO lamps to light. During vibration tests, a momentarily open circuit in any wire in the harness will extinguish its GO lamp. Voltage across the corresponding NO-GO lamp rises beyond its firing voltage so that the NO-GO lamp lights and will remain lit even after the momentary open circuit has vanished. At the end of the test the operator can readily see which, if any, of the wires in the harness have open circuited. Because the glow lamps can be of very small size, the overall size and cost of this package remains practical for harnesses containing several hundred wires.

The system as described has been used successfully in harness testers, and may, therefore, be of interest to the readers of "Application News."

Very truly yours,
THE BENDIX CORPORATION
ECLIPSE-PIONEER DIVISION
I. L. Fischer, Senior Engineer
Advanced Electronics Laboratory

Suggested lamp for above circuit — Signalite type T2-32-1.
If B+ is 90 Volts DC, all R's should be 33K ½W
If B+ is 135 Volts DC, all R's should be 82K ½W
If B+ is 250 Volts DC, all R's should be 220K ½W

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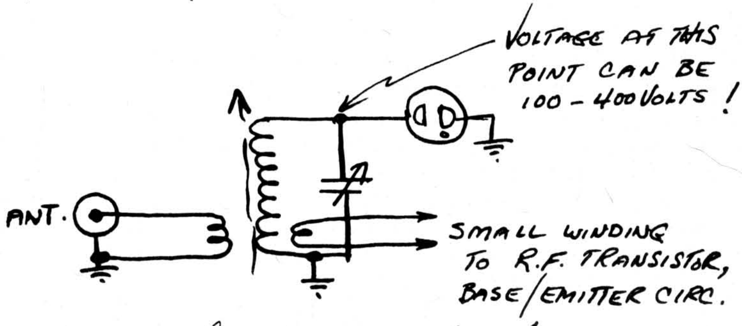
Viva la glow lamp!

Dear Ed:

Congratulations on your new publication, "Signalite Application News." It is the sort of idea which comes from newsy little papers or articles of this kind that is often just what the design engineer needs to solve a specific problem.

An application in which the neon glow lamp is especially valuable is as follows:

Various transistorized communication receivers, particularly mobile and marine, are often subjected to severe overloads at their antenna terminals.



Viva la transistor!

The voltage levels which can be created at the receiver's input by the high powered transmitter on an adjacent vehicle are often able to destroy the input transistor of such a unit, and for that matter can even destroy the tuned circuits immediately connected thereto. The resonant rise of voltage of such circuits is conveniently limited to 50 volts or so by the use of a low voltage glow lamp, and this fact, coupled with the typical 10 or 12 to. 1 step-down at the transistor input terminals of such an input coil, is sufficient to protect typical R. F. transistors.

At first glance, it appears that damage could be done to the transistor during the instant immediately following the beginning of a dangerous power burst before the lamp had a chance to light. Two factors, however, are in our favor at this point.

1. The transistor input diode is generally of sufficient thermal capacity that we can safely wait until the glow lamp would normally be expected to light.
2. The glow lamp in fact ignites much more rapidly with R. F. voltage than it does with a D. C. step function.

Perhaps this application is of interest to some of your future readers.

Very truly yours,
METROTECH INCORPORATED
Earl J. Peterman, Chief Engineer

Suggest Signalite LT2-32-1 because of its high current carrying capacity.

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Glow lamp lost its usefulness

Gentlemen:

I noted with interest your article on the use of Glow Lamps for Arc Suppression in Volume I, No. 1 of the Signalite Application News.

We did, for a number of years, use a glow lamp in the application described. However, we found that after a number of operations the lamps proved to be ineffective, and we subsequently switched to a more effective (and expensive) device.

Briefly, we discovered that the inductive surge voltage was initially limited to 120 volts across a 48 volt relay using an NE-2 lamp. After one million relay contact operations, the surge voltage increased to 160 volts and after six million operations the voltage increased to almost 200 volts.

Incidentally, we evaluated a number of Signalite Glow Lamps and found the RT2-32-1A to be just as effective initially as the NE-2. It too lost its effectiveness, however, after a number of operations.

Subsequent investigation has led us to the conclusion that the glow lamp loses its effectiveness due to the increased ionization time of these lamps after a million cycles. It is known that in these inductive circuits the rise time is shorter than the ionization time of the glow lamp and as a result, only a portion of the surge voltage is suppressed. If the ionization time is extended beyond the decay time of the circuit, obviously the glow lamp has lost its usefulness as an arc suppressor.

Very truly yours,
HONEYWELL
Special Systems Division
Howard A. Fink, Systems Engineer
Digital Design Group

We are very careful to note that each application of a glow lamp as an arc suppressor must be reviewed with its own set of parameters. The rated life of a glow lamp is a function of voltage and current. Therefore, in on-off applications such as an arc suppressor, peak currents, average currents, pulse wave shape and pulse time duration will be the determining factors that affect the lifetime of the lamp. At extreme points such as high level of stored energy, low back emf, etc., glow lamps may not be the answer or a compromise must be made such as a glow lamp and a small current limiting resistor.

Since there is a large difference in the current carrying capacity in the NE2 and the RT2-32-1A, there should have been a difference in life. Perhaps the compromise of a glow lamp and small current limiting resistor would have been the answer in this case. The small series resistor would have partially dissipated the initial high peak current that occurs the instant the lamp ionizes and would have caused the stored energy to be dissipated over a slightly longer period of time than without the resistor, thus integrating the current that would flow through the protection circuit. By proper choice of this resistor a compromise may be arrived at which reduces arcing and maintains the life expectancy of the lamp. I must emphasize once again, if the amount of energy stored in the inductive load is beyond the power carrying capacity of the glow lamp, another means must be found to dissipate this energy.

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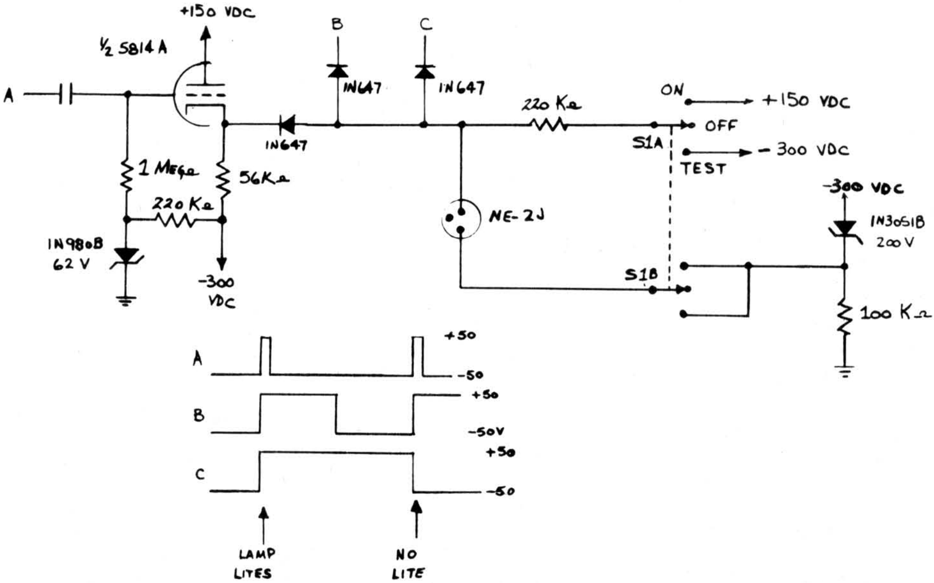
Just what we were looking for

Dear Mr. Bauman:

Enclosed is a circuit I designed to give a visual indication whenever three pulses appear simultaneously. The signals at B and C are gates of 100 V amplitude from —50 to +50. When a pulse appears at A, its DC level is changed so that it appears about —50 to +50 VDC also.

If SW1 is in the "on" position, the pulse at A will cause enough voltage across the neon tube to fire it. When the pulse disappears, the lamp extinguishes. To insure that the lamp is working, the switch is pressed against its spring loaded "on" position and 200 VDC appears across the lamp and the 220 K resistor, giving a check of the lamp.



While this circuit may not be exactly what you were looking for, I felt it is a different application of a neon bulb.

Very truly yours,
MOTOROLA, INC.
R. J. Boileau, Design Engineer
Radar Section

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Yes, maybe . . .

Dear Mr. Bauman:

The application described in my copy of Signalite Application News, Vol. I, No. 1, was of great interest.

We are in the process of developing a vibrator for use on an aircraft altimeter, using a solenoid and switch combination.

Our problem is two-fold; to maintain a more even voltage and to lengthen the life of the switch contacts. In both cases, I'm sure your Glow Lamp could help us.

However, we need a lamp which will operate on a normal voltage of 28VDC but which may fluctuate from 22VDC to 30VDC. The Glow Lamp would have to operate in the dark, and over a temperature range of -25° C to $+65^\circ$ C. A life expectancy of better than 2500 hours is needed also.

Can you help us?

Sincerely,
THE AEROSONIC CORPORATION
A. Bartow Fisk, Jr.
Supervisor, Lighting Dept.

There are no glow lamps that will ionize at 28 VDC nominal. However, with further circuit information we may be able to solve your problem with glow lamps by dissipating a major part of the stored energy.

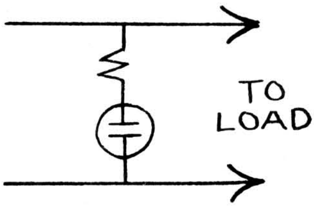
Voltage fuse

Dear Sirs,

This letter is in reply to your request for application pertaining to glow lamps. (Signalite Vol. I, No. 1)

Glow lamps are small, inexpensive components which are gaining in importance as one of the fastest growing devices used by the electronic engineer.

I would like to suggest a future use of the glow lamp as a *voltage fuse*. Refer to the following simple circuit:



If we can consider the voltage across the glow lamp as constant then any variation in voltage will result in a current variation through the lamp and series resistor. The lamp will provide a visual display of circuit loading with a qualitative measure of voltage variations being roughly proportional to lamp brightness. With too much excess voltage, of course the lamp will be destroyed.

Suitable circuitry can be made to take advantage of the variation in lamp brightness apart from the fuse application. I suggest the use of this brightness variation in conjunction with a photocell for use as the integral part of a constant voltage servo-controlled circuit.

I believe that these application ideas are so basic that they could easily lead to countless other ideas which I have not envisioned.

Sincerely,
Allan Brockstein, E.E.
Zenith Radio Corporation
(formerly with American Machine & Foundry)

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Samples on the way

Dear Mr. Bauman:

In reference to Signalite Application News Vol. I, No. 1 Article on "Glow Lamps Used to Suppress Arcing — Lengthen Contact Life" I have an application problem.

We are using 115 VAC relays with a NE2 Neon Lamp across the coil for indication. In your article, page 3, paragraph 3, you stated, "It is important to remember however, that the maintaining voltage of the lamp must be higher than the relay operating voltage."

Is not this indication glow lamp providing contact protection as well as indication? If not, what do you suggest we use to meet both needs?

Very truly yours,
Erie Strayer Company
Noel A. Ripley, Elec. Engr.

No, the indicator lamp is not providing contact protection. To provide this protection you will need a lamp that will not breakdown below 135 VAC. This lamp can be put across the relay coil without a current limiting resistor. I would suggest our T2-27-1W760. For the indicator we suggest you place an LT2R(30K) lamp and resistor assembly across the coil. This indicator lamp has an average life of 25,000 hrs. Samples of both are on their way to you.

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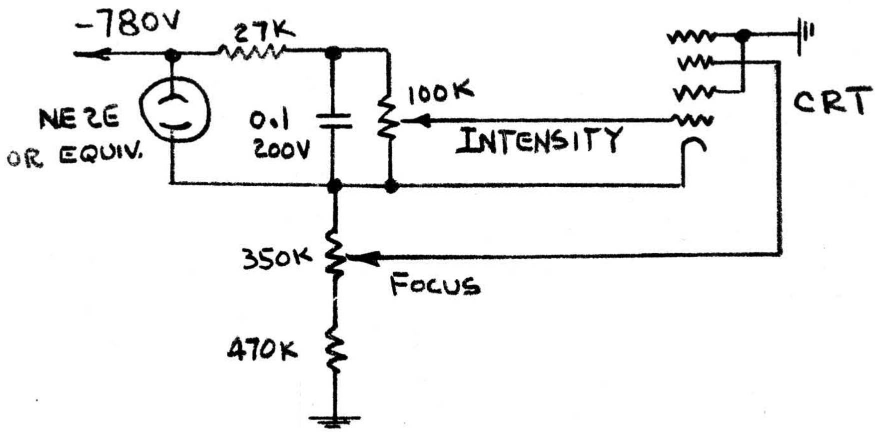
Pilot light and bias regulator

Dear Mr. Bauman:

I read your Volume I, No. 1 Newsletter, and in conformance to your request therein for glow lamp applications, I have submitted one application in what follows below:



In this application, the neon glow lamp serves two purposes, namely that of equipment pilot light and that of bias regulator for grid 1 of the CRT.

I hope that the above application might be useful for Newsletter publication.

Sincerely yours,
METRICS DIVISION
The Singer Company
Abraham Goodman, Section Manager

Excellent application! We would suggest substituting our T2-32-1 for increased life.

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TV on-off indicator

Gentlemen:

With reference to your first issue of "Signalite Application News" and your offer to exchange a Signalite Owl Eye Nite Lite for application problems or solutions, I submit the following. This is the simple problem that most TV set owners, especially of earlier models, face when trying to read the channel number in the dark. By mounting a neon glow lamp in the wall of the cabinet above the channel number, not only is a positive index mark provided but the soft light illuminates the nearby portion of the channel selector knob so that the channel number may be read without an annoying glare. Being connected across the on-off switch, it serves further as an indicator that the TV is turned on.

Very truly yours,
DELCO RADIO DIVISION
Frank S. Stein
Senior Scientist, Semiconductor
Research and Engineering

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CAN YOU SOLVE THIS?

Gentlemen:

Referring to your Application Forum article in Signalite Application News, I would be interested in obtaining a circuit diagram for a "blinker," in which a neon glow lamp is used, for signaling roadside hazards.

If this problem qualifies, I would of course be pleased to receive also a Signalite Owl Eye Nite Lite.

Sincerely yours,
Martin E. Nelson, Engineer
U. S. Army Corps of Engineers

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If you have a circuit design problem involving the use of glow lamps, or have developed a circuit in which glow lamps are important for design and/or economic reasons, we would like to discuss your application in a future issue of this newsletter.

Applications which in the opinion of Signalite have significant interest will also be brought to the attention of the editors of the leading technical publications for consideration as articles and featurettes. Your by-line and company credit will be given with your permission.

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