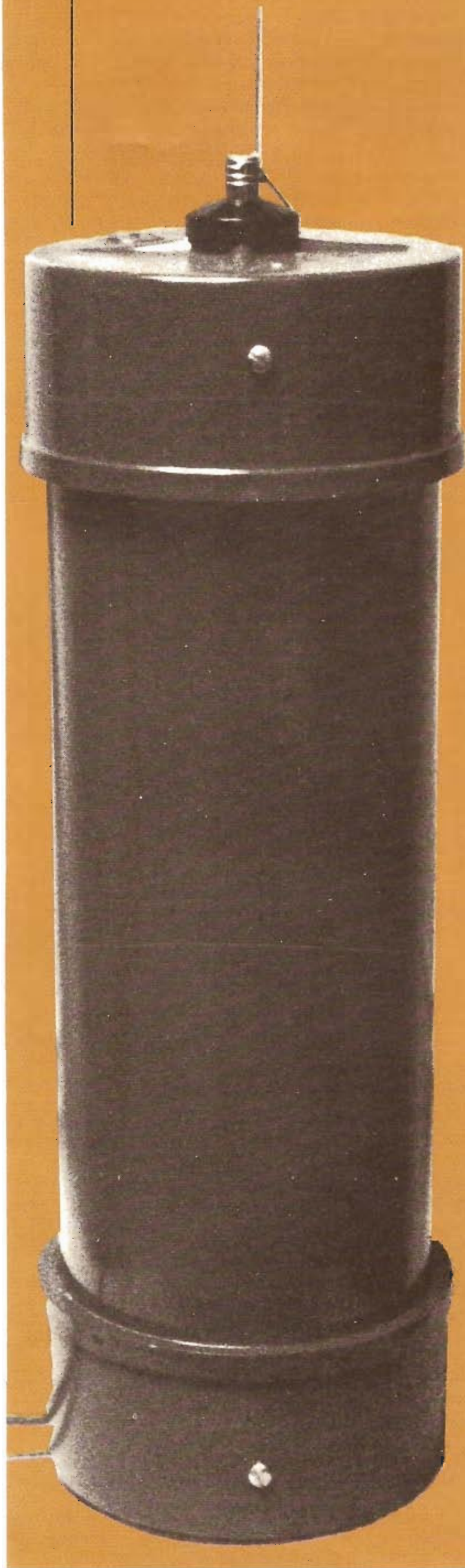

NEGATIVE ION GENERATOR

A great amount of interest has been shown recently in negative-ion generators. Build one yourself and see how it benefits you.

RONALD E. PYLE

WITHIN THE LAST SEVERAL YEARS, negative-ion generators have found increasing popularity. Many benefits from exposure to negatively ionized oxygen have been claimed.* For example, some experimental evidence indicates that certain respiratory ailments can be alleviated; migraines, acute anxiety, and depression can be reduced or eliminated, and seriously burned patients can experience reduced pain and infection, and accelerated healing.

Physiologically, it has been found that in atmospheres containing an excess of *positive* ions, serotonin, a stress neuro-hormone that inhibits oxygen absorption in the body, is produced in the blood and carried throughout the circulatory system. An excess of serotonin can result in dizziness, inability to concentrate, fatigue, migraine, depression, and shortness of breath. Negative oxygen ions, on the other hand, cause the degradation of serotonin into a harmless by-product.

Because an oxygen molecule in air contains unpaired electrons it can readily accept an electron produced by natural or artificial means to become a relatively stable negative ion.

Negative oxygen ions can be produced efficiently and safely using the high-voltage corona-discharge method. High-voltage negative DC of approximately −6000 to −9000 volts is used to charge the tip of an emitting needle. That results in the production of a large quantity of electrons that are emitted at high velocities from the tip due to the large accelerating potential. The relatively high-energy electrons that are released react with the oxygen molecules in the air to produce the desire negative oxygen ions.

*Voisinet, Roger. Journal of Environmental Sciences, July/August 1978, pp. 28 - 29.

How it works

Figure 1 shows a simple, low-cost circuit based on the high-voltage corona-discharge method. The NE555 is used in the astable mode. It produces a continuous squarewave at a frequency of approximately 40 Hz and duty cycle near 10% at pin 3. This squarewave output is then coupled through R3 to a Darlington transistor pair (Q1, Q2) that is used to switch the primary of a standard 12-volt three-terminal automobile-ignition coil.

The high-voltage, AC output from the ignition coil is then half-wave rectified by connecting it to the cathode of a 45,000-volt high-voltage diode assembly using standard high-voltage ignition wire. (Note the polarity of the diode carefully.) The resulting negative DC is then filtered by high-voltage capacitors C4, C5, and C6. A common sewing needle is used as the electron-emission source, and its blunt end is soldered to the anode end of the high-voltage diode assembly (often referred to as a stick diode).

In Fig. 2, a simple, unregulated, power supply for the negative-ion generator is shown. The output of power transformer T1 is half-wave rectified by D2, current limited by R5, and filtered by capacitor C7. The power supply produces (under load) approximately 10 volts for the circuit.

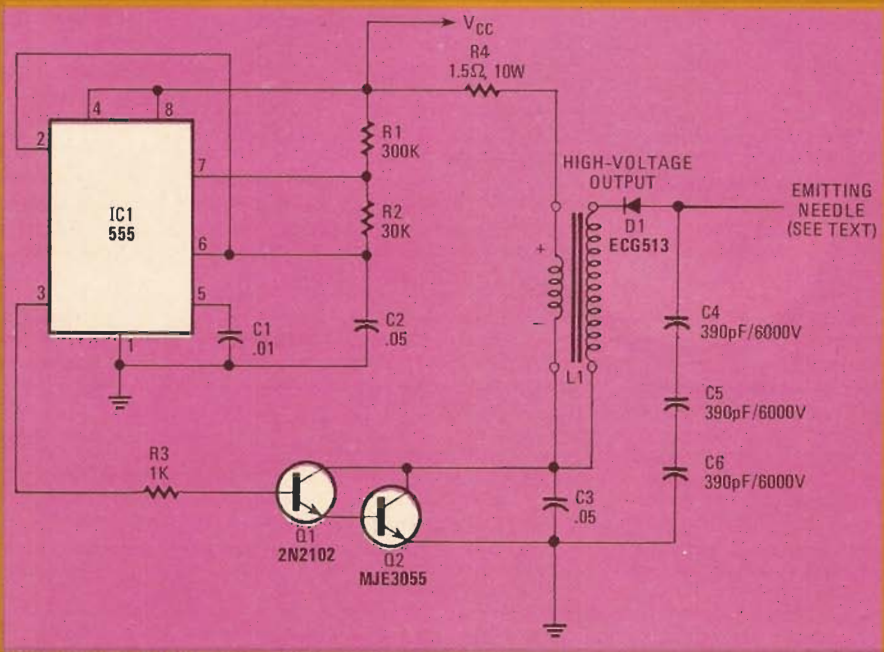

FIG. 1—SCHEMATIC DIAGRAM of the negative-ion generator. The NE555 is used in the astable mode.

PARTS LIST

Resistors ¼ watt, 5% unless otherwise indicated

R1—300,000 ohms
R2—30,000 ohms
R3—1000 ohms
R4—1.5 ohms, 10 watts
R5—5 ohms, 10 watts

Capacitors

C1—0.01 µF, 50 volts, ceramic disc
C2, C3—0.05 µF, 100 volts, ceramic disc
C4-C6—390 pF, 6000 volts, ceramic disc
C7—1000 µF, 35 volts, axial lead electrolytic

Semiconductors

D1—ECG513 45,000-volt diode array
D2—1N3880
Q1—2N2102 NPN transistor
Q2—MJE3055 NPN transistor
IC1—NE555 timer
L1—12-volt, three terminal, automotive ignition coil
T1—power transformer, 12.6 volts, 3 amps

Miscellaneous: PC board, perforated board, or IC breadboard; four-inch diameter PVC pipe with end-caps; high-voltage automobile ignition wire; hookup wire; heat sink, mica washer, and heat-sink compound; terminal strip; aluminum bracket material; line cord; ½-amp fuse; hardware, etc.

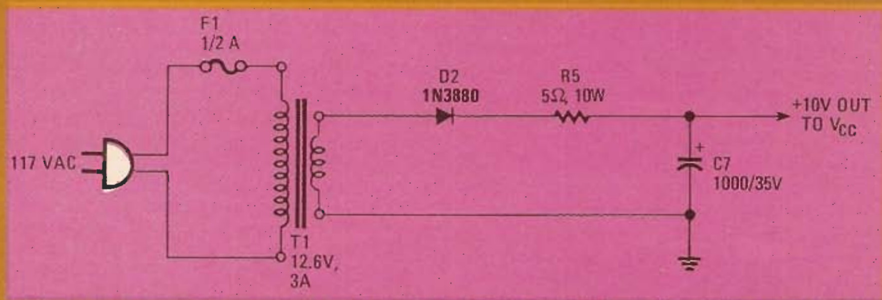

FIG. 2—THIS SIMPLE, UNREGULATED, POWER SUPPLY produces approximately 10 volts for the negative-ion generator.

Construction

The circuit in Fig. 1 can be built easily on a small (1¼ × 2¼ inches) piece of perforated board, printed-circuit board, or universal IC breadboard, as shown in Fig. 3. Transistor Q1 does not need to be heat-sinked as its load current (Q2's base current) requirements and therefore the transistor's power dissipation are not excessive. However, Q2 is mounted off the circuit board and heat-sinked for thermal overload protection as shown in Fig. 3. Because the MJE3055's (Q2) mounting tab is tied to the collector, care must be taken to isolate the mounting tab from ground. That is done by using a mica washer and heat-sink compound between the transistor's case and the heat-sink, and mounting the transistor using a nylon bolt.

The +10-volt power supply shown in Fig. 2 was built to allow for a compact installation. A right-angle aluminum bracket made from a 2½ × 3-inch piece of 3/32-inch aluminum sheet was epoxied to the top of the power transformer, T1, as shown in Fig. 4. A seven-lug terminal strip was then epoxied to the bottom of the aluminum

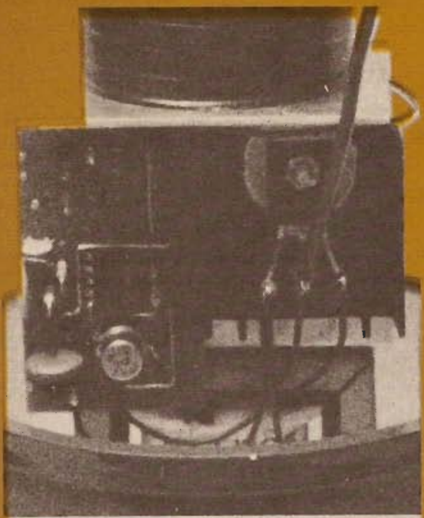

FIG. 3—THE ION-GENERATOR circuit is built on a small piece of circuit board. Transistor Q2 is mounted next to the board and should be heat-sinked as shown.

FIG. 4—A RIGHT-ANGLE BRACKET is epoxied to the top of transformer T1. The circuit board is mounted on the bracket using ¼-inch plastic stand-offs. The connections to the ignition coil, and the lead from the coil's high-voltage terminal, will be concealed by the PVC pipe in the completed project.

bracket for component mounting as shown in Fig. 5. The power-supply components—rectifier D2, power resistor R5, and filter capacitor C7—are then soldered to the terminal strip. The small circuit board and Q2 (mounted

FIG. 5—ALL POWER-SUPPLY components, except T1, are mounted on a terminal strip that is epoxied to the bracket.

FIG. 6—INTERIOR VIEW of the top PVC cap. Rectifier D1 and capacitors C4, C5, and C6 are shown.

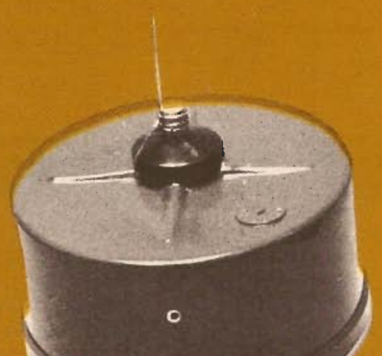

FIG. 7—A COMMON SEWING NEEDLE is used as the electron-emission source. The blunt end of the needle is soldered to the anode of the rectifier.

on its heat sink) are mounted on the other side of the bracket. Epoxy Q2's heat sink directly to the bracket, and mount the circuit board, using ¼-inch plastic stand-offs and epoxy, as shown in Fig. 4.

Another piece of 3/32-inch aluminum sheet measuring approximately 2½ × 2½ inches, was epoxied at a right angle to the top of the power-supply bracket as shown in Fig. 4 to serve as a mounting base for the ignition-coil assembly. Once the epoxy has set, the ignition coil can be epoxied to the mounting base. All solder connections between the power supply, coil, and circuit board can be completed now.

The completed assembly is housed in a piece of standard 4-inch diameter PVC 3/32-inch wall pipe, approximately 13 inches long, with two standard 4-inch PVC end-caps. The power supply, coil, and circuit-board assembly is bolted to the bottom end-cap after a suitable side hole is drilled for the 120-volt AC line cord.

The high-voltage rectifier, D1, and high-voltage filter capacitors C4, C5, and C6, are then mounted in place with epoxy through a 9/16-inch hole drilled in the top PVC end-cap as shown in Figs. 6 and 7. One end of the series-connected high-voltage capacitors is soldered directly to the anode of the rectifier; the other end is connected to ground on the power supply, coil, and circuit-board assembly. The automobile high-voltage ignition wire lead from the coil's high-voltage output is soldered to the cathode of the rectifier. A two-inch long common steel sewing needle is used as the emission source. The needle's blunt end is soldered to the anode of the rectifier. Make certain that the diode polarity is as shown in Fig. 1. In addition, after assembling the completed unit and PVC housing, make certain that the high-voltage connections are not located near any potential discharge-points on the assembly.

Summary

In the circuit shown, the high-voltage negative DC at the anode has been measured with a high-voltage probe at approximately −9000 volts, which is sufficient for generating negative oxygen ions. Although it is *not* lethal, the instrument is a high-voltage source and should be treated with respect and caution.

The "ion wind" generated by the rapidly moving ion flux from the emission source can be felt by carefully placing a finger near the emitting needle tip. For maximum effect, the negative-ion generator may be placed several feet from the user. **R-E**

"Looks to me like the audio stage is dead, indicating a shorted output transistor—but Pa thinks it's a split resistor."

hobby corner

Here's a look at negative-ion generators, and other tidbits,

EARL "DOC" SAVAGE, K4SDS, HOBBY EDITOR

IN JUNE 1980, I PASSED ALONG A REQUEST from Russ Lane for some information about building a negative-ion generator. Thanks for your responses.

For the uninitiated, there are those who maintain that exposure to air that contains negative ions promotes physical and mental well-being. I simply don't know whether it does or doesn't, so I can only say, "To each his own!"

In any case, there is general agreement that breathing ozone (O_3) for an extended period is unhealthy. Further, an ion generator will produce ozone if it is not adjusted properly. So, if you build your own, be sure to have all the information you will need and make the adjustments that prevent ozone formation.

Negative ions are introduced into the atmosphere when a negatively charged object "leaks" them into the air. To get an appreciable quantity of ions, you need several thousand volts—at least 5,000.

There are four convenient methods of producing the required high voltage. One is to begin with 110 volts AC or more from a transformer and add on a long series of voltage-doubler circuits. Another is to use a "firing transformer" designed to produce an arc (normally to ignite an oil furnace).

Very little current is needed to produce ions. Safety precautions with either of the above methods include placing a very high resistance between the supply and the charged object in order to limit the current in case you accidentally come into contact with it.

Two ways that are more satisfactory for producing high voltage require a little more circuitry. They are to use either an automobile ignition coil or a TV flyback transformer to change a low input-voltage into 5-to 20-thousand volts. For increased efficiency, the low voltage should be interrupted DC (square wave) rather than AC. That is usually done with heavy-duty switching transistors driven by a square-wave generator (a 555 IC) or by a feedback winding added to the flyback transformer.

There are two advantages to those last two methods. One is that the current is automatically limited. The other is that those systems are more readily adjusted to prevent ozone formation.

Of course, the final high-voltage must be rectified; the usual approach is to use a solid-state diode designed for TV high-voltage supplies. The negative output lead is connected to the "charged object."

Unit charges (electrons) disperse over the surface of an object with a concentration proportional to the radius of curvature at any given point. What that means is that the electrons collect around sharp angles and points (see Fig. 1). So, if you want them to leak off into the air, your object must have one or more sharp points. Then, with a good high voltage, the electrons "spray off" the charged object and ionize the air molecules.

That shape factor is the reason why builders of ion generators often use one (or more) sewing needles as the charged object. The negative output of the high-voltage supply is simply connected to the needle.

Because of the shape factor, you should be careful when you hook-up and route the high-voltage lead. Avoid leaving wire ends sticking out. Watch for sharp projections that may be left on a solder blob. Avoid sharp bends in the wires—use gentle curves when changing direction. After all, you want to lose as few electrons as possible before reaching the needle(s).

There you have the basics for building your own negative-ion generator. Special thanks to Dennis Doonan (Racine, WI), Istvan Mohos (Phoenix, AZ), Richard Kaufman (New York, NY) and others who came up with much of the foregoing information.

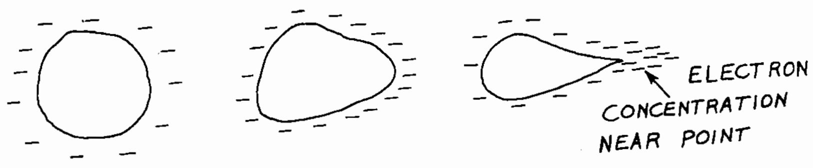

Fig. 1

Magazine index

How often does this happen to you? You remember an article with information that you need but you can't remember what issue it was in—maybe not even the year it appeared or in what magazine. You tackle the annual indexes if you have them or worse yet, the table of contents in each individual issue.

That process can be a real headache; it can take from hours to days. And that is only when you can remember the article—what about those articles that you have forgotten?

I have some magazine files that go back more than 25 years. Searching for something vaguely recalled used to be a chore, but not any longer—my *TRS-80* does the searching for me.

What does your microcomputer do for *you* besides play games? Put your computer to work keeping and searching a master index—one or more depending upon your needs.

An 8K or 16K computer can hold a surprisingly large index if you are careful about how you arrange the data. That is especially true if you use your imagination to create a coding system that will reduce memory requirements. Here's an example:

```
IDENTIFY UNMARKED IC'S
Radio-Electronics
P. 45, JAN 80
```

can become

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ICIDXMARK/RE0450180
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Of course you should use your own system, but it is obvious that the second entry takes less memory but conveys the same information.

Well . . . yes, it *did* take time to create the index files for the several magazines—especially for the ones that go back a number of years. Once done however, it takes only a few minutes every month or two to stay current.

Now my searches are quick and complete. The reference mentioned above will turn up in a long list if I key in "IC" and on a much shorter one under "ICID."

Don't let your computer just play around—put it to work. And if you don't have one yet, here is one more reason to get one.

Help!

Pat Hazen of New Orleans is asking for help in designing an alarm circuit to substitute for an output-meter indicator in a detection device. He is speaking specifically of the gas detector in the July 1976 issue of **Radio-Electronics.**

WRITE TO:

ASK R-E
Radio-Electronics
500-B Bi-County Blvd.
Farmingdale, NY 11735

AIR IONIZERS

I've heard a lot about air ionizers and am wondering how effective they really are. What can you tell me?—T.L., Hamilton, OH.

Experience tells me to stay out of this one. Probably more arguments start with the discussion of air ionizers and positive and negative ions than on "the direction of current flow." But I'll try and give you an answer without putting my foot in my mouth.

Research on ionized air and its effects on humans, animals, and plants has been going on since the middle 1930's. Here are some of the "findings" and opinions:

- The concentration of ions in the air does have a pronounced effect on animals and plants. Also, the polarity of ionization has a distinct effect on life.
- Ion depletion is said to cause depression, mental fatigue, headaches, and respiratory problems in man, and has been shown to reduce the survival rate of animals.
- Increasing ion concentration promotes healing, relieves the pain of burns, and promotes plant growth.
- High concentrations of *negative* ions seem to promote mental agility and alertness and, over the long term, greatly reduce employee-days-lost due to respiratory illnesses.
- Positively charged ions tend to promote hostility and aggressiveness while negative ions promote tranquility.
- Atmospheric pollution in cities and industrial areas tends to promote a drastic depletion in air-ion concentration and to increase the critical positive-to-negative air-ion ratio. Perhaps that explains why

Strange Power of AIR IONS

THE NEGATIVE IONS ARE THE GOOD GUYS—POSITIVE IONS THE BAD

BY HOWARD F. BURGESS

IN THE 1700's the naive and superstitious believed that "air electricity" could influence both mind and body. A crime committed when a strong dry wind was blowing was believed to be caused by the wind, and some judges in Europe were more lenient during these windy seasons.

Yesterday's fantasy is today's scientific fact. The most exciting research programs develop when an old superstition is found to have some scientific truth. Many, such as the riddle of "air electricity," are being put together one bit at a time. Like a jig-saw picture puzzle some pieces fall into place. Others which can be recognized as part of the picture must wait on a piece that is still missing.

Although there are still some important bits to find, the picture of "air electricity" is becoming clear. We now know beyond a doubt that it can do much to control the mind and body of man. It may be the secret of controlling disease.

In 1921 Frederick Dessauer, of Germany, recognized enough pieces of the puzzle to make a start and by 1931 a picture was beginning to take shape from the data he had been able to collect. He was convinced that "air electricity" was charged air particles which surround us at all times. He had also found that if the negative particles exceed the positive particles, a condition was created which was beneficial to both mind and body. Harmful effects were found when the positive particles exceeded the negative.

Since the early work of Dessauer, many men and many laboratories have added bits to the picture. Researchers have found that air electricity is really air ionization and the results depend upon whether the majority of the ions are positive or negative in polarity. The negative ions are the good guys and the positive ions seem to be the bad guys.

What is an Ion? "Ion" is a short name for a very small piece of matter. Ions are usually measured in millimicrons which are one thousandth of one millionth of a meter. Although small, the physics involved is quite complicated. However, for present purposes the explanation can be quite simple.

An ion is a molecule or group of molecules that has become electrically charged as a result of gaining or losing an electron. A "negative ion" is one which has gained an electron. A "positive ion" is one which has lost an electron. Ions are created in many ways. Any force which can dislodge an electron from an uncharged molecule will create two ions. The molecule which loses the electron becomes a positive ion and the molecule which picks up the wandering electron becomes a negative ion. When ions of opposite polarity collide, another exchange takes place and they are neutralized.

Nature is an endless source of ions. Energy from outer space such as X-rays, ultraviolet, and cosmic rays create ions. Radioactive material in the soil also contributes to the supply. Other natural events such as thunder storms, rain and snow add their effect. Even the wind and the moon have their part in the story.

Air is composed of several gases including oxygen, nitrogen, carbon dioxide and others in lesser amounts. Air also carries varying amounts of pollution in the form of microscopic particles of anything that man can dump into the atmosphere. Water vapor also has a major part in air ionization.

Air ions seldom consist of just one gas molecule. An ion generally consists of a cluster of gas molecules which are sometimes grouped around a water particle or air pollution material. These clusters are classified according to size. Small ions may consist of 3 to 8 molecules and are capable of rapid movement. They are somewhat important for their effect on man. The intermediate sized ions may have several hundred molecules. They move slower than the small ions, and have the greatest effect on living things. Ions classed as large may contain several thousand molecules. They move very slowly and are generally related to air pollution.

For research work ions of the small and intermediate size are desired. These can be generated artificially in several ways. Radioactive sources are very good ion generators but are difficult for the ordinary experimenter to obtain. Ions can also be generated by use of a high voltage applied between special electrodes. Another source is a simple electric heating element at higher than normal temperature. Generators usually require some type of electric filter to remove ions of the unwanted polarity.

Ions are disappointingly short-lived. After generation they will travel only a short distance before being neutralized by another particle.

Ion Effects. Many events generally accepted without an explanation are the results of natural ions. The oppressive feeling before a thunder storm that is felt by both men and animals is due to the predominance of positive ions ahead of a storm. The oppression may take the form of headaches, rheumatism or respiratory attacks. The fresh, wonderful feeling that follows a storm comes from the high level of negative ions that follows a storm front. A misty rain of small droplets usually raises the positive level while a shower of large drops brings up the negative count.

The strong dry winds which occur in some areas will bring up the positive count and may have a marked effect on the temperment of both man and beast. Tests have shown that in areas that have long been noted as health resorts, the ion count many times runs predominantely negative.

In a recent news broadcast from *Radio Moscow,* Doctor G. Tsitsishvili of the Sanitary and Hygenic Institute stated that it has been determined that the higher you live (above sea level), the longer you live. Although no mention was made of ions, the findings of the doctor are interesting. American researchers have found that the number of negative ions increases with altitude.

As in other things, man alters the level and polarity of ions. Ions produced by nature are generally of the small or intermediate size and are found in clean air. But, air pollution is a factor in generating large ions. Large ions are found in urban areas or where there is air contamination. They are slow in movement. Because they are large and slow, they absorb the smaller but faster ions that collide with them and so reduce any possibility of negative ionization.

Research in air conditioning has shown that ions in an unoccupied room with open windows will be very similar to that outside. If the windows are closed, ion level of both polarities will decrease somewhat. As people begin to occupy the room the number of large ions increases and small and intermediate ions will continue to decrease. The comfort factor will decrease as the number of large ions increase. Forced ventilation through duct work will decrease the ion density but will increase the unbalance in favor of the positive ions. It has been shown that air in close quarters can be kept at the correct temperature and humidity but the occupants will still be quite uncomfortable and distressed if the number of

(*Continued on page* 114)

MAKE YOUR OWN ION CHAMBER

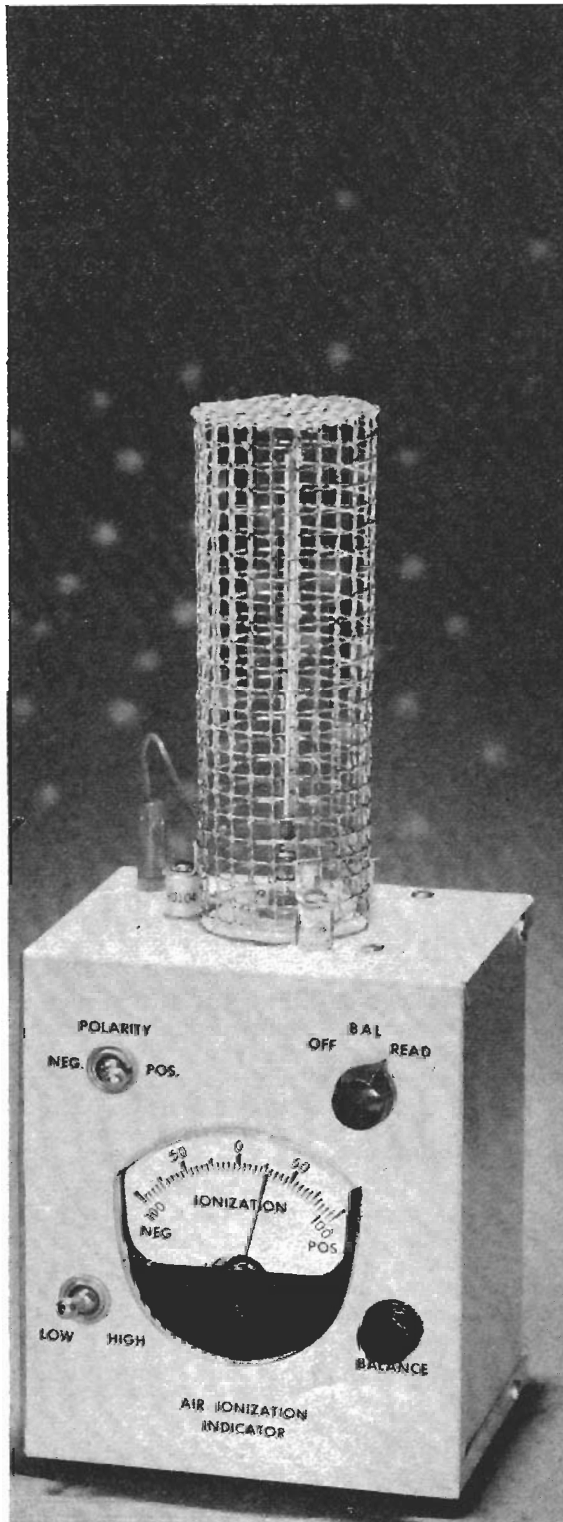
Detect and Measure Air Ionization Polarity

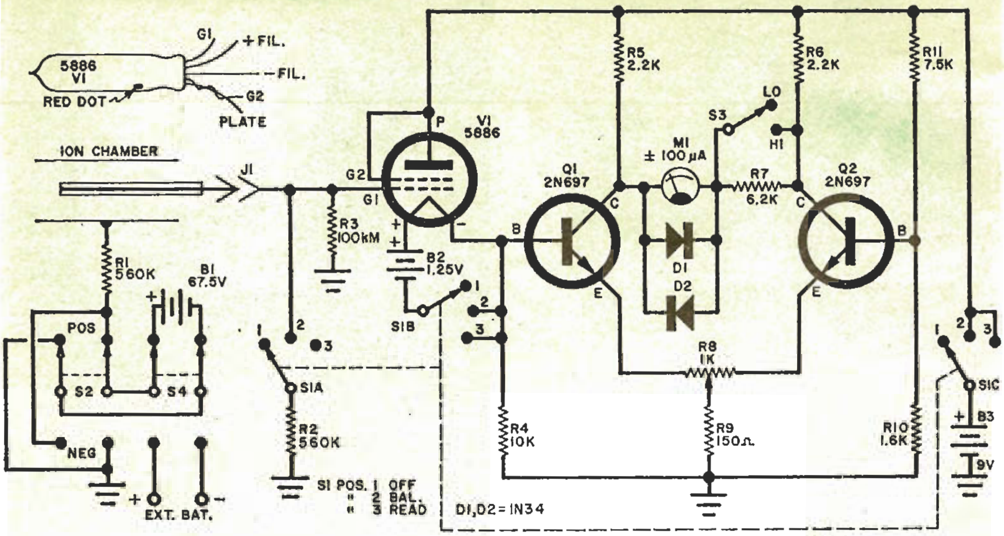
BY HOWARD BURGESS

USEFUL and interesting information can be gained about the effects of air ionization by making measurements under various conditions. A commercial instrument capable of doing this is expensive and delicate but a simple unit can be built which will indicate the polarity and relative amount of ionization present where larger changes are involved.

A home-built ion chamber is used to detect the ions of the polarity which we wish to count. The collected charges are then routed to the grid of an electrometer tube. This tube is a vacuum tube capable of sensing currents far smaller than those which can be detected by an ordinary tube. Currents in this type of instrument can be less than one millionth of a microampere.

The tube was chosen in preference to a field effect transistor because it can take more abuse from the high voltages which may be encountered in this type or work. Luckily the electrometer tube requires only a modest plate voltage. The output of the tube is quite low and requires amplification (transistors *Q1* and *Q2*) to operate the meter, *M1*.





Ions detected by the ion chamber develop a small voltage drop across the very high resistance of R3. This voltage is amplified and operates a transistorized bridge. Sensitivity depends on the value of R3 which must be extremely high to make the circuit effective.

PARTS LIST

B1—67½-volt B battery
B2—1.25-volt mercury cell (Mallory RM12R)
B3—9-volt transistor battery
D1,D2—1N34 diode
M1—100-0-100-microampere meter
Q1,Q2—2N697 transistor
R1,R2—560,000-ohm
R4—10,000-ohm
R5,R6—2200-ohm
R7—6200-ohm
R9—150-ohm
R10—1600-ohm
R11—7500-ohm
(*all resistors ½-watt*)
R3—100,000-megohm resistor (see text)*
R8—1000-ohm, wirewound potentiometer
S1—3-pole, 3-position ceramic switch
S3—S.p.s.t. toggle switch
S2,S4—D.p.d.t. toggle switch
V1—5886 electrometer tube (Allied No. 5886 59F2)
Misc.—Phone tip packs (4), standoff insulator (3), 1"x3" terminal strip, battery holders, 4"x5"x6" utility box, knobs, hardware, etc.
**Victoreen Instrument Div., 10101 Woodland Ave., Cleveland, Ohio 44104.*

Construction. The unit is housed in a 4" x 5" x 6" aluminum box and construction is quite simple. The small parts are mounted on a 1" x 3" terminal board as in the photo. Switch *S1* must be of high quality ceramic. The variable resistor *R8* can be a standard wirewound potentiometer; however a vernier or 10-turn potentiometer makes for easier adjustment if you are lucky enough to have one. The only unusual items are the 5886 electrometer tube (*V1*) and its grid resistor (*R3*) which has a value of 100,000 megohms. Both items are made by the Victoreen Company and are available from sources shown in the Parts List.

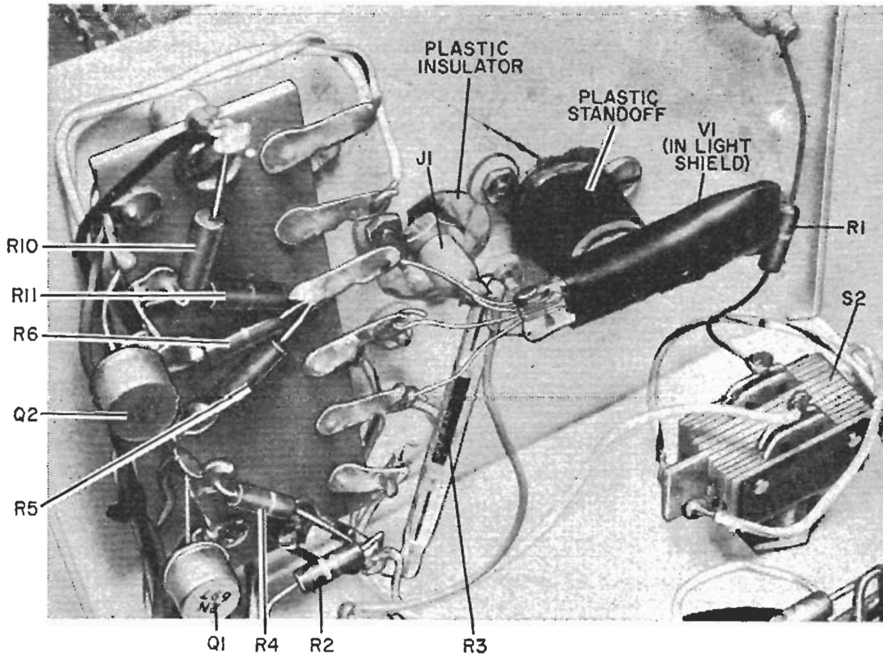
The tube must be covered to protect it from light while it is in operation or the photoelectric effect of light falling on the elements can upset the operation of the sensitive circuit. Only the best of in-

HOW IT WORKS

The ion chamber consists of an outer electrode which is in the form of a screen cage through which air can flow. The inner electrode is a rod in the center of the cage. If a polarizing voltage is connected with the negative to the cage and the positive to the rod, negative ions are attracted to the rod. This produces a voltage across resistor *R3*. The value of the voltage depends on the number of ions present. This voltage is sensed by the electrometer tube *V1* which activates the meter drive circuit. The meter is driven by transistors *Q1* and *Q2* in a balanced bridge circuit. The zero-center meter will read to right or left depending on whether the charge is positive or negative.

If the polarizing voltage is reversed to the screen cage the center rod will collect positive ions and the meter will read to the right to indicate the level of positive ionization.

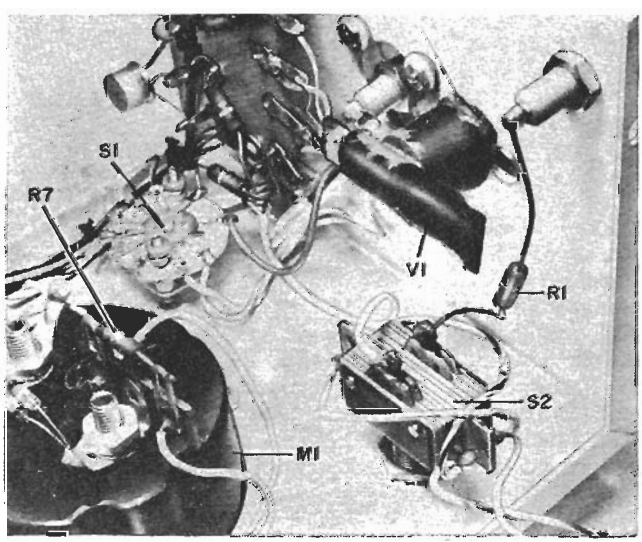
The sensitivity of the meter can be reduced by *S3* when high field strengths are encountered. The number of ions collected depends somewhat upon the value of polarizing voltage applied to the chamber. For personnel safety reasons the voltage should be kept below 250 volts.



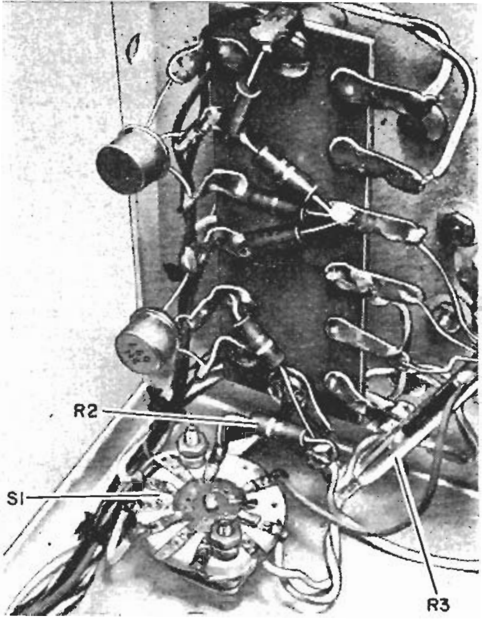
Component installation. Because the presence of light greatly reduces the electrometer tube sensitivity, it must be enclosed in an opaque tape housing. It mounts on a standoff.

sulation should be used in the grid circuit of the 5886 if full sensitivity is to be obtained. After assembly, all insulation in the grid circuit should be cleaned with alcohol to remove any oils or moisture left by the fingers.

The ion chamber, which is mounted on top of the case, consists of an outer electrode which resembles a small cage 6″ high and 2″ in diameter. It is constructed of ¼″ wire netting as shown in the photos. The bottom is open and is insulated from the metal case by three ceramic insulators. The polarizing voltage of 67½ volts supplied by the battery mounted in the case will be sufficient for most work. For experimental work where higher voltage is required, provision has



Switch S2 reverses the polarity of the ion chamber voltage. Resistor R1 is a safety resistor to reduce current flow in case of accidental short between cage and case.



Function switch S1 is located near the electronics board. Use a high-quality ceramic switch to prevent leakage around the very high value of resistor R3.

been made to switch to an outside source which can be connected to terminals on the rear of the case.

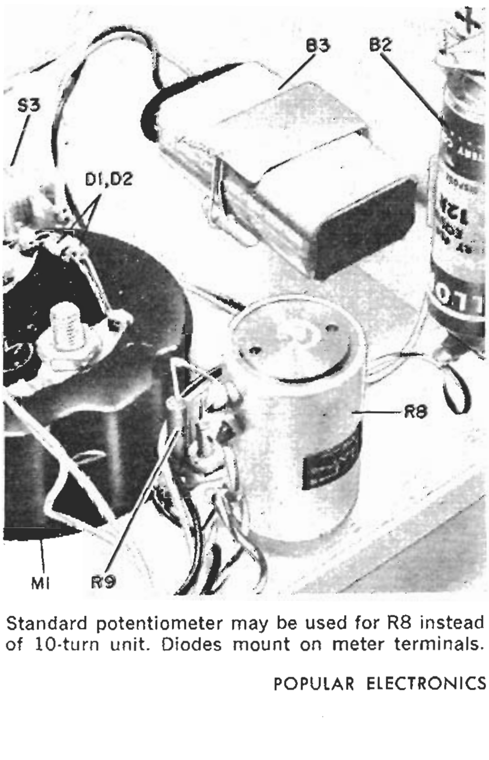
The cage is electrically above ground by the amount of the polarizing voltage. Resistor R1 has been placed in the circuit to prevent serious shock in case the cage is touched. Voltage to the cage can be removed by the switch in the rear.

The inner conductor of the chamber is a rod or wire 1/16″ in diameter and five inches long. A phone tip is mounted on one end of the rod and plugs into a tip jack. This makes for easy removal for experiments with other types of chambers. The tip jack should be mounted on insulating material of the best quality with a long leakage path. Do not depend on the insulation supplied on the tip jack; cut out a square of quality plastic as shown.

The 10,000-megohm resistor R3 is expensive. To make a substitute, use a ceramic-body r.f. choke, about 1½″ to 2″ long, with a pigtail at each end. Remove the coil and clean the form thoroughly. Draw a line of Higgins india ink about 3/64″ wide between the pigtails. Allow the ink to dry completely and never handle the form so as to touch the ink line or otherwise introduce body oils that might reduce the resistance. You may also use a narrow piece of PC board by drilling a small hole close to each end. Then wrap copper wires through each hole, leaving short lengths to make connections. Solder the wire wraps and draw an india ink line between the two solder joints.

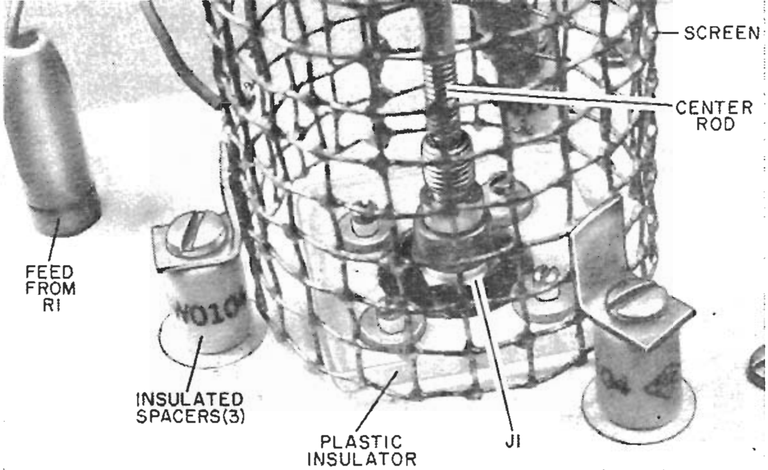
Adjustment and Operation. When the construction is finished and checked, place *S1* in the OFF position and *S3* in the LOW position and install the batteries. When *S1* is moved to the BAL position, the unit becomes operational but with greatly reduced sensitivity. The meter should now be adjusted to center zero. If the meter does not adjust to zero with *R8* near the center of its range, the value of *R10* should be changed to balance the currents of the two transistors. The value of *R10* can be raised or lowered a small amount as required.

When the meter zeroes near the midrange of *R8* and all appears well, put *S1* in the READ position and close *S3* by placing it on HIGH. Several seconds may be required for the meter to stabilize. If *S2* is in the POS position, the meter will read to the right for any positive charge. Now place *S1* in BAL and reverse *S2*. Return *S1* to READ and read the negative charge. Under normal conditions the readings will be small and nearly equal.



Standard potentiometer may be used for R8 instead of 10-turn unit. Diodes mount on meter terminals.

The cage is mounted on three ceramic spacers around the perimeter and is connected via an insulated lead to resistor R1.



Never change S2 *except when* S1 *is in the* BAL *position.*

If a lighted match is brought close to the chamber the results of ionization will be seen. Tobacco smoke blown into the chamber will also indicate ionized particles. If an ultraviolet lamp is available, turn it on the chamber and observe the results.

A small slow-moving fan is useful to force air through the chamber. A fan which stirs the air too violently or which has arcing brushes can generate ions of its own which can make measurements meaningless.

An interesting test can be made on electric heaters. Many heaters generate positive ions and the side effects that go with them. One electric hair dryer tested was capable of pushing the meter off scale from as far away as six feet. The use of such heaters will probably not cause any violent side effects but they have been known to cause drowsiness, fatigue and headaches. Long periods of continued use could be damaging to the general health. Heaters which are rich in ions usually have heating elements which glow brightly.

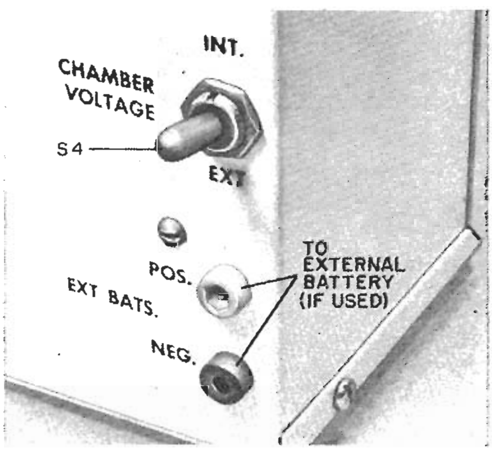
It has been found that metal duct work in some air conditioning systems creates a positive ion condition by attracting negative ions to the duct walls and leaving an excess of positive ions. The result can be minor respiratory troubles.

If the meter is placed near an automobile exhaust in a position which will allow the gases to reach the ion chamber large values can be read. In this case both positive and negative ions will be indicated. These will re-combine in a short time under normal conditions.

Radioactive material will also register on the meter. As an auxiliary use the meter can be used to measure or monitor radioactive conditions or fallout. Other types of chambers may be constructed for use in this field.

If the instrument is operating properly it will be sensitive enough to register movements of your body several feet away. This is a static charge on the body and not ionization. This effect can be reduced somewhat by connecting the meter case to a good ground.

Although this little meter is not as versatile as the sophisticated laboratory models, it will make many interesting measurements and it will introduce you to the fundamentals of what may prove to be one of the secrets of life itself. -30-

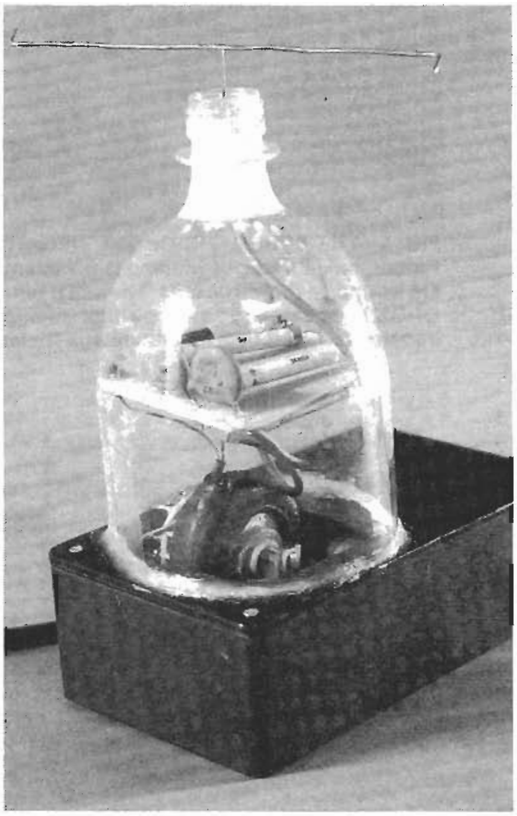


Switch S4 is used if it is desired to use a higher voltage for the ion chamber for more sensitivity.

BUILD A NEGATIVE ION GENERATOR

Build this negative ion generator and put some charge in your life.

ANTHONY J. CARISTI



IF YOU'VE SEEN ADVERTISEMENTS for negative ion generators in mail- order catalogs and wondered how they work, this project is for you. The simple version described here provides insight into their theory and applications, and is both informative and entertaining. Some of the demonstrations you can do with it will amaze you and your friends.

Many claims have been made for the beneficial attributes of negative atmospheric ions on human and plant life, especially by a Dr. Albert Krueger of the University of California. Studies have shown that negative ions promote physical and mental alertness and well-being, while positive atmospheric ions (such as in polluted air) cause discomfort and lassitude.

Certain negative ion properties can be demonstrated. For example, the surrounding air after a thunderstorm smells clean and fresh, due to generation of negative ions from lightning. The negative ions attach to smoke, dust, and pollen particles, bringing them to the ground to discharge, leaving fresh, clean air. That's why a cool room with a breeze is invigorating, compared with one that's stiflingly heated. Cool air is generally negatively ionized, whereas heated air is generally positively ionized.

Negative ions are air molecules with one or more excess electrons, produced in this case by a low-power, 9 to 14-kilovolt DC supply. The positive terminal is grounded, and the other (the emitter) is a needle exposed to air. (To generate positive ions, the polarities would be reversed.) Extra electrons on the emitter's surface produce a high local electric field owing to its pointed shape. The electrons exit the emitter needle's surface due to the polarization of surrounding air molecules between the emitter needle and ground. The electrons collide with the air molecules and produce negative ions.

A common misconception regarding high-voltage corona or arcing is that electrons are "overcrowded" on the tip, and forced off by mutual repulsion. What actually causes corona is the high electric field at the tip, which is directly proportional to the voltage, and is enhanced by sharpening an electrode tip to a fine point.

The high electric field strains the air molecules, polarizing them by a phenomenon called dipole polarization. If the electrode is positive, electrons are literally ripped off, creating positive ions, or if the electrode is negative, they're forced to accept electrons, creating negative ions.

High-voltage supplies like those in TV's need careful design, so no undesired discontinuities like sharp points or edges cause arcing. However, for the negative ion generator discussed here, the goal is to generate corona, not to avoid it, and the high electric field in the vicinity of a discontinuity more readily polarizes and ionizes air molecules.

The reason for the high electric field at the tip of a needle is due to its small localized radius of curvature. A sphere has a much more uniform electric field at its surface, due to its constant and much larger radius. The audible hiss caused by a high-voltage discharge is called "corona wind," and is often heard in older large-screen color TV's, especially on humid days, when the breakdown potential of the surrounding air is reduced, making the flyback transformer arc. You can often also feel it, if the corona is strong enough.

The negative ion generator described here is low-cost, easy to build, and uses a high-voltage flyback transformer from an old black-and-white TV. It generates high voltage, but at very low current. However, the safety precautions taken for any high-voltage device should be observed here.

The circuit

The schematic of the negative ion generator appears in Fig. 1; T2 is a TV flyback transformer with an open ferrite core partially enclosed in an aluminum bracket. The only original connections used are one low-voltage tap as ground, and the lead connecting to the flyback transformer output winding (at right).

The other low-voltage taps aren't used, and the new feedback and bifilar primary windings are wound on the ferrite core. The bifilar primary winding goes to the collectors of an astable multivibrator made up of Q1 and Q2, with the center tap driven by the +3–5 volts DC from IC1. The astable energy-storage elements are the inductances of the new feedback and bifilar primary windings.

The term bifilar means a pair of transformer windings optimally coupled by having been wound in the same direction, either adjacent to or, preferably, superposed on top of one another. The feedback winding goes to the bases of Q1 and Q2 for positive feedback, with the center tap driven by the +3–5 volts DC from IC1 through R3. The transistors are then forward-biased by the opposite ends of each half of the feedback winding.

When power is applied, the current through Q1 and Q2 is unequal, due to differences in doping, layer thickness, and base-emitter (B-E) turn-on voltage. That's what causes oscillation; if all the astable parts were perfectly balanced (nearly impossible), it might not oscillate at all. Whichever transistor carries higher current saturates due to positive base feedback, and the other cuts off.

When the sharp increase in transistor current in half the bifilar primary winding is maximized, the induced voltage reverses, so the second transistor conducts and the first one cuts off. The collector waveform

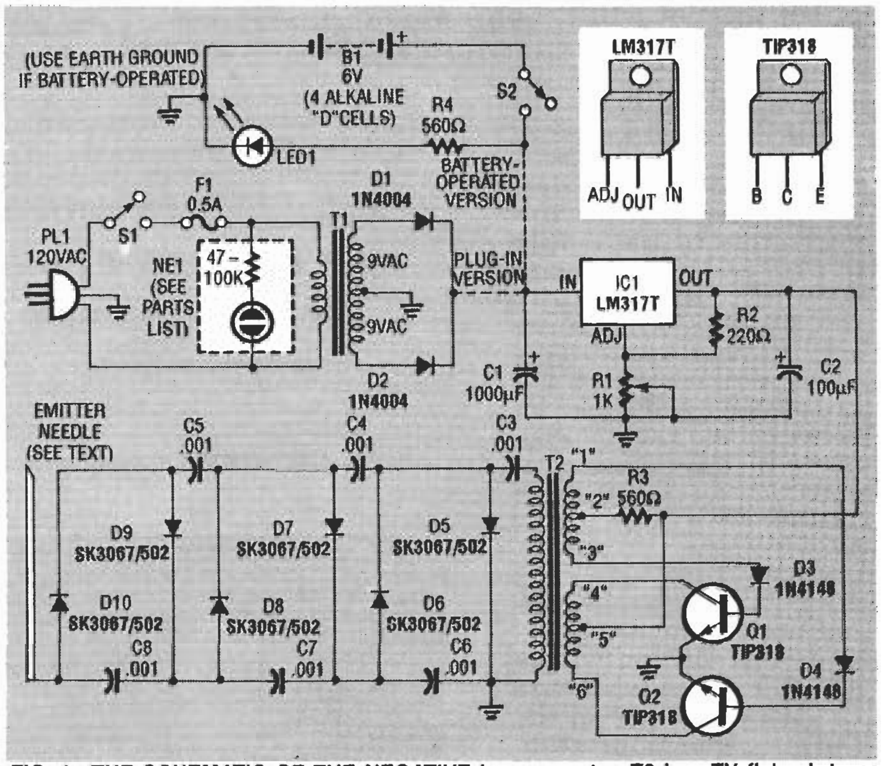


FIG. 1—THE SCHEMATIC OF THE NEGATIVE ion generator. T2 is a TV flyback transformer; only its output winding is used, and new feedback and bifilar primary windings are wound on the ferrite core. The bifilar primary winding goes to the collectors of astable Q1-Q2. Its square wave induces high voltage into the flyback transformer output winding, boosted followed by a ladder voltage-tripler −9 to −14 kilovolts.

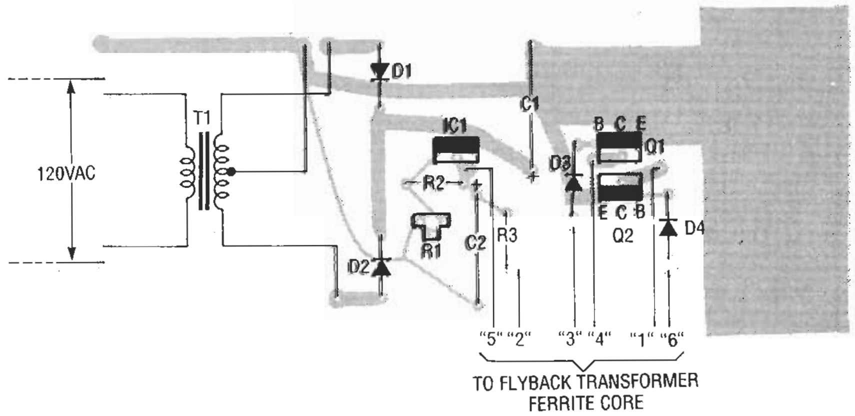


FIG. 2—THE PARTS-PLACEMENT DIAGRAM for the main PC board; Q1, Q2, and IC1 have U-shaped 1 × 1-inch copper heatsinks, with silicone grease for heat transfer; each goes on the main PC board without insulators. In the prototype, S1, S2, F1, and NE1 were omitted, and T2 was salvaged from a small-screen TV; note the new feedback and bifilar primary windings. Pin 7 had the highest resistance relative to the flyback transformer output lead, so it becomes ground.

fundamental frequency was 23.26 kHz, although higher harmonics greatly extend the total bandwidth. Also, the peak-to-peak bifilar primary winding voltage is four times that of the supply.

The astable square wave induces voltage into the flyback transformer output winding, proportional to the transformer turns ratio. A flyback transformer bifilar primary winding is normally quite small, while the flyback transformer output winding normally has about 2000–2500 turns, inducing −3 to −4 kilovolts.

Since the negative ion generator needs to produce −9 to −14 kilovolts DC, a ladder voltage-tripler with six diode-capacitor rungs is used to half-wave rectify and multiply the flyback transformer output voltage. Its operation is best understood in

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.

R1—1000 ohms, PC-board mounted potentiometer
R2—220 ohms
R3, R4—560 ohms (the former for the astable-flyback transformer combination, the latter optional for the battery-operated version)
R5-R6—200- and 40-megohm series high-voltage focus divider, RCA SK3868/DIV-1, used for an optional high-voltage range extender for a conventional high-impedance (10-megohm) voltmeter (see text)
R7—2.7 megohms

Capacitors
C1—1000 µF, 25 volts, electrolytic
C2—100 µF, 16 volts, electrolytic
C3–C8—0.001 µF, 10 kilovolts, ceramic disc
C9—0.001 µF, 500 volts, ceramic disc, optional for aluminum can/neon bulb experiment (see text)

Semiconductors D1, D2—1N4004 silicon diode
D3, D4—1N4148 silicon diode
D5–D10—RCA SK3067/502 high-voltage diode, 12 kilovolts PIV
LED1—light-emitting diode for the battery-operated version
Q1, Q2—TIP31B NPN transistor
IC1—LM317T adjustable voltage regulator

Other components
F1—0.5-amp slow-blow fuse with holder
NE1—120-volt AC neon-bulb assembly with 47–100K built-in series resistor for the plug-in version (Radio Shack 272-712)
NE2—neon bulb, type NE2 (not the part number), optional for experiment (see text)
S1—SPST toggle switch
S2—SPST toggle switch
T1—18-volt center-tapped transformer (Radio Shack 273-1515)
T2—standard TV flyback transformer (see text)

Miscellaneous: Plastic case (7.5 × 4.25 × 2.25-inches, Radio Shack 270-224), enamel magnet wire, three-wire line cord, emitter needle (made from either straight pin or sewing needle), RTV silicon rubber, heat sinks, four alkaline "D" cells (optional for battery operation), 2-liter plastic soda bottle, and a sewing needle.

NOTE: The following are available from Anthony J. Caristi, 69 White Pond Road, Waldwick, NJ 07463: Two etched and drilled PC boards (one each for the main and voltage-tripler sections) for $15.95, IC1 for $3.25, Q1 and Q2 for $2.75 each. Please add $2.00 for postage and handling with each order; NJ residents please add 7% sales tax.

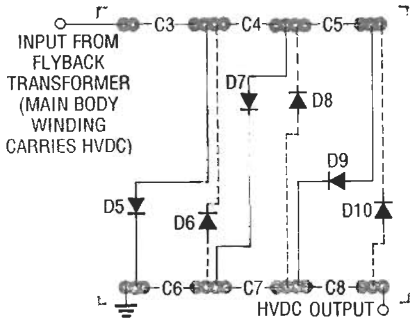


FIG. 3—THE PARTS-PLACEMENT diagram for the high-voltage PC board. The parts shown include high-voltage ceramic disc capacitors C3–C8, and selenium rectifiers D5–D10. D5, D7, and D9 go on the component side (solid lines), while D6, D8, and D10 go on the foil side (dashed lines).

segments. The AC waveform from the transformer is coupled to D5 and D6 via C3, charged through D5 acting as a clamp.

The peak-to-peak magnitude of the AC waveform at the anode of D5 equals that of the flyback transformer output winding, with a negative DC component of half the peak-to-peak value. The AC output waveform from the flyback transformer is coupled to the anode of D7 via C3 and C4, where D7 charges C4. The action is repeated again via D9, which charges C5. The DC potentials on C3–C5 add, tripling the voltage from the flyback transformer winding. The anode of D10 is the output of the negative ion generator, and should be at −9 to −14 kilovolts DC.

Power is supplied by either a standard full-wave rectifier followed by variable voltage regulator IC1, or four series "D" cells producing 6 volts DC. Although S1, S2, F1, and NE1 are shown in Fig. 1, they were omitted in the prototype. IC1 controls the DC voltage fed to the oscillator via R1. Since the negative ion generator output must be −9 to −14 kilovolts, and the exact flyback transformer turns ratio is normally unknown, adjusting R1 is mandatory. Once R1 is set, the negative ion generator output voltage will be stable.

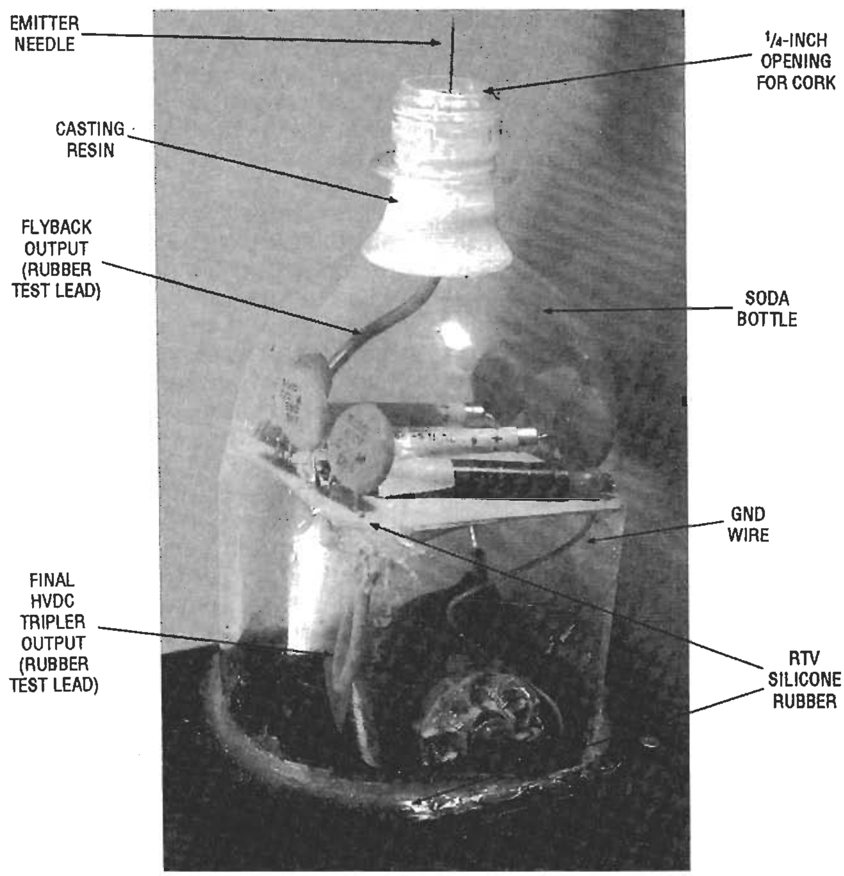


FIG. 4—THE NEGATIVE ION GENERATOR, showing the case, T2, plastic soda bottle, and the top of the high-voltage PC board, with D5, D7, D9, and C3–C8. Both the plastic soda bottle and high-voltage PC board are held in place with RTV. The neck is sealed with casting resin to within ¼-inch of the top; cover the needle with a cork when unused.

Construction

Next, we'll discuss construction, focusing on the main and voltage-tripler PC boards, the plastic cover for the voltage-tripler PC board made from the top third of a 2-liter plastic soda bottle, the emitter needle, and the cutout in the lid of the plastic case for the flyback transformer. Figure 2 shows the parts-placement diagram for the main PC board, and Fig. 3 the ladder voltage-tripler section. Remember to add S1, S2, F1, and NE1 off the main PC board, as shown in Fig. 1, if you want them.

The main section includes the regulated supply, oscillator, and flyback transformer, and goes on the single-sided PC board mentioned in the parts list, with the foil pattern shown here. The high-voltage PC board contains the ladder voltage tripler, connected to the main PC board by two leads, and the emitter needle is above the high-voltage PC board. In Fig. 2, Q1, Q2, and IC1 need heatsinks; you can buy them, or make them from 1×1-inch copper bent in a "U," with silicone grease for heat transfer.

The heat sinks go on top of the PC board without insulators. Neon lamp assembly NE1 acts as an indicator, and has a 47K–100K resistor in series with it. For battery operation, use LED1 in series with R4; use alkaline batteries, not carbon-zinc. Use a 3-wire cord with ground, or an earth ground in battery-operated versions. The voltage-tripler section is built to avoid arcing and shock. Cut the top third off a 2-liter plastic soda bottle, as shown in the lead photo, or use 4-inch diameter plastic PVC plumbing pipe.

Use 18-gauge rubber-coated test leads to connect the high-voltage PC board to both the flyback transformer output and the needle, to withstand high voltage, but not until indicated (more below). The heavy voltage-tripler output lead is soldered to the emitter needle, which goes upward through the plastic soda bottle and projects out of the neck, which is filled with casting resin. Don't fill the neck with resin all the way to the top; leave ¼ inch of the neck open, so you can cap the needle with a wine bottle cork when not in use.

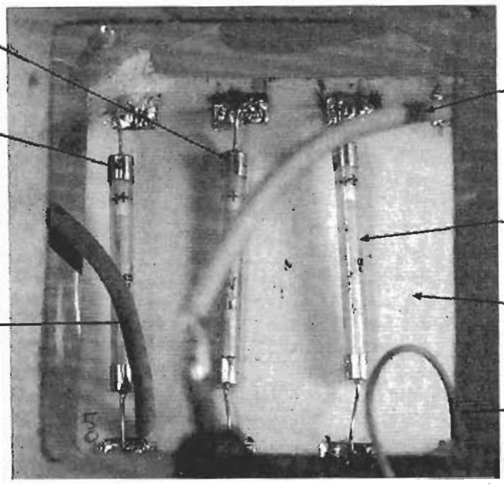


FIG. 5—THE BOTTOM OF THE HIGH-VOLTAGE PC board, showing D6, D8, and D10, and the attachment points of the ground lead and both high-voltage leads.

The voltage tripler shown in Fig. 3 consists of ceramic disc capacitors C3–C8, and high-voltage selenium rectifiers D5–D10. Note that D5, D7, and D9 go on the component side of the PC board, while D6, D8, and D10 go on the foil side. They're common to most TV's, so most TV repair shops should stock them; see the parts list.

Figure 4 shows a photo of the negative ion generator, with the closed case, flyback transformer, plastic soda bottle, and top of the high-voltage PC board showing D5, D7, D9, and C3–C8. The high-voltage PC board is held in place inside the plastic soda bottle top using RTV silicone rubber, and the plastic soda bottle goes on the top of the case the same way, for a water-tight seal that avoids condensation, and has good high-voltage attributes.

The markings and sizes of the high-voltage TV diodes used in the voltage tripler differ from those on standard diodes. They're much larger, and have a very high peak-inverse voltage (PIV) rating. Also, on a conventional diode, the cathode is normally marked with a band, whether a white band on a black body for such low-voltage rectifiers as the 1N4001, or a red band on a clear glass body, as with the 1N4148 or 1N914.

In high-voltage TV diodes, the body is generally either white, black, or see-through. In Fig. 4, D5 and D7 are white with a band of black "+" signs on the right end, while D9 is black with a dashed band of white "–" signs on the right end. The ends with the bands are the cathodes, for both diode body types; the reason for the "+" signs on D3 and D5 is that circuit power is normally considered as being extracted from the cathode ends in TV, and is called B+. In Fig. 5, D6, D8, and D10 all have bands of "+" signs on the cathodes.

A 3×3-inch hole was made in the case top for the flyback transformer; adjust yours as needed. Don't connect the voltage-tripler PC board to the main PC board until the final checkout below; put it aside and let the RTV dry overnight. The soda bottle and the high-voltage PC board are held in place using RTV. The rubber-coated test leads connect the flyback-transformer output to the voltage tripler and the voltage tripler to the emitter needle; the thin wire is the ground.

A flyback transformer is also called a tuned transformer, and consists of a ferrite core surrounded by a metal bracket, with a large coil of windings coated in plastic or ceramic with an *extremely* high dielectric breakdown voltage. Often, as with the flyback transformer used in the prototype, there are additional low-voltage output winding taps (seven, in that case) placed around a plastic ring on one side of the transformer coil, that have equally high-voltage breakdown characteristics.

That's all we have room for. Next month we'll finish up this project. **R-E**