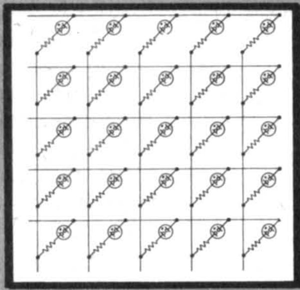
Signalite
APPLICATION NEWS
A General Instrument company



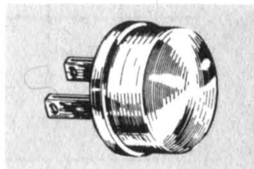
VOL. 2, NO. 3

Send Us Your Glow Lamp Application

The use of the neon glow lamp as a reliable circuit component has dramatically increased the need for application information. We are asking that you:

1) Send application examples—both general and specific

2) Send application problems or solutions to problems that we publish



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

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NEON GLOW LAMPS

AS OSCILLATORS AND STABLE FREQUENCY DIVIDERS

by: Edward Bauman
Chief Engineer, Signalite, Inc.

Whether an organ uses pipes or electron tubes, it is first and most importantly a musical instrument. Its ability to reproduce musical tones faithfully with regard to both its fundamental frequency and its tonal character, or color, provides the basis upon which the instrument is judged. The accuracy of the tuned frequency for any note on the scale must be within 0.1% if the instrument is to be considered at all acceptable.

Principles which apply to the most sophisticated electronic circuit design applications are used in the design of the Schober Organ. Electronically, Schober has produced instruments which closely simulate the tones of the modern pipe organ. They can generate tones having almost any desired waveform and thus any desired tone color. (Figure 1.) This has been accomplished in some electronic organs, such as the Schober Spinet, through the use of tone generators which use neon glow lamps as sawtooth oscillators and frequency dividers.

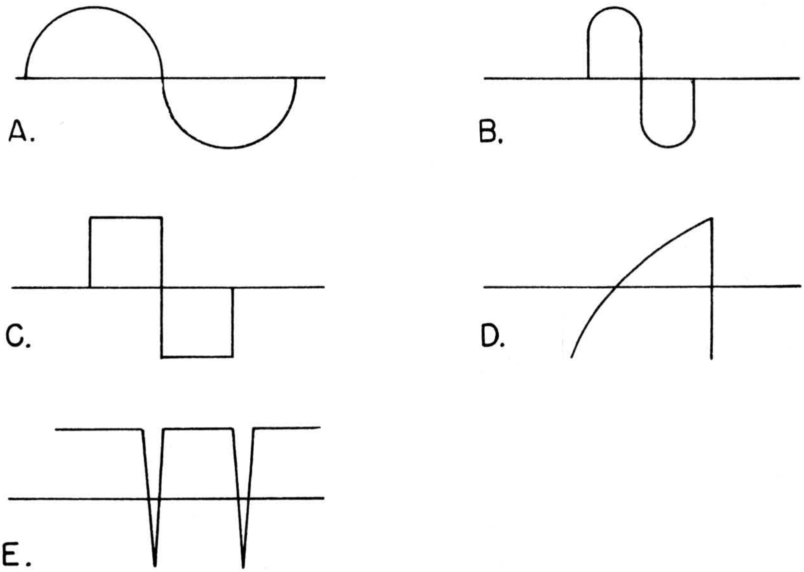
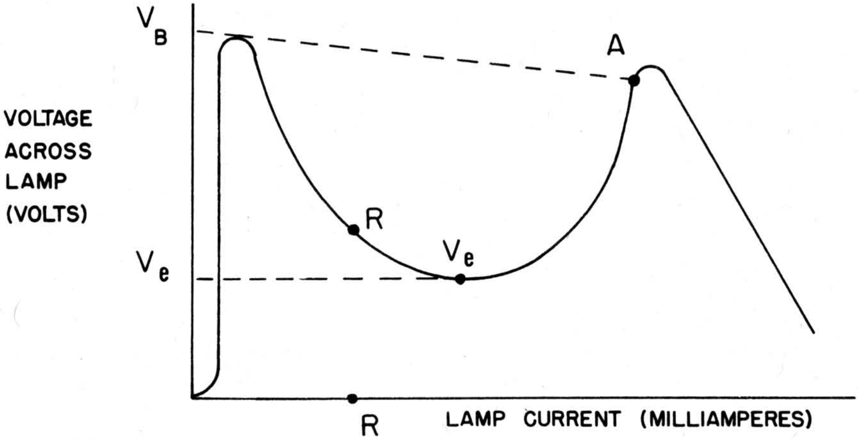


FIGURE 1.

The sawtooth waveforms, D in Figure 1, contain a great many harmonics in a distribution very convenient to understand. Stated succinctly, with the fundamental frequency as the standard of energy content, each harmonic has an energy content inversely proportional to its ordinal number. This means that the second harmonic — the frequency twice the fundamental — is half as strong as the fundamental; the third harmonic (3 times the fundamental) is ⅓ as strong; and so on. If the return line concluding the sawtooth were absolutely vertical, the wave would contain an infinite number of harmonics. In actual fact there is a slope to this line so therefore the number of harmonics is finite, perhaps going up to 30 or so. The sawtooth is filtered and altered in various ways in the organ to obtain many different tone colors.

One important use for neon glow lamps in electronic organs is as synchronized relaxation oscillators. It is easy to understand this type of circuit if we first review the basic relaxation oscillator which is used in many electronic devices. In the relaxation oscillator we take advantage of the bistable characteristics of the gas discharge device: that, when it is off, it will stay off until a critical voltage is exceeded, then turn on. When it is on, it will stay on until the current is reduced below a minimum current. How these characteristic differences between breakdown and maintaining voltage are utilized is shown in Figure 2.



As the voltage across the lamp increases, current remains essentially zero until point V_B is reached. This is the breakdown voltage of the lamp at which it begins to glow, and to pass current. As the current is decreased, a value (V_e) is reached at which the lamp will extinguish and an abrupt decrease in bulb current takes place.

FIGURE 2

For the lamp to oscillate, the magnitude of the supply voltage, E_B, must exceed the breakdown voltage, V_B, of the lamp. For maximum stability, it should be as high as practicable. The value if the resistance should be selected so that it falls in the region indicated by R on Figure 2. In operation, as the capacitor charges up, the voltage across the lamp increases until point V_B is reached. At this point the lamp fires, and the capacitor discharges through the lamp, increasing lamp current to point A. As the capacitor discharges rapidly, voltage and current follow the curve until point V_e is reached. At this point, since there is no means available for the voltage to rise, the lamp extinguishes. The capacitor then begins to recharge, and the cycle is repeated. Figure 3 shows the basic circuit simplified, and the sawtooth waveform generated.

A refinement of this circuit is used to produce a frequency divider to generate more than one octave tone. Frequency dividers of this nature have worked successfully in divisions of any integral between 2 and 10. In the electric organ we are primarily interested in divisions by 2, reducing by one octave at a time. This frequency division must be exact because the human ear hears pitch intervals or changes in the same logarithmic fashion that it hears audio power changes. That is, the apparent difference between two pitches (frequencies) depends on a multiplying rather than an adding factor. For example, the frequency difference between middle A (at 440 cycles) and the next A (at 880 cycles) seems the same to the ear as the interval of difference between middle A and the next lower A (at 220 cycles). Therefore, to create the next lower octave, once we have established a stable frequency, all we have to do is to divide the frequency exactly in half.

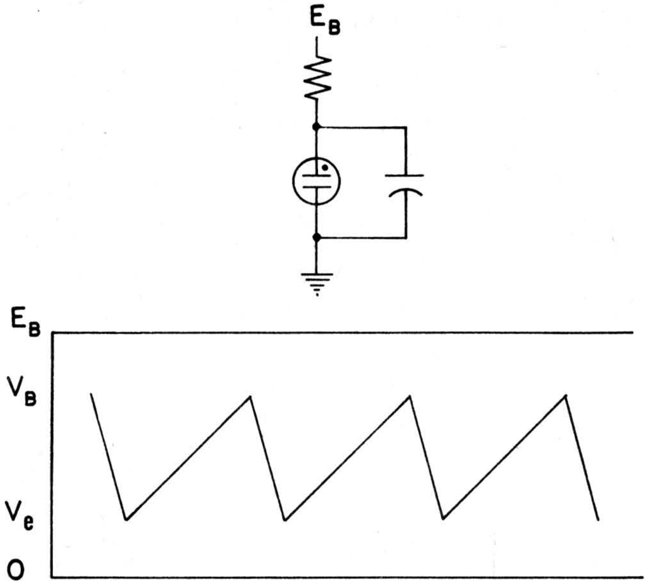


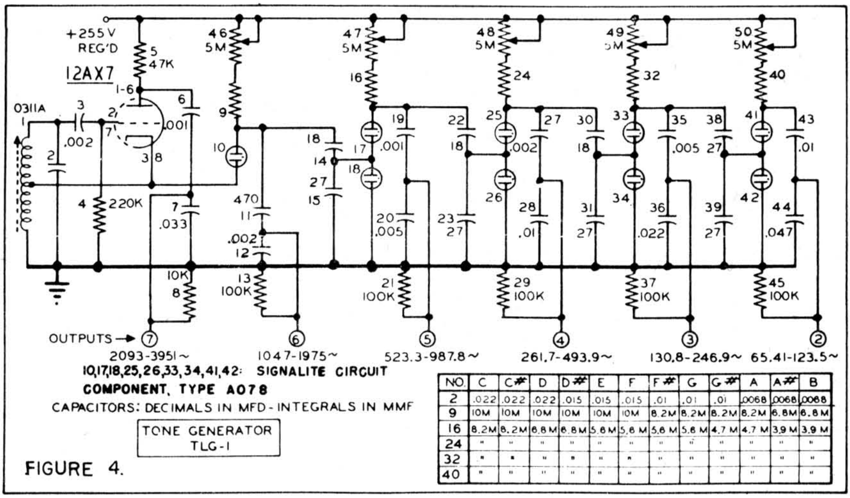
FIGURE 3.

In Figure 4 is shown a schematic diagram of a Schober Spinet tone generator. One triode tube, half of a 12AX7, is used as the master oscillator for stability. The circuit is one whose stability has been proved for many years.

A typical stage is one producing output 5 (523.3 cycles, C above middle C). This consists of a classical neon lamp relaxation oscillator comprising a resistance (16 and 47 in series) in series with a neon lamp (actually two lamps in series) between B+ and ground, with a capacitor (19 and 20 in series) across the lamp. The frequency of free-running oscillation for a given B+ voltage and lamp type is determined by the values of R and C and will be slightly lower than 523.3 cycles. In the Spinet the lamp used throughout is circuit component Type A0 78 produced by Signalite, Inc., Neptune, N. J. It has a breakdown voltage of 66 to 74 vdc, and a maintaining voltage of 52 to 59 vdc. Its leakage resistance is extremely critical in this circuitry since variations in it would entail special selections of the timing resistor, R. Specifications call for a minimum leakage resistance of 8,000 megohms, and the average of the lamps obtained is about 20,000 megohms, giving a comfortable margin to work with.

Output from this stage is taken through a capacitive voltage divider 19-20, which also acts as an impedance transformer. The output of terminal 5 is a low impedance output, therefore minimizing the loading effect on the relaxation oscillator.

In the specific circuit employed there are some significant deviations from the standard neon oscillator. The purpose of the deviations is to cause each stage to synchronize at exactly half the frequency of the previous stage, without causing the lower-frequency tone to couple back through the previous stage and be heard. Because of the synchronization, the stability is perfect.



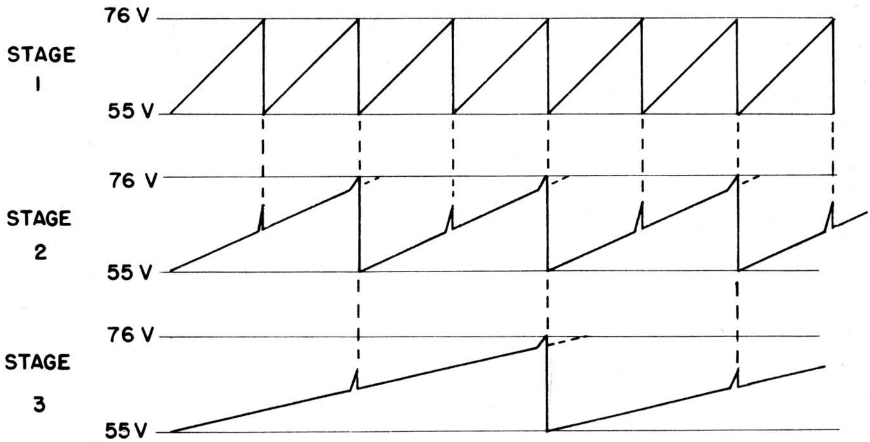
NO.	C	C#	D	D#	E	F	F#	G	G#	A	A#	B
2	.022	.022	.022	.015	.015	.015	.01	.01	.01	.0068	.0068	.0068
9	10M	10M	10M	10M	10M	10M	8.2M	8.2M	8.2M	8.2M	6.8M	6.8M
16	8.2M	8.2M	6.8M	6.8M	5.6M	5.6M	5.6M	5.6M	4.7M	4.7M	3.9M	3.9M
24	"	"	"	"	"	"	"	"	"	"	"	"
32	"	"	"	"	"	"	"	"	"	"	"	"
40	"	"	"	"	"	"	"	"	"	"	"	"

FIGURE 4.

To understand this, refer to the output 4 oscillator stage (261.7 cycles, middle C), which is identical to that for output 5 except that the value of the capacitors and resistors has been chosen for a free-running frequency about half of stage 5. A second output is taken from stage 5 through a second capacitive voltage divider 22-23. These capacitors are so much smaller than 19-20 that they do not significantly affect the frequency of oscillator 5. When lamps 17-18 fire, a negative pulse is applied through 22-23 to the junction of lamps 25-26 in stage 4. This pulse voltage is divided approximately in two through capacitors 22-23.

The B+ voltage being applied to stage 4 starts the standard neon oscillator build-up. When the negative pulse is injected, this voltage plus the voltage across the lamp at the time is not great enough to fire the lamp. (See Figure 5.) When the second pulse is injected, the voltage across the lamp has built up to a point close to breakdown voltage of the lamp, and the summation of the pulse peak voltage plus the existing voltage is sufficient to cause the lamp to break down. This transmits positive voltage to lamp 26 which also fires. Thus, the lamps fire on every alternate firing of the previous stage and at the point when the condenser is almost charged, dividing the frequency exactly in half, producing a one-octave difference. The same action takes place with every stage.

A special point about this circuit is important. It is most undesirable when playing a particular tone to hear anything of the tone an octave lower. While something of a higher tone is not noticeable — it appears to be merely a part of the harmonic development of the tone — a lower component is extremely noticeable. If the sync-pulse path from stage 5 to stage 4 could conduct equally well in the back direction, stage 4 tone would be heard in output 5. But for pulses at the 25-26 junction to get into output 5, they must pass through a voltage divider consisting of very small capacitor (22 and 19 in series) as the series leg and a very much larger capacitor, 20, as the shunt leg. The voltage division is 5,000/22, and the back-fed tone is thus inaudible.



The principle of frequency division in the Schober Spinet generator is shown in a simplified form here. The Signalite glow lamps in Stage 1 fire on each cycle, creating the sawtooth waveform indicated. The pulse from each cycle is injected to the following stage, increasing the voltage by the incremental peak. The second pulse increases the voltage across the lamp to the breakdown voltage and the lamp fires. Note that this must occur before *the voltage build-up in the capacitor reaches the breakdown voltage of the lamp, otherwise all synchronization would be lost. As shown here, Stage 2 creates the same effect on Stage 3, again dividing the frequency exactly in half. This process continues through the desired number of octaves in the organ.*

FIGURE 5

This organ is completely an electronic device. There are 12 tone generators of the type described above, one for each of the 12 notes of the chromatic scale. Through the use of a basic oscillator and five frequency dividers as described, it is possible to cover six complete octaves. The use of glow lamps as sawtooth oscillators and stable frequency dividers provides stable operation where, if there were variations in performance, the results would be noticeable and very unpleasant. This high reliability is obtained in a relatively inexpensive component and it can readily be seen that this application can be used in many other areas of operation, such as dividing a frequency standard, or as a source of accurate timing signals.

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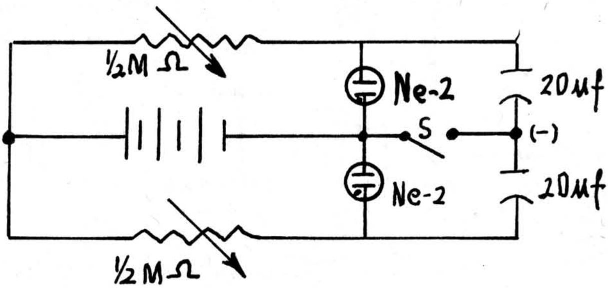
CAN YOU SOLVE THIS? ?????

Gentlemen:

In the circuit shown, the capacitors are 20 microfarad electrolytic. Both are in one case with a common negative terminal. The battery shown is a 90 volt commercial battery charger. With the switch closed, we have two identical relaxation oscillators in parallel. With the switch open, we have an astable multivibrator. The circuit works well as a multivibrator. The bulbs are very bright and the ganged pots vary the pulse duration from about .5 sec. to 5 sec. However, for some reason, which I cannot determine, with switch "S" closed, the lights will not glow. Can your readers determine what is wrong?

Dennis Kirson
American Electric Power Service Corp.



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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.

COUPLING ELEMENT FOR DC AMPLIFIERS

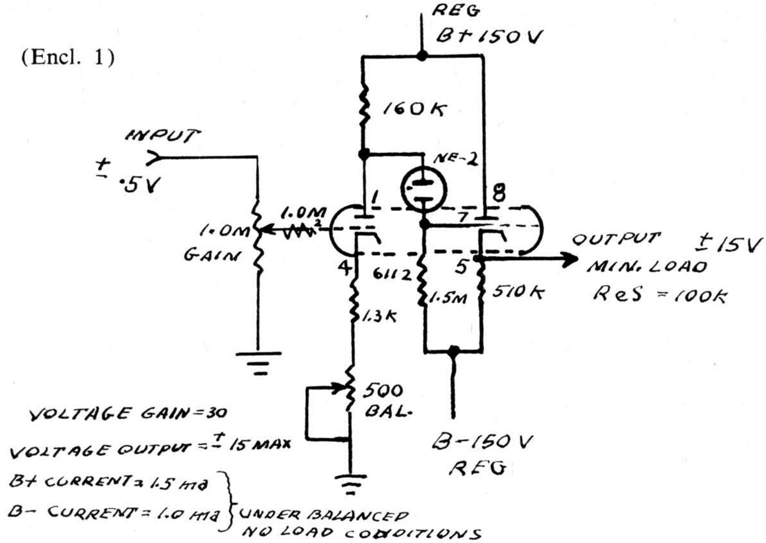
Dear Sir:

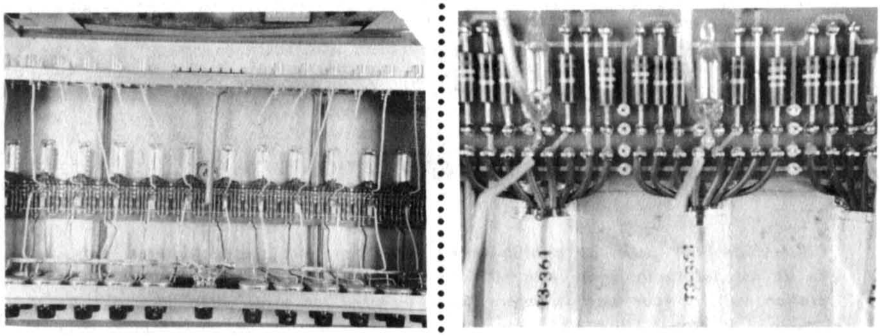
One of my most interesting and successful uses of neon glow lamp was as the coupling element in DC amplifiers. One of the circuits I used is shown (Encl. 1) and a photo of a 12 channel amplifier is included (Encl. 2). In the photos, notice that even though no power was being applied; the little neon rascals appear to be glowing anyway! (Accidental fluorescent lighting trick.)

In the circuit, the first triode is a conventional amplifier and the second is a cathode follower. The neon lamp provides offset voltage to permit the input and output voltages to operate about ground potential. The bottom of the gain pot could be returned to the output terminal for increased long-term stability.

Richard L. Shaum
Sandia Corporation

(Encl. 1)





(Encl. 2).

LIFE TESTING POTS

Dear Sir:

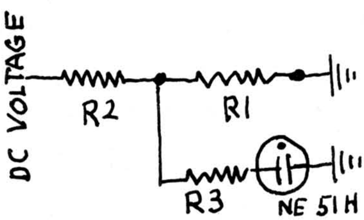
Here is an idea I have used for unattended life testing of potentiometers.

Voltage, R2 and R3 provide the proper operating conditions for the potentiometer under test R1, a bright indication for a permanent failure (open) and a dim indication for a temporary failure.

This circuit was successfully used to life test twenty 10 turn potentiometers. All shafts were ganged together and driven to both mechanical limits. A mechanical counter and reversing motor were provided and all arms were brought out to a rotary switch for monitoring purposes.

When voltage is first applied the neon bulb will not fire because its threshold voltage has not been reached. If during the time of test R1 should open permanently, the neon lamp will glow with the intensity allowed by the series resistance of R2 and R3. If R1 should "heal" itself after opening, the neon lamp intensity will decrease to a dim condition for the voltage has not decreased to the extinguishing level.

Theodore J. Sreden, Sr. Engr.
Belock Instrument Corporation

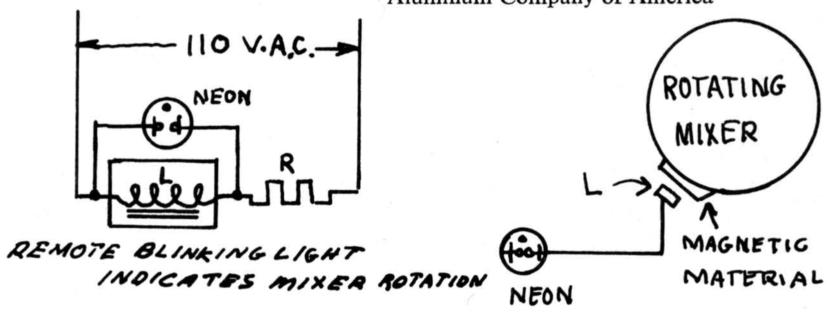


REMOTE INDICATION

Dear Mr. Bauman:

This circuit utilizes the change in impedance in the coil when magnetic material completes the magnetic path through the coil to cause the neon glow lamp to blink. This gives a positive remote indication that the machine is running.

Virgil R. Walker, Sr. Engr.
Aluminum Company of America



Ed Note:

A variation on this interesting application that does not require outside power would be to use an inductor with a moderately high turns ratio; and connect the neon lamp across this coil. Each time the magnetic material goes through the coil it will induce a counter EMF causing the neon lamp to glow momentarily. A further thought, if one of our readers is interested in a rotational counter, would be to place a photocell adjacent to the lamp and have the reaction of the photocell activate a counter.

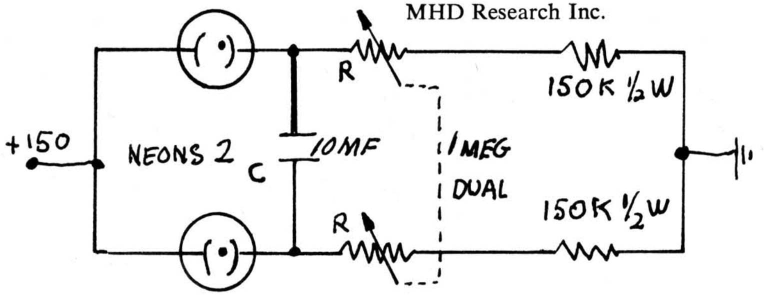
Dear Sir:

The circuit below is an astable triangular oscillator. The voltage across C closely approximates a linear triangular waveform. With the valves shown, frequency is variable from approximately 0.005 CPS to 0.5 CPS.

The upper frequency limit is set by the ionization time of the glow lamps. The lower frequency is limited mainly by the leakage resistance of C, which should be a high quality paper or mylar unit.

The circuit operates reliably over a range of at least three decades with a single control. C may be switched to obtain a very wide-range circuit.

I. D. Sarrell, Instr. Engr.
MHD Research Inc.



"FOR THE HAMS"

Dear Sir:

Glow lamps such as NE 45's are very useful in adjusting current fed transmitting antennas. The NE 45 is pushed into the large end of an alligator clip cover such as the Mueller #47, and a ¼ inch diameter dowel several feet long is pushed into the small end.

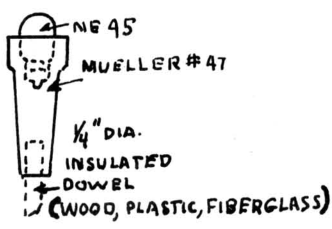
The lamp assembly is placed against the antenna element at the current feed point and slid along the element toward the end (maximum voltage point), noting the point where the lamp first ignites.

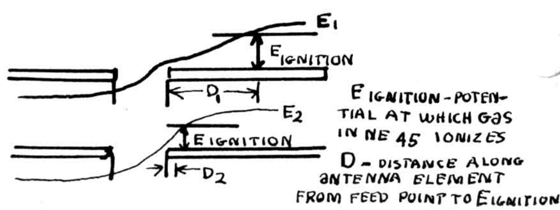
Any necessary adjustments are then made, and the above procedure is repeated, the object being to cause the bulb to ignite as near the feed point as possible.

This indicates maximum radiated power, since the more power, the higher the voltage at the antenna end, consequently the nearer the feed point the voltage becomes high enough to ignite the bulb.

This device is especially useful in field and mobile applications where it is not desirable to use bulky or expensive test equipment.

E. Millman
Radio Corporation of America





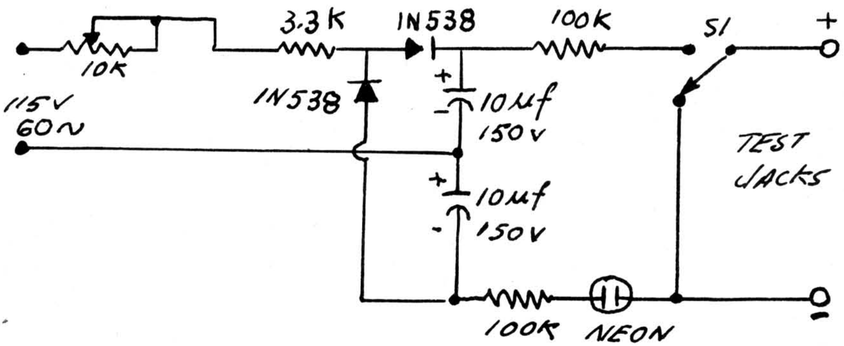
TROUBLESHOOTING

Dear Ed;

One of the most difficult jobs in electronic troubleshooting is locating a leaky capacitor. I have found that the enclosed circuit is very effective for this purpose. It is essentially a voltage doubler (actual voltage is controlled by R1). Depressing S1 applies voltage to the test item. The resultant blinking of the neon lamp, is an indication of the leakage of the capacitor.

With a little experience and practice, the results are very effective.

V. F. Banko
Thiokol Chemical Corp.
Reaction Motors Div.

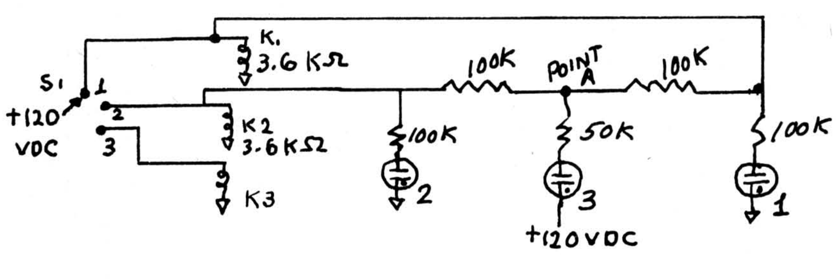


COMING UP ROSES

Dear Mr. Bauman:

Here's an application for the NE-51 that saved the day during the design and development of a large scale digital computer. The problem was to build a visual indicator to show the status of relays K1, K2, and K3. Since the relays operate from 120 volts dc, it would appear to be a simple matter. However, the problem is complicated by the fact that the only terminals that were accessible were those on K1 and K2. The other components were completely out of the question without considerable modification to the equipment. Here's how the circuit operates:

1. When S-1 selects K1, indicator #1 lights, point A goes to 60 volts holding off light #3.
2. When S-1 selects K2, indicator #2 lights, point A still holds off light #3.



3. When S-1 selects K3, however, point A is no longer at 60 volts dc and light #3 finds a return through K1 and K2 (3.6k ohms each). Note that light #3 is connected to 120 volts.

This circuit has given several years of reliable operation. Once again, "Viva La neon!"

Frank J. Lutz, Jr.
RCA Service Co.
Patrick AFB, Fla.

*

Typical circuit component applications for Signalite Glow Lamps

Counters	Surge Protectors	Pulse Generators
Voltage Regulators	Limiters	Photo-Cell Drivers
Voltage Dividers	References	Flip-Flops
Digital Readouts	Logic Circuits	Gating
Oscillators	Resistors	Relay
Coupling Devices	Timing	Time Delay
Switches	Trigger	Photo Choppers
Memory	Film Markers	Amplifiers
		Noise Generators

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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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