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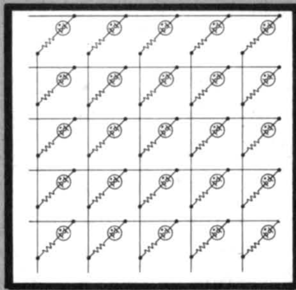
APPLICATION NEWS
A General Instrument company



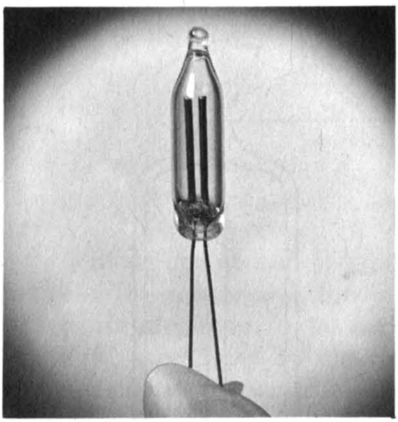
Vol. 6, No. 3

(This is the first in a series of articles which will be published in Signalite Application News *intended to aid you in the application of neon glow lamps by providing better understanding of the device. The second part will be devoted to a discussion of methods for turning on and turning off the lamps. Because of the extensive nature of this series, we welcome your questions and comments. — Ed.)*

DESIGN, OPERATION AND APPLICATION OF NEON GLOW LAMPS

By Frank McKendry
Signalite Inc.

Part I Construction, Operation and Operational Characteristics



Glow lamps, known variously as neon lamps, gas discharge tubes, and diodes, have been produced and used widely for better than two decades. Most commonly they are used as indicators in appliances and other equipment to indicate an "on" status or a "ready" status. In recent years improvements in the design and manufacture of these devices have resulted in increasing use as circuit components in electronic circuitry, measured by the same standards of performance and reliability as any other component in the circuit.

Working closely with customers over the past years, we have found that more intelligent use of the unique characteristics of glow lamps can almost invariably be obtained when these characteristics are known and understood. Unfortunately, the basic information upon which knowledge is built is not easily available. Application information, on the other hand, is readily available. To fill this gap, this series of articles will discuss how the glow lamp works, why it works that way and what can and cannot be done with it.

GENERAL CONSTRUCTION

The basic construction of neon lamps is shown in Figure 1. The envelope is made of glass sealed in two areas, the tip and press. In the press area the leads protrude through one end of a hollow cylinder of glass and the glass is heated and pressed about the leads. This holds them in mechanical position and forms a hermetic seal about the leads. The unit is evacuated and gas is introduced through the tip area prior to tipping off. Because the leads are mechanically held at sealing, the electrodes are controlled in spacing. This device, because it has only two electrodes, is called a diode.

Diode construction is used for the manufacture of indicators, circuit components, energy transfer devices, and voltage regulators.

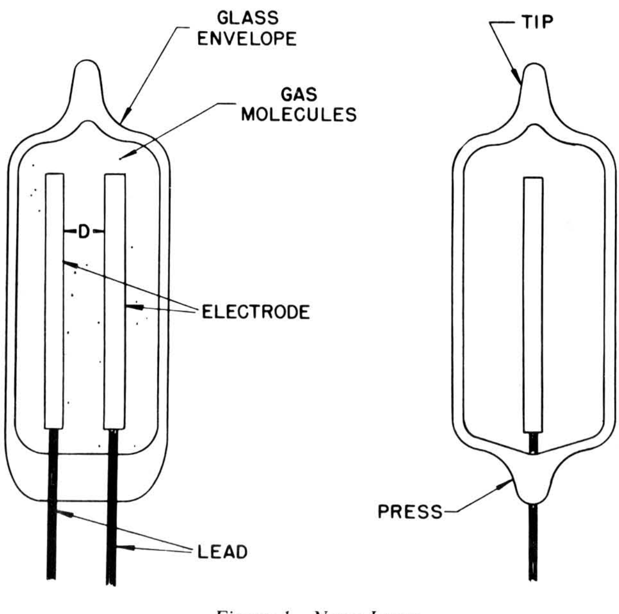
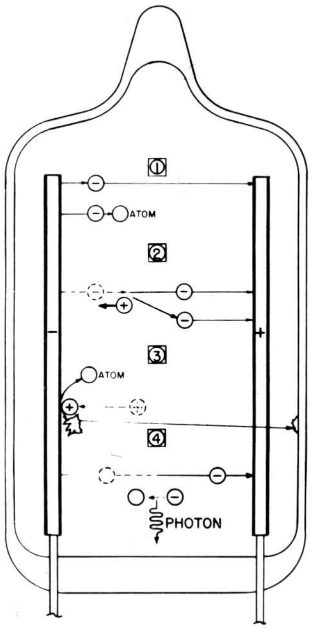


Figure 1 Neon Lamp

OPERATION

Figure 2 indicates, generally, the actions that take place within the device during operations. Specifically illustrated are:

1. Electron actions
2. Positive ion actions
3. Sputtering
4. Light emissions



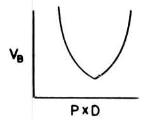


Figure 2 Electron action in a neon lamp

A diode operates in the following manner A voltage is supplied between the anode and the cathode which, when sufficiently large, will cause electrons to be emitted from the cathode surface. The electrons, accelerated by the electric field, collide with atoms of gas and can do one of two things.

1. The traversing electrons can "strike" an atom of gas and elevate one of its valence electrons to a higher energy state. It is a fundamental rule of nature that all physical systems shall be in their lowest energy state; i.e., Newton's apple. Consequently, at some time after being elevated, the electron will drop to a lower energy state. When this occurs, a photon of light is emitted, the wave length of which is determined by the difference in energy between the two levels the electron occupied.

The total light output from a glow lamp is the result of millions of such occurances at a given instant.

2. The atoms can have electrons knocked completely off in which case the atoms become positively charged ions. The electric field between the anode and cathode is in such a direction that the ions are accelerated toward the cathode. They collide with, and knock material off the cathode. This phenomenon is called sputtering. In general, two types of cathode are used in glow lamps; a., a metal base with an emissive coating over the metal; b., a bare metal cathode where the material is of a chosen type and uniform in material distribution throughout its volume.

Sputtering of an emissive coated cathode results in the emissive material being removed. This material has a low work function and is used to lower the firing voltage of the lamp. As the material is knocked off, the bare metal underneath is exposed. The bare metal has a higher work function than the emissive coating and therefore the breakdown and maintaining voltage of the lamp goes up.

Bare metal cathodes have higher breakdown and maintaining voltages than emissive coated cathodes because of these reasons. Sputtering takes place in these lamps just as in the emissive coated cathode lamps. However, when the surface material is removed by sputtering, the exposed material underneath is exactly the same as the sputtered material and no changes in the electrical parameters occur

Corona, or the illuminated region of a glow lamp, occurs in the area where the lowest work function exists on the cathode. It is possible to have two or more areas on the cathode with an identical work function. In this case, there is a distinct possibility that the corona will appear between either of these areas and the anode. In fact, the corona will move, in some random fashion, from one area of low work function to another area of low work function. When this occurs at a frequency of less than 25 cycles, it is obvious to the eye. This phenomenon is called flickering In most cases it is undesirable because it is distracting. We are presently investigating techniques that will define flickerers before they occur so that we can guarantee their absence from our product.

For proper operation glow lamps require some ions to be present in the tube. The ions are created by electron emission (photoelectric effect) which can be generated by light which has an intensity of five foot candles or more. Therefore, if a lamp is to be used in ambient light, few turn-on problems will be encountered. For applications where the lamp is to be used in the dark, radioactive material is added to the lamp. The emission from the radioactive material generates the necessary ions. Atomic Energy Commission regulations are strictly adhered to in the use of any radioactive materials. But in any case, the amount of radioactive material is so low in magnitude that it is not harmful. In addition, the glass envelope is lead glass and contains all emission within the tube.

In the upper right hand corner of Figure 2 is a plot of breakdown voltage vs. the product of pressure and spacing. The resulting curve is the Paschen curve. A given Paschen curve applies only to one gas or gas mixture. The breakdown voltage of a device is designed by choosing a pressure and lead spacing that will give the desired characteristics in conjunction with a given gas. Maintaining voltage is controlled by work function of the cathode as well as the particular gas used. Note that the curve indicated has a relatively sharp bottom shape. This results in a wide variation in breakdown voltage for small changes in spacing or pressure. Close tolerance devices require curves that are fairly flat in the pressure times distance relationship. This can be obtained with very specific gas mixtures.

OTHER TYPES OF CONSTRUCTION

There are many electrode configurations for diodes as well as many envelope shapes and sizes, but the operation is still that of a diode. Figure 3 shows a different type of construction. This device is called a trigger tube because it has three elements, one of which "triggers" or causes the tube to fire.

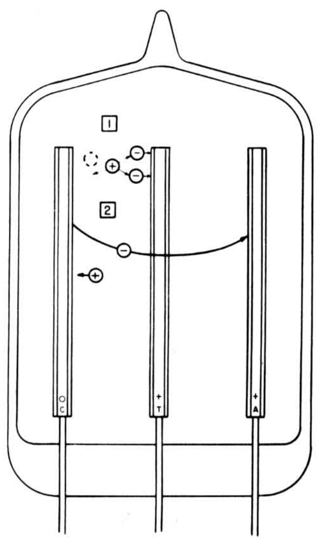


Figure 3 Trigger Tube

OPERATION CHARACTERISTICS

Figure 4A shows, diagrammatically, how light is generated by electrons "striking" an atom. An electron is elevated to a higher energy state and desires to return to the ground state. It does so at a later time and emits the energy change as light. The wavelength of the light depends on the energy change that the electron went through. The energy levels are restricted by quantum physics. Figure 4B shows the same results as 4A in different form.

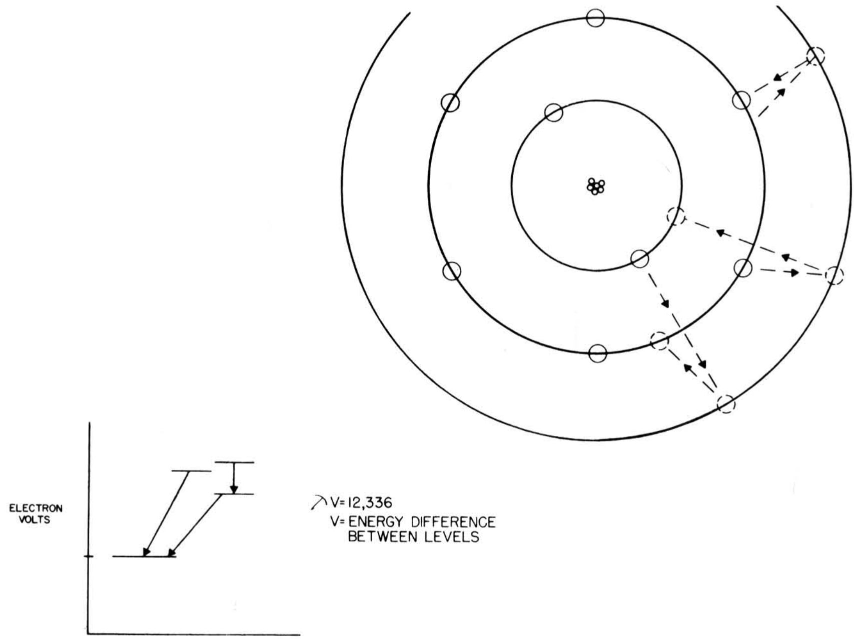


Figure 4 Light Generation

The wavelength of the emission can be calculated from the equation shown:

The spectral outputs of a gas diode are illustrated in Figure 5A and 5B for two different gas mixtures. These are the two most common gases used in glow lamps. Note that for neons (Figure 5A) the light output is in the wavelength of 5700 angstroms and higher This is the red response area of the human eye, and therefore appears red to the eye. The argon lamp (Figure 5B) has a red content above 5500 angstroms and into the infrared range, and a blue which is less than 4700 angstroms. However, because of the intensity of the blue and the fact that the eye cannot see infrared the red gets washed out and the lamp appears blue to the eye.

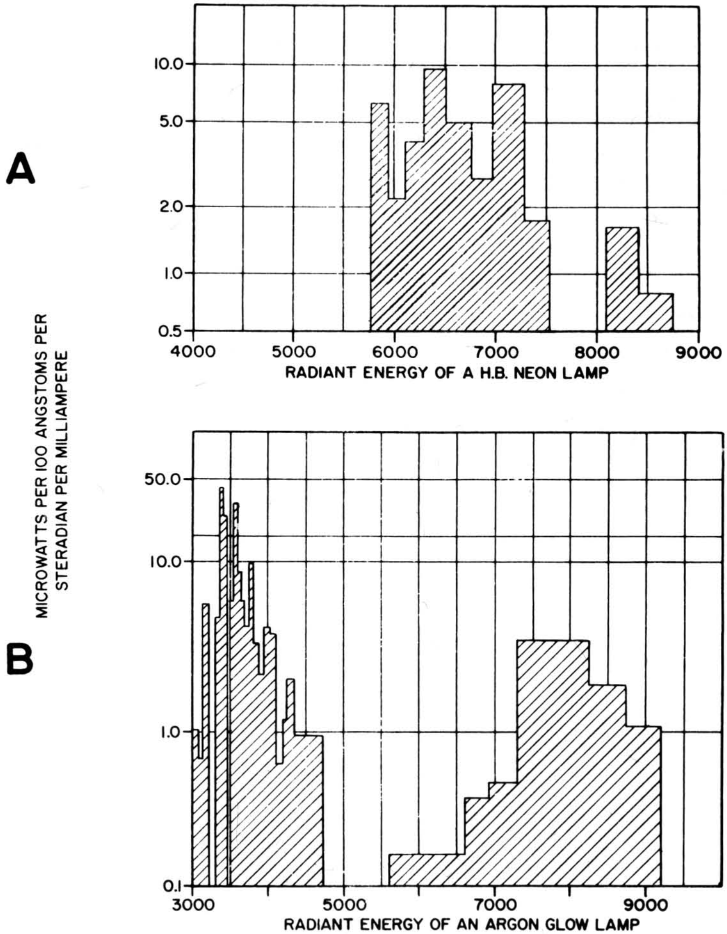


Figure 5 Spectral Distribution

The volt-ampere characteristics of a gas diode are shown in Figure 6. While the curve does not show specific voltages a wide range of breakdown and maintaining voltages is available.

The normal area for operation of a glow lamp is in the negative glow region and published specifications are given for this area. After sufficient current flows through the lamp to create 100% corona coverage, any additional current takes the lamp out of the negative glow area and into the abnormal glow area. This is hard to discern by eye, but the lamp is very bright. The sputtering rate is markedly increased and the tube life considerably shortened.

If the current is raised to a point above the abnormal glow area, the tube will go into an arc mode. For normal devices, this is also highly destructive. However, some devices are specifically designed to operate in the arc mode. These devices are used for pulse energy transfer in such operations as squib firing, drive of optical shutters, and the like.

The shape of the curve in the maintaining region is generally not of interest for light source devices such as indicators. However, for voltage regulators it is necessary that the maintaining curve be fairly flat over some specified current range. In the design of voltage regulators and voltage reference tubes, it is possible to hold this characteristic to within ± 1 volt variation. The current range is specified on our data sheets. Voltage regulator tubes have a much better temperature coefficient than zeners and also dissipate less power

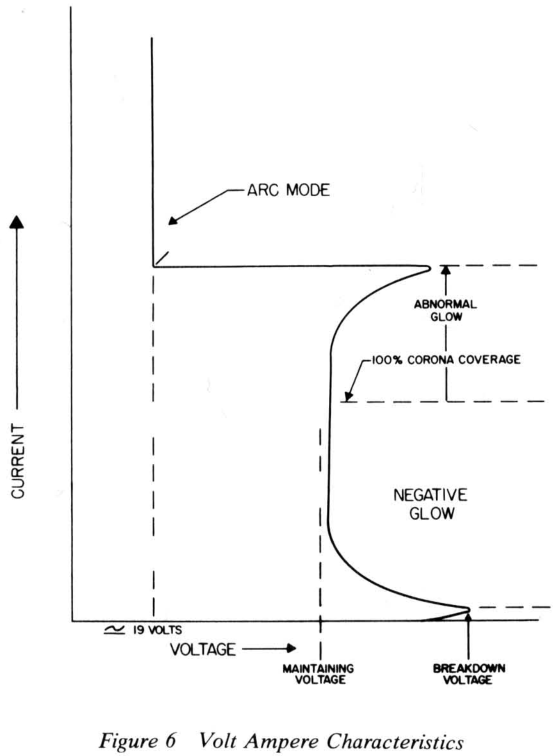


Figure 6 Volt Ampere Characteristics

CAN YOU SOLVE THIS ? ?????

NEEDS FLUX MONITOR

Gentlemen:

I wish to contribute a problem common to all plants for your consideration. A typical Electrician has trouble with control relays. It would be a great help to have a device to monitor flux conditions in the relay to determine conditions.

This might be done with a Magnetoresistor and a neon lamp which would glow in a certain way when the Magnetoresistor is held on the iron. It could indicate normal or abnormal flux. This, in turn, could show lack or armature movement, friction, welded contacts, or low coil voltage.

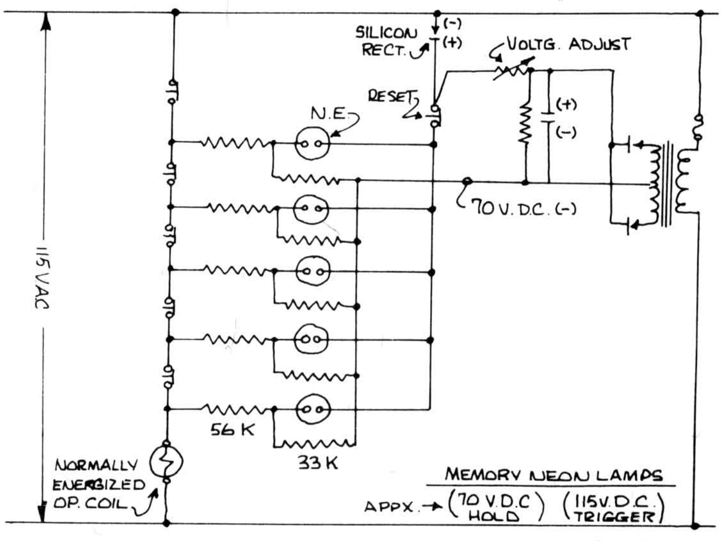
Truly yours,
Elmer V Crager
Keystone Steel & Wire Co.

ANSWER TO CAN YOU SOLVE THIS. Vol. 5, No. 4

WHO STOPPED THE LINE?

Gentlemen

The enclosed scheme may solve the conveyor line stop switch problem

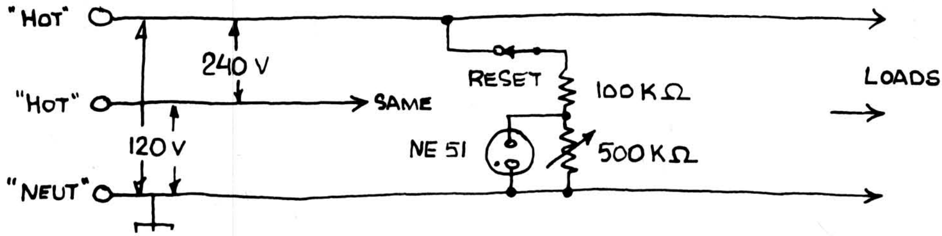


Best regards,
C. C. Earnhardt
Duke Power Co.

NEONS AND HIGH VOLTAGE SPIKES

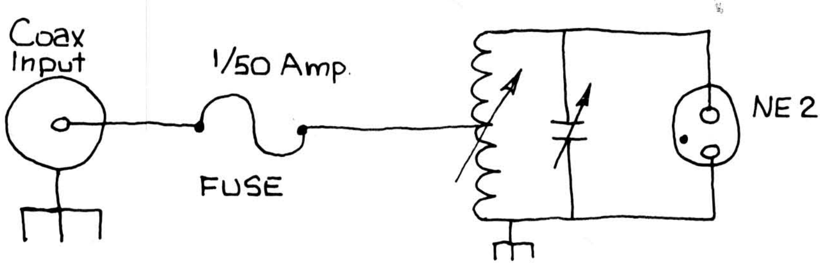
Dear Sirs:

Below is a circuit used here to indicate that a transient or other high line voltage condition has existed. Three similar circuits are used at our power distribution panel One between each line and neutral and the third between lines.



The variable 500K resistor is set at the value needed to allow sufficient voltage across the neon bulb to light it when the line voltage reaches its "high" value we seek to detect. A Variac helps in the initial set up of the detector I have had the circuit trip only once in winter in 4 years. But it trips every couple of weeks during the summer, probably lightning storm transients.

We have replaced the usually used diodes across the coax input to a radio receiver with the following.



The fuse prevents damage to the first RF coil while the NE2 prevents high voltage spikes from going beyond the first stage. Since using this scheme we have not had one case of front end damage even with our transistorized equipment. It also presents lower losses and less detuning than diodes.

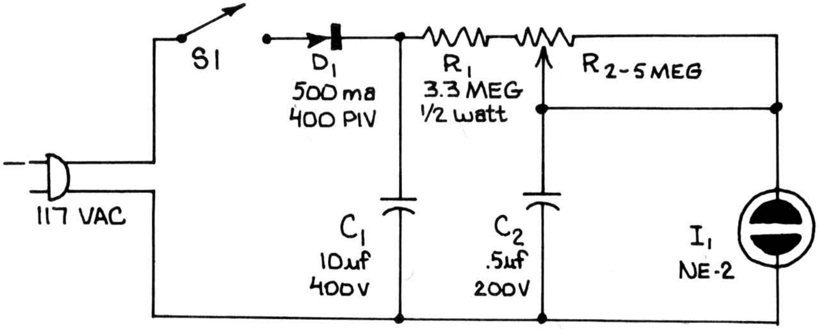
Sincerely,
Donald Van Dorn
University of New Hampshire

DARKROOM METRONOME

Gentlemen

The following circuit is a good one for film developing.

Flash rate of the neon relaxation oscillator is determined by time constant of R_1, R_2 and capacitor C_2.

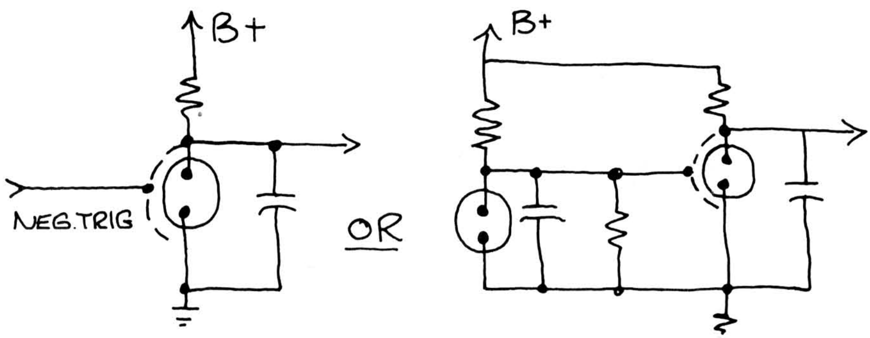


Very truly yours,
Paul Gwozdz
Dover, New Jersey

3 FOR THE PRICE OF 2

Dear Sir·

The two terminal neon light can be made into a three terminal device by the addition of a small metal strap or plate cup for an octal tube connected around the neon light.



SYNCHRONIZED RELAXATION OSCILLATOR

FREQUENCY DIVIDER

R. E. Renfrow
Honeywell Inc.

Ed. Note.

If the shield is connected to the cathode, or lower breakdown, the breakdown voltage will go up. If it is connected to the anode, or higher potential, the breakdown voltage will go down. Either of these will affect the oscillation.

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Drop Us A Line. .

If you have an interesting application of neon glow lamps in your circuitry. or a problem concerning the use of neon lamps, 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 home.

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*

* * * * *

For information about Signalite Neon Glow Lamps for circuit component and/or indicator applications, for specifications on lamps, for general information about Signalite and its products, call us at any of the following telephone numbers:

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