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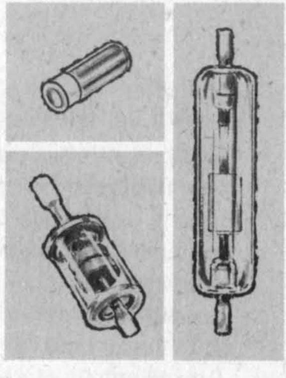
APPLICATION NEWS
A DIVISION OF GENERAL INSTRUMENT



Vol. 11, No. 2

Signalite, 1933 Heck Avenue, Neptune, N. J. 07753

YOU MAY NEED AN EXPLOSION !

By: Donald Baker Moore*
Staff Physicist
Explosive Technology

Boom...bang...bruum...are sounds we immediately hear when "explosives" are mentioned.

While most of the 1½ billion pounds of blasting agents activated annually in the U.S. are utilized in demolition, mining and excavating, there are many specialized applications for explosives now appearing that are generally unknown. These sometimes novel applications literally reach from the moon's surface to your trouser pocket.

We'll touch upon a couple of exotic examples, then detail an industrial research problem that was solved using explosive technology.

One "gee whiz" example is seen in space exploration. When the Apollo astronauts were ready to return from the moon, an explosively-actuated "guillotine" severed the dozens of electrical and hydraulic connections

*_The author wishes to extend acknowledgement to Mssrs. J. Johnson and G. Nistler of Explosive Technology, and to Michael I. Distefano of Signalite, for their valuable assistance in the preparation of this article._

that otherwize would have anchored them permanently to the space craft's descent stage—and the moon.

Explosive welding, the technique employed to laminate nickel alloy to a copper substrate comprising the base for the "sandwich" coins we use, is another instance of practically-applied explosive energy. Other applications range from almost magical production of industrial grade diamonds to the explosively-actuated Jet-Axes firemen use to gain access to otherwise inaccessible flaming interiors. Currently both the Air Force and Federal Aviation Authority are experimenting with explosively-actuated escape hatch systems capable of performing safely and reliably in an instant, under all conditions, with no possibility of jamming or sticking.

How does the scientist or engineer look at explosives when blue-printing their use to solve a seemingly insoluble problem? They see explosives as simple, highly reliable, virtually instantaneous sources of very high pressure and temperature. Most common explosives detonate or react at a rate of seven to eight thousand meters per second (five miles per second) with shock pressures of up to 200 kilo-bars (three million pounds per square inch), and temperatures of three to four thousand degrees Centigrade (five to seven thousand degrees Fahrenheit). Typically, a mass of five grams (about the weight of a five-cent piece) yields some five kilogram calories (20 Btu) in one or two millionths of a second.

In itself this amount of energy is not particularly impressive—only enough to boil a couple of teaspoons of water to steam. A similar amount of petroleum burned in air releases ten times as much energy. The *astonishing* thing is that the power available from this small charge—if it could be utilized fully—approaches 20 million kilowatts, or effectively twenty times the instantaneous output of Hoover or Grand Coulee dams.

The primary objective of today's explosive science, therefore, can be viewed as a continuing effort to devise techniques of channelling potentially immense explosive power into desirable ends, i.e., directing and dissipating it usefully.

Along with some dozen other firms, Explosive Technology specializes in designing and supplying devices and systems in which explosives are used to solve a technological problem the solution of which can not be effected rapidly or simply by other means. Often, as in explosive welding, it may be impossible to get the job done using any other technique. The ability of ET specialists to satisfy critical performance standards is due primarily to past and continuing research and development activities utilizing optical, electronic, and flash X-Ray instrumentation which routinely examine explosive events with a time resolution to less than one-one-hundred-millionth of a second.

A challenging and unique industrial problem serves as an excellent example to illustrate both the use of explosive devices, and how some of the problems in their use can be solved. The facilities of a major concern include a 6" O.D. tubular steel gas turbine drive shaft having 3/8" thick walls. Turning at up to 15,000 rpm, the shaft drives a complex test system. Initial operation indicated that it was possible for the turbine to run away, thereby totally destroying the test equipment and facility. This prompted the company to investigate what alternatives might be available for installing some type of emergency disconnect on the shaft that would prevent the possible catastrophe.

Inevitably, a "quick fix" was sought that would require an absolute minimum of redesign or rebuild. A clutch arrangement was not acceptable since this would have to be massive, costly, and would recessitate a major undertaking. It was ultimately decided that instantaneous severance of the shaft would be the most appropriate means for preventing possible turbine run away, since it was felt by the company's technicians that this kind of emergency was a relatively remote possibility, and should replacement of a cleanly severed shaft be necessary, this would not be too great a job.

There were, however, several critical restrictions pertaining to this problem. For one, the severance system had to completely cut the tubular shaft instantaneously upon command—regardless of shaft operating speed or load. Also, the system had to function 100 percent reliably, even after months or years of being on "standby"—yet it must be designed so as to preclude any possibility of inadvertent actuation. Additionally, if and when it was brought into action, the system must not affect adversely any adjacent components or structures. The system, likewise, was required to be sufficiently safe and simple so that it would not require the services of specialists or experts for installation, testing, maintenance, or inspection. Finally—the system had to be immune to an environment of heavy oil spray and the presence of strong electromagnetic fields, such as are commonly found around heavy-duty motors and generators.

If all of these qualifying factors could be satisfied, it appeared that explosive severance offered the best means of solving the problem. The complete explosive system would include: the explosive severance device itself, a detonator or initiating charge, and appropriate power supply for triggering the system.

There was available, fortunately, an Explosive Technology development called "Jetcord", used widely in aerospace severance systems. This is a special explosive charge similar to the military shaped, or "hollow" charge, comprising a metal-sheathed, explosive-filled, linear-shaped charge, having an approximate chevron-shaped cross section. (Figure 1) "Jetcord" is available in a size range that permits the cutting

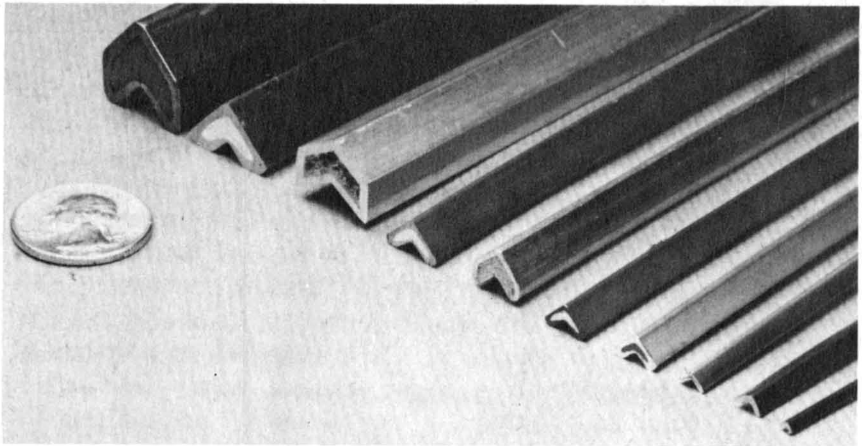


Figure 1. Typical Jetcords

of a few mils of aluminum, up to sizes containing more than a pound of explosive per linear foot—big enough to slice through several inches of steel. It is quite safe to handle, and has a good record for performance and reliability under the demanding conditions encountered in military and aerospace applications. Thus the consensus was that it could satisfactorily be utilized to solve the problem under discussion.

Initiating the explosive device raised a different problem. In this instance, the use of a conventional, highly sensitive electric blasting cap would not be feasible in the area of high-powered electrical machinery. There was a satisfactory alternative, however, in the form of very insensitive devices known as Exploding Bridgewire, or EBW, detonators whose development was largely an outgrowth of World War II. EBW detonators differ from conventional types in that they require currents of thousands of amperes delivered in a few microseconds before they will detonate. Under such electrical impulses, the detonator bridgewire literally explodes, and the resulting high temperature shock produces detonation of the subsequent explosive column. Smaller currents—or longer energy input times—result in merely fusing the wire and melting or burning a small amount of adjacent material, but cannot result in a conventional or high order detonation.

Given the explosive severance device, "Jetcord", and an EBW detonator, the remaining task was to obtain an appropriate firing unit. Such a unit typically comprises a high voltage DC supply, and special non-inductive pulse capacitor that can be charged to 2000 volts, and upon command can be short circuited through co-axial cables to the EBW detonator. Firing systems of this kind have been used in experimental studies and in some military and aerospace applications. They are, however, rather specialized, and presently are not common in conventional explosive applications.

While high voltage supplies and low inductance capacitors and connections are readily available, the key component of firing systems of this type is the triggering device. This can be a special high voltage relay, a vacuum switch, or it can be a self-triggered spark gap. The first two are bulky and not inexpensive and require a drive circuit. (It should be noted that a vacuum switch must itself be triggered with a low energy, high voltage (approx. 50% of E_Z) firing pulse, thus further complicating the circuitry.)

For some time, Explosive Technology had been investigating the possibility of producing inexpensive EBW firing units using self triggering by means of a voltage breakdown device or surge arrestor, arranged in series between the detonator and charging capacitor, and adjusted to fire when the capacitor is charged to the proper voltage for effective output. Requirements for such a unit were that its operation must be highly reproducible; it must trigger reliably at a predictable calibrated voltage; it must be capable of thousands of operations (including regular performance test verification), and must break down each time to a very low impedance capable of passing from one to two thousand amperes with very low power loss.

With many types of surge arrestor devices available for circuit overvoltage protections, a number of these were examined, but it was found that while they might be effective for ordinary applications, they would not stand up to the demanding technical requirements peculiar to the system under discussion.

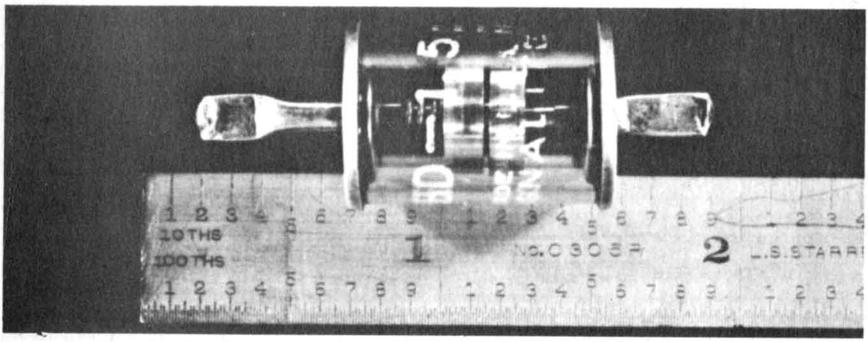


Figure 2. Signalite Uni-Imp UBD-1.5 Surge Arrestor

Ultimately, the Signalite Uni-Imp Model UBD-1.5 (Figure 2) was found to be a precision device of rugged and durable design whose electrical characteristics made it ideally suited for this mode of operation. A spark gap or gas-filled surge arrestor will conduct when the applied voltage is sufficient to ionize the gas within the envelope. When the ionization is complete, current can flow; the impedance of the gas drops to a few tenths of an ohm, and the tube drop can be less than 10 volts. It is this characteristic which makes these devices ideal energy transfer switches. Explosive Technology purchased and tested models of this switch, designed to trigger at different voltage levels. The Uni-Imp UBD-1.5, triggering at 15000 volts, transfers the required high current to fire the EBW detonator.

The complete power supply and firing circuit incorporating this switch is shown in Figure 3, and typical output current vs time oscilloscope is seen in Figure 4.

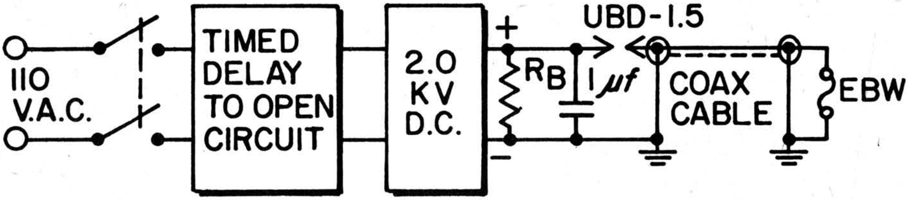


Figure 3. Firing Circuit Functional Diagram

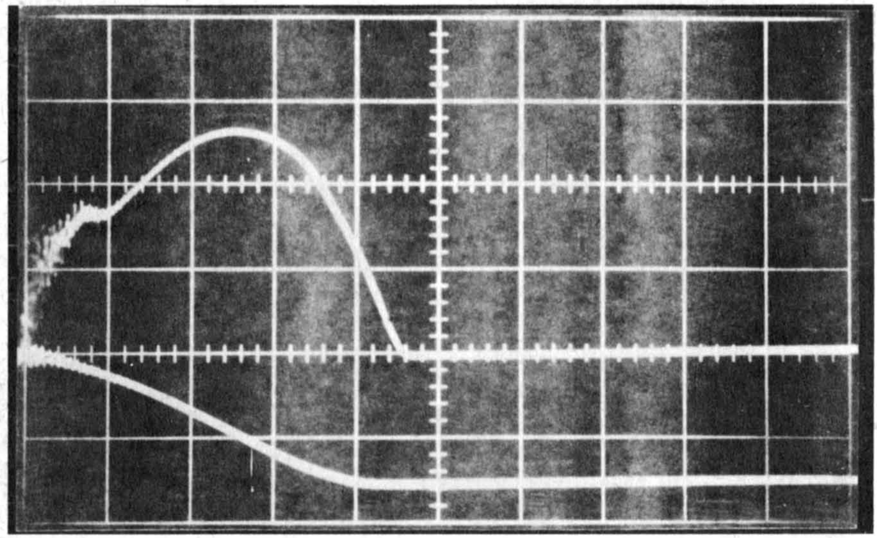


Figure 4. Current Discharge Scope Trace

A simple non-regulated, two-kilovolt supply is connected through an ordinary "make" switch, or "red button", to the 110 volt AC line. Upon command, pressing the switch turns this supply "on" and charges the firing capacitors in approximately one-tenth of a second. There are two parallel systems for redundant reliability. As the capacitors reach the pre-established trigger voltage of the Signalite switches, these break down and dump the capacitors' energy through the coaxial leads into the EBW detonators. The only extra feature is the time-delay holding relay which is inserted to disconnect the power to the DC power supplies after a second or so. This prevents the DC supply from operating into a short circuit in the event the exploding bridgewire device does not open the circuit completely after detonation. Otherwise, there is possibility that the DC supply could burn out.

With selection of the appropriate size "Jetcord" to perform the cutting action, an EBW detonator which meets the environmental requirements and is capable of readily initiating the "Jetcord", and with a suitable firing unit, the only remaining objective was to "package" the system. Figure 5 depicts the explosive severance system housing installed around a dummy drive shaft, and Figure 6 shows the same system after firing and severing the dummy shaft.

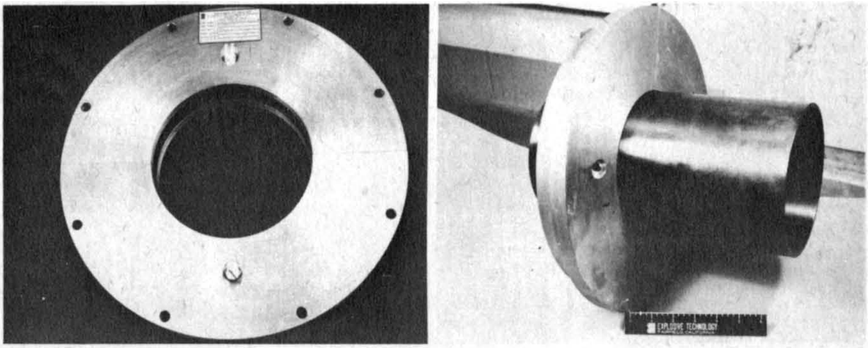


Figure 5. Turbine Shaft Severance System Set Up for Test

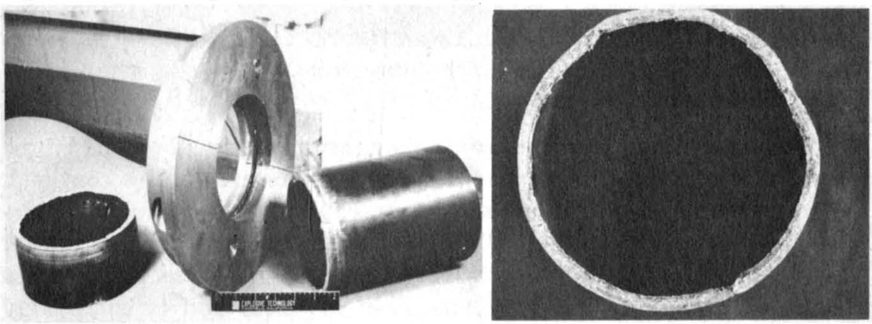


Figure 6. Severed Shaft After Test

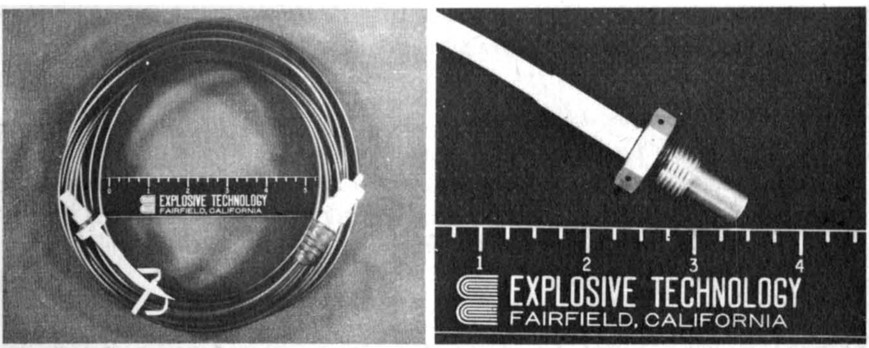


Figure 7. EB W Detonator Unit with Coaxial Cable Firing Lead and Threaded Fittings

The EBW detonator (Figure 7) is seen as delivered, potted as a unit with a coaxial firing lead and threaded fittings. Figure 8 illustrates the firing unit with two coaxial high voltage output receptacles and the input receptacle for the 110 volt supply. (Not shown is the remote control box which simply consists of the 110 volt normally open switch and the time delay protective relay.)

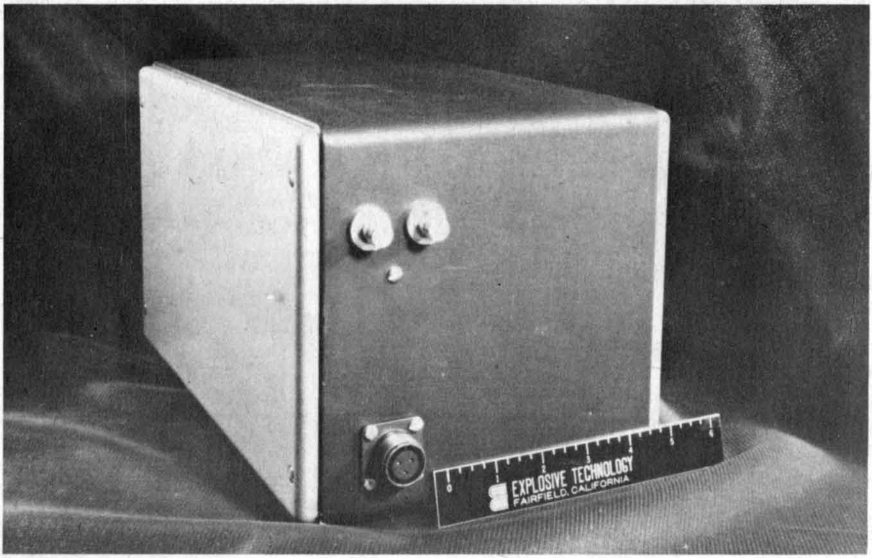


Figure 8. Firing Unit with Two Coaxial High Voltage Output Receptacles and One Input Receptacle

The total system described contains approximately 12 grams (three quarters of an ounce) of explosive whose effects are totally confined, and yet which will, within a tenth of a second after demand, sever the 3/8" thick steel wall and 6" O.D. steel shaft rotating at high speed. There is no external hazard since there are no high velocity fragments produced. The system is only energized at need, and is completely inactive in the standby condition. The power supply and pulsers can be tested as desired, either by firing test detonators suitably enclosed in a sandbucket or other fragment shield, or by merely triggering the unit with special neon spark flashers installed in place of the coaxial detonator leads.

The system is designed with a safety margin so that it will still operate even if the AC main voltage is 100 volts or less. Laboratory tests have proved that neither the triggering characteristics of the Signalite UBD-1.5 nor its firing performance are altered, even after hundreds of EBW shots.

It is our hope that this project—successfully integrating explosives technology with Signalite spark gaps to solve an extraordinary industrial research problem reliably, safely, and relatively inexpensively—will serve as a practical inspiration to those scientists and engineers faced with finding a solution to their problems which at the moment seem insoluble.

KOLTS APPOINTED MARKETING MANAGER

Robert C. Kolts has joined Signalite as Marketing Manager where he is responsible for marketing and sales of all of Signalite's product lines, including neon indicator lamps, circuit components, and transient voltage protectors.

Prior to joining Signalite Bob was Eastern Region Microwave Sales Manager for Philco-Ford, Sierra Operation, in charge of sales and marketing programs from Boston, Mass. to Washington, DC. Previous assignments were as vice president, Electronics Division, Auriema International Group, Inc., managing international sales and marketing operations for a diversified group of electronics firms, and as marketing manager with Micro-State Electronics, a subsidiary of Raytheon Co., as supervisor of sales contracts.

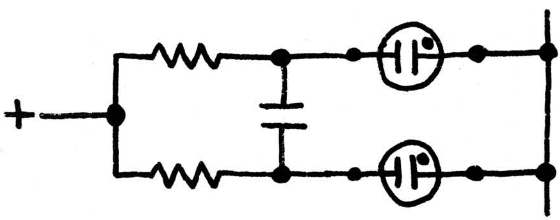
He received his B.S. degree from Clarkson College of Technology, and later completed Raytheon's Middle Management Course.

CAN YOU SOLVE THIS? ?????

Dear Sirs:

I would like to build a twelve lamp ring on a panel where each neon lamp blinks in sequence going around a circle. I have built a two lamp system (the eyes in a plastic owl) where the two lamps alternated but have been unable to extend this system to incorporate additional lamps in a sequence that would blink the desired lamps at times I wished.

The circuit I used for two lamps is drawn below:



I have seen the twelve lamp system in some store windows, so I know there are circuits available.

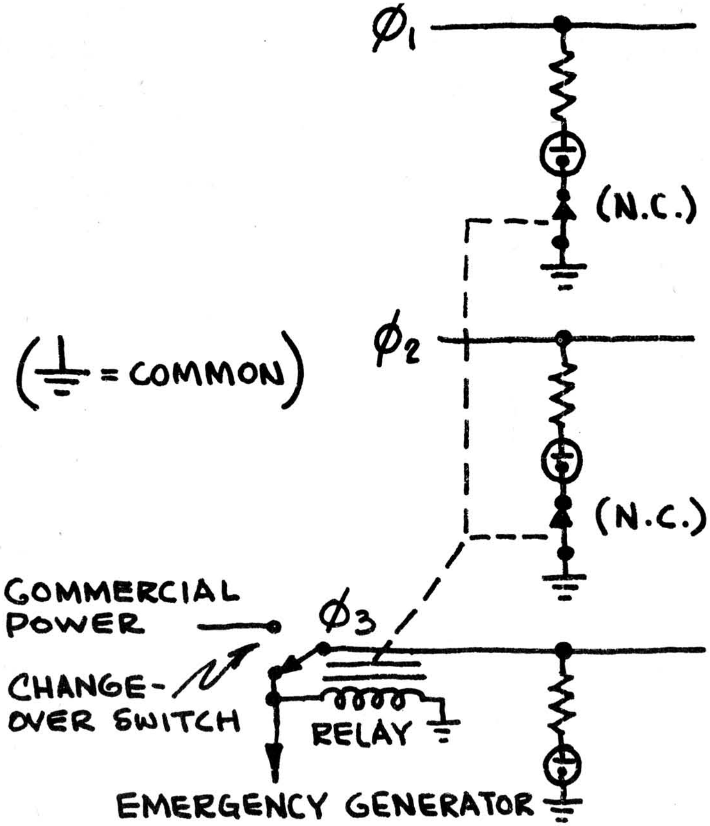
Thank you,

Merwyn Sommer
Electronic Design & Development

ANSWER TO CAN YOU SOLVE THIS: VOL. 10, NO. 1

Gentlemen:

In reference to the WBAL-TV problem, (pg. 463, Vol. 10, No. 1) there are clever ways involving some complexity that would produce the desired result, but a simple and inexpensive solution would be as follows:



Upon loss of commercial power, the changeover switch is thrown, the generator is started and the relay is energized thus opening the contacts which prevent phase 1 and 2 lights from glowing. Phase 3 light monitors the generator output. An additional light could be used on the commercial power side of the switch to indicate restoration of normal power. I realize that this is not a total monitor, but it might be useful for this application.

Yours truly,

William Faux
FAA

Ed. Note: While this solution fulfills the requirements set forth by Mr. Claus, it might be noted that proper operation depends on a manual changeover switch.

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.

NEONS PRAISED AS SIMPLE TIME SAVERS

Dear Sir:

Your Volume 9, No. 3 issue of Signalite Application News has prompted me to write describing an extremely simple use of neon glow lamps which I have been using for years. You touched on this use in the issue mentioned.

In televising "remote" telecasts from stadiums, auditoriums and other locations outside of the normal studios, much equipment is used requiring in some instances long A.C. extension cords. Because of the possibility of these cords becoming disconnected due to traffic, when a piece of equipment fed from such a cord fails, it greatly simplifies a quick return to operation by merely noting on the connection box whether power is still present. For this I have used extension cords terminating in square electrical boxes with several A.C. outlets. A neon glow lamp on this box indicates continually if power is present at the box end of the cord, many times several "extension cords" away from the power source.

This same use is handy in construction work, where extension cords are always being pulled from the socket. When your power tool goes off, you can instantly tell if the tool or power feed is at fault.

It is now even easier to make up such combination outlet and indicator boxes since Hubbell, for one, has a duplex outlet available with an internal neon lamp. I have even installed one of these in my bedroom where it serves not only as a small nightlight but is a constant check on loss of power, once a very common occurrance in my suburban location.

As mentioned, these uses are simple but they have saved more time in our operation than just about any other use I have seen documented in your publication. If you are a handyman, using power tools, you can appreciate this solution to a common problem.

Sincerely,

Otto R. Claus
WBAL-TV, Baltimore

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Drop Us A Line . . .

If you have an interesting application of neon glow lamps or spark gaps in your circuitry . . . or a problem concerning the use of these components, drop us a note telling about it. Interesting letters will be published in a future issue of the *Application News* - and we will send you an Owl Eye Nite Lite for your interest.

Applications which in the opinion of Signalite have significant interest will also be brought to the attention of the editors of leading technical publications for consideration as articles and featurettes. If you would like help in preparing your material for publication, just send us the facts and data; we will put it in the correct form for publication. Your by-line and company credit will be given with your permission.

For immediate technical application or circuit design assistance, you may contact Signalite directly at:

TWX: 201-775-2255 *TEL: 201-775-2490*

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For information about Signalite neon glow lamps, spark gaps, and other gas discharge products for circuit component and/or indicator applications, for specifications on Signalite components, or for general information about Signalite and its products, call us at any of the following telephone numbers:

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