STRIKE IT RICH
WITH A SCINTILLATION COUNTER

The scintillator's sensitivity makes it superior to any Geiger counter.

By Jim V. Cavaseno

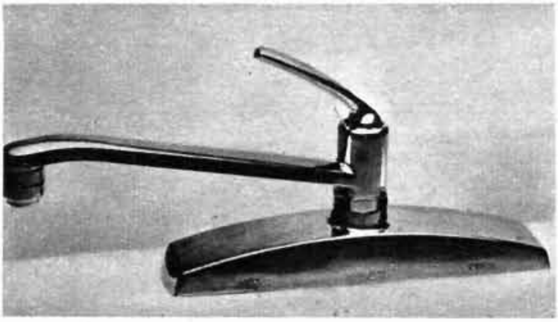
IT has long been the custom in the electronic age to simplify any device after once it has been invented. We have tried this with the scintillometer, an instrument used for the measuring of radioactivity. The unit described in this article has been designed for prospecting and searching for uranium and has been simplified to the extent that its accuracy of readings is slightly off as compared to lab jobs, but its sensitivity is excellent for prospecting and it compares favorably with commercial instruments.

We went prospecting around the southwestern part of Colorado and though we didn't strike it rich, we had a good time and gained a wealth of experience. Mainly we were able to determine just how good the instrument here described would be for a prospector. We also took along some tools and test equipment so we were able to make changes in the design of the scintillation counter as ways were found to improve it. This we did a few times while we were out there, and we now have, we believe, the best possible scintillometer for prospecting use. We found quite a few different species of rock containing uranium, but there are a lot of loose radio active rocks around Colorado's mountains. The problem is to trace them back to the place they came from, to find the so called mother lode. When you have done this, you'll never have to work again.

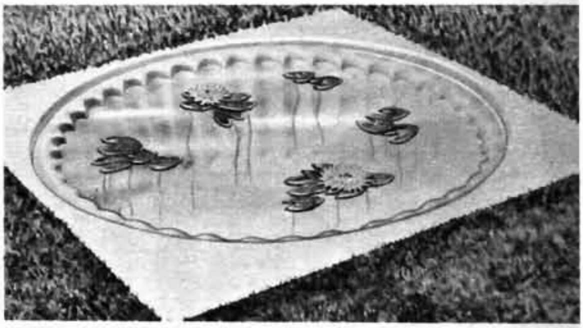
There are many companies who will buy good claims, but never be hasty in selling. Get the best deal you can, but

8. The Electropanel converts 220 v current to 110 v, permits housewives to use four appliances without danger of overloading.

9. Stencil lettering guides come in Roman, Gothic and Old English letters, in sizes ½ to 2½ in.; they can be used many times.

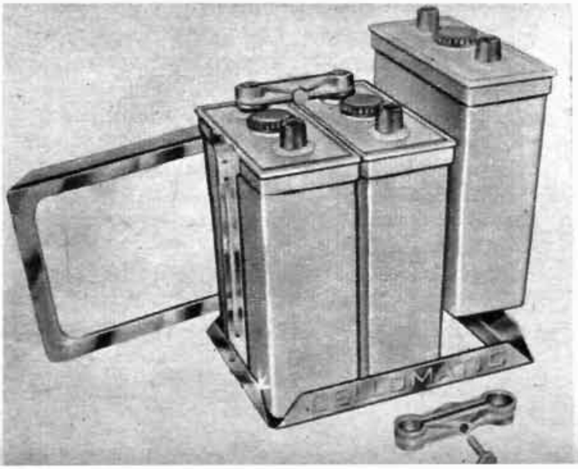


10. New type mixing faucet has only one handle. With finger tip motion, you can mix hot and cold water at any pressure.

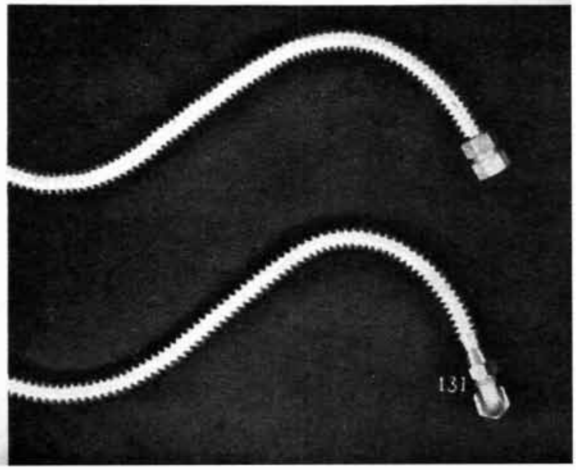


11. Molded plastic garden pool has 48x48 in. overall dimensions, 12-in. deep. The drain-equipped pool holds 75 gallons of water.

12. Cellomatic auto battery has replaceable cells. This arrangement allows user to change individual cells when they go bad.



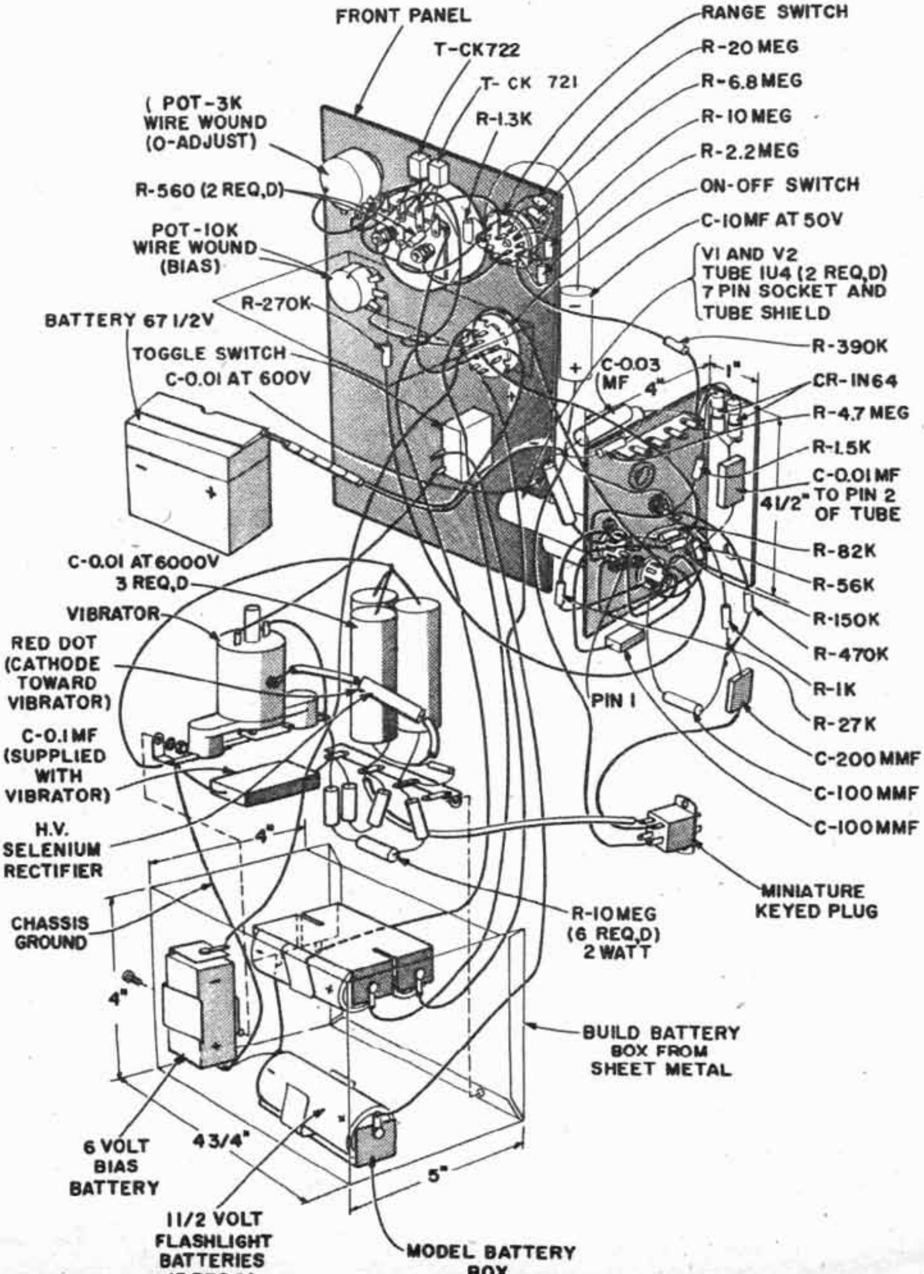
13. Cobra flexible gas connectors allow you to move gas appliances away from walls and floors for easy cleaning and painting.

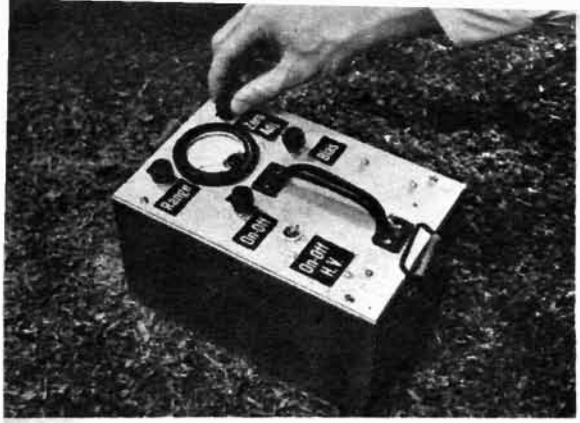


be sure you don't sell out completely. Always keep a certain amount of stock for yourself so that if the claim develops into a well paying mine, you'll always get your cut.

We were able to simplify the scintillometer by using a simpler circuit, and making the whole instrument lighter to carry. The last is very important, as anything you carry for long periods seems to become much heavier.

Five different parts are required for a scintillation counter. The detector to pick up radio activity and convert it into electrical pulses; the counting circuit to amplify the pulses; a form of discrimina-





Last step in readying the counter is the adjusting of the zero control on the meter.

The detector is built into a probe unit for greater mobility and ease of handling.

tor circuit whose output voltage will be a measure of the frequency of the pulses being fed into it; a voltmeter circuit to measure the output of the discriminator, and lastly, the voltage supplies for the various sections.

We decided to build the detector into a probe unit for two reasons. First, it would be more useful that way since a smaller detector will fit into smaller cracks and holes, and being at the end of a cable, it may be let down a cliff or other inaccessible place without endangering yourself. Secondly, the main cabinet doesn't need to be carried by hand. It can be fitted with straps for carrying on the shoulder. We used one strap around the shoulder and another around the waist; this way it isn't loose enough to bounce around when you bend, walk or jump.

The detector consists of a 6199 photomultiplier tube, a sodium iodide crystal (thallium activated), one inch in diameter by ½ inch thick; nine 10 meg ½-watt resistors, one 20 meg ½-watt (these must be 5% or better), three 220 mfd mica condensers (these are not critical); the socket for the 6199 phototube which is a standard TV picture tube socket, except that it has all twelve pin connections and is known as a duodecal socket, and a piece of three-wire shielded cable (not longer than ten feet).

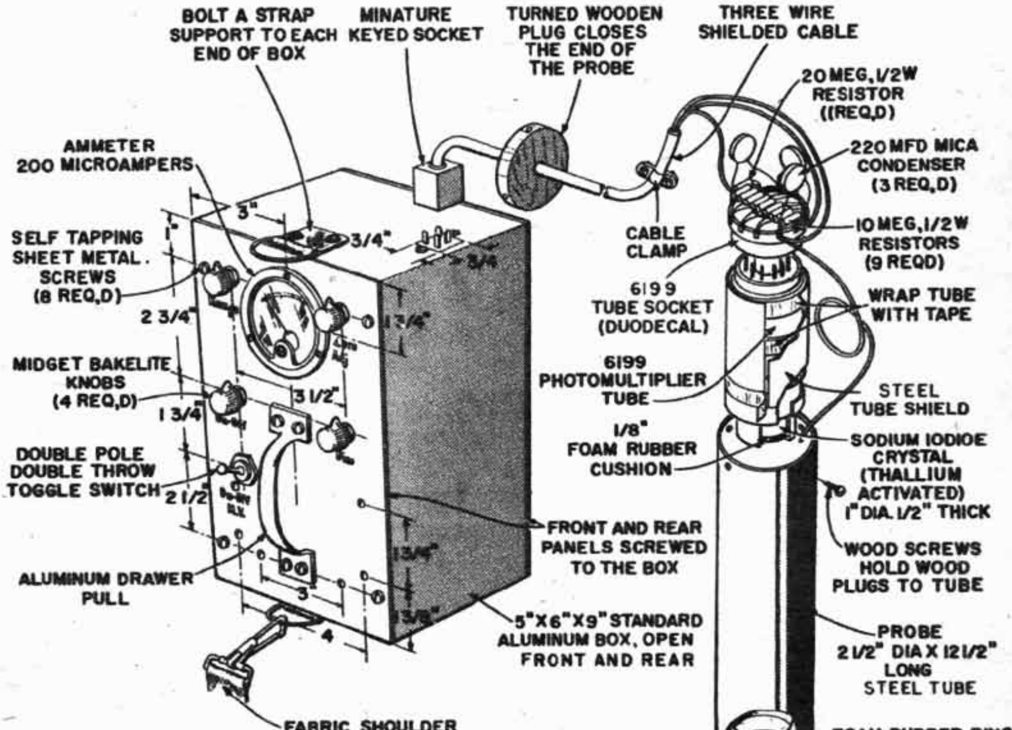
The counting circuit consists of a more or less standard multi-vibrator with the second tube biased to a point where it will only oscillate when a pulse is fed to it, and will cease oscillating when the pulses fed to it are stopped. The arrangement of this circuit is such, that when it starts oscillating, the amplitude of the signal will be constant, regardless of the amplitude of the pulses being fed to it. However, the amplitude of the generated signal will vary if the frequency of the pulses being fed to it is changed. The lower frequency pulses fed to it correspond to a higher amplitude generated signal. The signal from the generator is fed to the discriminator circuit, which is made up of the two 1N64 crystal diodes, the 4.7 meg resistor and .03 mfd condenser, and the 1500 ohm ½-watt resistor. The DC output of this circuit is then dependent on the frequency of the pulses being fed into the multivibrator circuit.

The meter circuit is nothing more than a DC voltmeter, transistorized to increase the sensitivity of the meter.

Voltage supplies for the various circuits are batteries, except for the 1,000 volts required to operate the 6199 phototube; this is supplied by a vibrator high voltage supply circuit. It comes in two parts. The vibrator has a self contained autotransformer and is about four inches square by 1½ inches thick, and is all wired for use. All that need be done is to connect in the two flashlight batteries and the switch. The high voltage selenium is about two inches long, ¼-inch in diameter. It is designed to handle up to 5,000 volts. The output of this circuit is about 2,000 to 4,000 volts, depending on the adjustment of the vibrator points which are adjustable with a screwdriver. Six 10 meg 2-watt resistors are used to drop the voltage out of the selenium. The value of these are .001. These condensers will hold their charge for about five minutes after the vibrator has been shut off, and therefore, the instrument will still operate for that length of time. If larger condensers are used, the charge may be held for a longer period of time. Of course, the quality of the condensers used will have a greater effect on the time they will hold a charge than the value in mfds.

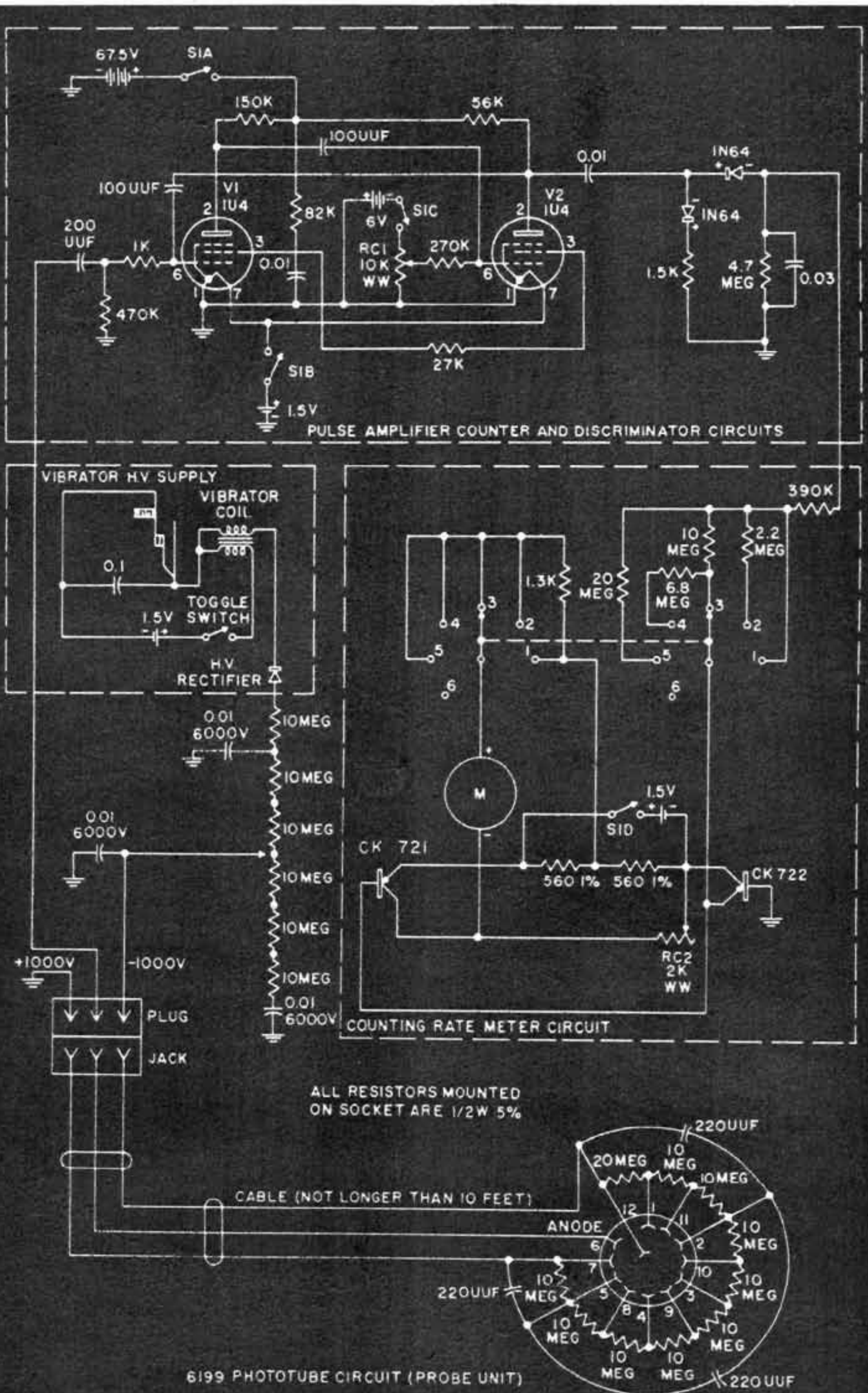
The total cost of the parts for the HV supply is only a little less than the price of three 300-volt batteries which would be just as good, so one may wonder why we went to the bother of building our circuit. For one thing, it is much lighter to carry, and secondly, if we used batteries after they wore out, new ones would be required at their high cost as compared to the 25 cents for the two flashlight batteries used in our circuit. Naturally, if one desires, he may use HV batteries and thereby simplify construction.

The main cabinet contains the meter and the four controls as shown in the photos. The sensitivity switch is on the upper left, meter zero adj. on the upper right hand corner, bias adjust on the lower right, and the on-off switch on the lower left. These controls are placed as close as possible to the meter to make sure they will clear the sides of the cabinet, but re-check before you drill the holes. There is a second on-off switch on the side of the cabinet. This is for the HV circuit. As stated before, if we can turn off the vibrator and still leave the rest of the set on, it will continue to operate for about five minutes off the



charged HV condensers. After this, the vibrator is again turned on for a few seconds to recharge the condensers. The batteries that operate it last about three hours running steady, and we found that they gave us an average of about two days service in actual use.

Start construction by obtaining a metal box large enough to hold all the components [*Continued on page* 162]



ALL RESISTORS MOUNTED ON SOCKET ARE 1/2W 5%

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(ours is 9x5x6), and cut and drill all the holes for the meter and controls. Also, cut and shape a metal shelf to hold the tubes and wiring for the counter circuit. This is attached to the front panel and held there by the nuts that also hold the on-off switch and bias control, and is installed so that the shelf is just under the meter. The tubes are mounted toward the rear of the shelf leaving enough room for the meter depth.

The HV vibrator supply and the four flashlight batteries are mounted below, and the 67½-volt battery and the 6-volt bias battery are mounted on a second shelf in the cabinet about one inch below the shelf mounted on the front panel. This will allow a certain amount of shielding from the vibrator below. Battery holders should be used for the flashlight cells and the bias cell so that in changing you just remove the old and snap in a new one. If you solder them, it will be hard to replace them in the field since you will also have to solder in new ones when replacing. The cabinet has the top as well as the bottom removable.

Having installed the shelves and controls (don't mount the meter yet as it may be damaged in knocking around the panel while you wire it up), proceed to wire up the counter circuit and tubes. Mount the detector connecting cable jack on the cabinet and then wire up the HV circuit. Install the battery holders and vibrator in the bottom part of the cabinet, mounting all the components on terminal lugs. Wire up the meter circuit, this is done by mounting a terminal board with five terminal lugs directly on the meter, using the meter connecting screws to hold the terminal board to it. Also mount the transistors and other components on this board. The zero pot and range switch are mounted on the front panel. The terminal board should be cut small enough to fit through the hole that has been cut for the meter so that if you wish to check this circuit you may remove the meter together with the terminal board and all the components.

After completing these circuits, test them to be sure they are working properly. This is done by connecting the necessary batteries and adjusting the zero pot for a mid-scale reading on the meter. Next, adjust the bias control RC1 for maximum negative bias on the grid of the V2, thus causing the counter to stop oscillating, and readjust the zero pot so it reads a little more than zero. Also check to be sure that you can swing the needle through zero with the zero pot. Now, adjust the bias pot slowly until the meter reads full, and slowly adjust it back to the exact point where the meter jumps back to a near zero reading. If it only jumps back to a half-scale reading use the zero pot to bring the needle down a little more to a near zero reading. Don't try to bring the needle down to zero with the bias control as this will reduce the sensitivity. The correct setting of this control is the point where the needle just jumps back to a low reading, after which it should not be moved except when required by the weakness of the batteries.

After setting up, test the set by touching the finger to the input condenser lead. This should cause the meter to read since the body always has a small AC charge which is enough in this case to start the set working. If a square wave generator is available you can further check the instrument for sensitivity and calibration as follows. Set up the counter as explained above and feed into a signal of about 30 cycles. This should cause the meter to read about full on the No. 1 position of the range switch. Now, turn the generator output down. The meter should now return to zero. If it doesn't, try removing the generator output lead from the counter circuit and note if the meter now returns to zero. Some generators cannot be turned down completely and there is always a small signal across the output cable, which in some cases is enough to start the counter and cause the meter to read. Now, with the generator connected and the meter showing a reading, adjust the signal generator to give a full reading on the meter by varying the frequency; varying the signal generator output control should not have any effect on the meter reading. After adjusting the signal generator frequency to the exact point that gives a full scale reading turn the range switch to the next higher counting range and check it in the same manner, noting at what frequency you get a full reading. The frequency is equivalent to counts per second, which can be converted to counts per minute by multiplying by sixty. The circuit has been designed to read full at approximately 2,000 cpm on the first range, 10,000 cpm on the second range, 50,000 on the third, 500,000 on the fourth, and about 2,000,000 on the last. Most signal generators don't go up this high (33,000 cycles per second), but if it goes up to about 20,000, you should get about a ¾-scale reading on that.

Having completed that part of the instrument proceed to wire up the high voltage circuit according to the diagram and install it in the cabinet, checking to be sure that the cabinet will close properly.

The high voltage output cannot be accurately measured with ordinary test equipment, even a VTVM. The output current is so low that the test equipment will load it down and give a false reading. So you must take into account the resistance load the meter is placing on the circuit and figure the actual voltage. If you have a high voltage probe for your VTVM, you can use it and be reasonably sure that the voltage you read is correct, since the load resistance of these probes is very high. Lacking this equipment, another method may be used to check the high voltage and will be described later in the article.

Next, start building the probe unit. Having obtained a 6199 photo-multiplier tube, a socket to fit it (which is a standard picture tube socket, but with all twelve pin connections, and is known as a duodecal socket); a one-inch diameter by half-inch thick thallium activated sodium iodide crystal (a larger one of course will be better, but it costs much more); a ten-foot piece of shielded cable (three wires including the shielding); a piece of tubing about two inches in diameter and about ten inches long, made of any type of metal, but preferably of stainless steel. Also, a thin aluminum can to hold the sodium iodide crystal, cut and shaped as shown in the drawing, a tube of silicone grease, and a piece of emery cloth or sandpaper of about 200 grade or finer.

Wire up the socket as follows: first wire in the resistors starting with the 20 meg between pins one and twelve; then, each succeeding 10 meg resistor in its turn. You will find that they will lay nicely one next to the other right across the bottom of the socket. Next, wire in the condensers (220 mfd), and connect the cable; don't mount the jack at the other end yet. Shape the tubing by cutting slots all around one end, about ½ inch in and ½ inch apart. Now, bend these in, closing the end slightly and forming a shoulder. File out the hole that remains so that the aluminum crystal holder end will just fit in the hole. Glue a thin piece of sponge rubber around the inside of the hole; this will prevent damage by shock when the probe is in place inside. Now, make a cap for the other end of the tube. Cut a metal disk of aluminum or any other metal, about four inches in diameter. Draw a circle in the center of it to the size of the tube you are using. Make V cuts in as far as the circle you have drawn and bend the ends down around the tube so that it just fits over the tube.

Drill a ¼-inch hole in the center, for the cable to come through, and about four or five holes around the sides. Place it over the tube and drill holes in the tube to correspond with the holes in the cap. These holes should be smaller, to hold the cap on with self-tapping screws. Now, push the cable through the ¼-inch hole of the cap and make a knot in the cable about five inches from the socket end. This will limit the amount of cable that will pull through the hole so that when the instrument is completed the probe may be held by the cable without danger of tearing the connections loose from the socket. Mount the connecting plug at the other end of the cable.

We are now ready to work on the crystal. It is very important that this work be done in the exact order given. Clean off a table or bench with a flat surface to give yourself enough room to work freely. Place the emery cloth or sandpaper, sanding side up, and tack it down so that it will lay flat and will not move. Also, have near you on the table a roll of Scotch waterproof

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tape, the tube of silicone grease, a small can of shellac or other oil base paint, the 6199, a piece of either silk or rayon cloth, and the aluminum crystal holder. Fill the top part with silicone grease, working it to the edges with the finger. Take a piece of ¼-inch thick sponge rubber, cut to fit the inside of the top of the can, and with the fingers work the silicone grease into the rubber until it is thoroughly soaked. Now, insert it in place inside the top of the can. The grease will hold it in place. The rubber will keep the crystal pressed against the 6199 when the job is completed. This is important for the probe to work properly.

Remove the crystal from the seal in which it came, and holding it with the piece of wrapping in which it came (don't touch it with the fingers), polish one side of it on the emery until all scratches have been removed from the surface. The polishing must be done very slowly so as not to build up heat as this will cause the crystal surface to become soft, making it impossible to continue the polishing. You will then have to wait 'til it cools and hardens before you can start to polish again.

When all the scratches have been removed polish the crystal a little more on the silk or rayon cloth and try to get a real smooth surface. Next, apply a thin coat of silicone grease all over the crystal and on the part of the 6199 that will be against it and press the crystal in place on the 6199, moving and turning it to make sure you get out any air bubbles. Now, take the aluminum can and place it over the crystal, slowly pressing it down and forcing out the excess grease until you are reasonably sure it won't go down any more, and that the sponge rubber inside the can is against the crystal. Wipe away the excess grease and pressing the can down firmly, apply the waterproof tape all around the can and the 6199, making the tape hold the two together. Paint over the tape to insure that the crystal will be sealed against moisture since this will ruin the crystal in a few days.

If you do not want to do this part of the work, you can buy the crystal already polished, canned and sealed; this however will cost quite a bit more.

After the crystal is mounted apply a few layers of regular friction tape around the 6199 to take up the space between it and the metal tube so it won't rattle around. Solder a wire from the connecting cable shielding to the metal tube on the inside, grounding the tube. Make this wire long enough so that when you remove the 6199 from the tube you will have a little leeway. Plug the 6199 in its socket.

Install the probe into the metal tube and close it up, making sure that the crystal holder protrudes through the hole that has been cut for it in the other end of the metal tube. Having done this, the instrument is now ready for use. Plug the probe into the main cabinet and turn everything on except the HV. Adjust the set as described earlier so that it is ready for use. Now, turn on the HV and readjust where necessary. It is a good idea to get a piece of radioactive rock to test with. There are several places that sell these, one of which is Ken Research, 525 Rivervale Road, Rivervale, N. J. They have calibrated samples with which you may also check the calibration of your completed scintillometer. Use these samples to check the calibration on each range of the range switch to see that it is working properly.

As stated earlier, if you don't have the proper test equipment to test the HV, you can find the correct voltage on the voltage divider resistors. First, connect the HV lead of the probe to the last resistor and try to get the instrument to work by setting it up and holding a radioactive sample in front of the probe. If it works then leave it as is. If it doesn't, then you have to determine if the voltage is too high or too low as follows: Slowly adjust the bias control one way then the other; this should cause the needle to swing from one end of the scale to the other. If it doesn't, the voltage is too high and you need more resistors in series. Most likely, however, the voltage will be too low which will be shown by placing a radioactive sample near the probe, moving it slowly closer. The needle will start to rise and as you get closer it will reach a certain point and then start to

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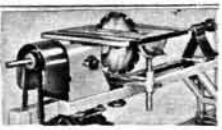

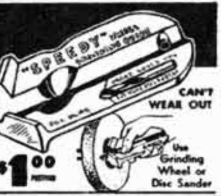

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fall again. This simply means that the 6199 is drawing more current than the HV circuit can supply, which in turn is dependent on the voltage supplied. This means that you need less resistance in series. Connect the HV lead to a tap on the HV divider, which is nearer to the vibrator, and try again. Keep doing this until you find the point that will allow the needle to read full on the first range and stay there, even with a highly radioactive sample, and when you remove it the needle should again drop to a low reading. In this circuit, the design is such that the needle moves up faster than it moves back. It is better this way because we want the set to give an immediate reading when placed in a radioactive field. The time it takes the needle to swing back is not nearly as important as the time it takes to swing up.

The best method of setting up the scintillometer is by first turning on the two switches and allowing about one minute to warm up. Adjust the range switch to the No. 2 position. Next, adjust the bias control for a full reading on the meter, and very slowly back it off until the needle jumps back to a lower reading. Continue adjusting in the same direction as long as the needle keeps moving down. When the needle stops moving you have arrived at the correct setting for the bias control. Now adjust the zero control so that the meter reads just a little above zero. The set is now ready to be used on this range. When you change the position of the range switch, you may have to readjust the zero control. Once the bias control has been adjusted you should not need to touch it again unless the batteries become worn. In six months we have found that the only batteries that needed replacing were the ones used in the vibrator circuit.

When you have completed the instrument to your satisfaction close up the cabinet and tighten all screws and stand back and admire the work you have just done. You have built a truly wonderous device; an instrument that may well make you as rich as it has made many other people. •

[*See Parts List on opposite page*]

PARTS LIST

METER AND COUNTER

1 Cabinet; ICA #29801
1 Meter 200 microamps; Weston model 506
1 Switch 6pos 2 ckt; Erie #3612-03
1 Switch 2pos 4 ckt; Mallory #3242J
2 IN64 xtal diodes
2 IU4 tubes
2 Sockets with shields, 7 pin miniature
1 Transistor CK722
1 Transistor CK721
1 Control 10,000 ohms, small
1 Control 2,000 ohms W/W, small

All Resistors ½ watt 10% or better

2 560 ohm
1 1,000 ohm
1 1,300 ohm
1 1,500 ohm
1 27 K
1 56 K
1 82 K
1 150 K
1 390 K
1 470 K
1 2.2 meg
1 4.7 meg
1 6.8 meg
1 10 meg
1 20 meg

Condensers

2 100 mmfd
1 200 mmfd
2 0.01 mfd
1 0.03 mfd
1 10 mfd 10 volt; Electro

Batteries

3 Flashlight, size D cells
1 RCA VS068, 6 volts or equiv.
1 Eveready 467, 67½ volts or equiv.

HIGH VOLTAGE CIRCUIT

1 Vibrator HV supply; model # MVT-10
1 HV selenium rectifier; Bradley # SE245
1 Toggle switch
6 10 meg 2 watt resistors, 10% or better
3 0.01 mfd condensers, 6,000 volts

PROBE UNIT

1 10 in. length steel tube, 2-in. dia.
1 10 ft., 3 wire shielded cable
(2 wires plus shield)
1 Duodecal socket; Cinch Jones # 3B12
1 #6199 RCA Photomultiplier tube
1 Thallium activated sodium iodide xtal 1 in. dia., ½ in. thick
2 oz. tube silicone grease
1 Aluminum can to hold xtal (use old filter can, 1⅜ in. dia., rip open and clean out)
3 220 mmfd condensers
1 20 meg ½ watt; 5%
9 10 meg ½ watt; 5%

NOTE: MECHANIX ILLUSTRATED has made a special arrangement whereby readers may purchase all parts of the Scintillation Counter as a kit for $110.00, plus postage, from Lafayette Radio, 100 Sixth Avenue, New York 13, N. Y.