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NOVEMBER-DECEMBER 75¢

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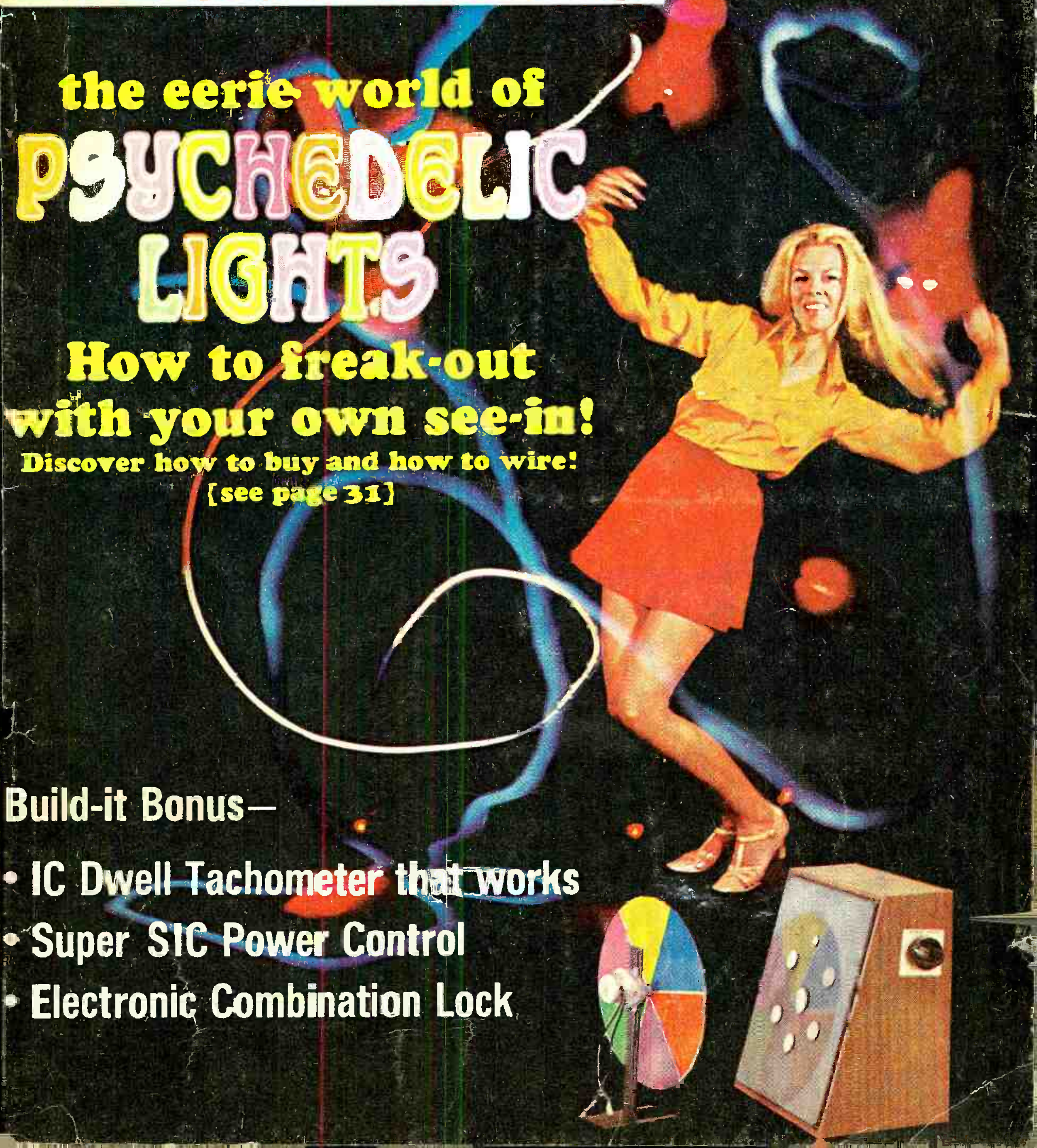
[see page 31]



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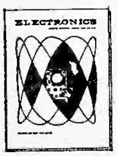

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• November/December 1968 • Vol. 7 No. 2

e/e elementary Electronics

Dedicated to America's Electronics Hobbyists

Cover Photo by Leonard Heicklen

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☆ Cover Highlights

elementary Electronics

Nov./Dec. 1968 Vol. 7/No. 2

Dedicated to America's Electronics Experimenters

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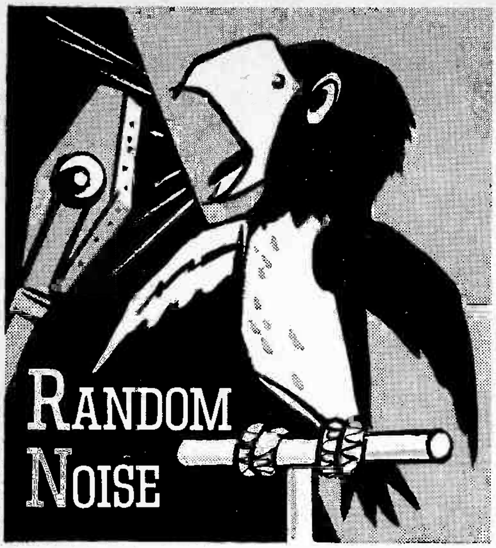

By Julian M. Sienkiewicz, Editor

Flower children, did you dig this issue's groovy cover? Man, you don't know what fun is until you've set up a shooting session in a studio that winds up in an *Electric Circus*. Cynthia Williams, carrying on on our cover, is a real-life go-go dancer with credits in some of the swingingest go-go joints on the east coast.

The shooting session began simply enough. First we set up the bouncing lights. Easy enough! We used Edmund Scientific's latest—MusicVision. The components we used were a knocked-down slide projector for a strong beam of light, a loudspeaker unit with tiny mirrors, and a rotating color wheel to generate colored dots of bright light that bounced in step with the bass beat of the music. Now, with Cynthia all costumed in go-go regalia, we switched on the music and the fun began. Even if you're a fox-trotter from the twenties, the magic of psychedelic lights will put you in step (or is it hip?) with the flower children of today. But don't take our word, petal people, turn to page 31 for the electronics of a see-in!

Here's why the camera is better than the mind's eye. Snapped at practically zero time, Cynthia is caught swinging a mean hip amid our psychedelic lights.

Honk Honk! While boating this past summer my camera and I came upon the Red Dog weather alarm in the hands of a *hot dog* operator.

The Red Dog weather alarm may revolutionize small boat fog and foul weather safety. Installed conveniently on the dash, it can be used for individually controlled blasts or set to signal automatically when running in fog.

Only the control knob shows on the dash. The 2½ x 2½-in. sounding unit is concealed. Red Dog can be used as a regular horn by simply pressing the knob. But when the knob is pulled out and locked into position the horn blows automatically for 3 to 5 seconds at one minute intervals in compliance with U.S. Coast Guard regulations.

Okay, boys, set sail and pray for fog—then tune your ears on this Lorelei's fog horn. Man, what a blast!

Cmdr. David Newton Lott, USNR Ret., author of "Rules of the Road, Illustrated," has commented, "The Red Dog fog and foul weather alarm, with its new automatic alarm feature, is one of the greatest developments for safety at sea I've seen since radar was perfected. This should be mandatory on all types of vessels."

But don't let us tell the entire story. Get all the facts from Red Dog, Inc., Box 116, Mattapan, Mass. 02126. The Red Dog people may mention some facts like: units available for 6, 12 and 32 VDC at $14.95, solid brass switch and knob chrome-plated, knob designs let you replace existing controls, etc.

As for the *hot dog* operator, let's say you can see same in Lower New York Bay this coming summer. Have a nice winter, boys.

Einstein Made Waves. The long search for gravitational waves, which scientists have

(Continued on page 12)

World's greatest hear-ins.

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The World of the "Solid State"

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believed for 50 years should exist but never were able to find, may end within the year—successfully. Gravity waves would be a gravitational analog to electromagnetic waves, such as radio, light and X-rays.

The latest report on detection of events possibly caused by gravitational waves. from Dr. Joseph Weber of the University of Maryland, moves close to definite commitment. Others using the same experimental information would probably have been even more definite.

Dr. Weber's instruments, which operated 24 hours a day for several years, respond about once a month to a common external excitation which may be gravitational radiation. However, he will not make a stronger statement at least until the results of other tests now underway are available.

If these results are negative, then Dr. Weber and his co-workers or others in the field may be able to pinpoint the cause of the events so far recorded by his instruments.

The existence of gravitational waves is predicted by Einstein's theory of general relativity. Any mass that is accelerated should generate gravity waves. If a gravitational wave as strong as the earth's magnetic field hit this planet, you would be lifted from your seat and buildings from their foundations. Since nothing remotely resembling such events has ever been detected, gravity waves are known to be extremely weak. Thank goodness for small blessings!

Dr. Weber's instruments to detect gravity waves are based on the small effect they are predicted to have on a relatively large mass. When the gravity wave penetrates the mass, it is jiggled slightly. Dr. Weber's group uses aluminum cylinders weighing 3000 pounds to search for gravitational radiation at 1660 cycles per second. The cylinders are mounted in delicate isolation to prevent mechanical or electromagnetic effects from setting them into vibration.

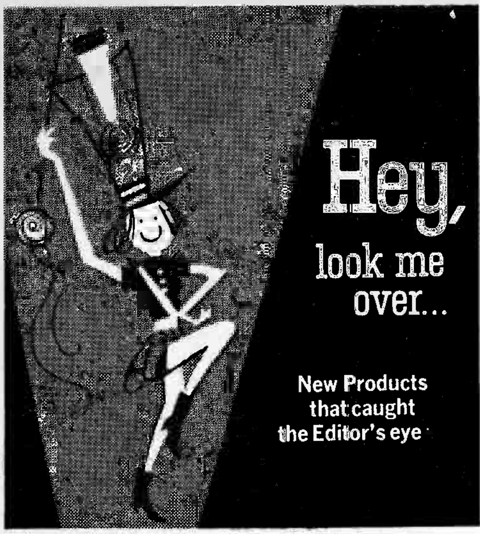
"KMD4313, Mobile One to Base!"

Historical TV tubes, among the world's first, were recently donated to the Smithsonian Institution by Dr. Philo T. Farnsworth, noted scientist of International Telephone and Telegraph Corp. Five 40-year-old camera and picture tubes, plus all of his documents and laboratory notebooks of the time, were given on invitation by the Smithsonian. Dr. Farnsworth earned the sobriquet "Father of Electronic Television" for his inventions in his late 'teens and early twenties, which triumphed in the patent courts. The tubes, dating from 1927, include, left to right on the table, the first image dissector, first projection oscilloscope, a primitive image orthicon with electron multiplier and the first oscilloscope tube with a flat screen. Victoria Lynch of ITT holds the world's first oscilloscope with internal deflection plates. Don't drop it, Victoria! ■

Because the radiation is so weak, the changes that have to be measured amount to only a few parts in 100 billion. The Maryland team, however, has developed equipment sensitive enough to measure the imperceptible motion occurring when a possible gravitational wave jiggles a cylinder.

Two instruments are used to help eliminate unwanted effects, their response in time being checked against each other. Delicate seismometers and tiltmeters are used to check against the events recorded being natural or man-made earthquakes, or a slowly subsiding building, either of which will confound the readings.

The ideal detector for gravitational waves would have several instruments such as Dr. Weber uses spread out over miles in the form of a cross. In that way, the source of any gravitational wave could be detected since there should be a time delay between receipt at any antenna compared to the next in line. Dr. Weber has taken a step in this direction by separating his two instruments by 700 miles. ■



History on Tape

On this 60-minute tape are the actual voices of six American statesmen in excerpts from their famous speeches. With narration by Burgess Meredith, here are the voices of Franklin D. Roosevelt, Harry S. Truman, Dwight D. Eisenhower, John F. Kennedy, Adlai E. Stevenson, and Douglas MacArthur. It can be played on any tape recorder, and the price, postpaid, is $5.00. Order from John L. Nanovic, 60 E. 42nd St., New York, N. Y 10017. Orders on school or educational stationery, $4.00.

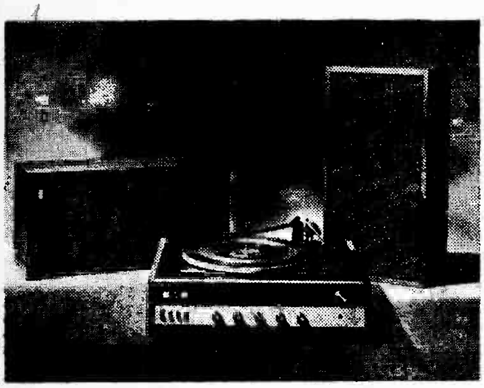
John Nanovic "Sounds of History" Tape

For the Two-Music-Center Family

Fisher has come out with a moderate-priced pair of compact home music systems; the Fisher 120, an FM-stereo phono system that sells for $299.95, and the Fisher 125, a complementary system that includes an AM tuner section as well as FM-stereo, which sells for $329.95. Their newly-designed FM front ends and IF amplifier

Fisher 120 FM-Stereo Phonograph Music Center

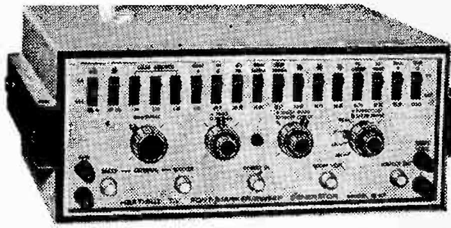
sections incorporate FETs (field effect transistors) and ICs (integrated circuits). Baxandall feedback circuits are used in the bass and treble controls. A main/remote speaker switch, loudness contour and full tape and phono facilities are also included. Atop the receiver is a 4-speed automatic turntable with cue control, anti-skating, balanced tone arm and magnetic cartridge, and automatic shut-off. A pair of Fisher XP-55B speaker systems, which retail separately for $49.95 each, are included with each 120 and 125 package. The speaker systems feature an 8-in. free-piston bass speaker with heavy magnet structure and a 3-in. wide-range treble speaker. Anything else you'd like to know? Write Fisher Radio Corp., 11-40 45th Rd., Long Island City, N. Y. 11101.



Fisher 125-AM/FM Stereo Phonograph Music Center

Cover Six Bases at a Glance

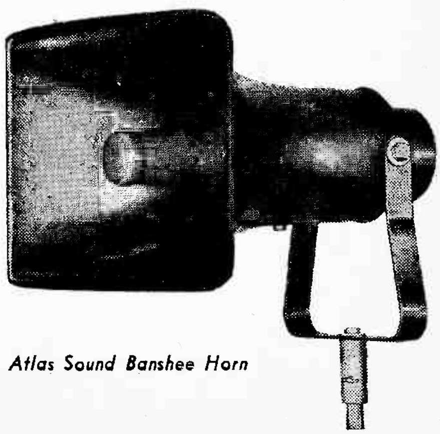
The Heath Co. has put on the market the Heathkit IG-57 post marker/generator at $135.00. The IG-57 will display as many as six markers at a time, obsoleting the old time-consuming variable marker system. Markers are provided for color bandpass alignment; picture and sound carrier frequencies for channels 4 and 10; FM tuner, FM IF and discriminator alignment; and TV sound IF adjustments. 400 Hz modulation is built in for trap adjustment and checking and adjusting FM tuners. A variable voltage supply is provided for use as a source of positive or negative bias. The sweep generator portion has 5 linear sweep ranges, covering the sweep necessary for TV tuned circuits in sound IF, color bandpass, video IF circuits and for proper overall RF/IF response. The IG-57 also has a trace reversing switch, a blanking switch and a phase control so the markers will appear as in the set manufacturer's alignment instructions, regardless of the 'scope used. For literature on the IG-57, write to the Heath Co., Benton Harbor, Mich. 49022.



Heathkit Model IG-57 TV Post Marker/Generator

How to Drown out the Instruments

For all you vocalists who're tired of having your sonic time beaten by amplified guitars, drums, organs, sitars, and all like that, Atlas Sound has produced the Banshee. It's a cobra-flare horn, and it will spray out the vocals with 125 watts of peak power. Frequency response of the Banshee is 100 to 12,000 Hz, and the sound intensity is claimed to be 131 dB! Man, that should drive your ear drums to the center of your head. Impedance is 16 ohms. Banshee has a built-in pre-wired phone jack; you just insert a speaker cable with a two-conductor phone plug and everybody can really dig those crazy lyrics. Atlas recommends a speaker stand to elevate the sound above the crowd. It's best to keep the audience below the sonic boom. Atlas has two models, the SS-4 for $25, the SS-2 for

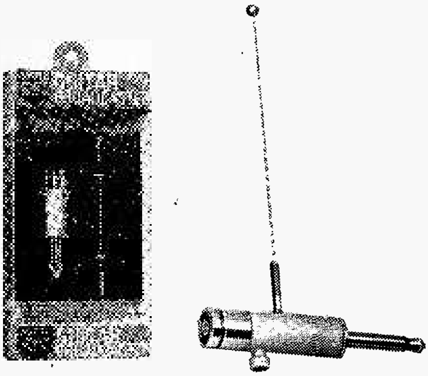


Atlas Sound Banshee Horn

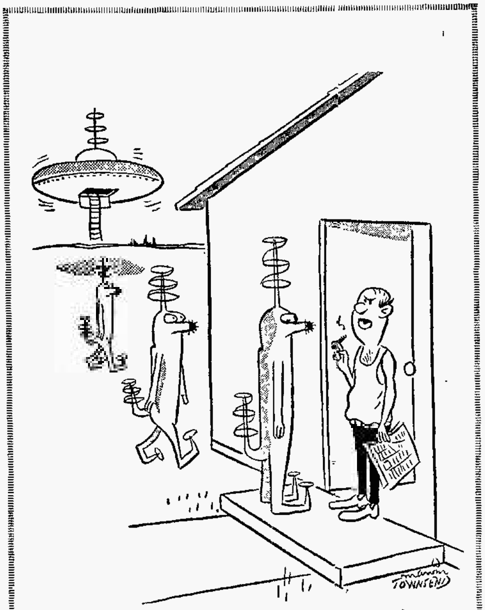
$48. The Banshee is $121.00, and for more poop, write Atlas Sound, Parsippany, N. J. 07054.

Radio Station "Your Own Guitar"

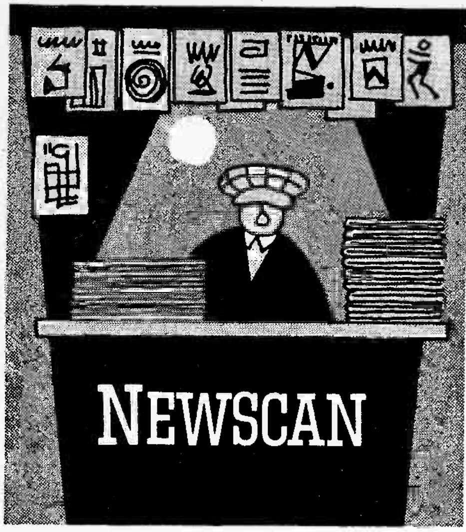
This Guitar Broadcaster plugs into the output jack of any electric guitar and broadcasts its sound to an FM radio up to 50 ft. away from the source. The unit will also operate with other electrified instruments. The solid-state device is 3¼-in. long and about ⅝-in. in diameter, and lists at $14.95. The Guitar Broadcaster has a frequency response of 20 to 15,000 Hz and 6mW input power with no distortion or feedback. The maker, Saxton Products, recommends using their B-101 battery. For further information, write Saxton Products, Inc., 215 N. Rte. 303, Congers, N. Y. 10920.



Saxton Products Guitar Broadcaster



"Don't bug me, Bosco! Go find the ham who welcomed you to this planet."



Push, Pull—Click, Click!

A new method of directly plating any solid surface with any metal, alloy or nonmetallic substance at million-per-day production rates and low unit costs has been developed for industrial and scientific use. Typifying the plating applications are the Schick Krona-Chrome razor blades. These stainless steel blades are plated with chromium in an automatic process using high vacuum, radio frequency electrical power and ion bombardment for a coating-to-surface bonding impact 1,000 times greater than conventional plating processes.

Developed by Varian Associates Vacuum Division, the new industrial equipment can process materials of any dimension including continuous lengths. Called vacuum plating (or more technically RF-induced plasma sputtering), the high-energy, high-adhesion plating process has mated permanently such dissimilar substances as metals to glass, textiles, fibers and plastics; glass to stainless steel or other metals; titanium and other metals which are difficult to work on ceramics or other metals; as well as conventional plating materials such as copper, chrome and nickel on any surface.

RF-induced plasma vacuum sputtering essentially is a basic new technology which offers industries a practical and economical method of adding hardness, insulation, conductivity, decorative finishes, or other desired qualities to common materials to facilitate further manufacturing steps. The process operates as follows: the material to be plated is placed in or passed through a sealed chamber which, as the first step in the automatic cycle, is evacuated to a pressure equal to an altitude of 600,000 feet above sea level—115 miles in outer space.

When this vacuum is attained, a small amount of inert argon gas is introduced.

The plating material is fastened as a target to the inverted 'V' of two plates which are charged negatively to —2000 volts at a frequency of 13.5 million cycles per second. This radio frequency energy excites the entrapped electrons, causing them to collide with the argon atoms and changing them in turn to positively charged ions to result in a gaseous plasma characterized by a violet-colored glow-discharge. These positively charged argon ions are attracted to the target plate. Striking the plating substance there, they dislodge atoms which carom to the material on the substrate table below.

The atoms strike the surface to be coated with an energy level approaching 300 electron volts—sufficient to cause them to burrow with great velocity into microscopic crevices to establish a uniform bond of uniform thickness.

As an example of the plating speed obtainable, fabric of any width can be coated with gold at a speed of 20 feet per minute.

Varian also announced it has established a laboratory open to all industry, to assist manufacturers in the proper evaluation of Plasma-Peak sputtering or other of its vacuum deposition processes.

Scientists have developed a new method of plating any solid surface with any metal, alloy or non-metallic substance such as glass or plastics. Process combines high vacuum, radio frequency electrical energy and ion bombardment (which produces eerie plasma glow in photo) to slam atoms of plating material on to surfaces with 1,000 times the force of prior plating techniques.

Cast an Electronic Ballot

A new type of vote recorder that permits ballots to be tallied by computer was used by Boston College students during the recent Campus Council elections. It was the first time the new table-top vote recorder, manufactured by Seiscor, a division of Raytheon Company's Seismograph

☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆

Voting is easy for Boston College coed Gerri Spaits of Cotasauqua, Pennsylvania. Step one is to pick up a data processing card, which replaces the written ballot. Then, instead of marking the ballot, Gerri punches it with a stylus. The punched ballot can be read by computer at a speed of several hundred ballots a minute. The simplicity of operation eliminates complicated instructions, speeding voter flow. Poll watchers are Mary Doherty of Milton, (front left) and Barbara Donovan of Arlington.

Service Corp. subsidiary, has been used in a campus election anywhere in the country.

Student computer programmer Michael E. Byrne, a junior from Marlboro, Massachusetts, processed 2015 ballots, the largest vote ever cast in a Boston College election, through a computer immediately following the close of the day-long election. The computer, which was programmed to reject an illegal choice (such as voting for more than one candidate when only one vote was permissible) printed out the election results in just three minutes.

Electronic voting systems were authorized by the Massachusetts legislature in August, 1967. Earlier, only lever-type mechanical machines or paper ballots could be used in the state. This is only the beginning of what will be nation-wide electronic vote recording.

In the past, the 5000 students at Boston College have used written ballots. Vote tallies were prepared manually, collected from the polling places, assembled and tallied. Final results often were not available until the following day. We old folks will have the same trouble during the presidential elections this year. If a few key states have close votes, it is possible we may not know our next president for 24 to 72 hours after the polls close.

With the easy-to-use electronic voting system, a data processing card, replacing the paper ballot, was given to each student signing in at the polling place. Following the instructions printed on the machine, the student inserted the data card into the recorder and pressed a stylus opposite the name of his candidate. This punched a data hole in the card which the computer would later record as a vote. No operating difficulties were reported by the poll watchers, who had been briefed on the machine by a Raytheon representative prior to the election.

The 12 vote recorders, one for each 500 students enrolled in the schools of Nursing, Business Administration, Education, Arts and Sciences, and Philosophy, were located near major campus walkways. Although the actual voting procedure took only seconds, many curious voters lingered to watch their classmates operate the machine.

The chances are you will not be able to cast an electronic ballot this year. But whether you pull a lever or "X" a box, vote! It's the greatest!

Flat as a Board—Almost

One of the most precise optical mirrors ever made will be used in the world's largest optical collimator at Wright-Patterson Air Force Base, Ohio. The 100-in. diameter mirror disc for the gigantic collimator was fabricated by Corning Glass Works from fused silica, among the purest materials made by man. The huge disc was ground and polished to produce a prescribed curved surface accurate to *one-millionth of an inch*.

Fused silica is ideal for precision optical systems because of its thermal stability and suitability for exact finishing. The same kind of material was used by Corning to build the 157-in. mirror blank for Canada's Mount Kobau National Observatory, the 144-in. mirror blank completed recently for the European Southern Observatory in Chile, and nine other massive optical applications in recent years.

The 7,500-pound collimator mirror is suspended 70 feet below ground, at the bottom of a 155-foot, vertical vacuum chamber housed in a ten-story building. Precision of the testing facility will be maintained by aligning all optical components to a 55-foot, low-expansion metal tube inside the lower section of the chamber.

The 720,000-pound system "floats" on a series of air-filled rubber tubes to reduce the effects of external vibrations. Special air conditioning equipment will maintain dust-free air and controlled temperatures.

The Air Force said a collimator is a special optical instrument through which an object—such as a resolution target or chart—is made to appear at an infinite distance from the observer. It could be described, the Air Force said, as an extremely well corrected telescope with a transparent resolution chart or target mounted accurately in the focal plane and illuminated by a suitable light source.

That's a lot of words, even for the Air Force. Simply, a collimator is a device which supplies light rays that are perfectly parallel to each other, as if the light came from a pin-point source from the end of space.

School Days

Thirty New York City school children are listening to records and watching movies in school more than usual lately, but their teachers are all for it. The students—from the third through sixth grades at Bedford Stuyvesant's Public School 81—are taking part in a remedial reading program to see how well they can improve their reading skills with an audio visual learning system developed by CBS Laboratories. Each day during class the youngsters sit down with the compact desk-top system and get "private" tutoring. The system's prerecorded voice converses with the student and tells him how to proceed with each lesson. Word pictures appear simultaneously on a tiny viewing screen in front of the children.

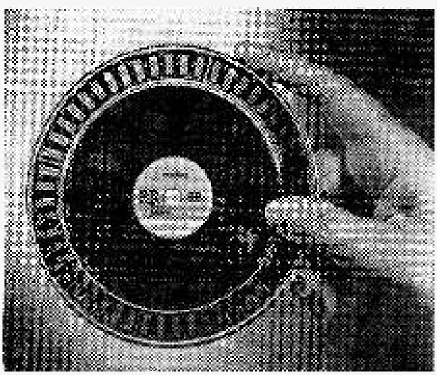
If the student selects the wrong answer, the machine remains silent, flashes a red light and waits for him to try again. If he selects the right answer, the correct word or phrase appears on the screen and his correct choice is reinforced by the pleasant *female* voice. Similarly, the new system tutors the students in group instruction.

Morton Feinman, P. S. 81 principal, emphasizes that the system is not a substitute for the teacher. Instead, he said, it provides a versatile tool to aid teachers and students.

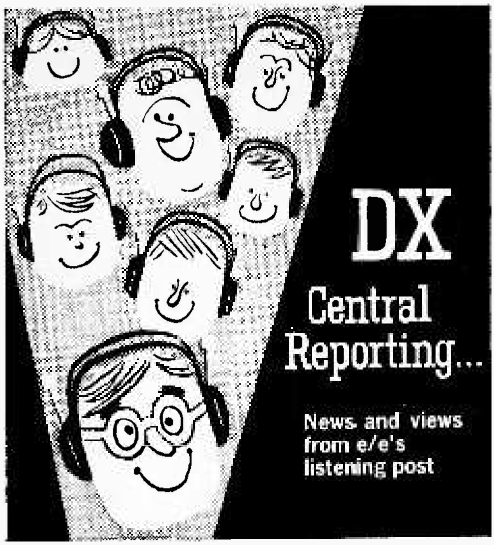
The programmed learning system developed by CBS Laboratories, a division of Columbia Broadcasting System, Inc., is being manufactured and marketed by Viewlex, Inc., for less than $350. Called the AVS-10, it is a portable electronic device about the size of an overnight carrying case. AVS-10 has a built-in viewing screen 5 inches high and 8 inches wide. It plays specially-designed audio-visual program cartridges.

The tiny cartridges, carrying up to 52 picture

(*Continued on page* 103)



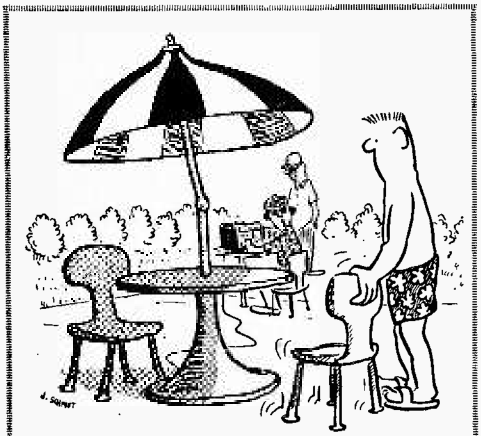
Here's the CBS programmed cartridge, the first of its kind to combine sight and sound in one unit. Cartridge is five inches in diameter and one-quarter inch thick. Eighteen minutes of recorded program material and 52 synchronized picture frames are included in one cartridge.



Those Missing IDs

A couple of years ago the Voice of America announced it would no longer QSL reports from the United States. The resulting hue and cry was of such proportions that the VOA hastily reversed its decision. Latest on the VOA is that it has now decided to delete all local IDs except for one relay operated by BBC at Wooferton, England. This means that whether you hear the VOA station at Colombo, Ceylon, or Marathon, Fla., all you'll be told over the air is one thing —that these programs are coming from the Voice of America in Washington, D.C.

Official VOA frequency schedules complete with locations are periodically distributed to various editors (including some club editors). Even so, this information simply isn't available to the majority of SWLs. This action (or lack of action) leaves most of the *lone wolves* out in the



"Don't sit there—that's my antenna!"

VOA BCB Frequency Schedule*

kHz	Transmitter Location and Power (kW)	Intended Reception Area	(GMT) Time
760	Viet Nam (?)	Viet Nam	1100-1650
791	Thessaloniki, Greece (50)	Greece	0450-0650 1000-1700
		Greece (Sundays)	0650-1000
		Europe	1700-2250
920	Malolos, Poro, Philippines (50)	Philippines	1500-1650
1140	Malolos, Poro, Philippines (1000)	South-East Asia	1200-1650
1178	Okinawa (1000)	East Asia	1100-1600
1180	Marathon, Fla. (50)	Caribbean	1200-1400 2300-0400
1196	Munich, Germany (300)	Europe	0300-0750 1600-2400
1259	Rhodes, Greece (150)	Mid-East	0300-0750 1400-2350

* The frequencies and times are projected by the Editors of ELEMENTARY ELECTRONICS based on propagation data and previously announced transmissions by VOA. SWLs are urged to monitor the following frequencies this Fall for VOA broadcasts: 3980, 3990, 5965, 5995, 6005, 6015, 6020, 6030, 6035, 6040, 6050, 6055, 6060, 6065, 6075 and 6080.

cold. Furthermore, frequencies are subject to sudden change especially when things get hot in different corners of the world.

The new VOA policy does have a couple of very definite propaganda advantages. First, the relays at Rhodes and Thessaloniki will no longer have to admit on the air that they are broadcasting from Greece—a military dictatorship which the Voice would rather not be publicly associated with. Second, should clandestine transmitters carry VOA programs, as happened during the Cuban missile crisis, the operation will be unannounced and, maybe, unnoticed.

The Towers Game

Speaking of clandestines, those who think R. Libertad, BBC Botswana, and R. Americas are happenings can take comfort in the fact that the best is yet to come. That equally publicized *hunt* for portable BCB towers makes all those other clandestine quests appear almost square by comparison. Now, so that no one becomes completely lost in this maze, let's make a couple points clear. Any BCB array can be moved—with difficulty. But, a portable antenna has been specially designed so that it can be moved easily, set up, and made fully *operative* at a location in the shortest possible time. Such an array can be used with any BCB transmitter and with any appropriate power source.

The tower hunt began when an SWL "discovered" that the VOA's two-masted portable array at Marathon, Fla., had been replaced with a three-tower permanent job. His reasoning sounded good, but there was one catch. The two portable towers hadn't been removed; instead they had simply been absorbed into the three-tower job in February 1963.

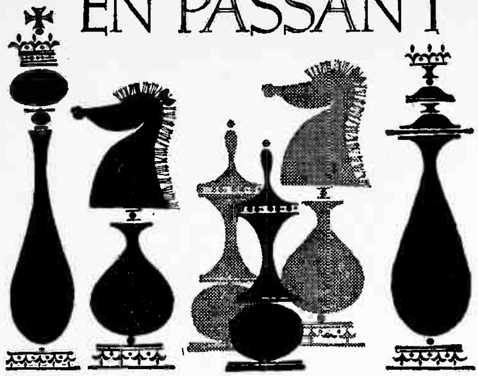
Now this move raises an interesting question, especially if you're a taxpayer. Since the Voice did go to the trouble and expense of additional construction at the Marathon site (1180 kHz), why didn't it build a wholly conventional array and free the valuable portable towers for emergency uses? After all, in 1965 the VOA built a badly needed 50-kW BCB relay at Hue, S. Vietnam, and took at least six months to get this one on the air. Had their portable antenna system been available, it could have been on the air in two weeks (though using lower output power at the beginning).

Now the plot thickens. The portable array at Marathon was rushed into action during the Cuban missile crisis, opening November 13, 1962. Simultaneously, another Voice outlet appeared on 1040 kHz and a couple months later its location was announced at Sugar Loaf Key, Fla. But according to RADIO-TV EXPERIMENTER (DX on Wings, April/May 1968), the original its location was announced as Sugar Loaf Key, did not come on until later. Though pressed on the point, the VOA has consistently avoided either confirming or denying it. They do deny that the Voice itself has ever operated airborne relays. But, as already mentioned, during the missile crisis stations not operated by the VOA (like R. Americas, which VOA 1040 at times relayed) carried Voice transmissions. When asked the date Sugar Loaf actually came on the air, they would say only "about" the same time as Marathon. Thing is, some SWLs claim the original 1040 unit came on at the same time.

So you see, as we pry deeper into the *towers game*, the less we know. Portables can pop up anywhere. Case in point is "DX the Land of Thai," the SWL feature in this issue of ELEMENTARY ELECTRONICS. Thailand has its share of portables. Check out this exciting feature. ■

"But, Honey, I'm really on a desert island!"

EN PASSANT



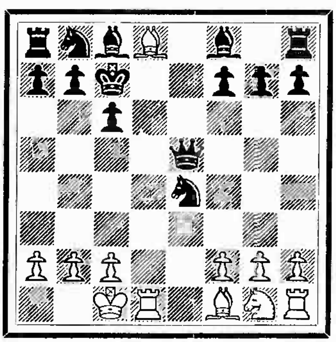
BY JOHN W. COLLINS

A while back, in my fourth *e/e* chess column, I gave a selection of mates that can happen when the pieces are hardly out of the box—Fool's Mate, Scholar's Mate, Smothered Mate, and Legal's Mate. Less primitive, and a little longer, though equally instructive and picturesque, are the following quicky mates. Recognizing these various mating patterns, and knowing how to handle them, is bound to improve your style of play.

Double Check-Mate—brutal finish. Richard Reti (White) and S. Tartakower, both international masters, ran off this Caro-Kann Defense at Vienna in 1910.

1 P-K4	P-QB3	7 B-Q2	QxKP
2 P-Q4	P-Q4	8 0-0-0!	NxN??
3 N-QB3	PxP	9 Q-Q8#!!	KxQ
4 NxP	N-B3	10 B-N5##	K-B2
5 Q-Q3	P-K4?	11 B-Q8 mate!	
6 PxP	Q-R4#		

Black



White

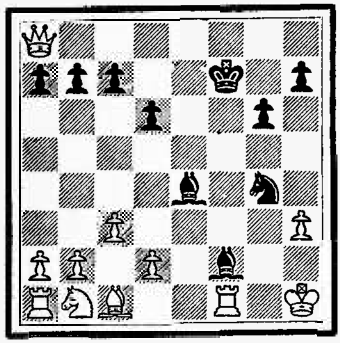
Blackburne's Mate—which exemplifies perfect coordination between two Bishops and a Knight.

A Giuoco Piano, Jerome's Gambit, played at London, 1880, this one was perpetrated by James H. Blackburne, Champion of England, on Anon. *(Continued on page 22)*

Continued from page 21

1	P-K4	P-K4	8	QxR	Q-R5
2	N-KB3	N-QB3	9	0-0	N-B3
3	B-B4	B-B4	10	P-B3??	N-N5!
4	BxP#??	KxB	11	P-KR3	BxP#
5	NxP#	NxN	12	K-R1	B-KB4!
6	Q-R5#	P-N3?	13	QxR	QxP#!
7	QxN	P-Q3!	14	PxQ	BxP mate!

Black



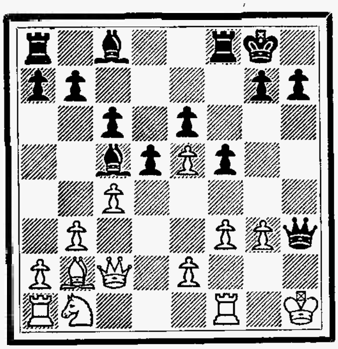
White

Greco's Mate—a pretty old one. A mating device with Rook and Bishop, Gioachimo Greco wrote about it in his book of 1619.

Carlos Torre, a Mexican master, gets a chance to use the Greco, substituting a Queen for a Rook, when Ernst Grunfeld, Austrian opening theoretician, makes an amazing mistake on his 12th turn. It is a Dutch Defense, played at Baden-Baden, 1925.

1	P-Q4	P-K3	9	B-N2	N-Q2
2	N-KB3	P-KB4	10	N-K5	Q-B3
3	P-KN3	N-KB3	11	P-B3	NxN
4	B-N2	P-Q4	12	QPxN??	B-B4#!
5	0-0	B-Q3	13	K-R1	NxP#!
6	P-B4	P-B3	14	PxN	Q-R3#
7	Q-B2	O-O	15	B-R3	QxB mate!
8	P-N3	N-K5			

Black



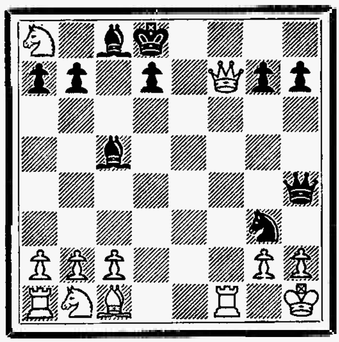
White

Bishop and Knight Mate. Once the stage has been set, a Bishop and Knight can end it quite nicely.

This Scotch Opening was played in England in the Nineteenth Century and was won by H. E. Bird from Mr. X.

1	P-K4	P-K4	9	B-Q3	NxP
2	N-KB3	N-QB3	10	0-0	NxP!
3	P-Q4	PxP	11	RxN	R-K8#
4	NxP	Q-R5?	12	B-B1	N-Q5
5	N-N5	B-B4	13	QxBP	N-K7#
6	Q-B3	N-B3	14	K-R1	RxB#
7	NxP#??	K-Q1	15	RxR	N-N6 mate!
8	NxR	R-K1			

Black



White

Game of the Month. Wilhelm Steinitz (1836-1900) was the first recognized World Champion. The "Father of Modern Chess," with its scientific approach, his style was positional and he strove for a strong, unassailable center which afforded the possibility to prepare methodical, vigorous wing attacks.

Like every great player, however, Steinitz could play brilliant combinative chess too and the following partie against Von Bardeleben (Black), Hastings, 1895, a Giuoco Piano, is one of the most profound in that realm.

1	P-K4	P-K4	14	R-K1	P-KB3
2	N-KB3	N-QB3	15	Q-K2	Q-Q2
3	B-B4	B-B4	16	QR-B1	P-B3?
4	P-B3	N-B3	17	P-Q5!!	PxP
5	P-Q4	PxP	18	N-Q4	K-B2
6	PxP	B-N5#	19	N-K6	KR-QB1
7	N-B3?	P-Q4?	20	Q-N4!	P-KN3
8	PxP	KNxP	21	N-N5#	K-K1
9	0-0	B-K3	22	RxN#!!!	K-B1
10	B-KN5	B-K2	23	R-B7#!	K-N1
11	BxN	QBxB	24	R-N7#!	K-R1
12	NxB	QxN	25	RxP#	Resigns
13	BxB	NxB?			

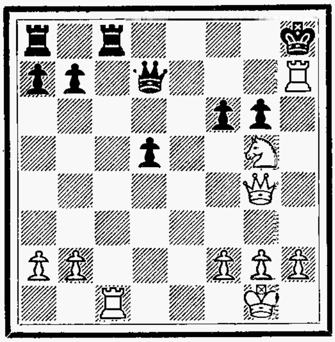
(Diagram top of next page)

Why did Black resign? Because he must wind up a piece behind, lose his Queen, or be mated. Here is the analysis—

A. If 25 . . . . QxR 26 RxR#! (not 26

Position after 25 RxP#

Black



White

NxQ??? RxR# 27 Q-Q1, RxQ mate) RxR 27 QxR# Q-N1 28 N-B7# K-N2 29 QxQ# KxQ 30 N-Q6 and White wins going away with his extra Knight.

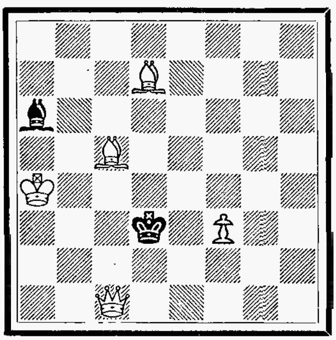
B. If 25 . . . . K-N1 26 R-N7# KxR (if 26 . . . . QxR 27 RxR# and White wins much as he did in A) 27 QxQ# (taking with check makes the difference) K any 28 RxR and White wins easily.

C. If 25 . . . . K-N1 26 R-N7# K-R1 (if 26 . . . . K-B1 27 N-R7#! K-K1 28 R-K1# and White mates in two) 27 Q-R4# KxR 28 Q-R7# K-B1 29 Q-R8# K-K2 30 Q-N7# K-K1 (if 30 . . . . K-Q1 31 Q-B8# Q-Q1 32 N-B7# K-Q2 33 Q-Q6 mate and if 30 . . . . K-Q3 31 QxP# Q-K3 32 QxQ mate) 31 Q-N8# K-K2 32 Q-B7# K-Q1 33 Q-B8# Q-K1 34 N-B7# K-Q2 35 Q-Q6 mate.

And Steinitz must have seen it all when he played 22 RxN#!

Problem 15
By Nicholas Kosheen
U.S.S.R.

Black



White

White to move and mate in two.
Solution in next issue.

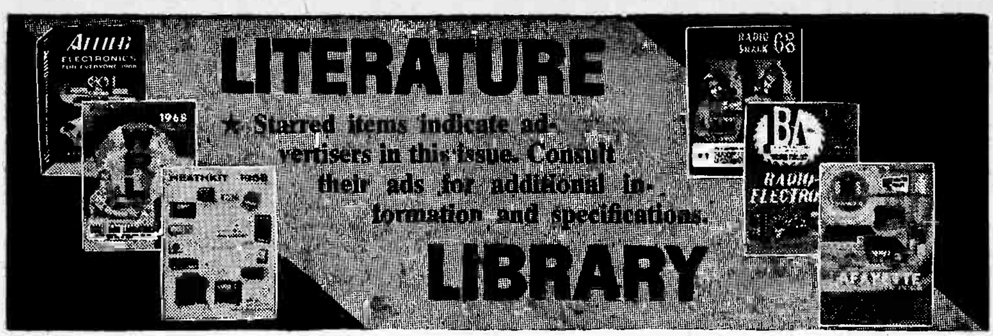
Problem 15 has only seven pieces, and is not difficult, but it has three nice, different mates. See if you can find them all!

Solution to Problem 14: 1 P-K3.

News and Views. Pal Benko, probably the most successful competitor in Swiss-tournament history, carried off first prize of $1250 by scoring 7½-½ in the 1968 National Open at Lake Tahoe, Nevada. Rev. William Lombardy and Tibor Weinberger tied for 2nd and 3rd with 7-1.

Julio Kaplan, Junior World Champion and Champion of Puerto Rico, compiled 6-1 to win the 2nd Puerto Rico Open, which was held at the University of Puerto Rico, San Juan. Kurt Brasket and Nickolas Rossolimo also scored 6-1, but dropped to 2nd and 3rd on tie breaks.

With a resurgence of his best form of a few years ago, Donald Byrne, professor of English at Pennsylvania State University, and one time chess pupil of the writer, has captured two important firsts in recent months. In December, he won the Marshall Chess Club Quadrangular Tournament with 5-1, ahead of Bisguier, Seidman, and Sherwin. And, in July, he won the Atlantic Open with 7-1, ahead of Day 7-1 (who was placed 2nd on tie break), and Rossolimo, Shipman, and Zukerman, all bunched at 6½-1½. ■



CB—AMATEUR RADIO—SHORTWAVE RADIO

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96. Get your copy of *E. F. Johnson's* new booklet, "Can *Johnson* 2-Way Radio Help Me?". Aimed for business use, the booklet is useful to everyone.

★129. Boy, oh boy—if you want to read about a flock of CB winners, get your hands on *Lafayette's* new 1969 catalog. *Lafayette* has CB sets for all pocketbooks.

103. *Squires-Sanders* would like you to know about their CB transceivers, the "23'er" and the new "S5S." Also, CB accessories tbat add versatility to their 5-watters.

46. Pick up *Hallicrafters'* new four-page illustrated brochure describing Hallicrafters' line of monitor receivers—police, fire, ambulance, emergency, weather, business radio, all yours at the flip of a dial.

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116. Pep-up your CB rig's performance with *Turner's* M+2 mobile microphone. Get complete spec sheets and data on other *Turner* mikes.

48. *Hy-Gain's* new CB antenna catalog is packed full of useful information and product data that every CBer should know. Get a copy.

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115. Get the full story on *Polytronics Laboratories'* latest CB entry Poly-Pup. Full 5-watts, great for mobile, base or portable use. Works on 12 VDC or 117 VAC.

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★135. Get with ICs! *RCA's* new Integrated Circuit Experimenter's Kit KD2112 is the first of its kind and should be a part of your next project. Get all the facts direct from *RCA*. Circle 135.

140. How cheap is cheap? Well, take a gander at *Cornell Electronics'* latest catalog. It's packed with bargains like 6W4, 12AX7, 5U4, etc., tubes for only 33¢. You've got to see this one to believe it!

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23. No electronics bargain hunter should be caught without the 1969 copy of *Radio Shack's* catalog. Some equipment and kit offers are so low, they look like misprints. Buying is believing.

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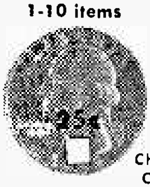

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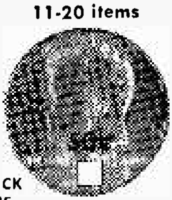

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ELEMENTARY ELECTRONICS ETYMOLOGY

By Webb Garrison

Dynamo

▲ Generation of electricity by mechanical rather than chemical means was first accomplished in 1831. Michael Faraday rotated a copper disk edgewise between poles of a horseshoe magnet, obtained a weak but continuous direct current. Many refinements and improvements were made in the next few decades. As a result, magneto-electric machines came into wide use.

One scientist, Werner Siemens, concluded it wasn't necessary to use a permanent magnet. In January, 1867, he described a new kind of generator to the Berlin Society. It relied upon a rotating armature equipped with coils in which current was induced by action of electro-magnets—which were themselves excited by the current produced. From Greek for "strength," Siemens called his device the *dynamo-electric machine.*

This self-exciting source of power proved the key to rapid expansion of the electrical industry. By 1882 England had 5 lighthouses and France had 4 equipped with electric arcs fed by rotating dynamo-electric machines, driven by steam engines. S. P. Thompson abbreviated the name to *dynamo.*

Strictly speaking, a dynamo is a direct current generator—as opposed to an "alternator." But in practice the name formed from the notion of "power" is applied to all types of generators. □

Rubber

▲ Members of a French scientific expedition visited South America in 1735. While in Brazil they became acquainted with a tree whose milky sap hardens into an "elastic resin." Natives called it *caoutchouc.* Samples reached Paris in 1736. Chemists analyzed the stuff and concluded, correctly, that it is made up entirely of carbon and hydrogen.

Long regarded as a curiosity, it was eventually found useful for erasing the strokes of black lead pencils. Some persons called the imported oddity "lead-eater." Others used a title formed from a German term for a device that subjects a surface to friction with pressure. Linked with an allusion to its origin, the popular name for the New World substance became *Indian rubber.*

Charles Macintosh, an enterprising Scot, imported liquid latex with which to make the first waterproof coat, or macintosh. In 1839 Charles Goodyear accidentally learned how to "cure" rubber's instability by treating it with sulfur. From this discovery it was an easy step to perfect the use of rubber as insulation

Today small quantities of it are still used in making erasers, but the quality that gave *rubber* its name has shrunk to insignificance by comparison with its role in helping feed electricity through homes, cars, and manufacturing plants. □

Cesium Clock

▲ German chemist Robert Bunsen is best known for having invented the Bunsen burner. But his most important contributions came from research.

Working with G. R. Kirchoff, he was among the first to put the spectroscope to use. With it, the two men analyzed flame spectra of many substances. One of them clearly revealed two blue lines never before noticed. Bunsen reasoned that they must point to existence of an undiscovered metallic element of the alkali group. From *caesium,* Latin for "blue sky," he proposed that element *x* be called *cesium.* When isolated it was found to have an atomic number of 55 and to be relatively abundant (70 times as common as silver).

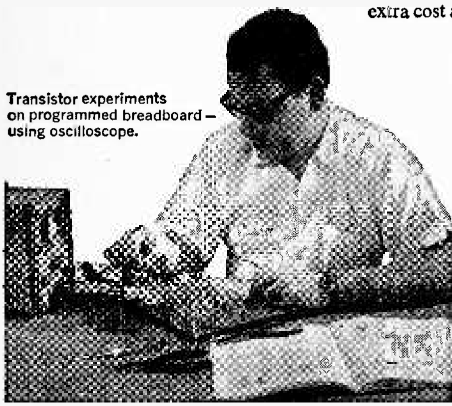
Cesium eventually found important uses in photoelectric cells and pickup tubes of TV cameras. Intensified study of the metal led to discovery that its atoms produce discrete radio waves that can be measured directly.

Except for magnetic fields, external factors such as temperature do not affect the frequency of about 9200 megacycles per second. Since this is within the wavelength used for radar, techniques for handling this frequency are well advanced.

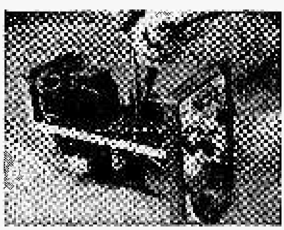
Using a radio transmitter tuned in to match the frequency of cesium atoms, technicians produced the world's most accurate device for measuring time: "the cesium frequency standard."

Accurate though it is, that label is too formidable for ordinary use. Disregarding the fact that our word "clock" stems from a Latin term for the bell with which the typical early pendulum clock was equipped, it became common to speak of the *cesium clock.*

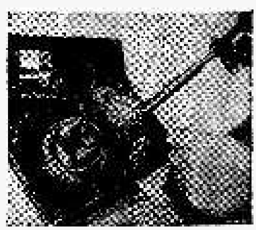
Taken literally, this name would point to "the bell-ringer that produces sky-blue lines in the spectrum." Actually, the cesium clock employs a silvery-white metal which fosters electronic measurement of time with a margin of error so small that no bell could mark it: one second in 3,000 years. □



Transistor experiments on programmed breadboard – using oscilloscope.



Construction of Oscilloscope.



Construction of Multimeter.

as our neighbors see us...

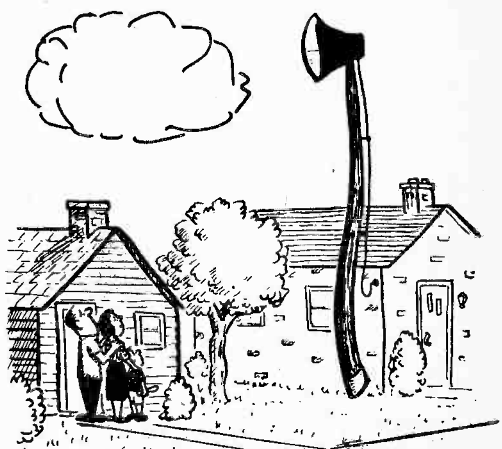
by Jack Schmidt

. . . during the DX contest

. . . when testing

. . . when entertaining

. . . when their set fails



. . . and our new antenna

COVER STORY

elementary Electronics NOV-DEC 1968

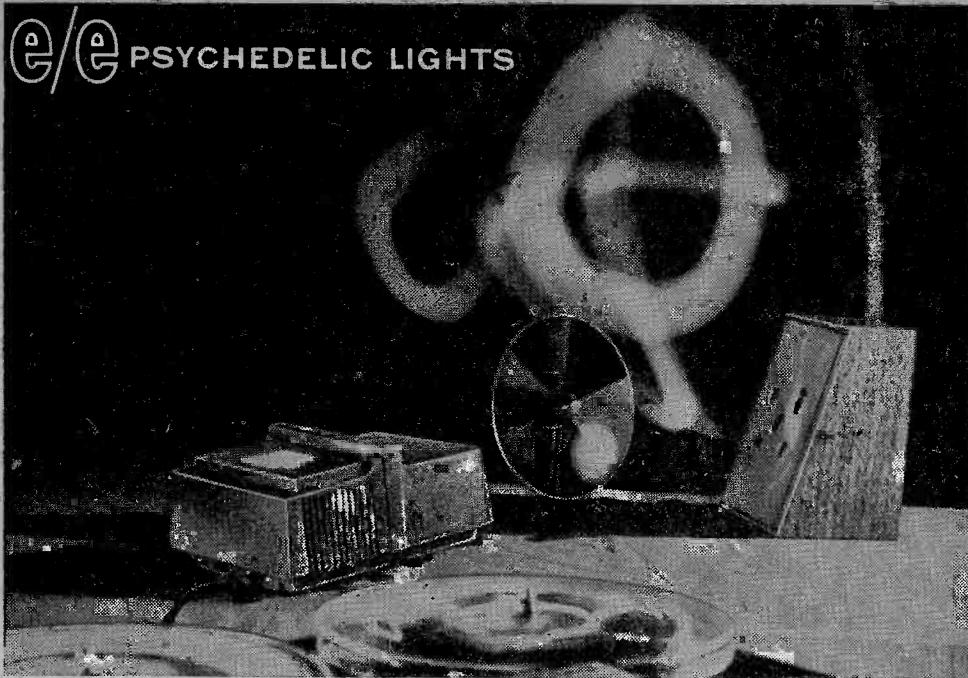
the eerie world of

PSYCHEDELIC LIGHTS

By Len Buckwalter
K1ODH/KQA5012

Can't make it to New York's Electric Circus . . . or the Acid Trip in San Francisco? No matter you can create your own psychedelic light productions. Thanks to new devices appearing on the market, the wild lighting of the discotheque is making the home scene. Now you can have a freak-out at your own see-in! It's just the thing for happenings, *(Continued overleaf)*

e/e PSYCHEDELIC LIGHTS



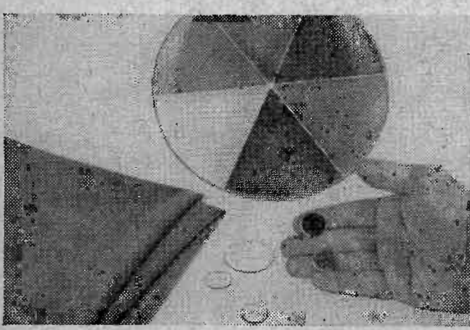
The new sight and sound of music. MusicVision system developed by Edmund Scientific Co. paints any surface with colorful patterns and swirls. Surface will bulge as colors follow changing tones and volume.

rock groups, *in* or *way-out* parties, in fact most any event that needs a visual turn-on. Try these effects at a school dance, if you dare. The faculty might observe, "It's a multi-media trick to overload our senses, but look, we're flying, baby, we're flying!"

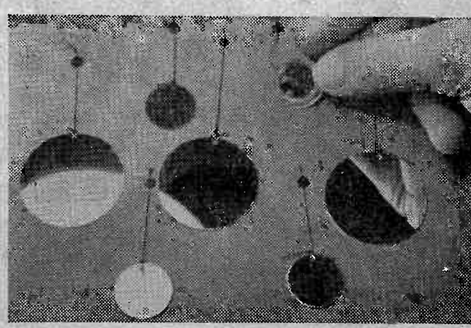
The First Spark. Mixing light and music isn't new. A century ago Frenchmen coupled gas jets to an organ-like instrument and produced one color per note. In this country, a Professor Rimington demonstrated a color organ projection system back in 1893. Through the roaring 20's, color-music concerts were the rage. And today a handful of manufacturers produce a color organ for attaching to a hi-fi music system. As music plays, it lights lamps which glow different colors according to low, middle or high notes.

The color organ, though, is showing its age. It creates a sedate display with about as much action as you'd find at a temperance tea. Most home color organs are small-screen affairs and entertainment value is short-lived. Hardly a match for today's 100-decibel ear-shredding beat.

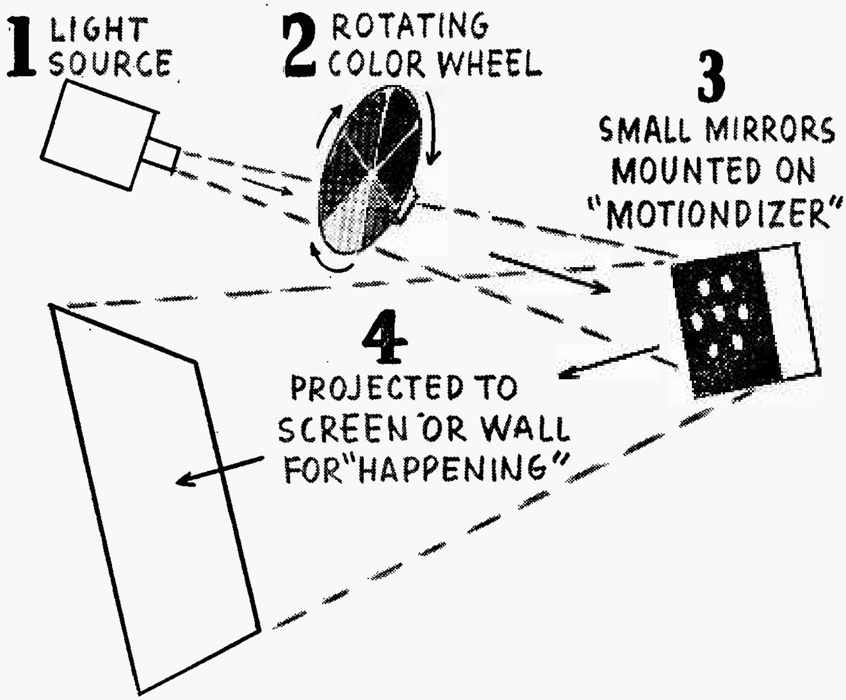
Leaping Lumens! The color organ is a *has-been*! It's rapidly being replaced by the



Basic materials for assembling MusicVision system can be purchased separately. Special front-surface mirrors, color wheel, and rubber membrane are shown.



Mirrors are mounted on rubber membrane stretched across speaker opening. Here they are suspended from threads to obtain a bouncing-ball effect.

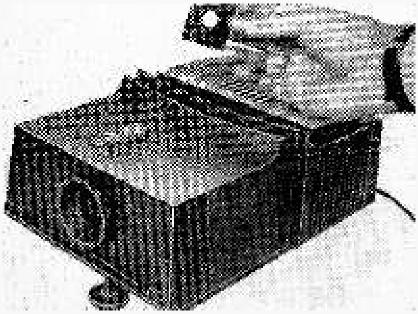


MusicVision system can produce prancing, colored light beams with a simple arrangement of components. Light from source passes through color wheel to face of Motiondizer. Mirrors reflect beams onto surface.

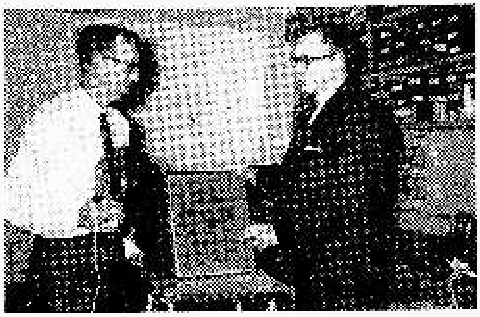
"light show". Developed to a brain-crushing degree in California, a light show can grip a whole room with brilliant, swirling color that rocks the retinas. Projected against dancers, it thrusts them in limbo. Viewed at a poetry reading, it makes you forget the couplets don't rhyme. Produced by a master showman, a light show has even been known to cause "spin-ins"—a disabling assault on the senses—among spectators. The freaky fireworks of the light show, however, have been limited to strictly professional performances.

The reason is that little hardware has been offered to the home experimenter wishing to try his hand at psychedelic lighting. Techniques used in professional shows are incredibly messy, require more compounds than are found in a Gilbert chemistry set, and need considerable artistic talent for impressive results.

A professional light show, for example, might begin with a glass dish filled with about an inch of water. It's placed on a 1000-watt overhead projector to cast an image over a large area. The operator runs the show by dropping dyes, stains, elixirs, even Easter Egg colors, into the water. Throughout the

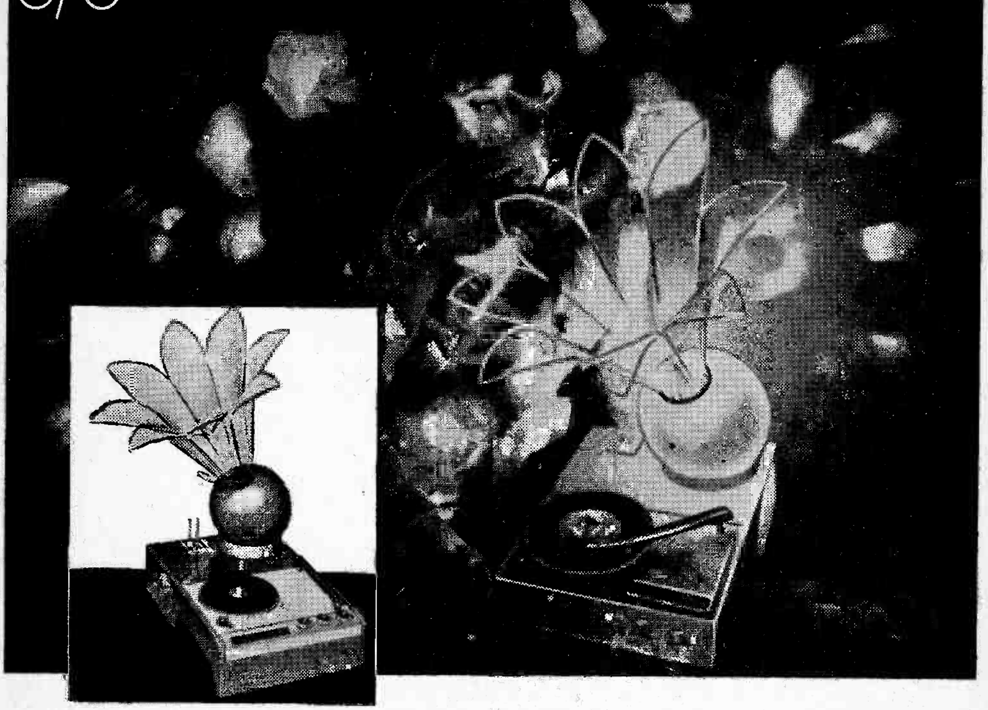


When using your 35 mm slide projector as a light source, you'll need an aperture like one in photo. This produces narrow beam for smaller mirrors.



King-size version of MusicVision comes in 12-in. size. At left, holding color wheel, is Norman W. Edmund. Jack Jennings, an engineer, is at right.

e/e PSYCHEDELIC LIGHTS



Clairtone of Canada really knows how to treat a girl! Illustrated is their Light Fantastic—a self-contained unit with phono and AM radio. Turn on either and images are projected from large plastic flower.

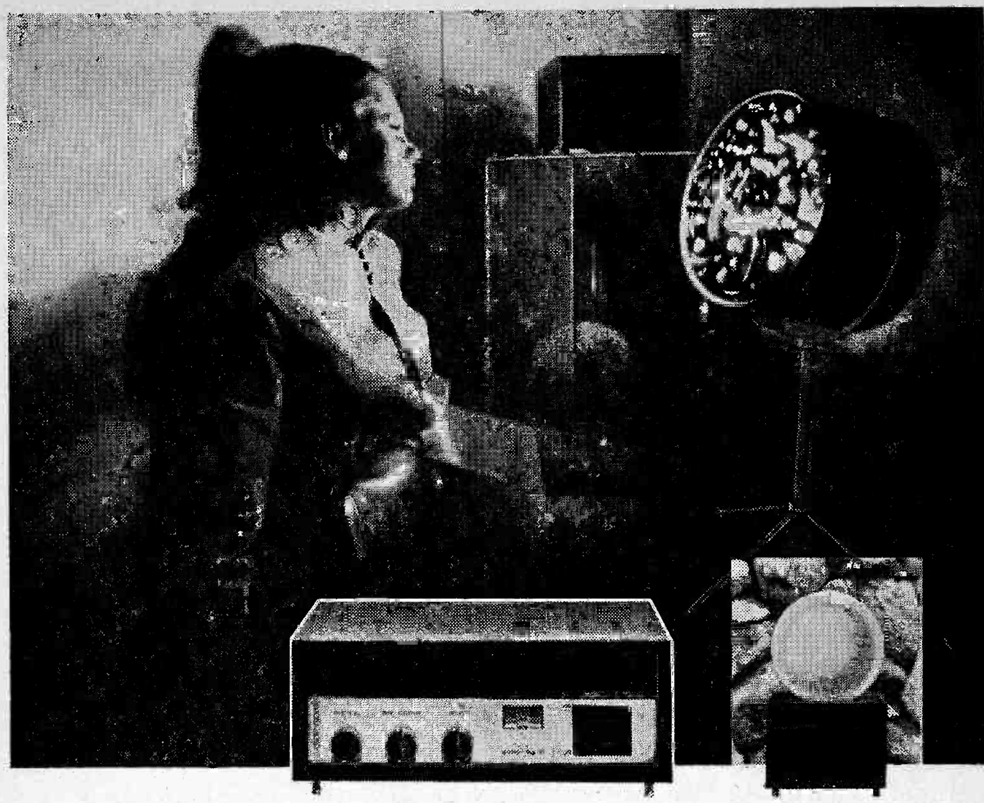
room appears a spooky flow of abstract color patterns. Trails of other colors are created by sprinkling tiny particles that diffuse and sink in the dish. Mineral oil poured into the solution spawns weird globules that migrate across the field. Effects are multiplied as the operator blows his breath across the dish or gently stirs the surface. Adding sulphuric acid sends bubbles swirling through the solution. A dramatic, splashing display fills the room as the operator squashes a concave dish into the brew.

Despite tremendous sensory impact, this sloshy technique, as you might imagine, would corrode Mr. Kleen's earring. Concocted in the home it could widen the generation gap into a Grand Canyon. But if this kind of visual scrambled eggs sounds appealing, fret no more. Electronics is coming to the rescue. More manufacturers are bringing out audio-visual systems that produce special lighting effects with far less of a mess.

MusicVision. One is an intriguing apparatus recently introduced by Edmund Scientific. Called "MusicVision," it's completely dry, and energized by the loudspeaker terminals of a hi-fi, phono or radio. It responds to the musical beat by flinging blobs and squiggles of colored light across walls and ceilings. Depending on how the system is rigged, it creates varying basic patterns. Circles of light, for example, may expand into widening orbits reminiscent of an exploding solar system. Other patterns spill sidewise into bowls of psychedelic spaghetti. Images rise and fall with the beat line of the music, with transient effects shimmering through.

The operating principle is simple, yet ingenious. The basic unit is the "motiondizer"; actually a speaker with a rubber membrane stretched over its mouth. When music sets the speaker in motion, the paper cone pumps air against the rubber membrane. Since most energy is delivered by bass notes, the membrane twangs into motion mainly with the beat of the music.

On the outside of the rubber membrane are special "front-surface" mirrors (which don't reflect a double-image, as with ordinary mirrors). Since the mirrors are loosely suspended they're kicked into vibration by the membrane. Although their gross movement



On a trip? Only this Canadian miss knows. Sure thing is that she's making the scene with Clairtone's Visual Translator. Solid-state control unit and light globe attach to hi-fi and convert audio into colors.

follows the musical beat, some random wiggling, as our photos show, also occurs. By shining a strong light on the vibrating mirrors, reflections on a distant wall spread out to bounce and gyrate over a large area. Color is added to the display by a rotating color wheel in front of the light source.

For $45 you can own a factory-made MusicVision (using your own 35 mm slide projector as a light source). A handy experimenter can reduce that cost if he has some items on hand and tries the kit approach. You can use your own speaker and cover it with rubber membrane material ($3), paint your own color wheel (disks are about $5), and buy an assortment of front-surface mirrors (about $8). Then you'd need an aperture for your slide projector ($2) and supply your own motor for turning the color wheel. The motor is a small clock-type geared down to 12 rpm.

Thus for about $20 in parts you can acquire the hard-to-find items for a MusicVision system. (A price list of all items is available from MusicVision Facts, Edmund Scientific, Barrington, N. J. 08007.) A benefit of the kit approach is that you can experiment with varying effects. The light patterns are closely related to how mirrors are fastened on the rubber membrane. A mirror mounted on its center favors a thick pattern; an off-center mirror elongates the image. One group of patterns (called wild waves and bouncing balls) occurs when mirrors are suspended by short threads. The instruction manual tells in detail how to obtain various displays.

Visual Translator. Another electronic delight to clobber eye and ear was recently brought out by Clairtone, a Canadian electronics manufacturer. The company calls its new devices "light machines" but they're basically color organs carried a step further. Unlike tamer versions of the color organ, some Clairtone models break out of the small-screen category and project heady hues around the room. By commanding the complete visual environment, these devices create more of a mind-snatching atmosphere.

Clairtone instruments begin with the color organ idea of splitting the audio spectrum into several primary colors. It's a 3-channel system: low tones in the music produce red

(Continued on page 105)

Miracle on the Platte

BY FRANK WINCHESTER GRAY

Christmas is a milestone of time for most of us—even more so than the first day of a new year—for it usually brings a flood of sweetly-sad memories, flushed with emotional warmth of childhood days at home.

Strangely enough, the Christmas Eve I shall always remember best had nothing to do with home and family. The experience began with purely selfish motives, and concluded with the realization that I had unintentionally played a part in bringing what must have seemed a miracle into the lives of some people.

It was December 24th, and the year was 1926. I was running a wholesale radio business in Denver at the time. The afternoon was overcast, and the wind from the north was steel-edged. Occasional flurries of snow freckled the windshield of my Jewett sedan with canvas top, as I drove out across the bleak plains to the west of the city, heading for pine-clad foothills of the Rockies.

A crazy trip, I thought—probably a wild goose chase. As I gunned the car along an icy two-lane highway, side curtains flapping, wind whistling through every opening, I thought of the formal dinner and dance at the Country Club I was missing that night, and began to question the decision that had started me on a lonely drive over many miles of mountain roads in unpredictable weather.

It had begun with a telephone conversation about an hour before. I was alone in the office, finishing up some paper work. My stenographer, stock room man, and radio technician had gone home at noon. The phone rang. At first I could hardly hear the far-away voice—it sounded like the cracked and high-pitched tones of an old man.

I finally gathered he was interested in a radio set. We had just graduated from the crystal set and earphone era, and radio receivers were still battery-powered, with three dial tuning, and were sold with all accessories extra. He asked about the best radio we had in stock. I explained it was a mahogany console, with six-tube superheterodyne set, dual speakers built in, retailing complete for about seven hundred dollars.

To my surprise, he said he would take it, but on one condition—that we deliver and install it that night. I asked where he was located, and surmised from his description that he ran a small hotel, a fishing and hunting resort, over on the North Platte River, about sixty miles from Denver.

"Can't we deliver it the day after Christmas?"

"Nope, we got to have it tonight, or not at all. Some of my friends and kinfolks are coming in from the mountains. They've never heard a radio, and I want it to be a surprise."

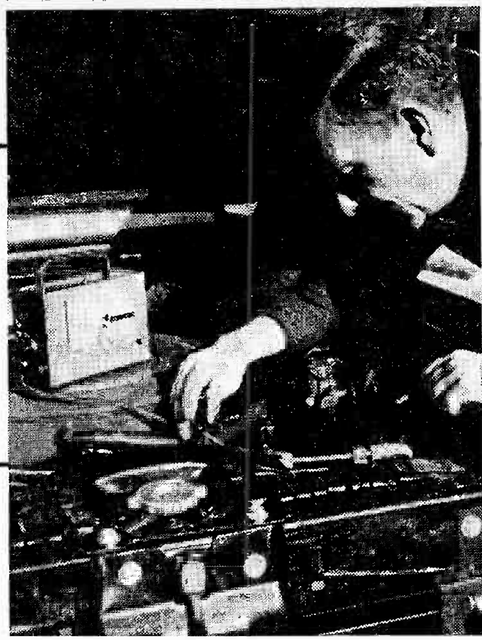
"How will you pay for it?"

"Cash—got the money right here in my pocket. You just get that radio over here and set it up, and you needn't worry about your money."

I did some fast mental arithmetic. There was no dealer involved in the sale, and the wholesale and retail profits combined came to about three hundred fifty dollars. At that time and age, I would have gone almost anywhere, tried just about anything, for that kind of money.

"All right," I said, "I'll get the radio over to you tonight." *(Continued on page 108)*

REV-BUSTER



This mighty monitor puts your car on the go-go-GO and saves you money, too!

By Ron Michaels

Round and round it goes . . . but just how fast is your engine's crankshaft turning? Engine rpm—or revolutions per minute—is something you must know when you service any engine. And a tachometer like the Rev-Buster is just the device to tell you rpm and a few other things as well.

You'll use your Rev-Buster as a guide when you adjust engine idle or when you monitor a voltage regulator setting. You can use it to check automatic transmission shift points and to adjust engine speed prior to tuning the ignition system. (All of these techniques are explained in any good auto service manual.)

As a bonus, the Rev-Buster also measures *ignition point dwell,* a technical term that indicates the percentage of time the ignition points are closed as the engine turns. This is a convenient gauge to use when setting point gap.

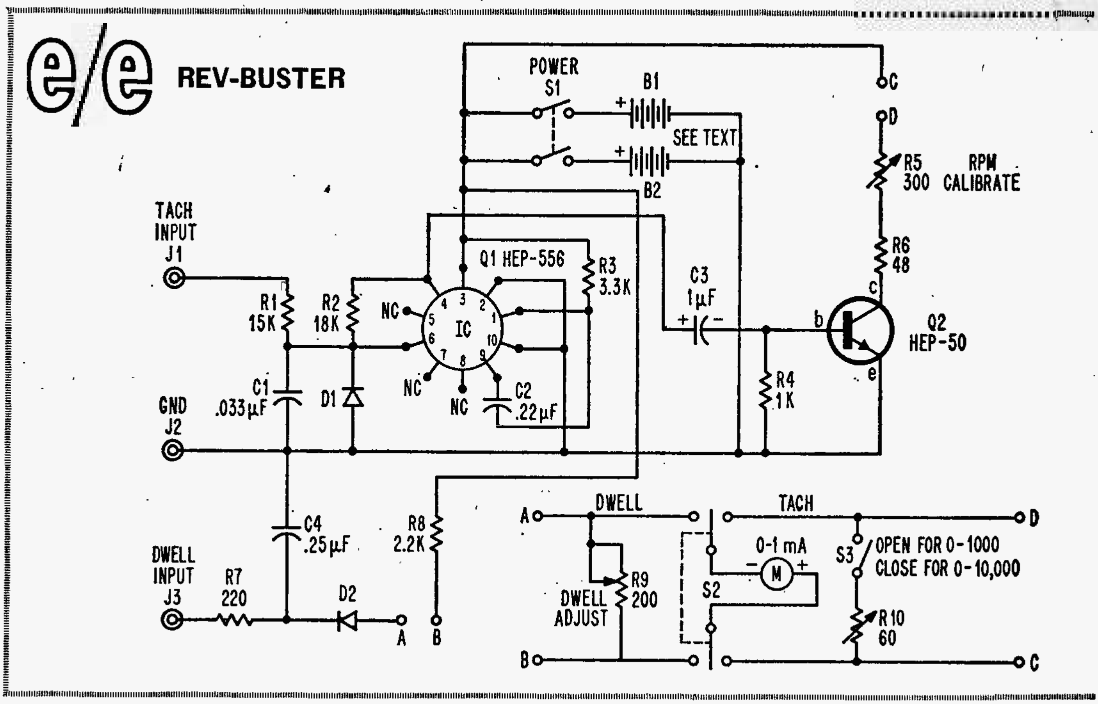
In case you've been too busy to do any servicing lately, remember that the ignition points in your car's engine are a pair of switch contacts that are periodically opened and closed by a rotating camshaft inside the distributor. Each time the points open, current flowing through the primary winding of your car's ignition coil is interrupted, and a high-voltage pulse is induced in the coil's secondary. This pulse is routed to the appropriate spark plug by the distributor and a spark flashes across the plug's gap.

For most efficient engine operation, the points must be open (i.e., producing a spark) each time the compressed air and fuel mixture inside one of the cylinders is ready to be ignited. This adjustment can be made in two ways.

The hard way is to use a point setting gauge to attain maximum gap between the points when they are fully open—a rather laborious task. The easier way is to use a dwell meter to measure the length of time the points remain closed, and adjust the points until the dwell reading agrees with the specified value listed in your car's service manual.

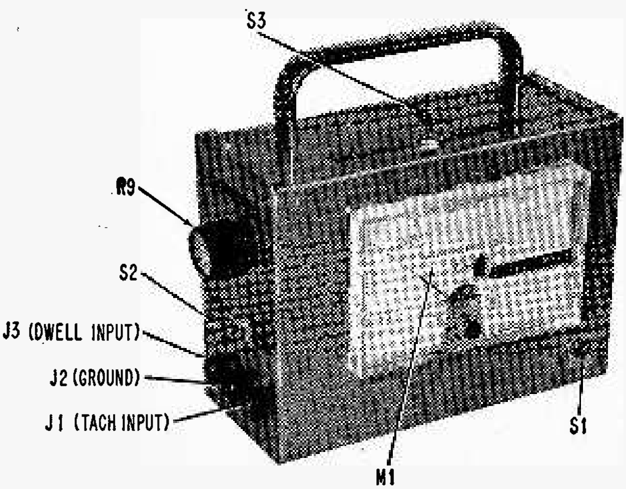
How It Works. The tachometer is basically a pulse counter circuit. It counts high-voltage pulses supplied to the engine by the ignition system. The rate of these pulses—the number of pulses per minute—is directly proportional to engine rpm, and the Rev-Buster's panel meter can be calibrated to read engine rpm directly. We'll say more about this shortly.

Heart of the pulse counter circuit is an



IC (integrated circuit) that functions as a *one-shot multivibrator.* The job of the multivibrator is to take the rough, ragged, nonuniform pulses produced by the ignition system and transform them into smooth, uniform output pulses. One output pulse comes from every input pulse.

These output pulses go on to transistor Q2, which functions as a meter amplifier. The net result is that the greater the rate of the ignition pulses supplied to Q1 (IC), the greater the rate of the output pulses, and the greater the reading on the panel meter.



The meter circuit is equipped with a switch-operated shunt resistor R10 to provide two rpm ranges: low rpm (0 to 1000) and high rpm (0 to 10,000). For most applications, the low range is more practical. But the high range is useful for checking transmission shift points and ignition tuning curves. Note that the instrument can also be used when you're out on the road—just run long test leads from the engine compartment through the firewall.

Ignition pulses are produced across the ignition points as they open and close. To measure rpm or dwell angle, you connect the Rev-Buster's test leads between the *hot* terminal on the distributor (the terminal connected via a slender wire to the ignition coil) and *ground.*

The dwell meter circuit is similar to a simple ohmmeter but with a few important modifications. While we want current to flow through the points and into the panel meter when the points are closed, we don't want the

Layout is designed for efficient servicing. Access to control R5 is through grommet on back of panel.

PARTS LIST FOR REV-BUSTER

B1, B2—Four 1.5-V pen cells in holder (see text)
C1—0.033-uF, 200-V capacitor
C2—0.22-uF, 200-V capacitor
C3—1-uF, 10-V electrolytic capacitor
C4—0.25-uF, 200-V capacitor
D1, D2—300-V silicon rectifier (GE 1N1695 or equiv.)
J1, J2, J3—Banana jacks (2 red, 1 black)
M1—0-1 mA, DC panel meter (Allied 52B-7209 or equiv.)
Q1—Integrated circuit (Motorola HEP-556)
Q2—Npn transistor (Motorola HEP-50)
R1—15,000-ohm, ½-watt resistor
R2—18,000-ohm, ½-watt resistor
R3—3300-ohm, ½-watt resistor
R4—1000-ohm, ½-watt resistor
R5—300-ohm, hum-adjust potentiometer
R6—48-ohm, ½-watt resistor
R7—220-ohm, ½-watt resistor
R8—2200-ohm, ½-watt resistor
R9—200-ohm, linear potentiometer
R10—60-ohm, hum-adjust potentiometer
S1—Dpst toggle switch
S2—Dpdt toggle switch
S3—Spst toggle switch

Misc.—5 x 7 x 3-in. aluminum chassis box, small chassis box for calibrator, AC line cord, 2 10k resistors (for calibrator), binding posts (red and black), test leads (red and black), alligator clips, banana plugs, mercury batteries (optional), carrying handle, perf board, push-in terminals, ¼-in. insulators, grommet, decals, tape, hardware, wire, solder, etc.

ignition system to force current backwards through the meter when the points are open.

Silicon rectifier D2 accomplishes this by blocking current flow whenever the input voltage rises above 5.3 V—a condition that exists whenever the ignition points are open. Capacitor C4 bypasses any high-voltage pulses that appear across the test leads before they can do damage to the meter circuit. This same function is performed in the tach circuit by the network composed of R1, D1, and C1.

Building Tips. Most of the circuitry is wired on a 4 x 4¾-in. piece of perf board. Push-in terminals are used as wiring points. All board components are mounted on the top surface, except calibration control R5 which is mounted to the bottom so that it can be reached through a hole in the rear of the cabinet.

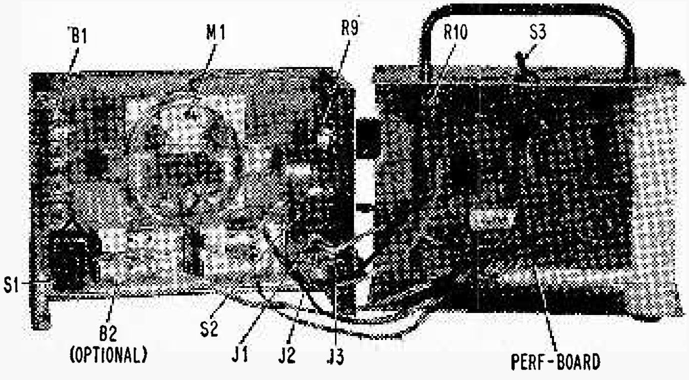
The cabinet is a 5 x 7 x 3-in. aluminum chassis box. The carrying handle is just a convenient accessory. Mount the panel meter and power switch S1 on the cover. The input jacks, hi/low range switch S3, function switch S2, and dwell adjust control R9 also go on the cover, as shown in the photos. The PC board should be mounted with ¼-in. insulated spacers to keep the board away from the inside of the case.

Generally, the parts layout isn't critical, but be sure to double-check the orientation of the IC when you mount it (a ring of push-in terminals makes a fine socket). The tab is under pin 12. In the schematic, the pin diagram represents the IC when viewed from the bottom.

Also, you should note the correct polarity of the silicon rectifiers and the electrolytic capacitor. Take care not to overheat the semiconductor components when you solder their leads in place (alligator clips make good heat sinks).

The power supply consists of two independent battery holders. Each holder has four pen cells wired in series, and they are paralleled when the power switch S1 is on. This arrangement helps maintain a constant supply voltage (6 V), an important consideration, since calibration accuracy depends on the power supply voltage.

You can eliminate one of these battery holders by using only

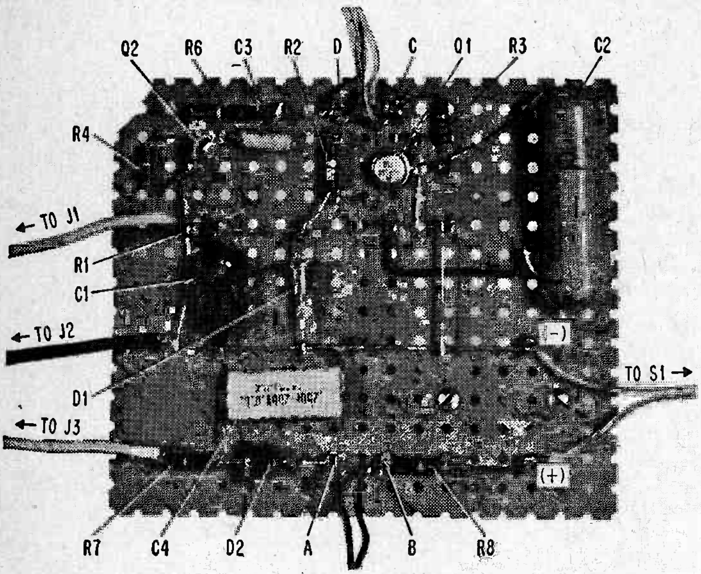


Two battery holders are mounted inside case, but only one was used (see text).

mercury cells in just one holder instead of conventional cells. Mercury cells maintain a relatively constant output voltage throughout their lives, but at a substantially greater cost.

Make your test leads from two 48-in. lengths of insulated wire—one red, the other black. Mount alligator clips at one end and banana plugs at the other.

Calibration and Use. To use the instrument just examine the function labels shown in our photos. For a tachometer, flip S2 to TACH, flip S3 to desired rpm range, and plug your test leads into the appropriate jacks; the ground lead goes to the center jack (black), while hot lead for TACH is at right—use the jack at left only for DWELL.



Connect the test leads between the hot terminal on the distributor and ground. For a *negative ground* (the most common) ignition, connect the ground lead (black) to a ground point in the car, and the hot lead (red) to the distributor. For *positive ground* ignitions just reverse the leads.

For a dwell meter, flip S2 to DWELL, plug your test leads into the appropriate jacks, and connect the leads as you did before.

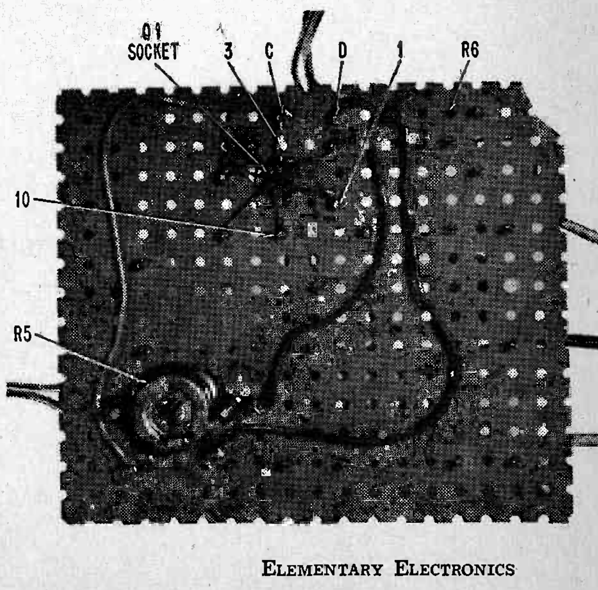
Calibrating the tach requires a stable signal source of known frequency. The most convenient is the 60-Hz power line in your home. To use it, you simply build a calibrator using any line cord from your junk box. Two 10k resistors are wired in series with both leads from the AC cord. The leads should go to black and red binding posts, with all components mounted in a tiny aluminum chassis box for safety. The resistors serve to lower the line voltage before it is applied to the tach input.

The tach automatically clips off the bottom half of the 60-Hz sine wave so that pulses are applied to the circuit at a rate of exactly 60 pps. This 60-pps rate represents different values of rpm, depending on the type of engine you are working with.

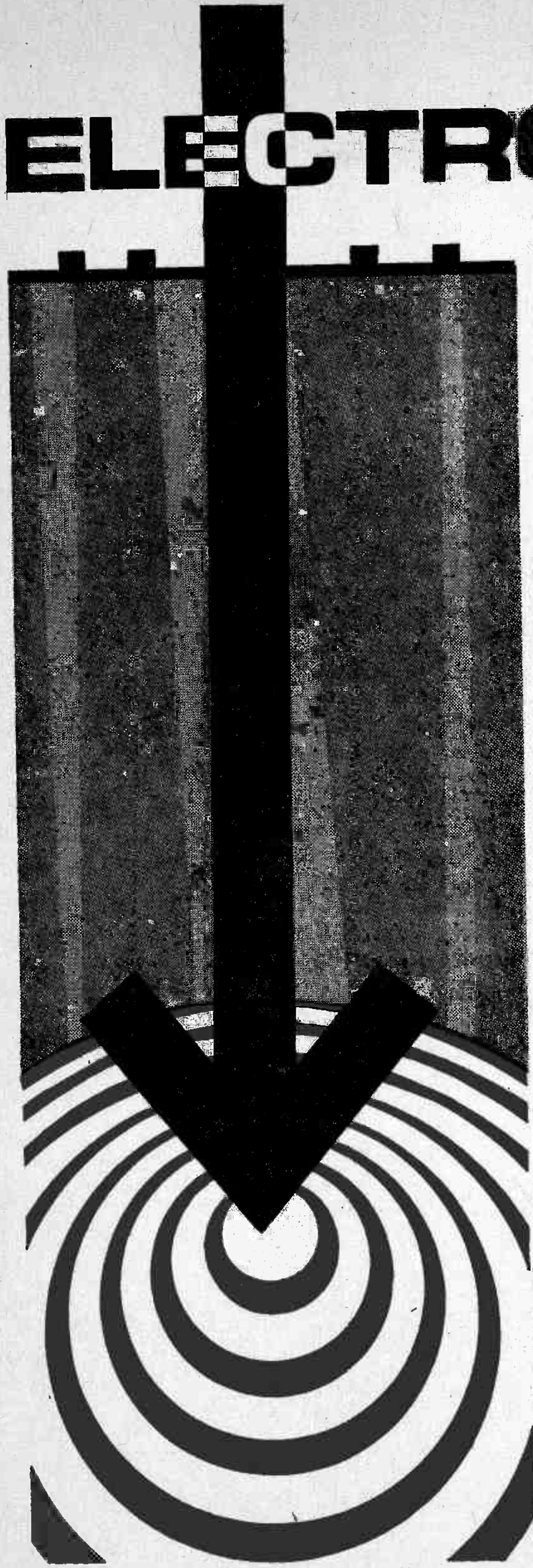
The ignition system of an 8-cylinder engine produces 60 pps when the crankshaft is turning at 900 rpm. A 6-cylinder engine turns at a rate of 1200 rpm, a 4-cylinder engine at 1800 rpm.

(Continued on page 103)

At left is top of perf board. Wiring almost corresponds to schematic. Below is underside of board. Calibration control R5 aligns with hole on panel.



ELECTROLOCK



By James Robert Squires

Think key rings are a drag? Protect your goodies with this fast action combination lock

Want to get rid of some of those keys you carry around each and every day? Here's an electric lock requiring less than thirty components, and happily none of them is a key. The Electrolock has three combinations that you set yourself. You preselect one combination at a time as the need arises.

Most locks will open sooner or later to the talented thief. This super lock has four buttons and requires that you push three of them simultaneously to open it. Even assuming that the burglar knows this, he has one chance in four of hitting the right combination.

If he tries two buttons at a time, he will never open the lock, but his chances are fifty-fifty of sounding the alarm. Should he try one button at a time, his chances are one in four of running down the lock's battery if he chooses to stand there and wait for the fuzz. Your chances, however, of having a lock that is safe from children, strangers, and prowlers, are very good indeed!

Not only will this groovy gadget serve to lock up medicines, valuable papers, and whatever treasure you may have lying around, but the mechanism will also prove a boon to a variety of experimenters. For instance, people researching with animals might wish to use the Electrolock as a remote control unit to open cages or doors leading to labyrinths. The pushbuttons might even be replaced with treadle switches, so that the lock slug would release a pellet of food as a reward for the correct response.

In applications where only qualified personnel are given access to certain equipment, the lock could be used to turn on a power relay, thereby triggering the equipment. The alarm would then indicate misuse of the system. The many variations possible with the Electrolock should keep you busy for months.

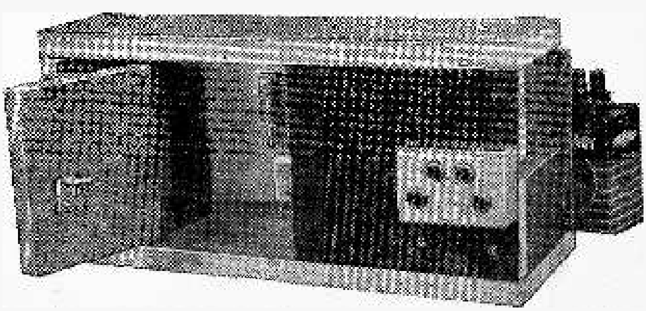
Three of Four. Three of the four buttons are required to open the lock. The fourth button in *each* of the three combinations can do two things. First, it operates an interlock circuit which disconnects the coil driver, and second, it sounds an internal buzzer or sends an alarm signal providing 300 mA at 30 V for 15 seconds to actuate an external warning device. Both of these features can be switched off at the Control Box if they aren't needed.

During construction, or when you are troubleshooting the circuits, it's handy to be able to turn on the lock driver circuit independently. The Lock Test switch S4 is on the Control Box for that purpose.

Three separate units (the Control Box and Button Box plus the lock mechanism) are used to simplify mounting the Electrolock in just about any cabinet layout. Admittedly, the cabinet shown in our photos is no beauty and belongs in some dank, dark lab. However, any custom installation should work wonders, so long as the wires are not too long. This particular lock is not recommended for outdoor use unless the units are mounted in a watertight box and the coil is sealed with a good varnish.

Custom Built. Both chassis are drilled according to whatever specifications you choose. Parts layout is not critical, so just follow our photos. The three rectangular holes needed for slide switches S4, S5, and S6 are best cut by using each switch as a template. Care should be taken to deburr all holes after you've finished drilling.

The coil slug layout shows the physical dimensions of this home-brewed mechanism. Polystyrene tubing that has an outer dia of 3/8 in. and an inner dia of 1/4 in. is excellent for the coil form. Two 3/4-in squares (1/16 in. thick) should be glued to either end of the

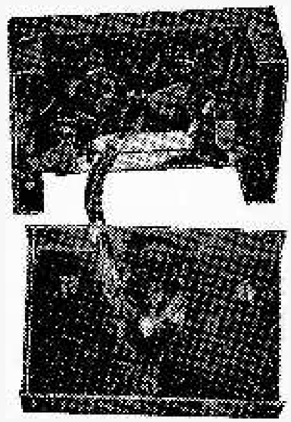


Positions of lock mechanism and Button Box in author's version. Arrangement of S1, S2, S3, and S8 is up to you —as is cabinet design.

Position	Combinations	Interlock
1	S8, S1, and S2	S3
2	S8, S2, and S3	S1
3	S8, S1, and S3	S2

tube. A 1/4-in. hole is drilled in one end only, and then this hole is aligned with the hole in the tube. The coil slug passes through this hole.

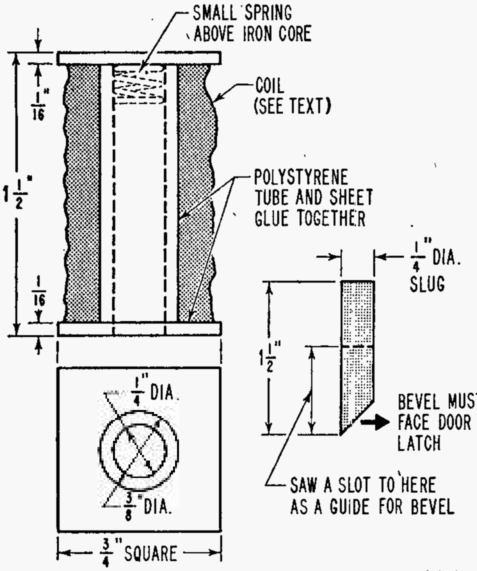
Wind 600 turns of #30 enameled copper wire as evenly as possible over the coil form. Leave about 10 in. of wire at either end of the coil for further wiring. The coil may then be coated with varnish or wrapped with tape to hold the wire in place.



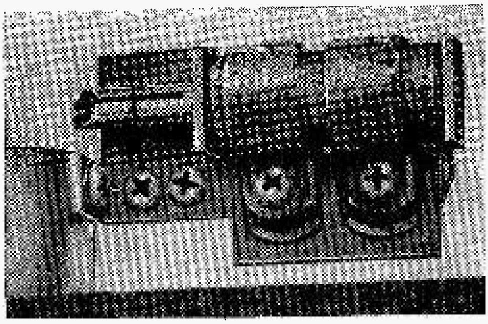
Button Box with cover removed. Emergency Power Jack (J2) goes on bottom flange of back cover.

The slug used in this version of the Electrolock was the remainder of the shaft cut off of rotary switch S7. The shorter shaft facilitated mounting the switch on the chassis. Saw a slot in the shaft and bevel one side as shown in the photo. The bevel allows the latch to close easily.

A pointed screw inserted at the rear of the 1/4-in. dia slug and mounted to the lock support by means of a spring keeps the bevel



Extra care should be taken with lock mechanism. Make sure ¾-in. squares are firmly in place. Spring can be cemented to back and attached to screw in slug.



Lock mechanism has beveled slug to facilitate latching. Here, cable clamps are used to mount coil. Design of assembly will depend on individual needs.

facing the latch. Our photos illustrate one mounting technique used for the coil form. However, your installation may require a different arrangement.

It's easiest to start construction with the smaller Button Box. Mount the pushbutton switches in the top cover and Emergency Power Jack J2 and a grommet in the lower part of the chassis. When you're wiring the pushbutton switches, be careful to dress the wires so that they don't interfere with the switch mechanisms.

Wire the jack and dress all leads out through the grommet in the floor of the chassis. The length of these leads will be determined by your particular installation. It's a good rule to keep them as short as possible. Allow about 8 in. of wire for all wiring inside the Control Box (second chassis).

Selector Panel. The circuit board for the Control Box is an ordinary perf board assembly with push-in terminals. The component layout is indicated in the diagram. The resistors and diodes are placed side by side when wired onto the board. It is best to wire as much of the perf board as possible while you still have it free on the bench. Once it's mounted there will be much less working room.

Mount Q1, Q2 and R5 as shown in the diagram and photos. When they are mounted on the side of the chassis, attach the perf board to the bottom using ¼-in. spacers. The components already mounted can now be wired to the circuit board. When soldering wires to the base and emitter electrodes of Q2, snap an alligator clip onto the wires near the transistor's body. The clip will act as a protective heat sink.

Most of rotary switch S7 can be wired before it is mounted on the cover of the Control Box. When this is done, also mount slide switches S4, S5, S6, J1 (a yellow banana jack), and a grommet to the same cover.

Using a vise or some clamps, rig the cover of the chassis to a point just below the base. With the two parts of the Control Box so attached, you can wire the rest of the lock. Remember to keep the two leads to the lock slug as short as possible. There's

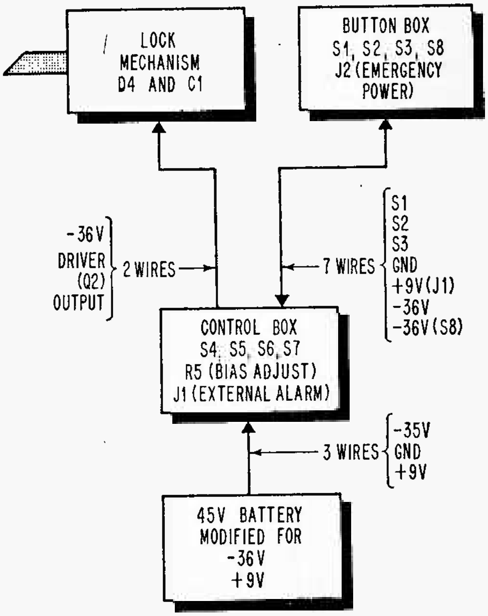
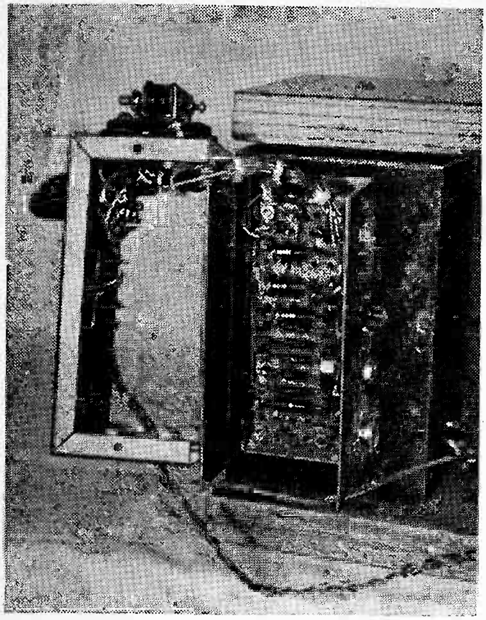
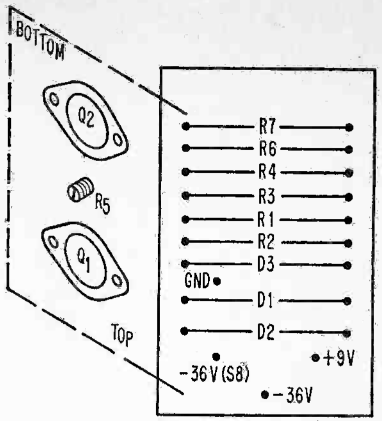


Diagram indicates connections linking up 3 major components. Leads should not be too long, as lock's performance may be adversely affected.



Control Box reveals layout of components. Note switches and buzzer at left, and perf-board assembly at right. Wiring pattern is neat due to harness.



Perf-board assembly (seen right side up in photo at left). Push-in terminals are used to wire components. Board should be wired before mounting.

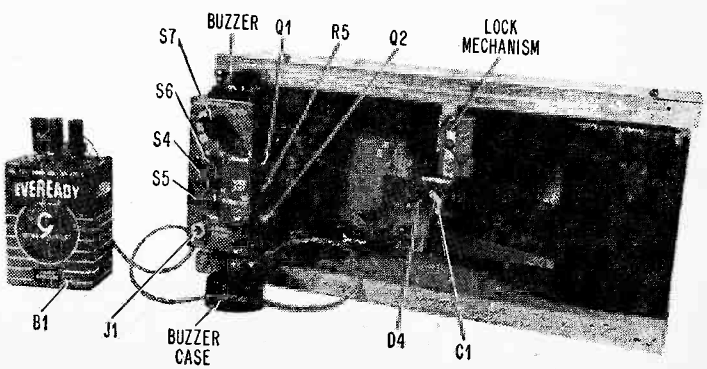
over an ampere flowing in these wires during the lock's operation.

Slicing a Battery. A 45-V battery (such as an Everyready 738) must be modified in order to obtain the proper voltages. Remove the cells (there are 30) from the cardboard case. Count down 6 cells from the +45 V end of the battery and attach a *ground* lead to the positive terminal of the 7th cell. Then remove the 22-V tap from the battery. After modification, the +45 V lead is now the +9 V lead and the −45 V lead is now the −36 V lead. These modified voltages are now ready to operate your Electrolock.

The only calibration adjustment is R5. Its purpose is to reduce positive bias on the driver transistor (Q2) as the battery ages. The voltage measured at the base of Q2 with a new battery should be set for +5 V with S8 *on* and all other switches *off*. When the lock coil is functioning, the voltage will go negative at the base of Q2.

When you first test your completed lock, pull Q1 out of its socket. Q1 is always operated by the fourth button of the combination. Pushing this *incorrect* button turns on Q1, sending the collector voltage almost to ground. This in turn prevents Q2 from turning on so that the lock will not work. Once the drive circuit of Q2 is operating correctly, the turn-off feature of Q1 can be tested. The table illustrates the selector switch positions and the combination for each position.

Interlock. Besides switching in Q1's turn-off action, the interlock switch also activates either the buzzer through S6, or an external alarm at J1. It's a good idea not to have the buzzer located too near the combination buttons. An intruder can hear the alarm and know at least that he should not be pushing that particular button. This increases the odds of his breaking the combination.



Control Box mounts on back of cabinet. Transistors Q1 and Q2 are on right side of case, along with R5. All switch functions are marked, and white lines indicate ON position of slide switches.

The driver transistor Q2 can be any one of a number of 10-watt, *pnp* power transistors (see Parts List). It is mounted directly on the chassis of the Control Box to obtain an additional heat sink. Care should be taken to keep this box from touching the pushbutton box which is at ground potential due to J2.

Whatever the reason, you can expect battery power to fail at some time. It is usually when you have to get into the locked area most urgently. Thus the Emergency Power Jack J2 is provided so that an external power source can be used to gain entrance. You won't have to crowbar your way inside! When using this jack, remember that S8 is bypassed and is no longer part of the combinations given in the table. The combinations are now operated with only two buttons.

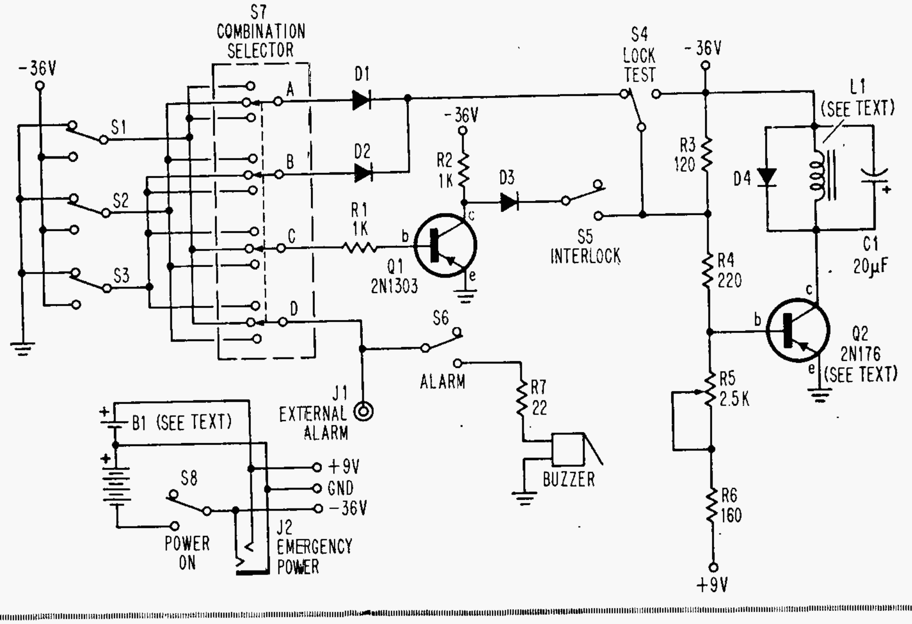
When the lock has been put into service it draws no power other than about 3 mA at 9 V. Switch S8 turns on the power used to drive the slug. There may be some final adjustment of R5 necessary to peak up lock operation. All circuits and components are rated for continuous operation. The Electrolock requires only a few tenths of a second to open the slug and then the magic door can be swung open.

Just keep your cool while you build the whole assembly, and your lock will keep its cool permanently. ■

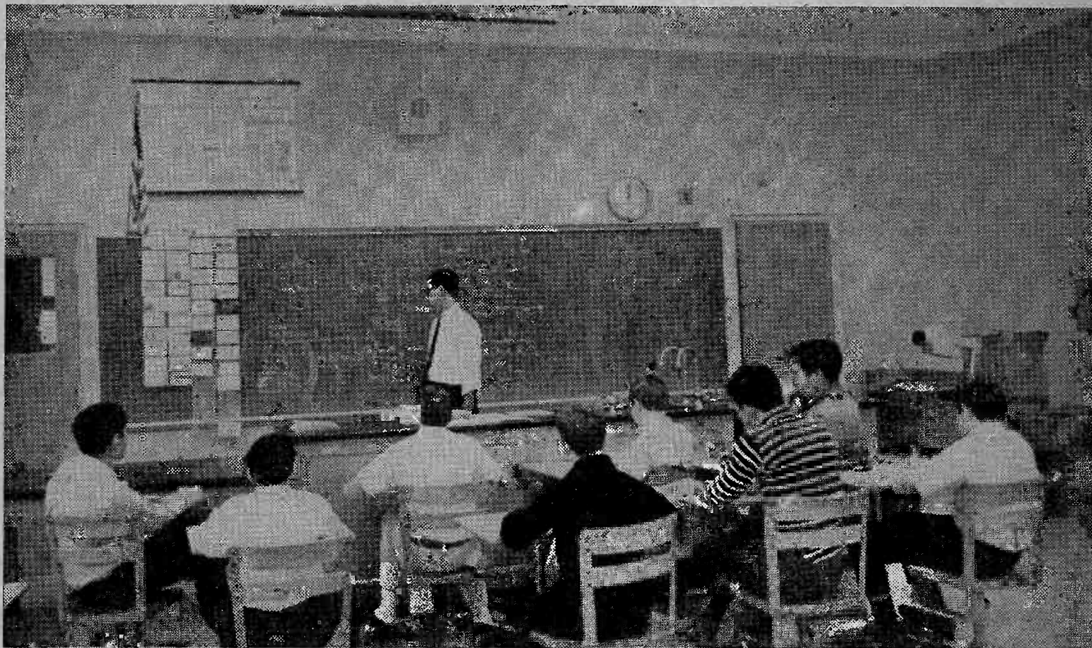
PARTS LIST FOR ELECTROLOCK

- B1—45-V battery (Burgess Z30, Eveready 738 or equiv.)
- C1—20-uF, 50-VDC electrolytic capacitor
- D1, D2, D3, D4—1N4364 silicon rectifier (Texas Instruments)
- J1—Banana jack (H. H. Smith #219, Allied 47E3922 or equiv.)
- J2—3-conductor phone jack (Mallory SCA-2B, Allied 47E1643 or equiv.)
- L1—Slug coil (see text)
- Q1—2N1303 transistor (Texas Instruments)
- Q2—10-watt, pnp, power transistor (RCA 2N176 or equiv.)
- R1, R2—1000-ohm, ½-watt 10% resistor
- R3—120-ohm, ½-watt 10% resistor
- R4—220-ohm, ½-watt 10% resistor
- R5—2500-ohm miniature potentiometer (Mallory MLC252A, Burstein-Applebee 14A934 or equiv.)
- R6—160-ohm, ½-watt 10% resistor
- R7—22-ohm, 1-watt 10% resistor
- S1, S2, S3, S8—Spdt, black pushbutton switch Switchcraft #203, Allied 56E4949 or equiv.)
- S4, S5, S6—4-A, spdt slide switch (Stackpole SS-26-1, Burstein-Applebee 12A768 or equiv.)
- S7—4-pole, 3-position, non-shorting rotary switch (Mallory 3243J or equiv.)
- 1—High-frequency buzzer (Johnson 114-400, Allied 17B8911 or equiv.)
- 1—5 x 2¼ x 2¼-in. chassis (LMB-778 or equiv.)
- 1—3¼ x 2⅛ x 1⅛-in. chassis (LMB-772 or equiv.)

Misc.—¼-in. (inner dia) polystyrene coil form, 1/16-in. polystyrene sheet, #30 enameled copper wire, coil slug, small spring, varnish, ¼-in. spacers, cabinet (see text), perf board, push-in terminals, decals, grommets, solder, wire, hardware, etc.



These Ham-lets



Have a Helper

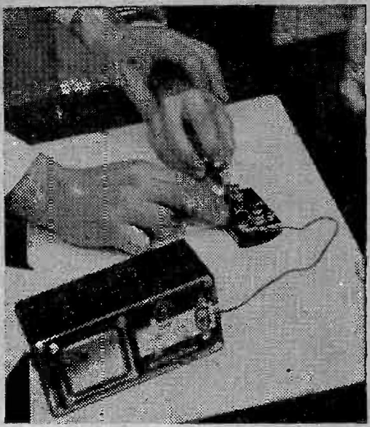
Will-to-learn puts these pre-teens far ahead of their counterparts in grasping physics principles.

You wouldn't expect many 12-year-olds to know an ohm from a resistor, and the truth is that most don't. But pre-teens dabble in everything from Hertz to hysteresis during Saturday morning ham radio classes held at North Junior High School in Great Neck, N.Y.

The idea behind the course is to help would-be hams get their licenses. Big bonus is that ham-lets are simultaneously introduced to basic physics principles, principles that would normally go over their heads but for their enthusiasm. Sponsored by the North Shore Junior Science Museum of Port Washington, N.Y., the course is one of a dozen offered elementary and junior high students.

Instructor for the course is Paul Hertzberg, a ham himself (he's K2DUX) who also teaches an advanced course to prepare older students for their General exams. Since a knowledge of Morse Code is a must for a ham license, actual code practice is weekly fare for these ham-lets with a helper.—*Robert Levine* ■

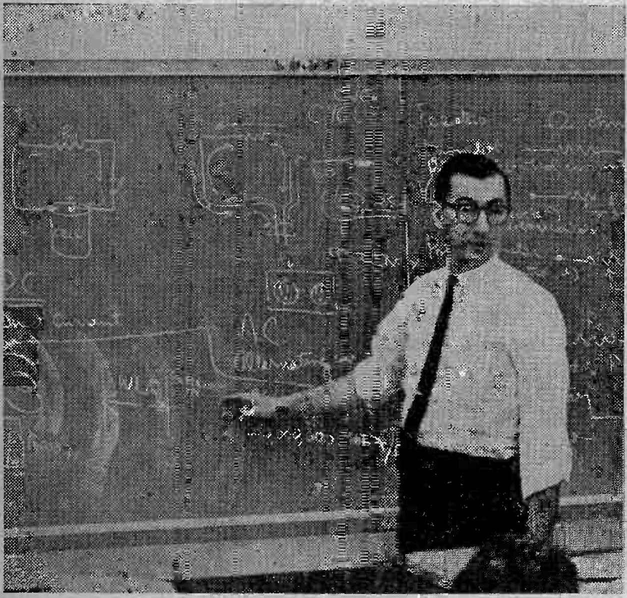
Di's ond dah's ore familiar language to instructor Hertzberg's students. Young minds prove able to grosp code readily.



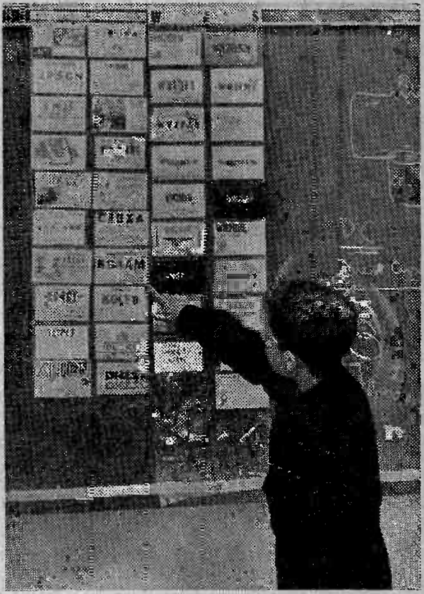
Students build own code-proctice oscillators, though this is commercial model.

Most popular part of course is tuning in and talking with homs from around the world.

Adom Kerner calls CQ over Heothkit SB-110 while fellow ham-let Larry Weiss looks on.



Subject matter frequently becomes pretty tough-sledding for youngsters, but most simply dig in and try even harder.



QSLs from world's most distont corners number among radio closs's proudest possessions.

For years, it seems, men of scope and vision have been telling us that the complete home-entertainment system is just around the corner. That we've already rounded that corner may come as something of a shock to some, but round it we have. And we did so with a device that has been described as the first major audio-visual innovation in home entertainment since color TV.

Conceived by the hard-think engineers at Sylvania Electric, the instrument is officially known as the Color Slide Theater. And CST it may be, though this seems a trifle tame a designation for a product that actually lets you name your game. For in truth, Sylvania's CST combines a color television set, an automatic slide projector, and a cassette-type tape recorder in one compact instrument.

Mad about the Munsters? CST serves them up in black-and-white or color. Yearn to partake again of Yellowstone's glory and grandeur? CST shows those slides in finest fashion, with or without your own taped narration, and automatically or manually, as you choose. Pine for a little Piaf or Prokofiev? CST sounds off with any tape you toss its way.

The slide system on the CST uses a circular tray which can accommodate up to 80 black-and-white or color slides. A small cathode ray tube, called a flying spot scanner, is used to transmit the photograph from the slide to the screen of the TV set. And changing from TV to slide viewing entails a simple flick of a switch.

In short, tapes (pre-recorded or home-brew), slides, or TV are yours for the taking with Sylvania's CST, an ingenious combo that truly lets you name your game.

—*Robert Levine*

Soldering Iron Control

Don't just stand there and let those itsy-bitsy PC boards burn up right in front of your nose. Use SIC to control your iron's heat—your motor's speed—the brightness of a bulb—power outputs up to 8 A—and even your temper

By James I. Randall

With the big boom in integrated circuits (that's ICs, folks), and with electronic components getting smaller every day, many an electronics hobbyist is discovering that soldering is no longer the simple task it used to be. A lot of care must be exercised to avoid damaging microminiature components with excessive heat. Most soldering irons are too big for many jobs, and yet, too small for others.

For these reasons we have designed *SIC*—a Soldering Iron Control. With *SIC* you can tackle most soldering jobs with an inexpensive solder pencil and a small assortment of interchangeable tips having different shapes. *SIC* can be built for about ten dollars and there are a number of fringe benefits, too! If you sneak a peek at *SIC's* schematic diagram you'll see that this device can also be used as a *motor speed control* for power controls such as electric drills, as a *lamp dimmer*, and as a *general control unit* in other applications requiring the control of currents up to 8 amperes.

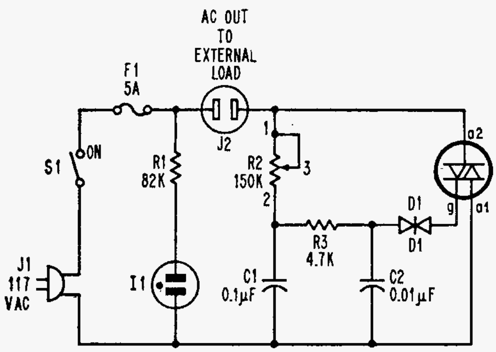
Circuit Design. The circuit for *SIC* is simple and straightforward. Two untransistor-like semiconductor devices, a Triac (Q1) and a bilateral trigger diode (D1) are used to provide full-wave control of external loads from 6 watts up to approximately 900 watts. The 150K pot (R2) and 0.1μF capacitor (C1) form an R/C time constant network which controls the length of time current flows in the load during each half-cycle of the 60-cycle voltage from J1.

On *each* half of the AC input cycle, C1

e/e SOLDERING CONTROL

charges through R2 until it reaches the breakover voltage of D1, at which point D1 fires and *gates* the Triac (Q1) into conduction. The Triac continues to fire until the end of the half cycle when the voltage across its anodes (A1, A2) is zero and the Triac automatically cuts itself off. Then the procedure begins again for the next half-cycle. Resistor R3 and capacitor C2 serve as a filter network preventing hash on the AC line from firing D1.

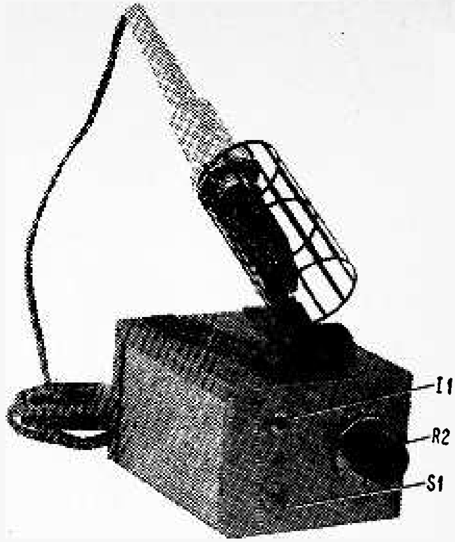
With R2 set at 150K (wiper 3 at terminal 1), the length of time required to charge C1 to the firing voltage of D1 is maximum and the time that current flows through the load during each half-cycle is minimum. As R2



is decreased (moving wiper 3 to some midpoint between terminals 1 and 2), C1 charges more rapidly to the trigger voltage of D1, causing current to flow through the load for a greater proportion of each half-cycle.

With R2 set at zero resistance (wiper 3 at terminal 2), the load will have current flowing through it for almost all of each half-cycle—over 95% of the time. During construction, hook up R2 so its resistance is zero when the control dial reads *10* (maximum power to the load) and its resistance is 150K when the control dial reads 0 (minimum power to the load).

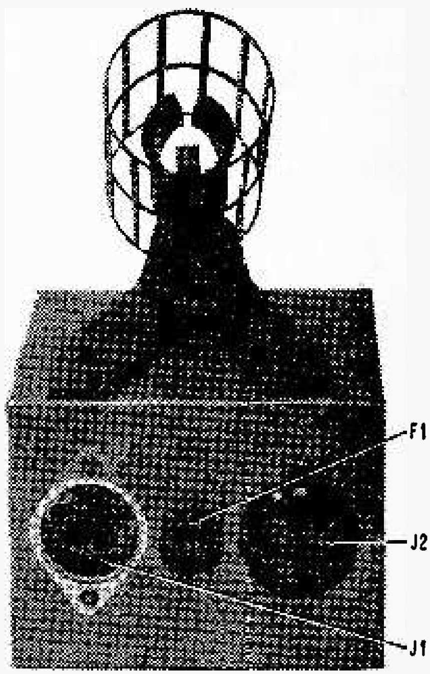
Construction. *SIC* was built into a 3 x 4 x 5-in. aluminum chassis box. It was necessary to cut off the ends of the Ungar 8000 soldering holder stand to make it fit the top of the box. A front view photo of the completed soldering iron control shows the positions of the control dial for the potentiometer (R2), pilot light (I1) and power switch (S1). The rear view photo shows the location of J1, J2, and the fuse holder for F1.



Front view of control unit. During construction, R2 should be wired so that dial reads 10 at minimum resistance. Iron plugs into connector J2.

Two semiconductor devices, a Triac (Q1) and a bilateral trigger diode (D1), control current over each half-cycle of AC. Note outline of Triac.

Rear view of SIC. Male chassis connector (J1) allows use of extension cords. Holder on chassis was cut down for even fit. Smooth all sharp edges.



PARTS LIST FOR SIC

1—0.1-uF, 400-VDC capacitor
2—.01-uF, 400-VDC capacitor
1—Bilateral trigger diode (Motorola MPT-32 or equiv.)
—5-A fuse, 3AG size
—Male chassis connector (Amphenol 61-110, Lafayette 32H2035 or equiv.)
-Female chassis connector (Amphenol 160- Lafayette 32H2030 or equiv.)
Neon lamp with holder and red jewel fayette 99H6226 or equiv.)
Triac semiconductor (Motorola MAC2 or iv.)
2,000-ohm, ½-watt resistor
50,000-ohm, linear taper, 1-watt po- ometer
00-ohm, ½-watt resistor
t toggle switch
—Aluminum chassis box, 3 x 4 x 5 in. (Premier 1005, Lafayette 12H8389 or equiv.)
1—Soldering iron holder (Ungar 8000, Lafayette 13H2116 or equiv.)
1—Fuse holder for 3AG size fuse (Littlefuse 342001, Buss HKP, Lafayette 13H6202 or equiv.)
Misc.—Line cord, soldering iron (Ungar 776), heating element (Ungar 4035, 47½ watts), solder tips (see text), hardware, knob (Lafayette 99H6105), wire, solder, etc.

The Triac (Q1) will handle currents up to 8 amperes, but use a 5A fuse because it is unlikely that currents larger than 5 amperes will be encountered in most applications.

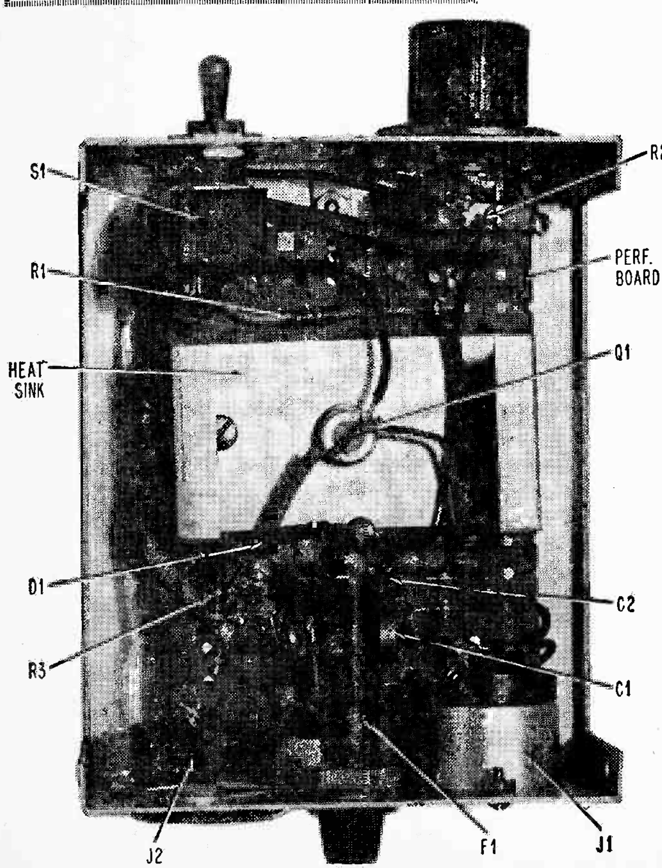
The photo of the interior shows the parts layout. To mount Q1, you can either purchase one of the many commercial heat sinks available, or do as the author did and make your own by cutting a piece of aluminum from a scrap chassis. The heat sink shown measures 1½ x 1½ x 2¾ in., which gives a total radiating surface of approximately 9 sq. in., counting the two small pieces on the ends.

The Triac is mounted directly on the heat sink. This becomes the connection for anode A2, so it must be electrically isolated from the chassis and all other components. Components C1, C2, R1, and R3, in addition to the Triac, are mounted on a 3 x 4-in. piece of perf board using push-in terminals.

SIC Use. Instead of the usual AC power cord, a chassis-mounting male AC connector (J1) is used for the AC input to *SIC* so that an extension cord of any length can be used. Be sure to select a line cord that is heavy enough to carry the load current so as to avoid an unnecessary drop in line voltage.

To use *SIC* as a soldering iron control, just plug your iron into AC OUT jack J2, connect a suitable extension cord to J1, plug this into an AC outlet, and turn *SIC* on. Select the setting on the control dial that will give you just enough heat for the job.

The author uses a pencil-type iron (an Ungar *(Continued on page 109)*



Interior view shows author's heat sink (for Q1) smack in middle of perfboard. Scrap aluminum is connection for anode A2 and must be isolated.

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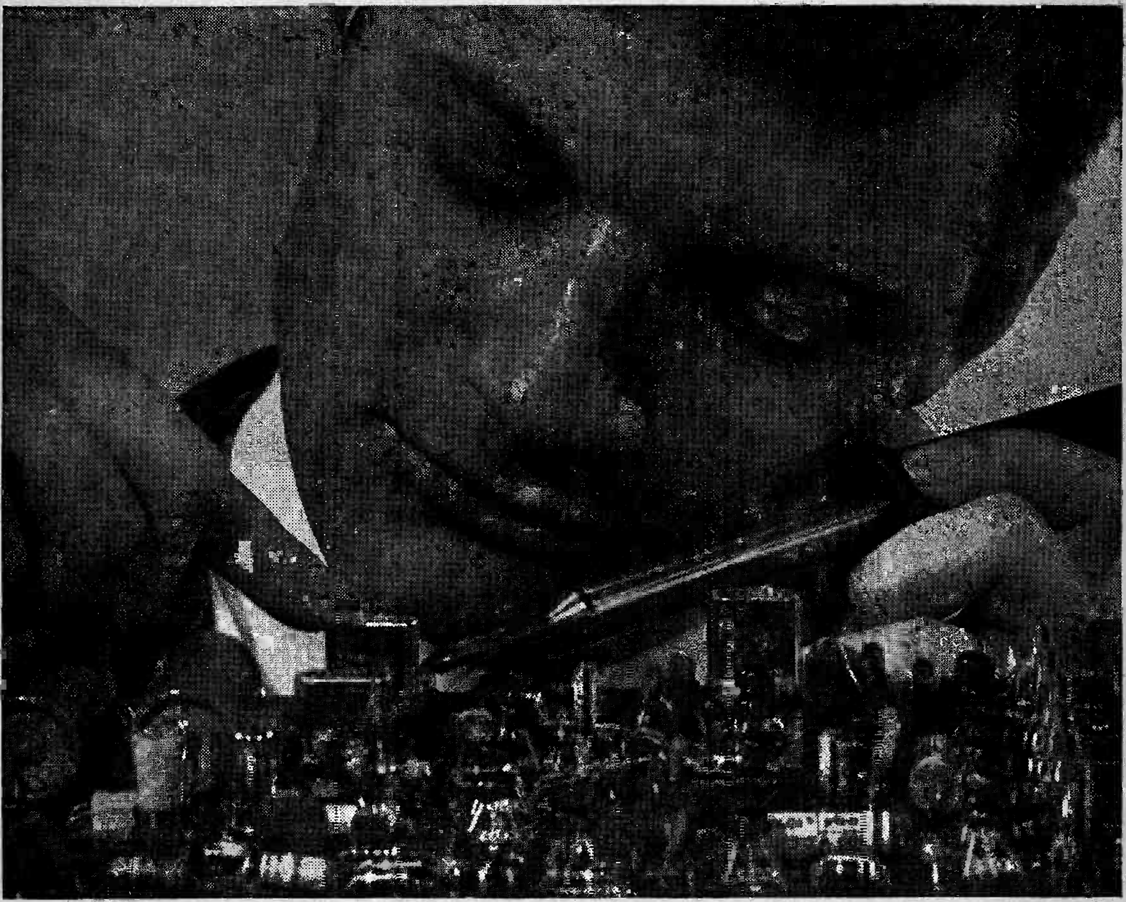

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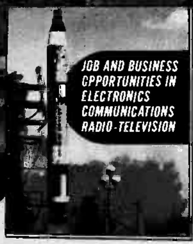

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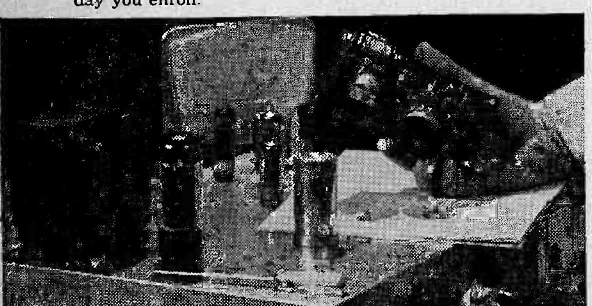

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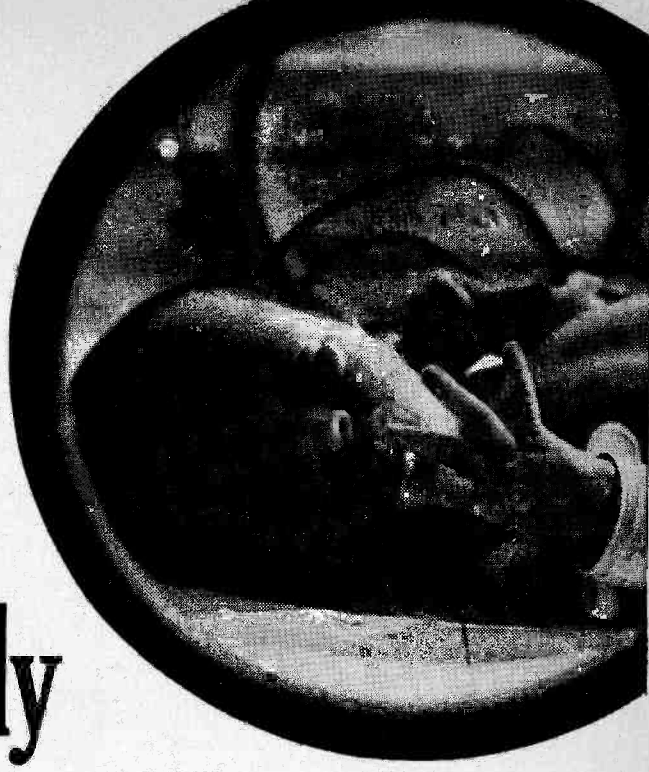
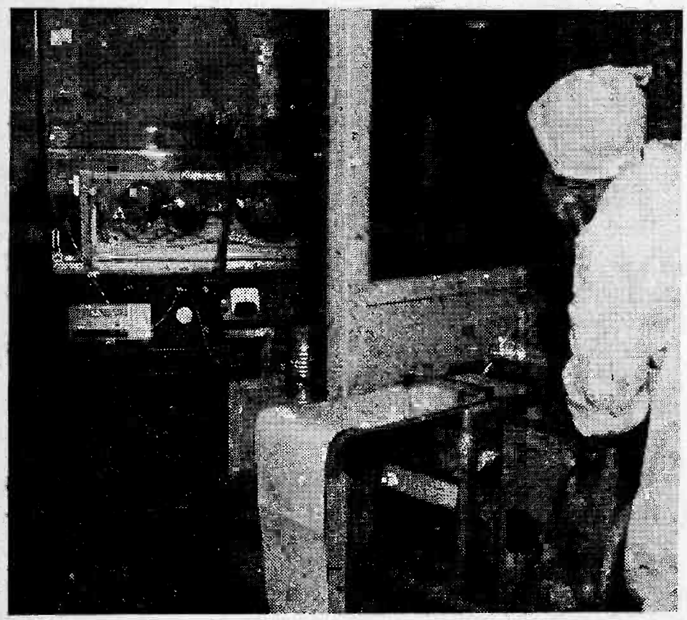
Bringing Up Junior Prematurely



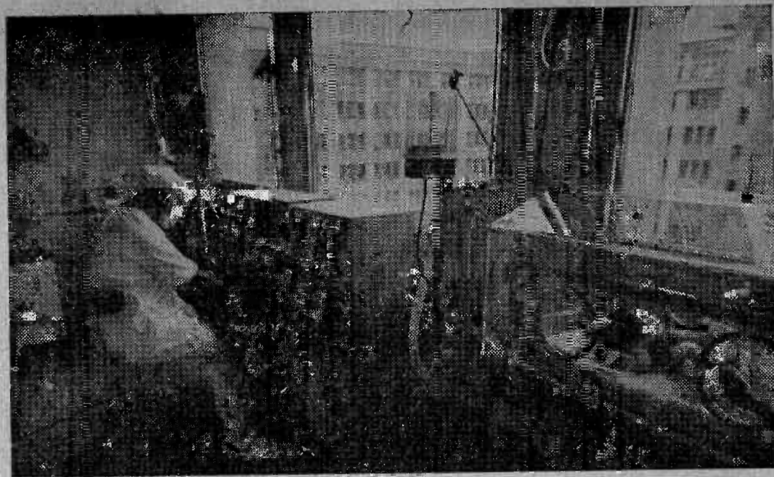


It's all in the hookup. Before any data processing can begin, raw data is needed. Here we see a lab technician examining trace recordings of a premature infant's respiration, temperature and heartbeat.

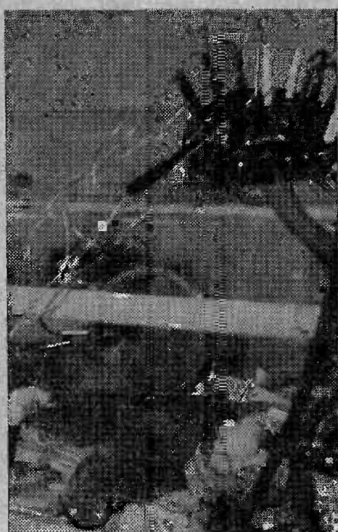
The newest miracle of the datamation age is the *electronic mother machine,* an automatic incubator monitoring system, which permits minute-by-minute care and surveillance of premature infants. Now in use at the Center for Biological Research of the Newborn at the Port Royal Hospital in Paris, the computerized incubator system has numerous advantages over earlier incubators.

A principal advantage is the system's ability to simultaneously record the respiration, temperature, and heartbeats of six incubator babies. These records and results of all tests, including electrocardio-

(*Continued on page 110*)

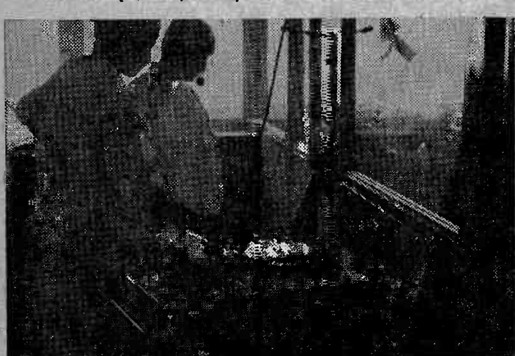


Keeping tabs simultaneously on the temperature, heartbeat and respiration of six babies lying in their incubators is the task performed by this automatic monitoring system. Doctor-observer is alerted automatically in emergencies.



People carry germs! So, to reduce exposure to infection all activity about the infants is telecast via cable to remote observers. TV camera (above) shoots through glass as nurse checks child. Lab technician (below) views video picture prior to making a video tape recording for reference.

By means of an electroencephalogram, doctors determine the gestation age of a premature infant, as well as any possible brain damage. Electrode connections (above) look weird but do not harm child. Doctors (below) interpret results as recorded.



It's What's Up Front That Counts

Proving-ground tests will start later this year on electronic vehicle-control systems which Ford Motor Company engineers see as a possible forerunner to automatic highways. Two initial programs, called Automatic Headway Control and Minigap, are expected to bring forth control equipment that could evolve later into fully automatic car-and-roadway controls.

"Our approach to future transportation systems is much like that of other innovators in this field," says James E. Heywood, chief research engineer for Ford's Development Group. "We are working on only a small segment of a complex question. We know that many ideas must be examined and tested before coordinated efforts can really get started."

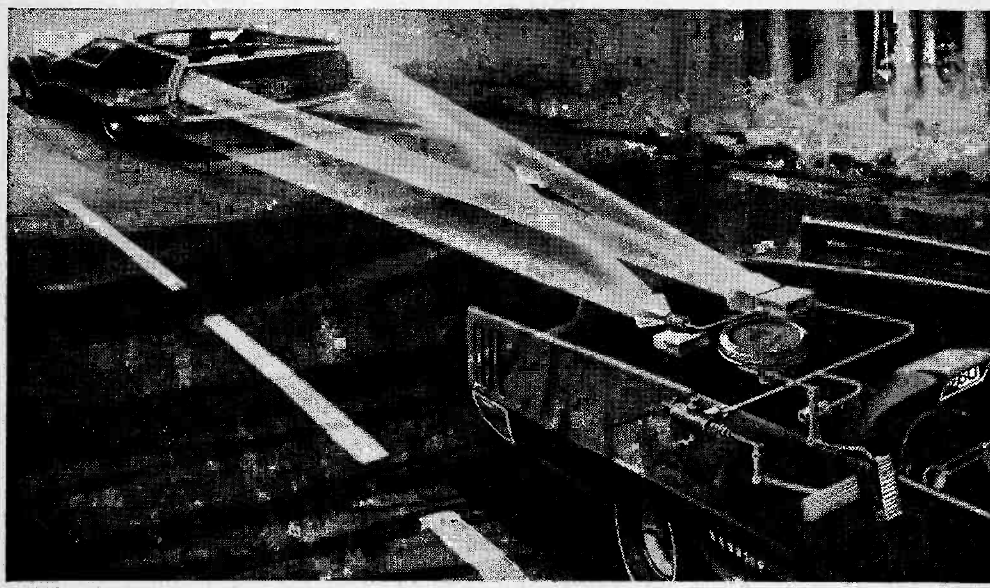
First of the two Ford systems to be tested will be Automatic Headway Control (AHC), which is essentially a computerized brake-and-throttle control unit. On the open road, it operates as a conventional speed-control device. But when an AHC car approaches another vehicle from the rear, an optical beam is reflected back to an electronic processor. This device reads the signal, then changes accelerator and brake settings as needed to maintain a safe following distance.

"This sort of control function will be useful in later, fully automated systems," Mr. Heywood observes. "Meanwhile, it could be applied in a shorter-range approach to relieve drivers of the stop-and-go decision-making of today's crowded urban freeways."

Minigap, the second experimental system, employs a caravan concept. With Minigap, cars on a highway would link together electronically in convoys to alleviate congestion. Trains of cars would be directed by lead vehicles. Though each individual car would supply its own power, drivers would be freed from operating chores altogether.

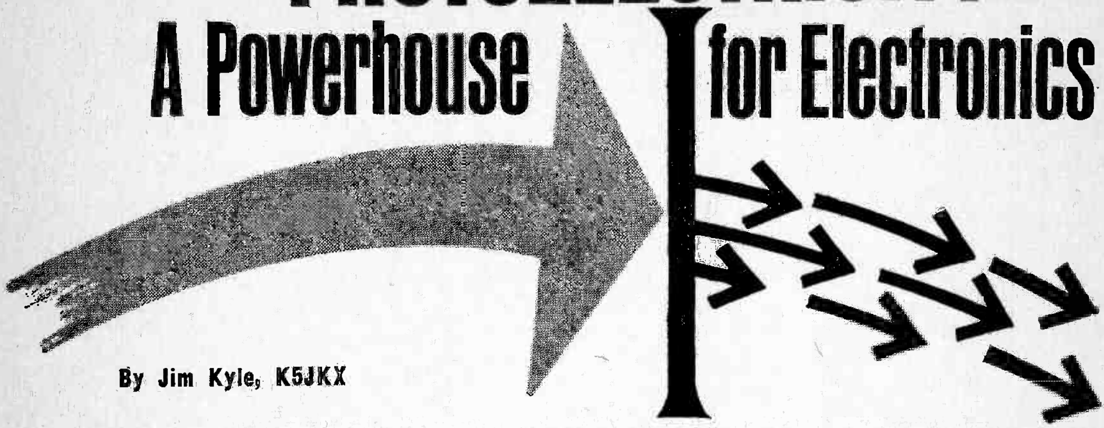
According to Ford's Electronic Systems Research engineers, Minigap spacing would be maintained by brake-and-accelerator control similar to that of AHC. In addition, it would employ an automatic steering system.

"We plan to begin testing the link-up controls in cars in the next few months," says Mr. Heywood. "We know that these systems are potentially capable of increasing both speeds and traffic-handling capacities of existing roadways.—*Joe Gronk*



With AHC, transmitter (at left) beams signal on car ahead. Taillights reflect beam to receiver, which reads signal and automatically adjusts brakes and accelerator to maintain pre-set following distance.

PHOTOELECTRICITY...
A Powerhouse for Electronics



By Jim Kyle, K5JKX

The amazing photocell responds to light in some truly fantastic ways!

A metropolitan TV station, a self-service elevator, a nationwide news service, a satellite orbiting the earth, a row of brilliant street lights illuminating an expressway, and a darkened movie theatre . . .

The common bond joining these diverse items is their dependence upon a *photoelectric* device. Something of a rarity only 25 years ago—when the term *electric eye* was ubiquitous—photoelectricity has now moved into our everyday life to such a degree that it's difficult to imagine the world of electronics without it.

Though its applications are now almost commonplace, the phenomenon of photoelectricity is not yet completely understood. Its explanation rests somewhere in the deepest theoretical layers of modern physics. However, you don't need all the deep theory to understand different types of photoelectric devices or how to apply them to your experiments.

You can build many interesting projects based on photoelectricity. Whether your interests are in gadgets for the house, supplementary aids for other hobbies, or science projects, the electric eye or *photocell* can help you with a bang.

Light-Actuated Devices. Before we get into the practical details of photocells and how to use them, let's take a quickie tour through the physical theory that underlies their operation.

While physicists are still arguing whether light and other forms of electromagnetic radiations (such as radio signals and X rays) are transmitted as waves or particles, most have agreed that *both* explanations make sense. Certain aspects of the theory demand the particle approach, while other areas are best approached by thinking of waves. Actually, each idea is accepted as being valid for those physical phenomena which they best explain.

When dealing with photoelectricity, light is thought of as arriving in little packets of energy known as *photons*. The frequency of any particular light beam is the rate at which the photons arrive, while the beam's brightness depends upon the number of photons arriving at any given time. In physics, this is known as the theory of discrete radiation. It was derived by Max Planck, and is an integral part of the Quantum Theory.

Einstein, working from Planck's ideas, went on to work out his (not so well-known) photoelectric equation. One of the two major classes of photocells is based upon it.

Some materials have an unusual property known as *photosensitivity*. When photons strike photosensitive materials, their impact causes changes in the structure of the material. The effect is determined by both the frequency and the brightness (or intensity) of the photons encountered. Some materials are sensitive to photons arriving at one particular frequency, while other materials are blind to that frequency but are photosensitive to others. Examples of photosensitive materials include plant leaves, photographic film, paper, and your skin.

Other materials react in a somewhat different manner. When hit by photons (usually of limited frequency range), they react by losing electrons from their crystal structure. The effect is illustrated in Fig. 1. If you shoot an air rifle at a pile of gravel, the pellet will knock some gravel out of the pile. But if you shoot at a pile of sand, the pellet will only bury itself in the sand. Such materials are photoelectric, since the change in electron balance of the crystal structure produces a change of electrical *charge* within the crystal.

One of the first photoelectric substances discovered, and still one of the most important, is the rare metal selenium. Other such substances include the chemical compounds cadmium sulfide and lead sulfide. The earliest photoelectric devices depended on selenium. By itself, selenium is not a particularly active photoelectric material. The effect of light striking the original selenium cells was to merely produce a change in the resistance of the metal. To obtain a more useful output, a high voltage had to be applied across the cell. The resulting variation in output voltage activated by photons hitting the selenium was amplified greatly for an effective output.

Such a cell is known today as a photoresistive or *photoconductive* cell. The term photoconductive is more accurate, since the cell's conductivity—not its resistance—increases when it is activated by light. Many of today's photocells are photoconductive, but only a minority employ selenium alone. Most use either cadmium sulfide, cadmium selenide, or lead sulfide.

As physicists learned more about crystal structure, they pondered Einstein's photoelectric equation and eventually built a different type of photoelectric cell. It's technical name is the *photovoltaic* cell, but it's popularly known as the solar cell or sun battery. It operates on the same basic principles but employs a junction of two materials which are sufficiently active to produce a useful output voltage when bathed in photons.

The most common photovoltaic cells use selenium and produce slightly over 0.60 V per cell at maximum output. Like other batteries, they can be connected in series to obtain any desired output voltage. Current output depends on the surface area of each cell, and banks of cells can be connected in parallel to produce more current. These are widely used as power sources for satellites.

Silicon is also used in photovoltaic cells and voltage output is about the same, but silicon cells are more resistant to radiation encountered in outer space. They are also more expensive.

Still a third photoelectric effect finds wide use, though it lacks a compact name. This is the effect light has upon *semiconductor* action. Electrons set free by the impact of photons are indistinguishable from electrons injected by other sources, and thus almost all semiconductors are photosensitive. Normally, this effect is masked by the opaque material in which transistors and SCRs are sealed. However, it is used to advantage in photodiodes, phototransistors, and light-activated SCRs (LASCRs).

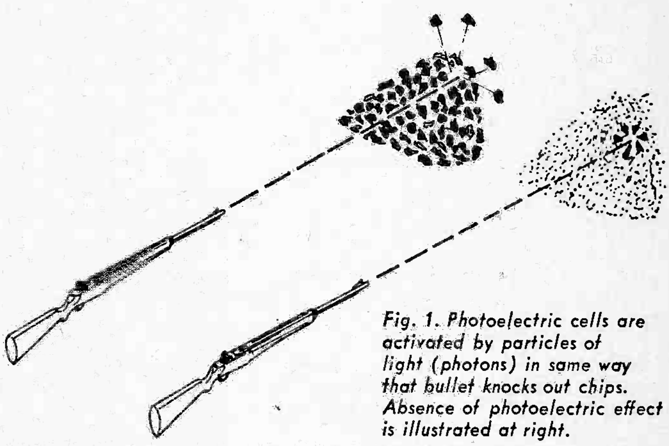


Fig. 1. Photoelectric cells are activated by particles of light (photons) in same way that bullet knocks out chips. Absence of photoelectric effect is illustrated at right.

From a physical standpoint, all three of these photoelectric effects are identical; the difference is merely one of degree. But for practical purposes, it's more convenient to class photocell into two categories: photoconductive devices and photovoltaic cells. All light-activated semiconductors are classed as photoconductive.

Photocell Characteristics. Like other electronic components, photocells are useful only because of their characteristics. And to make correct use of them their characteristics must be known down to the last spec.

All photocells are rated according to *spectral sensitivity* and *response time*. Spectral sensitivity refers to the frequencies to which the cell is most sensitive (or, if you prefer, to the colors of light where its response is greatest); response time refers to the time delay occurring between activation by light and the appearance of an output.

Most photocells have a spectral sensitivity similar to that of the human eye, but with a much wider range. Almost all respond well to ultraviolet light, which the eye cannot see. Many respond also to infrared radiation, though the response at this portion of the spectrum is not great. Fig. 2 shows the typical response pattern of a photovoltaic cell (selenium) as compared to the human eye.

The response time of photocells varies over a wide range, and depends somewhat on the intensity of the light. For small changes in intensity levels, the response is much slower than when intensity varies greatly. The time ranges from seconds (for some cadmium sulfide cells) down to microseconds (for photomultiplier tubes, gas cells, and iconoscopes).

Response time is an especially important characteristic in determining the usefulness of a cell for certain applications. For example, a cell with a maximum response time measured in hundredths of a second would be totally unsuitable for use in a light-beam voice communicator. Since the frequency range of the human voice ranges from 300 to more than 3000 Hz, if the cell requires even 1/100 of a second to respond, it cannot detect any frequency greater than 100 Hz and would be useless at higher frequencies.

In addition to these two basic characteristics, the two types of photocells each have an additional characteristic. Photoconductive cells are rated according to the ratio between *dark* and *light* resistance. This is because the resistance of a cell when light is absent is normally several thousand times the resistance when the cell is illuminated and may range up to several million times as great. Photovoltaic cells are rated for output voltage and current under *standard* illumination (noon sunlight, or 5000 footcandles at 5900° Kelvin).

An important thing to remember when interpreting ratings is that all photovoltaic (PV) cells are also photoconductive devices. That is, a PV cell which is not illuminated has extremely high resistance. When connecting several cells in series to obtain a higher output voltage, failure to illuminate a single cell in the string will reduce total output voltage to nearly zero, just as a single burned-out bulb in a string of lights for a Christmas tree will cause the whole string to remain dark.

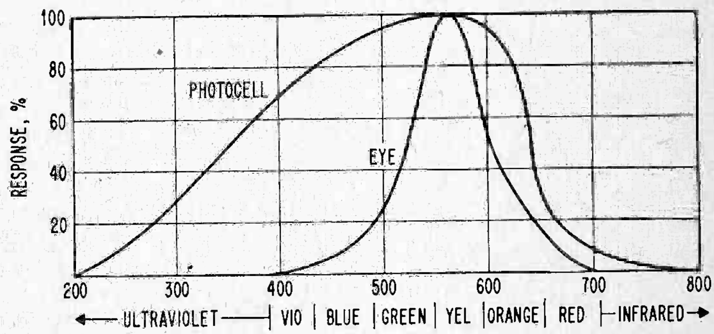


Fig. 2. Graph shows response of selenium cell to a broad range of frequencies. Typical cell (International Rectifier Corp. B2M) is compared with response of human eye over a range running from ultraviolet to infrared portions of light spectrum.

Photoconductive Gizmos. The majority of today's photocells are of the photoconductive variety. Almost all the devices which control electric circuits according to the presence or absence of light (such as automatic streetlighting and elevator safety doors) use photoconductive rather than photovoltaic cells.

The oldest of the photoconductive cells still in general use is the gas photocell. This cell resembles a radio vacuum tube, and many (but not all) fit into standard tube sockets. They normally have a selenium electrode together with a second electrode in a glass bulb filled with inert gas.

The gas photocell requires a DC bias voltage anywhere from 50 to 300 V. Its spectral sensitivity is very close to that of the human eye, and response time is extremely fast. The most widespread use of these cells is as the detecting element in professional sound motion-picture projectors (though magnetic recording has to some degree replaced optical sound recording). *(Turn page)*

Another surviving application of the gas photocell is in facsimile transmitters such as the Associated Press *wirephoto* network (see Fig. 3). This process somewhat resembles very slow television—a photograph is attached to a drum which rotates at a fixed speed. As the drum rotates, the photocell scans the photo while accompanied by a small, intense light source. The dot of light reflected by the photo varies in intensity according to whether the picture is dark, medium, or light at that particular spot. The photocell converts this variation in intensity into an electronic signal.

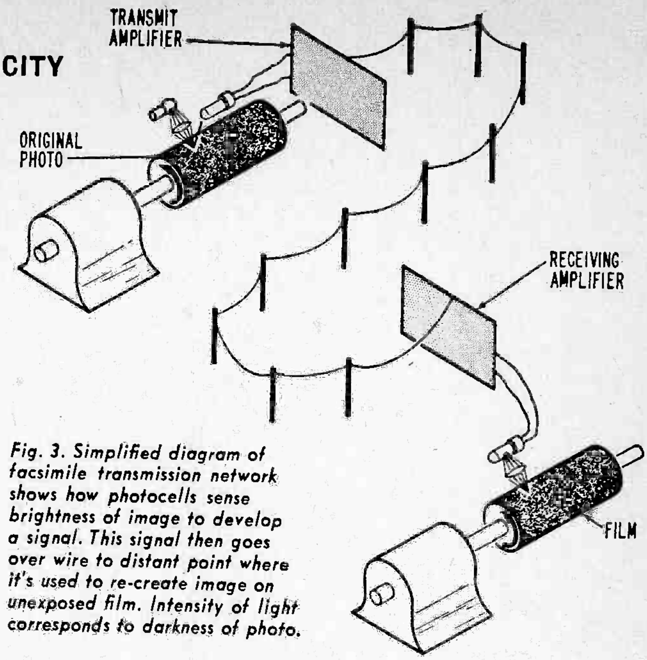


Fig. 3. Simplified diagram of facsimile transmission network shows how photocells sense brightness of image to develop a signal. This signal then goes over wire to distant point where it's used to re-create image on unexposed film. Intensity of light corresponds to darkness of photo.

The signal is then transmitted by wire to the receiving stations, where it is amplified and used to control the intensity of a neon lamp. This lamp is moving at exactly the same speed over a piece of unexposed film attached to a rotating drum which is synchronized with the first. The lamp's intensity changes with the signal, thus *wiping* an exact copy of the original photograph onto the film. An average 7x 9-in. photo requires just under 10 minutes transmission time to reach any point on earth.

In another photographic application, the gas photocell can be used as the trigger in a slave electronic flash unit. Fig. 4 shows such a circuit. When the photocell sees the burst of light from the master unit, it produces a signal which fires the slave flash. In both these applications, the gas photocell is used because of its rapid response time.

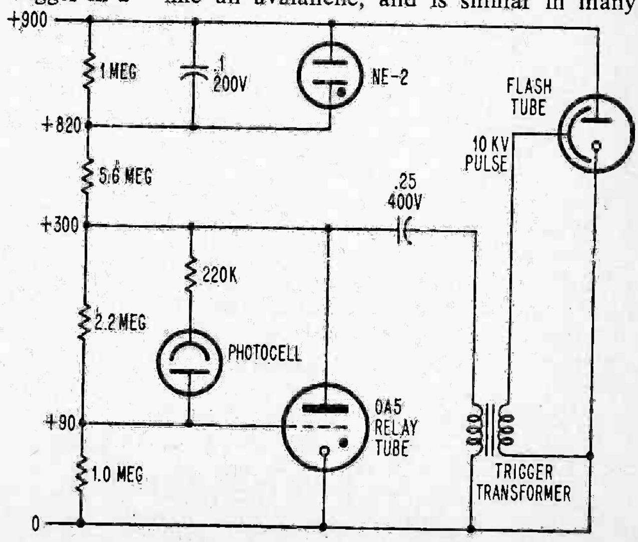


Fig. 4. Photographic (strobe) flash unit without power supply. Circuit shows how photocell triggers cold-cathode thyratron tube to fire strobe flash. When light activates cell, positive pulse goes to grid of relay tube and tube forms short-circuit. Trigger capacitor (0.25 uF) discharges through transformer's primary winding to produce firing pulse.

Two sophisticated relatives of the gas photocell are also widely used. One is the photomultiplier tube (which serves as the detector in most automobile headlight dimmers); the other is a whole family of TV camera tubes, including the iconoscope, vidicon, image orthicon, etc.

The *photomultiplier* tube combines two rather unusual electronic effects in a single glass envelope to achieve extreme sensitivity. One effect is photoelectricity; the other is electron multiplication.

Electron multiplication works somewhat like an avalanche, and is similar in many

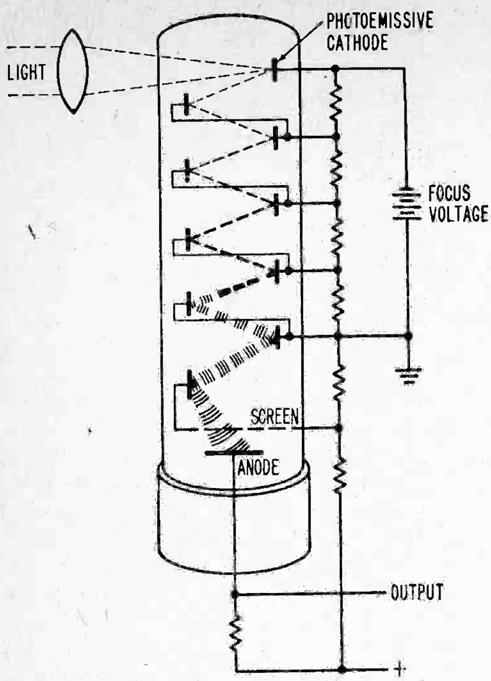


Fig. 5. Photomultiplier tube uses photoelectric effect and secondary emission to create avalanche of electrons. Only few photons are required to strike photocathode in order to obtain full output. Tubes are used where sensitivity to dim light is needed.

ways to the simplified rifle-and-gravel analogy offered earlier. Photons are not the only things which can knock electrons free. Other electrons can do the same thing if they are travelling fast enough!

In a photomultiplier tube (Fig. 5), the original electrons are blasted away from the *photoemissive* cathode due to the photoelectric effect. The first target electrode is the most positive electrode immediately available to these electrons, and they speed toward it at great velocity.

When they hit, they blast loose even more electrons than there were projectiles. Due to the arrangement of electrodes within the tube these electrons are deflected to the second target electrode (which has the same voltage as the first), and there still more are knocked loose.

All the electrons emitted from the first pair of target electrodes are attracted to the next pair in similar fashion. After each collision, more electrons are added to the growing stream, much as a powerful avalanche can start from a tiny snowball.

Amplification of several thousand times is not uncommon in a photomultiplier. These tubes have tremendous potential and have found wide application as detectors in telescopes and military hardware. (In auto headlight dimmers they can provide a strong output signal with no more light than that furnished by the headlights of an approaching vehicle 500 ft away.)

Take TV and See. Television camera tubes are indirect cousins of the gas photocell. They combine features of both cathode-ray tubes and photocells, while adding some of their own.

The earliest TV camera tube was the *iconoscope,* shown in simplified form in Fig. 6. In the iconoscope, an optical image is formed on a photoemissive mosaic by a lens system identical to that used in an ordinary camera. An electron beam from an electron gun similar to those found in oscilloscopes and TV picture tubes is then swept across the mosaic.

The mosaic is placed on top of a thin insulating layer that is on a metal plate within the tube. Each tiny portion of the mosaic is a separate photocell and also forms one plate of a small capacitor. The metal plate forms the other plate for each of these tiny capacitors and is grounded through a resistor.

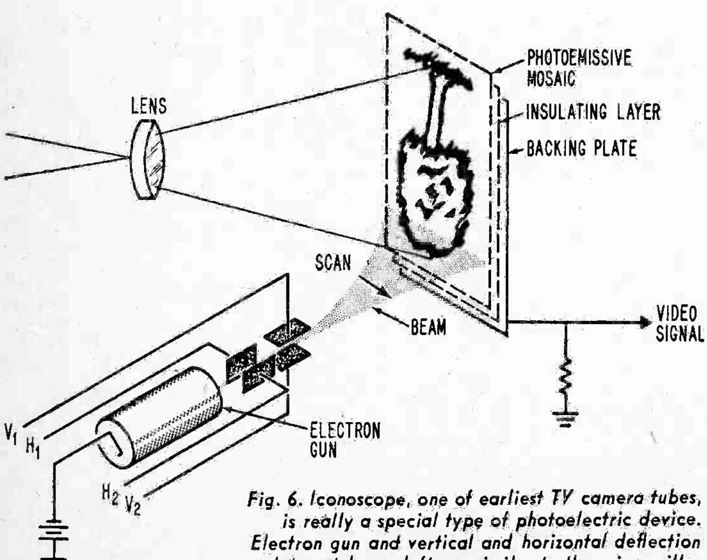


Fig. 6. Iconoscope, one of earliest TV camera tubes, is really a special type of photoelectric device. Electron gun and vertical and horizontal deflection plates at lower left are similar to those in oscilloscope CRT. Beam sweeps mosaic to produce signal.

e/e PHOTOELECTRICITY

The image formed by the lens induces a different electrical charge to form in each of the photocells on the mosaic. The charge is proportional to the brightness of the image at each point. As the electron beam sweeps across the mosaic, each of the tiny capacitors discharges. The average discharge current flows through the resistor to ground and forms the video signal of the iconoscope. The current path goes from the power supply to the iconoscope cathode, through the electron beam to the capacitors formed by the mosaic and metal plate, and back through the resistor and ground to return to the power supply.

Later camera tubes utilize the same general principles but offer improved sensitivity. The early iconoscopes would work properly only in bright sunlight, while modern camera tubes can produce good pictures in light too dim for human vision. But the differences are not major. For example, the basic difference between the iconoscope and the *image orthicon* is that the image orthicon makes use of secondary emission to charge its mosaic and contains a built-in photomultiplier to increase its sensitivity.

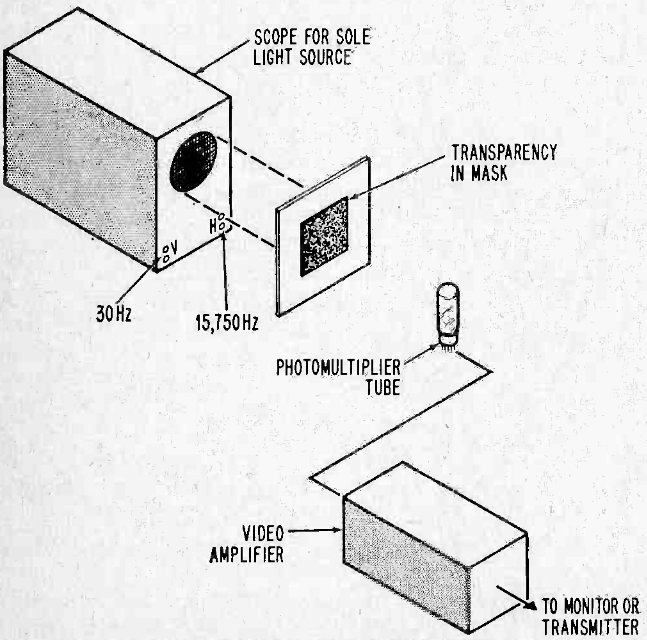


Fig. 7. Here's sketch of experimental flying-spot scanner that you can build. Signals are fed to H and V scope inputs to illuminate transparent photograph slide. Light variations, in step with TV signal, can be seen on another TV set.

An ordinary gas photocell or photomultiplier tube may be used to build an experimental *flying-spot scanner* TV camera capable of developing images of still photographs. Fig. 7 is a block diagram of just such a system. The light source is an ordinary oscilloscope. If the scanner is to be used with a commercial TV receiver acting as monitor, the scope's horizontal sweep should be synchronized to 15,750 Hz (the standard horizontal sweep frequency) and the vertical input signal should be a 30-Hz sawtooth waveform. The photo to be scanned—either a negative or positive transparency—is taped to the scope's screen and an opaque mask is fastened over it so that the only light escaping is that which passes through the photo.

The photocell is then set up to catch the light passing through the photo. A lens may be used to concentrate the light, but no image is formed. As the spotlight from the scope sweeps over the image on the photo, varying amounts of light pass through. The photocell responds continuously to the intensity of the light. The amplified output of the photocell is then fed to the video amplifier of the receiver, or it may be used to modulate a low-power vhf transmitter.

Such scanners have been used for many years by amateur TV enthusiasts. They are also employed in certain kinds of TV test equipment to provide an instant test pattern for general trouble-shooting.

Modern Photoconductors. The most widely used photoconductors today are solid-state photocells made from cadmium sulfide, cadmium selenide, and lead sulfide. These compounds offer a much greater ratio of dark-to-light resistance than do the older devices, as well as longer life and increased reliability. These advantages, however, come at a price. The response time of these cells is much slower than that of other photo devices. Their sensitivity is also dependent on the previous light level, and how long this level has been maintained.

For most general applications, these disadvantages are minor. In door openers and automatic power switches controlled by the presence or absence of light, extreme sensitivity and response times faster than 1⁄100 second are not necessary.

Circuits in which cadmium sulfide cells and their relatives are used can be simple or complex. One of the simplest is shown in Fig. 8. When the cell is dark the light is *off*, but when the cell is illuminated its resistance drops sufficiently to allow the light to glow brightly. The modification shown in Fig. 8A increases the circuit's usefulness in two ways. The relay permits more powerful loads to be controlled and also allows the light to be on when the cell is dark.

But the simple circuits in Fig. 8 have two major disadvantages when used to control yard lights. One is the use of an electromechanical relay which eventually wears out. The other is the fact that when the lights are *off*, the relay is *on*, so that power is always being used.

The more complex circuit shown in Fig. 9 eliminates both these problems by replacing the relay with a *Triac*. So long as the photocell is illuminated its resistance is low and the voltage necessary to fire the Triac is not developed. As daylight disappears, the resistance of the photocell rises and the voltage developed across it increases. When this voltage is great enough to overcome the Diac's stand-off voltage, the Triac fires, turning on the lights. Up to 500 watts may be handled by this circuit. For greater loads, heavy-duty switching devices are necessary.

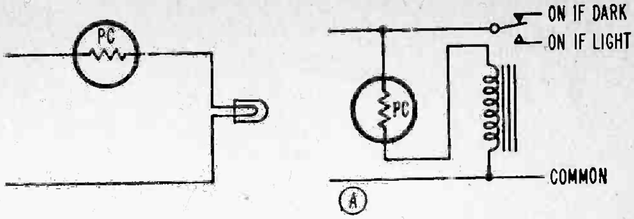


Fig. 8. Here are two simple power-control circuits using CdS photoconductive cells. Leads to left of circuit connect to either AC or DC power. As light level on cells increases, lamp (left circuit) increases in brightness and relay (right circuit) energizes, pulling down clapper on relay switch.

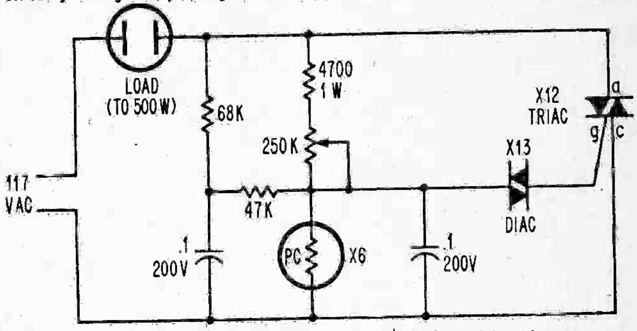


Fig. 9. For controlling heavy loads, photocell is teamed with SCRs and Triacs. Circuit above handles up to 500 watts. When light falls on photocell, load power is off. Potentiometer adjusts cell's effect for different ambient light levels. Switch photocell with 4700-ohm resistor to make load power come on with light.

Since photoconductive cells have such a large ratio of dark vs. light resistance, they may also be used as relays. Fig. 10 shows several typical circuits. Applying power to the lamp bulb causes the photocell's resistance to drop and is the same as applying power to a relay coil. While relays of this type are not capable of taking the same power loads handled by electromechanical relays, they do operate rapidly and quietly in signal circuits and are being used more and more. For such uses, companies manufacture assemblies which have both the lamp bulb and photocell in the same case.

This arrangement can be used as a remotely-operated volume control or voltage divider by adding a resistor and varying the amount of power applied to the lamp bulb (Fig. 11). The brighter the bulb, the lower

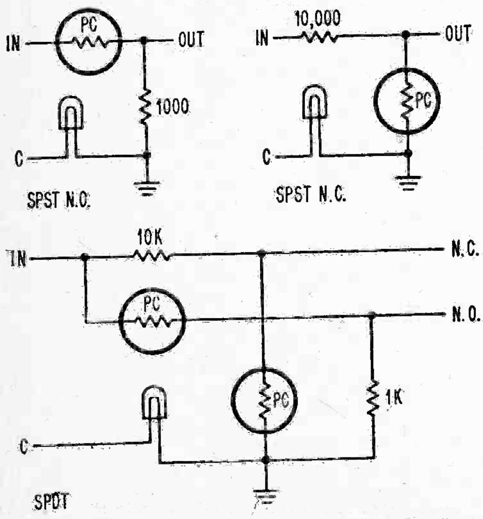


Fig. 10. Want to get chatter out of relays? Simple: use photoconductive cells as noise eliminators. When light comes on, photoconductors' impedance drops to near zero—resistance is high when there's no light. C indicates lamp's control voltage.

the output. If the positions of the resistor and the photocell are reversed as in Fig. 11A, the output will increase with bulb brightness. If remote control from several independent locations is desired, a number of bulbs can be arranged to light the same photocell. In this case, the brightest bulb will control the photocell's resistance. A majority vote effect also occurs in a circuit of this type. If all the bulbs are bright, the photocell's resistance is less than if only one bulb is bright and the rest are dark. Many variations are possible, including a simple analog computer which adds by turning on additional lamps.

Photosensitive Semiconductors. While photosensitive semiconductors belong in the general class of photoconductive devices, their characteristics warrant separate examination.

As already noted, all semiconductors are photosensitive to at least some degree. But those designated as photodiodes, phototransistors, or LASCRs are specially designed and packaged to make maximum use of the effect.

Photosemiconductors combine the ruggedness and wide resistance range of cadmium sulfide (CdS) cells with the rapid response time of the gas photocell and photomultiplier. However, they are usually costly. When first introduced, photodiodes sold for $77.00 each. A photosensitive semiconductor can be used any place where an ordinary, equivalent semiconductor is employed, but with some differences. A photodiode, for instance, exhibits the wide *change* of resistance when illuminated. It can be used in place of a normal photoconductive cell in low-power circuits, but cannot handle appreciable power levels.

Phototransistors are usually connected only at their collector and emitter terminals; the base terminal remains floating. When not illuminated, they show the high collector-to-emitter resistance of a turned-off switching transistor. This amounts to tens or hundreds of thousands of ohms. When light falls on them they turn *on* and the resulting transistor action reduces resistance to fractions of an ohm. Response times are similar to those of switching transistors—from tens of microseconds down to fractions of microseconds.

Phototransistors are widely employed in industry as speed-sensing devices for reading

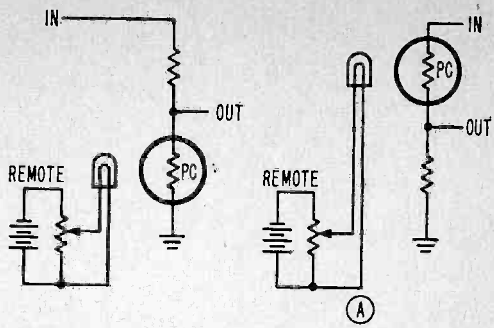


Fig. 11. Photocells offer noise-free remote volume control. Light intensity controlled by potentiometer varies resistance of photo unit in voltage divider.

digital data from punched cards and punched paper tape, and as *on/off* switches similar to photoconductive cells. Their expense makes them unattractive to experimenters at present, but cost can be expected to come down as their use expands.

The LASCR performs all the functions of an ordinary SCR, but requires no gate signal to trigger it. Instead, it is triggered by light. One LASCR available to experimenters at moderate cost is General Electric's GE-X2. A typical circuit incorporating this device to create an electric candle is shown in Fig. 12. The bulb is initially dark, but lighting a match and bringing its flame into view of the X2 turns *on* the LASCR and lights the bulb. Light from the bulb keeps it *on*. You turn the bulb *off* by cupping your hand around it, being sure that your hand shadows the X2 from the bulb's light.

Photovoltaic Cells. A little more than 10 years ago, practical photovoltaic cells became available to experimenters at moderate prices with the introduction of selenium *sun batteries*. For several years almost no other component was so prominent in electronics magazines. But with the advent of photoconductive cells which could be used in more versatile circuits, the emphasis on the photovoltaic cell decreased and many of today's experimenters hardly know they exist.

Space scientists, however, are extremely conscious of them. Since the photovoltaic

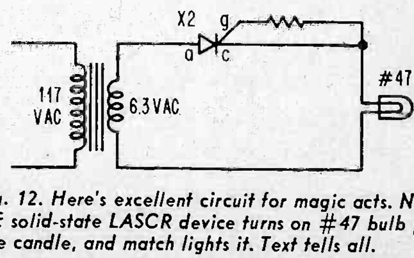


Fig. 12. Here's excellent circuit for magic acts. New GE solid-state LASCR device turns on #47 bulb just like candle, and match lights it. Text tells all.

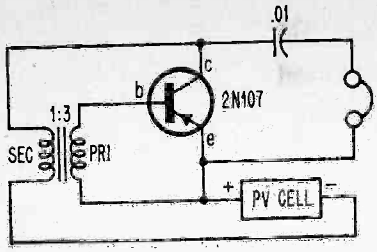


Fig. 13. Let your desk lamp power this one-transistor oscillator. Transformer is typical low-cost audio type. Key in phone circuit makes it a cheap CPO.

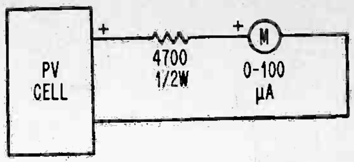


Fig. 14. This diagram tells why Seymore, the shutter-snapper, is a great photographer. Light-powered cell deflects meter to indicate photo facts on dial.

cell converts light directly into electricity, it offers the only practical method of powering electrical devices on satellites and space probes which must operate for more than a few weeks.

Each cell has a maximum output of 0.6 V. Current is determined by surface area but seldom exceeds 20 mA per sq. in. in direct sunlight. To obtain the amounts of power necessary for powering spacecraft electronics, thousands of cells are connected in a series-parallel arrangement to boost both voltage and current.

For experimental use, one single cell can produce a useful output. When illuminated by high-intensity light from either the sun or a DC-powered light bulb, it will produce several hundred millivolts of pure DC suitable for transistor experiments. Fig. 13 shows a light-powered transistor oscillator circuit which produces a signal only when the photovoltaic cell (an International B2M sun battery) is illuminated.

Current produced by a photovoltaic cell depends not only on its surface area, but also on the amount of light which reaches it. For this reason, the PV cell is widely used as the sensing element in photographic exposure meters (light meters). In addition to the cell, only a milliammeter is needed. Addition of a series resistor (see Fig. 14) converts the meter into a wide-range instrument capable of operating in either dim indoor light or in bright sunlight.

Calibration of a light meter is a rather unusual procedure, since it is based on the fact that doubling the distance between a light source and the meter will cut the intensity of the light to ¼ of its original value.

A new 100-watt frosted (not *soft* white) bulb operating at 117 VAC at a distance of 40 in. from the cell in a darkened room will produce a light intensity of 10 footcandles

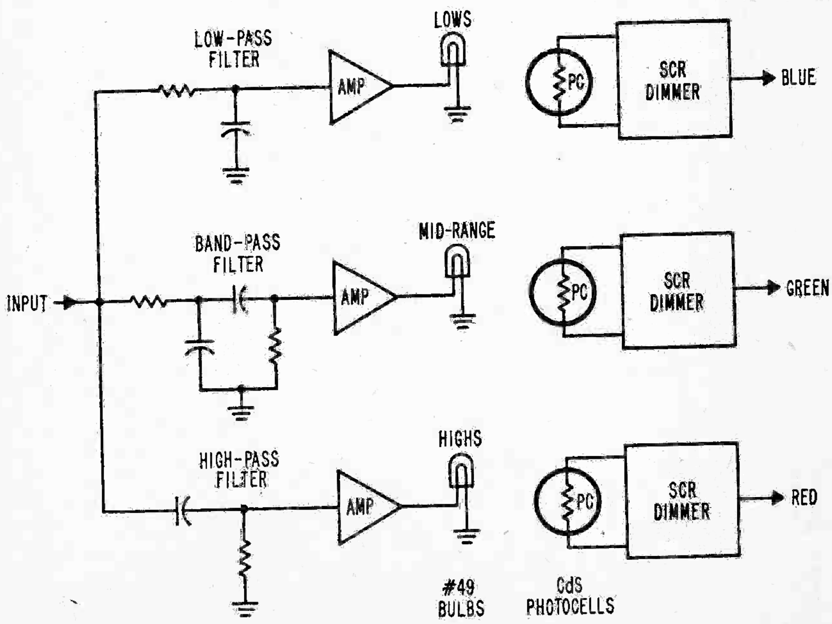


Fig. 15. This is it—the theory-eye view of a photocell-controlled music color organ. Input to circuit is audio from hi-fi set. Filters let different frequencies power different colored lamps. Volume controls brightness.

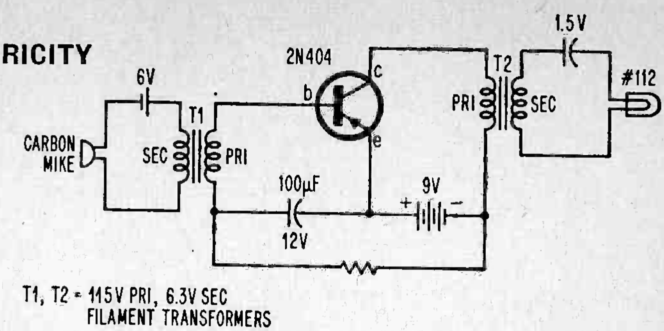


Fig. 17. Want to talk on a light beam? Well, here's the transmitter that'll work for you. Flashlight bulb #112 offers good fidelity.

(within 8%). Reducing the distance to 20 in. will increase the intensity to 40 footcandles. With these two facts in mind, a larger bulb may be substituted and the distance from meter to bulb adjusted until the reading is again 40 footcandles. Cutting this distance in half will then increase the light intensity to 160 footcandles. This process may be repeated with varying sizes of bulbs and different distances until the whole scale is calibrated.

To obtain a check, noon sunlight on a clear day is about 5000 footcandles. To convert the footcandle readings into photographic exposure settings, the recommended shutter speeds and lens settings for sunlight may be assigned to the 5000 footcandle mark. If the light level differs from 5000 footcandles, lens settings must then be adjusted by the amount of the difference.

Colorful Applications. Photoelectric effects have so many applications that it's possible only to scratch the surface in this limited space. Those already described, as well as those which follow, may be used as starting points from which you can develop your own ideas.

One of the more spectacular applications of photoconductive cells is their use as the key-control element of a color organ. The cells control the brightness of various colored lamps in time to both the frequency and loudness of recorded music. Such devices are popular during the Christmas season for control of decorative lights. Fig. 15 illustrates the basic circuit.

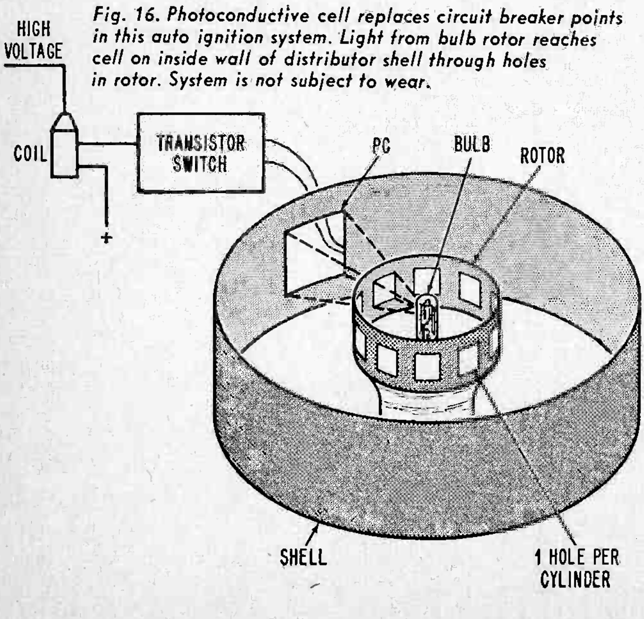
Fig. 18. Want to listen to a light beam? It's easier than you think. Simple diagram proves the point.

The three amplifiers are identical low-power units operating in the audio range. Signals for these amplifiers are obtained from the same music, but each amplifier's input is filtered so that each responds to a different portion of the audio spectrum. The amplifiers drive an ordinary pilot bulb which only lights at certain frequencies.

Each pilot bulb serves as the light source for its associated photocell, and the photocells in turn serve as control resistors for conventional SCR lamp dimmers. When the pilot bulb fed by a specific amplifier is bright, the photocell's resistance is low and the colored light controlled by that SCR is brightest. This circuit may be considered a variation of the circuit shown in Fig. 8A, but with the following differences: the remote control signal is furnished by the fil-

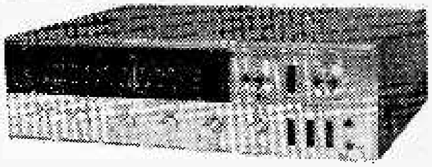
(Continued on page 102)

Fig. 16. Photoconductive cell replaces circuit breaker points in this auto ignition system. Light from bulb rotor reaches cell on inside wall of distributor shell through holes in rotor. System is not subject to wear.



e/e HIGH-FIDELITY

Lafayette Radio Model LR-1500T 150-Watt Solid-State AM/FM Stereo Receiver



If we accept the term *state of the art* to mean the latest innovations in modern component design, the Lafayette LR-1500T stereo receiver is such an instrument. It has an FET front end, integrated-circuit (IC) IF amplifiers, and pulse-overload delayed protection circuits.

The LR-1500T has solid-state construction and is jam-packed with features useful to even the most demanding audiophile. On the rear apron one finds jacks for a tape head, tape recorder input and output, auxiliary input, and a magnetic phono input.

The magnetic phono input is provided with a three-position sensitivity switch. This allows the amplifier output to be equalized between the usual high-level inputs and a magnetic phono pickup having any common output voltage.

To the Rear. The rear panel has outputs for both main and remote speakers as well as a *mono* center-channel output. This is not a power output but rather a voltage output intended to drive a mono center-channel amplifier, or a mono distribution amplifier—say for feeding the patio or playroom.

The rear panel also contains both a switched and unswitched AC outlet, an external AM antenna input, and both external and internal FM antenna terminals. An adjustable AM loopstick is also mounted on the rear apron.

Moving to the front, we find just about any possible mode of operation: phono, tape head, auxiliary, AM, FM, and finally, MPX filter. The MPX filter position is FM stereo with a filter cut in to reduce noise common to weak signals. Indicator lights behind the front panel show the selected operating mode.

A mode switch also determines how the amplifiers are operated, providing left or right channel only, mono, stereo, stereo reverse, left channel to both outputs, or right channel to both outputs. When the mode switch is in stereo position and the selector switch is in FM or the MPX filter position, the receiver automatically switches to stereo-receive operation if the tuned station is transmitting stereo.

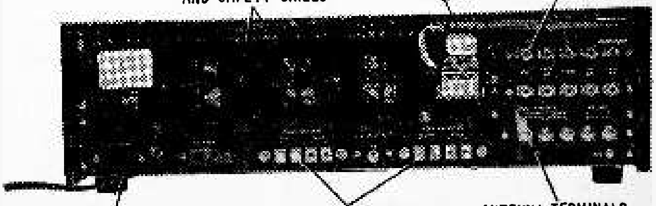
Switches Galore. A tape-monitor switch connects the amplifier's input to a recorder's output when a 3-head deck is recording. It also selects the recorder's stereo playback or its left or right channel.

Concentric bass and treble controls are provided as well as switches for loudness and high and low filters. A concentric volume control is mislabeled *balance/volume* — actually, there is no balance control. Each volume control determines the sound level of just one channel.

A mute control mutes interstation noise on FM and AM, and a speaker mode switch selects either the main or remote speakers, or both, or headphones. Both a stereo phone jack and a stereo tape recorder jack are provided on the front panel. Naturally, there is a tuning knob.

The receiver is so jam-packed with components that the schematic is the size of a road map. The FM front end uses 2 FETs (field-effect transistors) to make the front-end circuitry virtually immune to overload. Even the full output of our signal generator

(Continued on page 106)



AM loopstick is mounted on a pivot and can be oriented for best reception. Plastic shield protects output transistors and phono cables.

DXing the Land

Here's how to become the DX King of Siam! Know when and

The major religions of South-East Asia expound the belief that the universe is *cyclic* and we are all bound by the laws of *cause* and *effect*. Despite their orderly view of the world's destiny, just about everything on that part of the globe is *chaotic*. For the past few years Washington has been working desperately in an attempt to prevent another Vietnam in the ancient *cyclic* kingdom of Siam, now known as Thailand. The results, at least radiowise, are still more confusion and mystery. All of which adds up to top-flight DX and SWL interest.

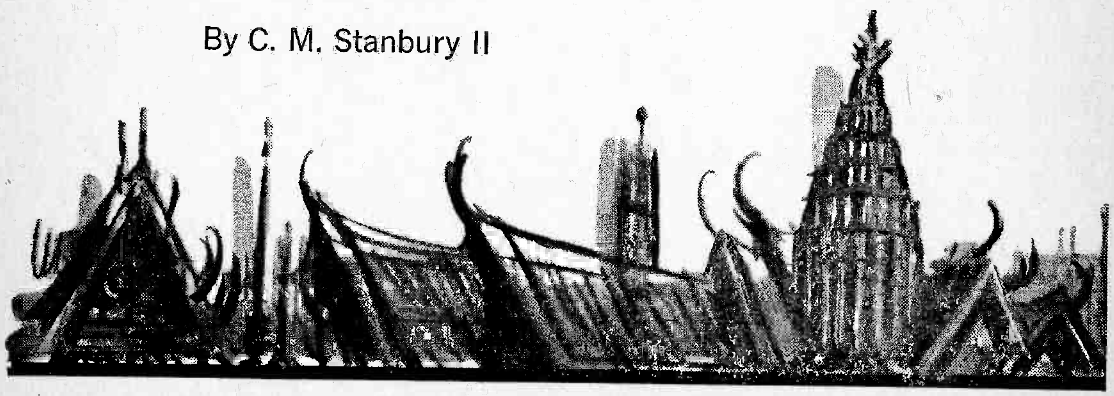
Your first step along the tangled path of Thai DX is, of course, to log and QSL the country. This is not too difficult a task. Any shortwave listener, no matter how simple his gear, can log Thailand provided he doesn't mind getting up a little early—a standard requirement for all Thai reception. Just tune to 11910 kHz at 0525 EST and nine out of ten you'll hear the overseas service of R. Thailand opening up in English. This one transmits from Thai's capitol Bangkok, and is operated by the Ministry of Information. This organization is an excellent verifier. There, you've got your first QSL on its way. On an inexpensive receiver without accurate calibration, the DXer will probably spend a little time hunting before hitting the frequency.

ABBREVIATIONS

BCB	broadcast band
c/o	care of
DX	long distance, distant (contact or country)
DXer	hobbyist who seeks DX contacts
EST	Eastern Standard Time
kHz	kilohertz (kilocycles)
kW	kilowatts
NA	North America
PST	Pacific Standard Time
QRM	noise and signals interfering with desired signals
QSL	decorated postal card or letter from station acknowledging reception report
R.	Radio (as in Radio Thailand)
RFA	Radio Free Asia
S/On	sign on
SW	shortwave
SWL	shortwave listener
TTV	Thai TV Company

Co-Channel Capers. This same Bangkok station, R. Thailand, is also heard with transmissions intended for domestic consumption on various frequencies. Look for it on 9653, 7115, 6070, and 4830 kHz. They've been reported by NA SWLs from time to time. It is at this point that chaos and confusion begin. For example, while the Ministry of information uses 6070, the Ministry of Education, also transmitting from Bangkok, uses 6062 kHz at the same time. You can certainly expect some co-channel interference problems. Take a gander at our chart "Thai DX at a glance" on page 72.

By C. M. Stanbury II

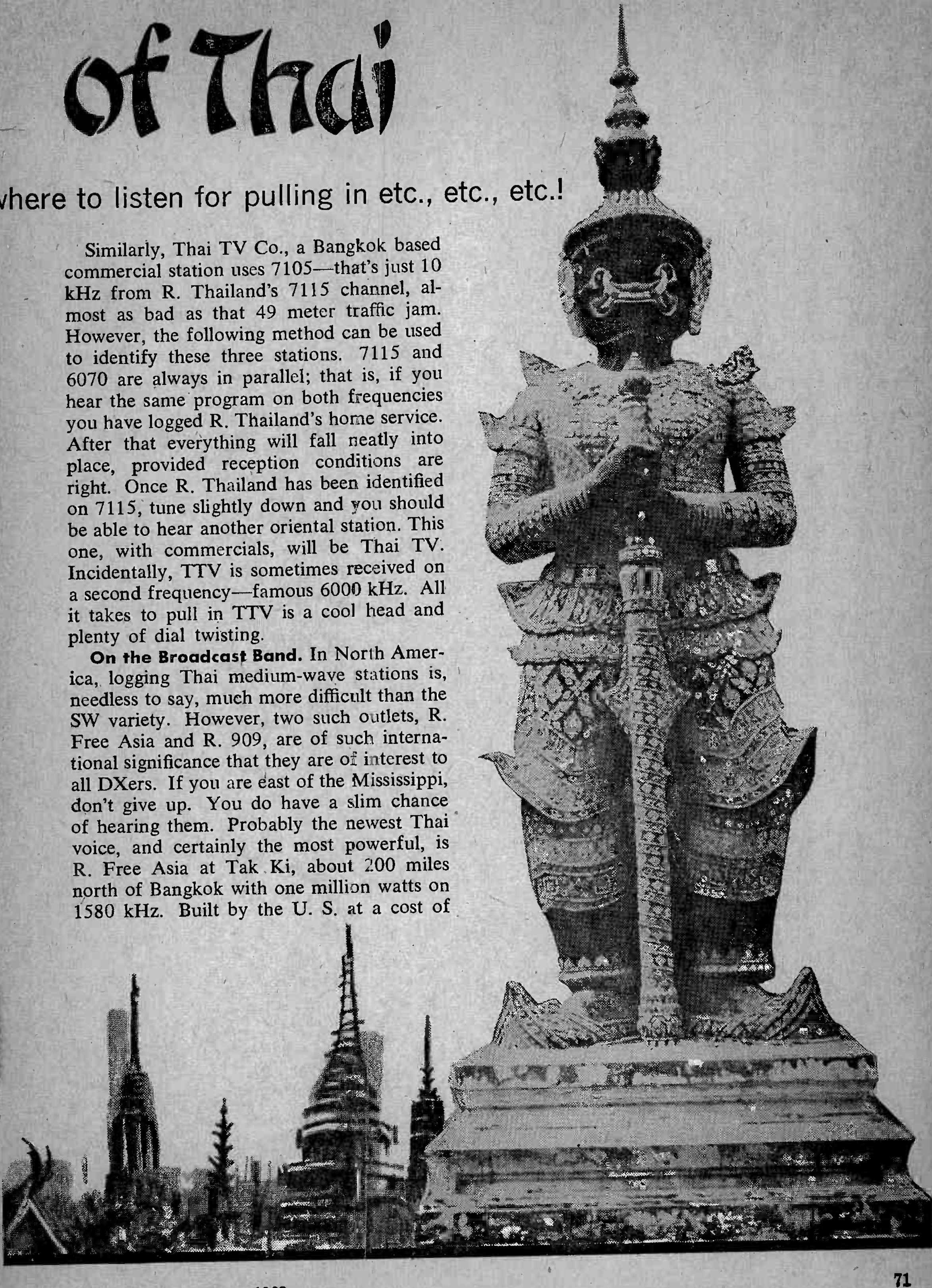


# of Thai

where to listen for pulling in etc., etc., etc.!

Similarly, Thai TV Co., a Bangkok based commercial station uses 7105—that's just 10 kHz from R. Thailand's 7115 channel, almost as bad as that 49 meter traffic jam. However, the following method can be used to identify these three stations. 7115 and 6070 are always in parallel; that is, if you hear the same program on both frequencies you have logged R. Thailand's home service. After that everything will fall neatly into place, provided reception conditions are right. Once R. Thailand has been identified on 7115, tune slightly down and you should be able to hear another oriental station. This one, with commercials, will be Thai TV. Incidentally, TTV is sometimes received on a second frequency—famous 6000 kHz. All it takes to pull in TTV is a cool head and plenty of dial twisting.

On the Broadcast Band. In North America, logging Thai medium-wave stations is, needless to say, much more difficult than the SW variety. However, two such outlets, R. Free Asia and R. 909, are of such international significance that they are of interest to all DXers. If you are east of the Mississippi, don't give up. You do have a slim chance of hearing them. Probably the newest Thai voice, and certainly the most powerful, is R. Free Asia at Tak Ki, about 200 miles north of Bangkok with one million watts on 1580 kHz. Built by the U. S. at a cost of



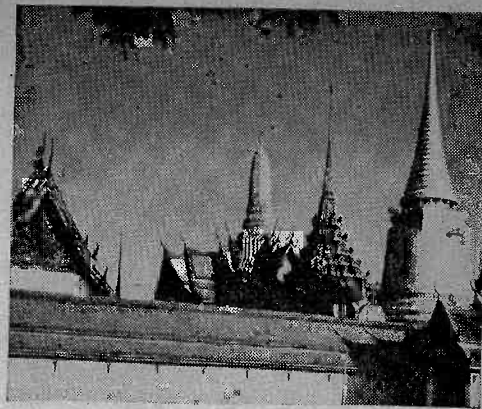
six million bucks, it was turned over to the Thai government for a token payment. RFA blankets South-East Asia, most with Voice of America programs.

Unfortunately, RFA apparently does not S/On until 0630 EST (0330 PST). At that time there is severe ORM from powerhouse XEDM in Mexico, as well as WCLS in Georgia. Also, you can expect BCB day-timers along the east coast to cause trouble year-round. Nevertheless, DXers west of the Mississippi should watch for this one during the spring and fall equinox periods, and even DXers east of the Mississippi have an outside chance during December and January.

THAI DX AT A GLANCE

kHz	Station	Location	Time (EST)
843	R. 909	Sakon Nakhon	After 0500
1580	R. Free Asia	Tak Ki	0630
4830	*R. Thailand	Bangkok	Dawn
6000	Thai TV Co.	Bangkok	Dawn
6062	Ministry of Education	Bangkok	Dawn
†6070	*R. Thailand	Bangkok	Dawn
7105	Thai TV Co.	Bangkok	Dawn
†7115	*R. Thailand	Bangkok	Dawn
9423	Voice of the Thai People	China	0800
9653	*R. Thailand	Bangkok	Dawn
11910	*R. Thailand	Bangkok	0525

* Ministry of Information
† Identical programming

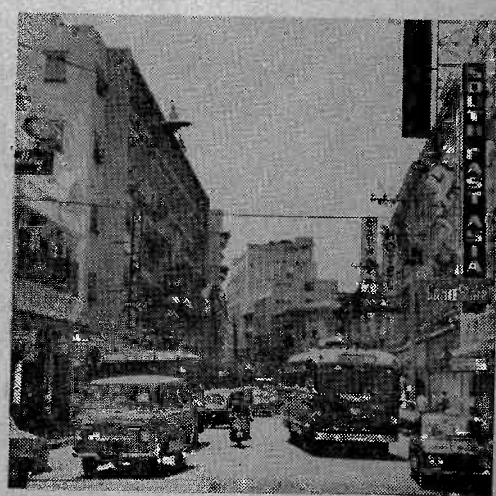


Buddhist temples with their lovely and lofty minarets are Thailand's answer to our skyscrapers.

While R. Free Asia may be Washington's biggest propaganda gun in South-East Asia, the capers of a certain portable BCB unit (or units) are even more significant. This is so partly because they appear to tie in with various behind-the-scenes radio activities in other parts of the world, and partly because the portables demonstrate just how confused the situation in SE Asia is generally.

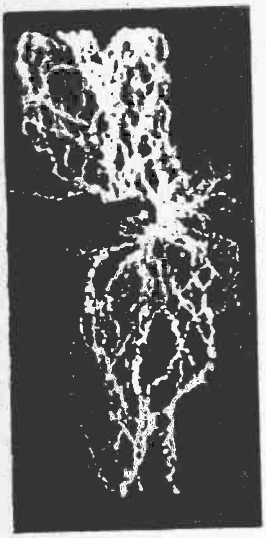
Key to All the Mysteries? The first portable in Thailand (power 50 kW) was at Khan Kaen on 843 kHz near a major U. S. air base in the east central part of the kingdom. The primary assignment of the Khan Kaen set-up was to counter propaganda from the Maoist "Voice of the Thai People," which uses R. Peking transmitters. This was 'way back in 1963 and last heard in 1965.

(Continued on page 110)



Five centuries apart in travel techniques but only one mile distant from each other—that's the scene down Bangkok way today! Photo at left looks like an invasion of Venice—at right, it's like New York at noon.

SPARK SPECTACULARS



Snap . . . Crackle . . . Pop . . . If you've got a spark blaster in your lab and a good cool at the switch, here are some experiments that'll brighten up your day with lights truly psychedelic man!

By Erik Horneman

Sparks can't be all that bad. Fact is, reader response to our Cigar Box Spark Coil (see ELEMENTARY ELECTRONICS, September/October, 1968) was so enthusiastic that we decided on a follow-up article for a strong one-two punch. These hot items—experiments with plenty of pizazz—should set your equipment ablaze with the weirdest lights ever!

The ½-in. spark delivered by your Cigar Box Spark Coil is admittedly unimpressive when compared with the far larger discharges created by even a small Tesla coil. And yet it's quite possible to make a ½-in. spark *look* as if it were several inches long. Moreover, by using multiple sparks, it's possible to fill an area 12 in. in diameter with a really spectacular display of electrical power!

How can a spark be a ½ in. long and several inches long at the same time? The clue: *It's not how long you make it, it's how you make it. . . . !* (Yes, our Cigar Box Spark Coil was used in *all* the experiments described in this article!)

In a sense, the lowly induction coil is a poor man's—or lazy man's—Tesla coil. Many of us never get around to building a Tesla coil because of the fairly high cost, or because the project seems a bit too demanding. Of course, you can stick your fingers into the discharge corona of a Tesla coil and feel no ill effects (it's all potential), but don't try this with a spark coil because it can deliver a nasty shock. During operation, you must avoid all contact with anything attached to the secondary terminals of your spark coil.

Some Classics. Most school and public libraries have books dealing with electrical experiments. These describe standard demonstrations that are performed with spark coils. For example, Jacob's Ladder consists of a series of sparks that climb upward along the gap between two vertical-wire electrodes that are closer together at the bottom than at the top.

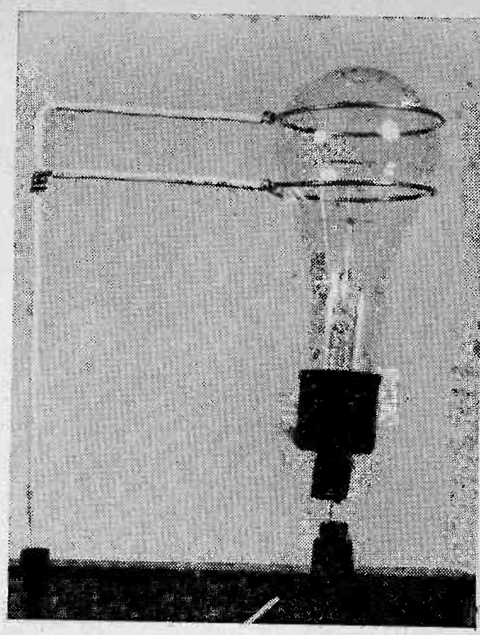
e/e SPARK SPECTACULARS

Lavender corona produced by 150-watt bulb. Only one prong from socket is connected to coil's terminal.

Another familiar experiment is the formation of a lavender discharge corona inside an electric light bulb. The experiment is done by screwing a clear 150-watt bulb into a socket having two male prongs. You connect only the prong making contact with the end terminal of the bulb to the high-voltage terminal of the spark coil. A lavender glow fills the bulb, and discharge streamers will leap from the filament to the glass envelope.

This simple experiment can be made more dramatic by adding one or more discharge electrodes that connect the outside of the glass bulb to the second high-voltage terminal of the coil. Use heavy, insulated wire (such as #12) to form the rings and leads; remove the insulation from those parts of the wire which make contact with the bulb. The brighter glow and more vivid streamers will make the experiment decidedly more spectacular.

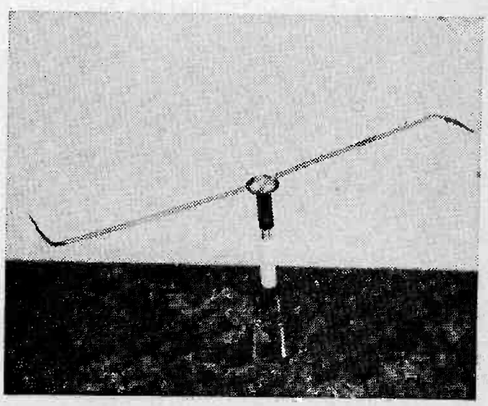
Most of the experiments described in this article should be performed in a dark room for best effect. To be safe and sure, place a dim light near the coil switch so that it can be operated without risking any contact with a high voltage.



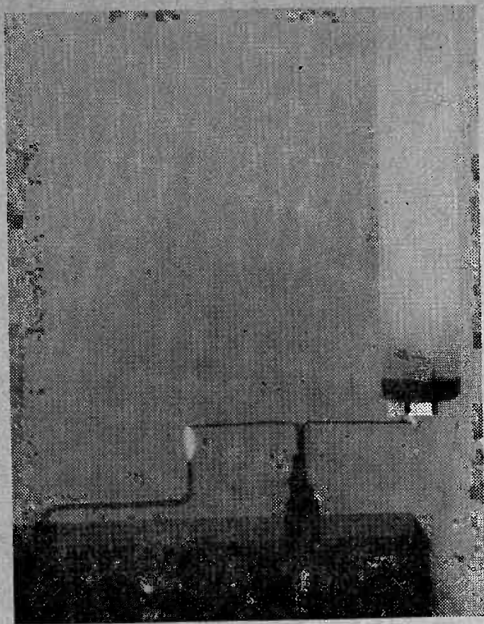
More spectacular displays occur when wire conductors are looped around bulb. Bright rings of light encircle bulb near electrodes. Streamers aren't seen.

Psychedelic Pinwheel. Most electronics enthusiasts are aware that small pinwheels can be made to spin rapidly if invisible electron jets are made to stream off the tips of the pinwheel. These experiments are usually performed with Tesla coils and Van de Graaff generators. However, the common spark coil can also cause such pinwheels to spin!

An easy way to make a pinwheel that stays put on its pivot is to solder a 5-in. length of light wire to the end of a small, *hollow* rivet. Bend the tips of the wire to



Pinwheel is made from 5-in. wire soldered to top of hollow rivet. Rivet is supported on sharpened end of #12 wire plugged into high-voltage terminal.



Tips of wire are slightly bent to form nozzles. Here, coil's second terminal and fluorescent lamp serve as electrodes for spinning pinwheel's arcing flashes.

form electron nozzles as shown in our photo. Add a short length of heavy wire to the main high-voltage terminal of the spark coil. This is filed to a sharp point at its upper end. Place the rivet on this pivot and then activate the coil. The pinwheel should spin at a good rate.

This experiment can be zipped up by adding electrodes or other components that will pick up and make visible the discharges emanating from the tips of the spinning pinwheel. For example, lead a heavy wire from the second terminal of the coil so that its end is about ½ in. below the tip of the pinwheel. Once during each revolution a crackling spark will jump from the pinwheel to the electrode.

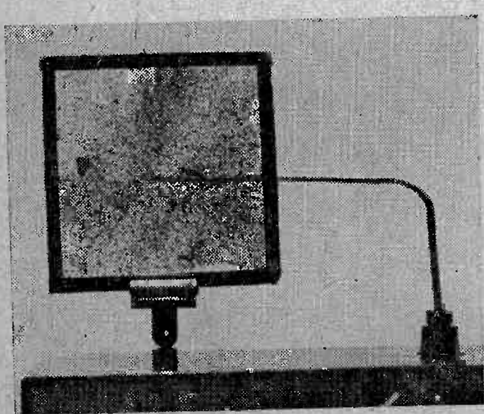
Additional electrodes can be added to get more sparks without putting so much *drag* on the pinwheel that it slows to a stop. In lieu of extra electrodes, mount a burned-out fluorescent light bulb (a 15-watter is good) so that one of its terminals is about a ¼ in. above the pinwheel tip. In a dark room, the combination of a crackling spark and a flashing light will produce a *psychedelic* effect that wows most people.

Lightning Machine. Now let's see how it's possible to stretch a ½-in. spark to 4 in. or more. This is done with the simple lightning machine shown in our photos.

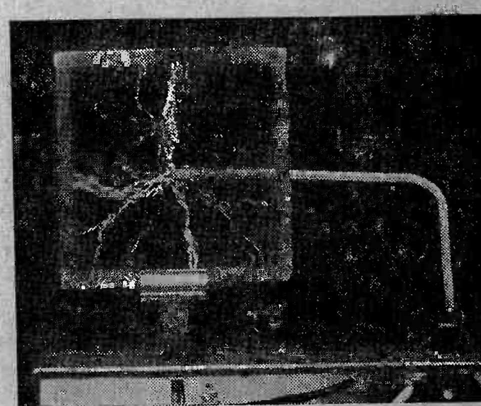
A sheet of glass measuring 4 x 4 in. is coated liberally with rubber cement. While the cement is still wet (work fast!) sprinkle it with iron powder. (This can be purchased from a science supply house.) Then quickly add pre-cut ¼-in. wide aluminum foil strips along the edges of the plate. Let dry.

Solder a short length of heavy wire to one tab of a spring paper clip. When this wire is attached to one of the coil terminals, the clip will support the glass plate and make electrical contact with the foil edging. Another piece of insulated, heavy wire is connected to the second high-voltage terminal and bent so that its bared tip just touches the iron powder in the center of the glass plate.

Operate this sparker in a dark room. Vivid sparks will leap repeatedly from the center contact to the foil edges. At times they travel in approximately opposite directions



Lightning machine comes in two versions. First has foil strips along edges (above), while second uses foil sheet at rear of glass coated with iron powder.



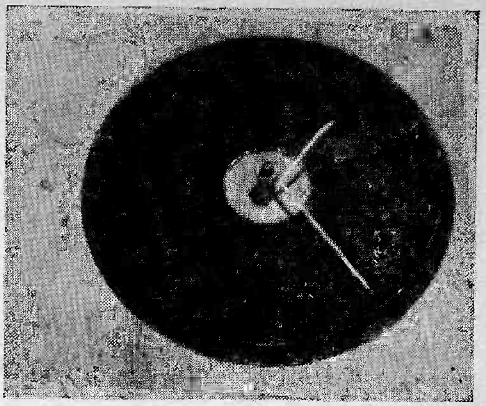
High-voltage electrode touches fillings on back of plate. Spring clip, with attached wire, supports glass and connects second terminal to foil edging.

to produce an apparent spark length of about 4 in. If the sparking is not as described, prepare another plate using more iron powder.

The spark generated by the coil is still only about a ½-in. long, but now it has been chopped up into a series of very short sparks that, collectively, create the impression of a long, continuous spark.

The discharge patterns produced with this spark plate are sharply defined when near a dark background. For a somewhat different effect, prepare another plate in the same manner but dispense with the foil edges. Instead, fasten a 4 x 4 in. sheet of foil to the rear of the glass. Don't cement it in place—just use bits of adhesive tape along the edges.

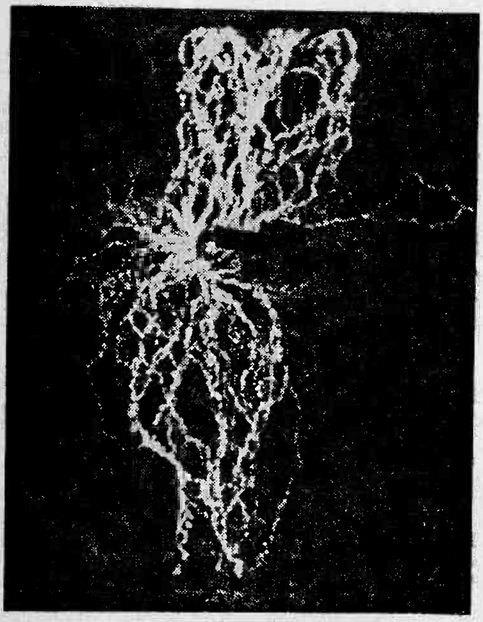
The plate is set up in the same way as before. The clip makes contact with the foil backing and the wire electrode touches the iron powder at the center of the plate. The discharge patterns will be like those seen before, but there will be a more delicate network of lavender sparks near the center of the plate—due apparently to a partial discharge through the glass to the foil backing. The *electric butterfly* was made with a foil-backed plate; the more delicate tracery cannot be seen in the photo.



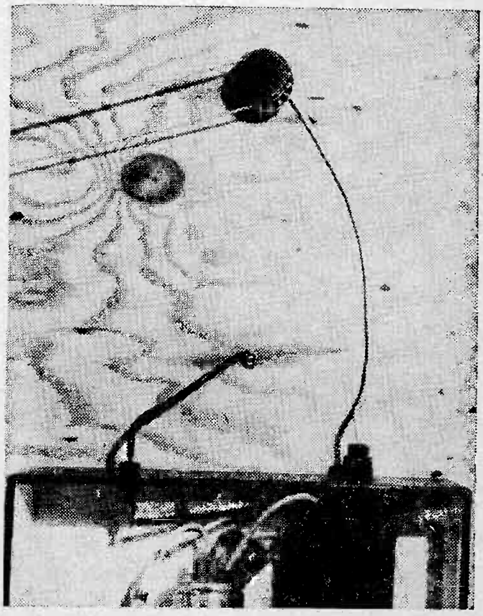
Display set up for both Bee and Aurora experiments. Disc covered with iron powder goes between ring and panel. Long sweep electrode is for Bees.

Electric Bees. These little devils seem to be buzzing angrily in a circle when your large circular *multi-spark generator* goes into action. This is a spectacularly noisy demonstration, but the basic idea is very simple. A large wire ring is connected to one high-voltage terminal of your spark coil, while a motor- or hand-driven sweep electrode—connected to the other terminal—whirls around to generate a series of sparks that jump to the ring.

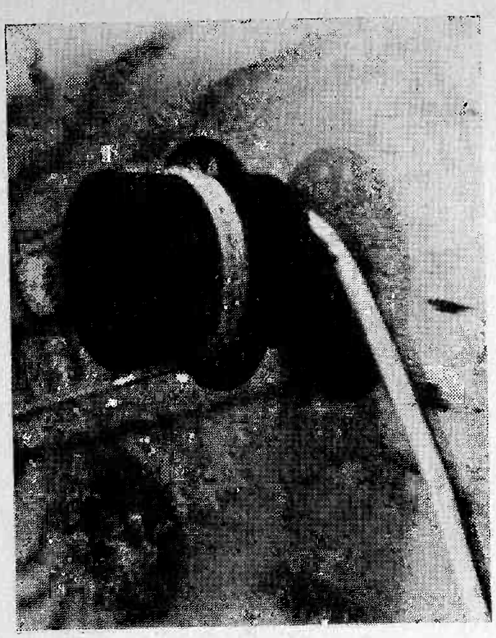
You can make the 12-in. dia ring from any heavy uninsulated wire. But it will be



Electric Butterfly is typical of discharge obtained with foil-backed plate. Delicate tracery isn't seen.



Rear of Bee/Aurora rig. Cotton belt on pulley goes to motor or crank. Short wire leads to ring.



Makeshift pulley made from rubber stopper and large lock washer. Long wire from spark coil makes contact with metal tube used for axle bearing.

far easier to combine the *next* experiment with this one if the ring is made from a metal strap about ⅜ in. wide. The author used the top ring from a discarded lamp shade by cutting out the center spokes and removing all but ¾ in. of the side wires leading to the lower ring of the shade. The ¾-in. pins left on the ring mount easily on a plywood panel. Simply push the pins into holes drilled at appropriate places on the panel.

Drill a hole through the wood panel at the exact center of the wire ring. Rig up some sort of wobble-free axle to pass through the board. Then on one end of the shaft, attach a small pulley wheel (you can probably improvise one from a rubber stopper and a large lock washer), and on the front end, attach a *removable* sweep arm fashioned from a stiff piece of insulated wire. The tip of the wire should be a ½ in. from the ring.

You can operate the sweep arm with a variable speed motor and a string belt. If the sweep arm turns freely, even a small toy electric motor will do; add a rheostat control if you like.

If you can't come up with a motor, make a hand-cranked pulley wheel and mount it on a board away from the high-voltage terminals of the coil. Be sure to use a non-conducting belt so that the motor—or your hand—is electrically isolated from the high voltage.

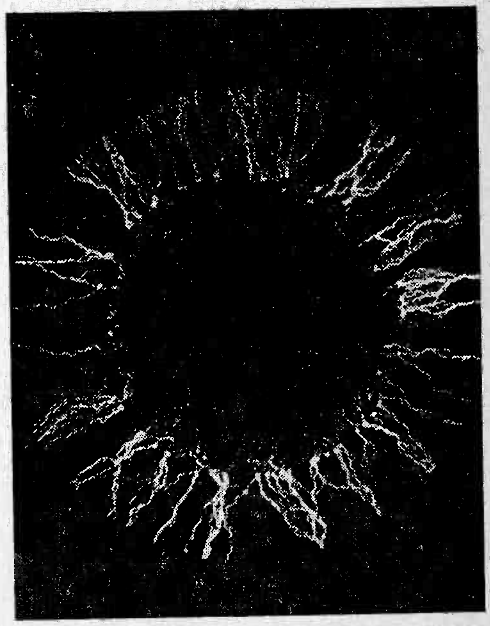
From one terminal of the coil lead a heavy wire to the metal tube that serves as a bearing for the sweep arm. A lead from the other terminal is attached to the ring.

Run the sweep arm at a speed of about 1 to two rps. A series of noisy sparks will be seen all around the ring. They exhibit a curious stroboscopic effect as they drift back and forth slowly. If you slow the sweep arm enough, the electric bees will bunch up into a swarm that circles round and round.

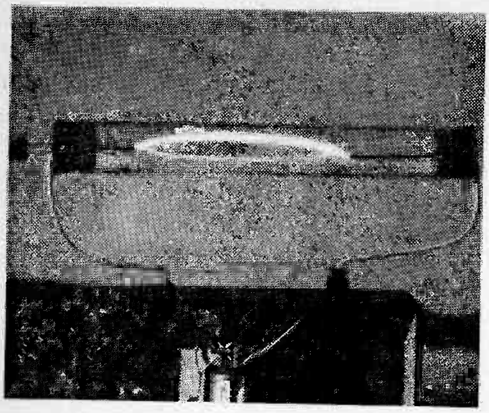
This experiment is a good showpiece. It also demonstrates that the seemingly continuous spark from a coil is actually a series of pulses.

Aurora Electricalis. The electric bee setup can be modified in two ways: by addition of an iron-powder discharge plate, and by substitution of a shorter sweep arm. This will get you a nifty version of your own Northern Lights.

The discharge plate is made from a stiff cardboard disc about 1-in. larger in diameter than the metal ring. In the center of the disc cut a 3-in. dia hole, and then coat the disc liberally with iron powder, using rubber cement as before. Mount the disc *between* the ring and the wood panel so that the ring makes electrical contact with the iron powder. *(Turn page)*



Aurora Electricalis experiment produces long, flickering sparks. Discharge is peppered with tiny specks.



Curved streamer leaps across terminals 6 in. apart. Spark curves upward; lower discharge disappears.

The shorter sweep arm (about 3½ in. long) should reach to a point midway between the ring and the edge of the center hole. The bared tip of the sweep arm should skim very close to, but not actually touch, the surface of the disc.

Again, in the dark, set the sweep arm in motion and activate the coil. You'll see a series of small but bright pinpoint sparks along the sweep track, while the rest of the disc will be covered with an intricate lacework of electrical discharges.

Vacuum Streamers. If you have a mechanical vacuum pump, or can borrow one from a school lab, setting up a vacuum discharge tube is well worth the effort.

If possible, use a *plastic* tube about 10 in. long, 1½ in. in diameter, and having a wall thickness of at least ⅛ in. A ¼-in. dia tube can be used, but the larger tube shows up the streamer phenomenon better and makes it easier to add chemicals into the tube. Glass tubes can be used, but they should be shielded with a heavy, plastic sheet in case they implode.

Fit a rubber stopper into each end of the tube. Use the softer, white, gum-rubber type if available. Poke a hole into the center of each stopper with a sharpened needle or similar tool. Electrodes made from #12 wire are forced through these holes so that their tips—inside the tube—are about 6 in. apart. Also add to one stopper a short glass or plastic tube to which the pump hose can be fastened. Be sure that all connections to large tube are as leak-proof as possible.

After the electrode wires have been connected to the spark coil, turn out the room lights and activate the coil. Note that no discharge is seen. Turn on the vacuum pump. Immediately a lavender glow develops which changes into a continuous, wavy streamer bridging the space between the electrodes. If the streamer is not obtained when the vacuum pump is working at maximum efficiency, turn off the equipment and shorten the electrode gap.

Magnets placed on or near the tube will distort the streamer, proving that the discharge is composed of charged particles. Be sure to de-activate the coil before placing the magnets into position!

When the residual gas in the tube is air, the streamer will have a characteristic lavender color because of the presence of nitrogen. If you were to remove most of the air and feed in small amounts of other gases, different streamer colors would be obtained. Neon gas would provide a brilliant orange-red color, helium would give yellow, hydrogen would be red, and mercury vapor would produce a greenish hue. If the tube is coated with fluorescent chemicals or minerals, the ultraviolet light generated by the discharge will cause the tube to glow in various colors.

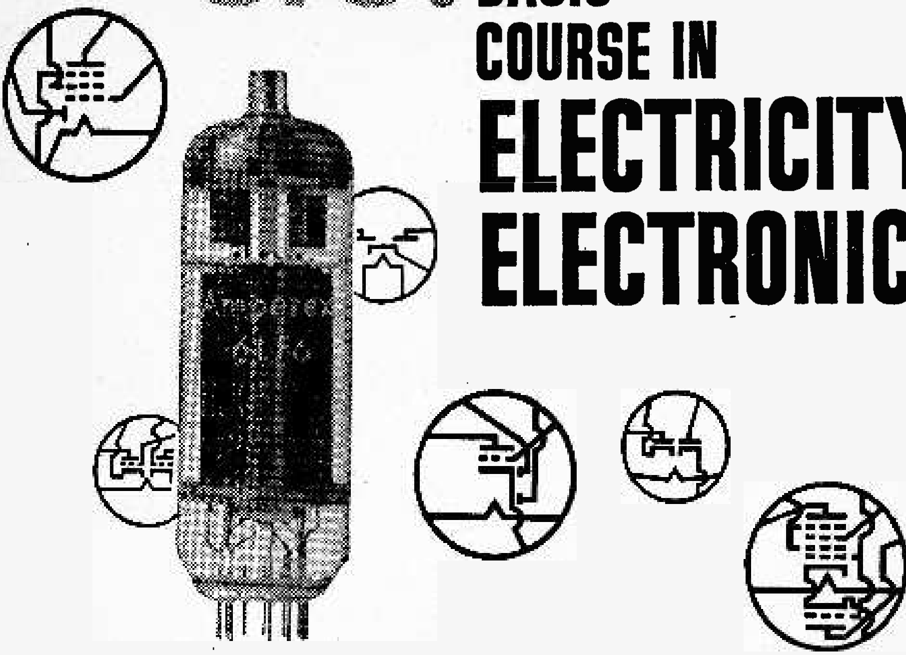
Rare gases are not readily available to most amateur experimenters. However, vari-colored discharge streamers can be obtained in another way—namely, by introducing the vapors of various liquids. For example, place a drop or two of strong ammonia into the tube before it is sealed and evacuated. The streamer will become a bright, creamy white. Ethyl alcohol vapor produces a pale blue-white streamer while acetic acid causes a slightly bluer color.

When using organic solvents such as acetic acid, use the smallest possible amounts because the plastic will be etched by such materials. No such problems are encountered with glass tubes.

Many interesting experiments can be performed with the vacuum tube using only the limited vacuum attainable with a mechanical pump. If the pressure in the tube is reduced still further—say with the aid of a mercury pump—the streamer will gradually broaden until it fills the tube at a pressure of about 20-30 millimeters of mercury. At still lower pressures, striations begin to appear which, on continued evacuation, develop into classic zone patterns known as Crookes Dark Space,

(Continued on page 107)

e/e's BASIC COURSE IN ELECTRICITY & ELECTRONICS*

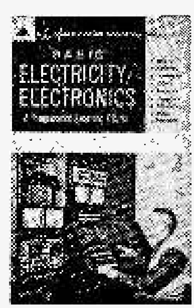


PART V—UNDERSTANDING VACUUM TUBES

WHAT YOU WILL LEARN. You are now going to learn the basic principles about a device you have seen before—a vacuum tube. One member of the vacuum-tube family is a diode. The vacuum-tube group has several other members, many of which amplify and reshape the signals passing through your radio and television receivers. You will become familiar with the other types of tubes, learn how they work, and become acquainted with how some of them are used in circuits.

WHAT ARE VACUUM TUBES?

You may know part of the answer to this question. In fact, at the beginning it's almost like counting on your fingers. If a *diode* has *two* active elements (cathode and plate) suspended in an evacuated (vacuum) enclosure (tube), then all other vacuum tubes probably have the same number of elements or more. Let's look ahead. A



* This series is based on **Basic Electricity/Electronics**, Vol. 1, published by **Howard W. Sams & Co., Inc.**

triode is a vacuum tube with *three* active elements. A *tetrode* has *four*, and a *pentode* has *five*. There are other tubes with more elements, and still others with special elements. However, they all obey the sam basic principles that will be discussed here.

Each vacuum tube has a *heater* to *heat* the cathode. Although the heater itself is not considered an active element, it performs a necessary function—it produces the heat to boil a cloud of electrons away from the cathode. Earlier vacuum tubes combined the function of the heater and cathode into one element—the filament. This technique is still used in some vacuum tubes.

HOW DOES A VACUUM TUBE WORK?

In a diode the heated cathode emits electrons and the plate receives electrons. The plate is kept positively charged to accept these electrons in a continuous flow. Have you wondered how a diode is constructed to perform these functions?

Vacuum-Tube Fundamentals

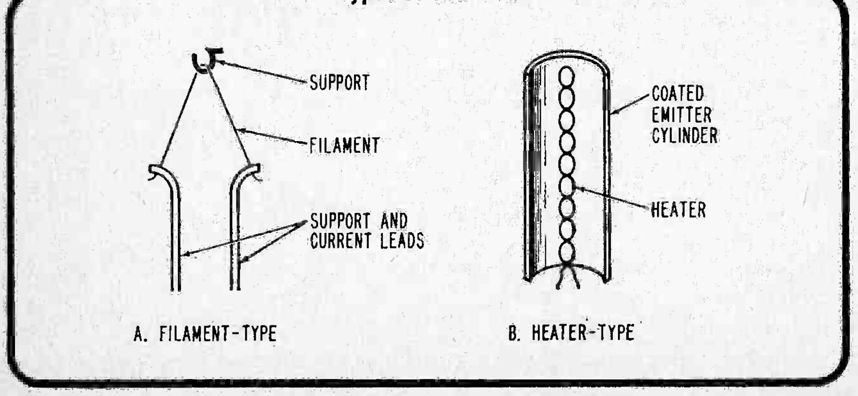
Although the heaters, cathodes, and plates of the various kinds of vacuum tubes may be built to slightly different dimensions and shapes, the operating principles of all vacuum tubes are the same. The tube elements are placed in a vacuum to eliminate any air molecules that would retard the free flow of electrons to the plate.

Heater and Cathode. The heater (filament) is a resistive wire which, when energized, raises the temperature of the cathode to the desired electron emitting level. Heater-cathode combinations are of two types.

Part A shows a filament-cathode. The single wire serves as both the heater and cathode; it is made of a material (normally coated or uncoated tungsten) that emits electrons when hot.

Part B shows a heater-cathode combination in which there are two separate elements. The cathode, coated with an electron-active substance, fits like a sleeve over the heater.

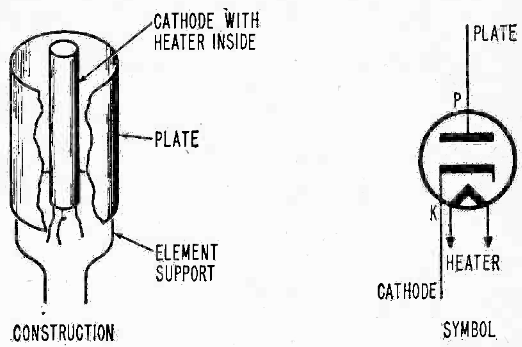
Types of Cathodes



The filament-cathode requires less current to heat it to an electron-emitting temperature. This type of cathode works best when connected to a DC voltage source. If energized by AC, tube current would vary with the AC alternations. But because AC current is more easily supplied, most of the tubes used in electronic equipment are of the heater-cathode type. The heater and the cathode are electrically insulated from each other so that the alternating current flowing through the heater does not affect the tube current.

Plate. The plate is usually a metal cylinder surrounding the cathode. Construction details and the accepted diode tube symbol are shown in the diagram.

Diode Construction and Symbol



Cathode Temperature. The number of electrons that form in a cloud around the cathode depends on the cathode temperature. The temperature of the cathode is controlled by the heat generated by the filament. There is an upper limit, however, beyond which a further increase in temperature will not cause an increase in electron emission. This is called *cathode-temperature saturation.*

Plate Voltage. The plate attracts electrons from the electron cloud when the plate voltage is positive with respect to the cathode. By raising and lowering the plate voltage, a greater or fewer number of electrons will be drawn from the cathode. This increases or decreases the value of plate current (tube current). The upper limitation, where a further increase in plate voltage will not attract any additional electrons, is called *plate-current saturation.*

Q1. A cathode emits ----------.
Q2. Plate current flows when the plate is ---------.
Q3. Plate current can be increased by increasing the -------- on the -----.

Your Answers Should Be:
A1. A cathode emits *electrons.*
A2. Plate current flows when the plate is *positive.*
A3. Plate current can be increased by increasing the *voltage* on the *plate.*

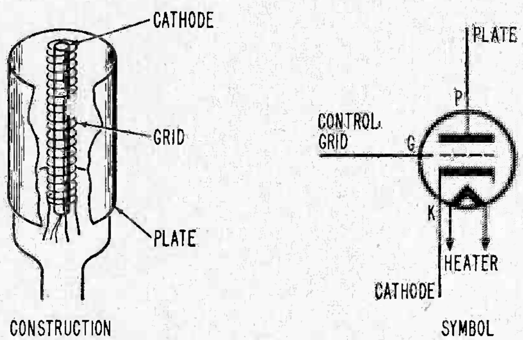
The Triode

If a diode has two active elements, it is logical that a triode must have three.

The cathode and plate are similar to those in the diode. The third element is a *control grid.*

Construction. The elements in a triode are supported in the same manner as they are in a diode. The control grid is a spiral of fine wire positioned between the plate and cathode. It is much closer to the cathode than to the plate.

Triode Construction and Symbol



Operation. Plate current in a diode is determined by cathode temperature and plate voltage. In a triode, the voltage of the grid with respect to the cathode also controls the amount of plate current. Since the cathode's temperature is constant, plate current is *not* affected under normal conditions and is not to be considered in the normal operation if in vacuum tube.

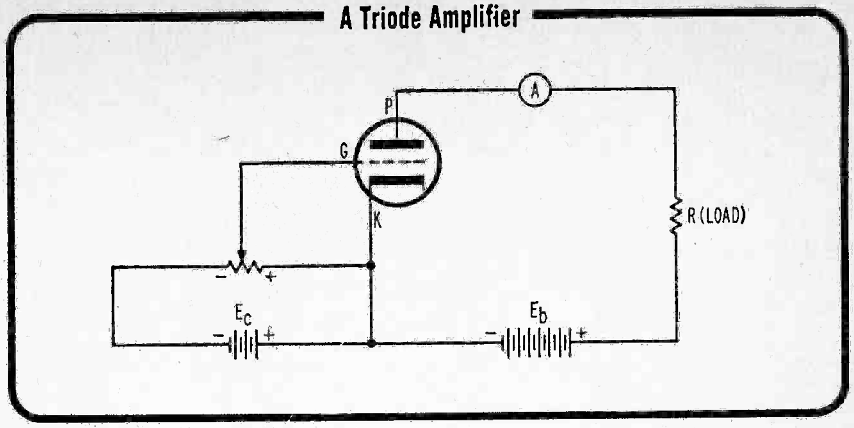
Because of its nearness to the cathode, the grid has greater control over the number of electrons reaching the plate than the plate does itself. Large changes in plate voltage cause only small changes in plate current. But small changes in grid voltage cause large changes in cathode-to-plate current.

In fact, if the grid is made sufficiently negative with respect to the cathode, the flow of current will be stopped or *cut off.* The lowest voltage at which this occurs is called the *cutoff bias.* Bias voltage is the normal voltage difference between cathode and control grid. The grid is usually more negative than the cathode.

Triode Circuit. Below is a circuit which shows how a triode functions.

Battery E_b is connected such that the plate is positive with respect to the cathode. In an actual circuit the positive voltage for the plate is normally obtained from a power supply. Battery E_c places a negative voltage on the grid with respect to the cathode.

When the grid voltage is sufficiently negative to cut off the plate current, no current will flow through load resistance R. If made less negative, the grid will allow some current to flow and a voltage will be developed across R (load). If made even less negative, more plate current will flow and a greater



voltage will be dropped across the resistor.

Assume that the change in grid voltage in the last two steps is 2 volts (from −6 to −4). Also assume that the change in the plate-resistor voltage is a total of 60 volts. This means that the grid-voltage change has been amplified 30 times (60/2). An AC signal on the grid would cause the same amount of amplification. This is how a triode amplifies.

Q4. The control grid is mounted closer to the (cathode, plate) than to the ------.

Q5. The voltage on the control grid that stops plate current is called ------- bias.

Q6. A triode amplifies because ------ changes in grid voltage cause ------ changes in plate voltage.

Your Answers Should Be:

A4. The control grid is mounted closer to the *cathode* than to the *plate.*

A5. The voltage on the control grid that stops plate current is called *cutoff* bias.

A6. A triode amplifies because *small* changes in grid voltage cause *large* changes in plate voltage.

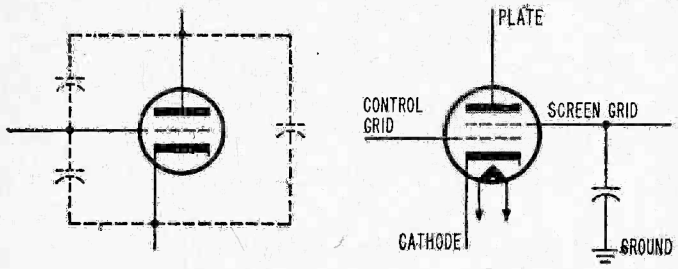
Multielement Tubes

Tubes having more than three elements are called *multi-element* tubes. The most common types in this group are the tetrodes (4 elements) and pentodes (5 elements).

Tetrodes. Triodes are very good amplifiers of low-frequency signals. At high frequencies, however, such as those used in radio and television, a triode distorts (changes the form of) a signal during amplification. The distortion is caused by the capacitance that exists between the plate and grid. Since these two elements are conductors separated by an insulator (vacuum), a capacitor is formed. Capacitance also exists between the other elements, but has less effect on the signal.

Part A in the diagram (on the next page) shows *interelectrode* (between elements) *capacitance* in a triode. Plate voltages are fed back to the control grid through this route, causing distortion. In a tetrode, the extra grid (called a *screen*) between the control grid and plate reduces the interelectrode capacitance and can be used to divert the feedback voltage to *ground* through a capacitor. Note the tetrode symbol in Part B. *Ground* is a wire (or the chassis) which serves as a common conductor for, or connection to, other components.

A Tetrode Is Better For High Frequencies

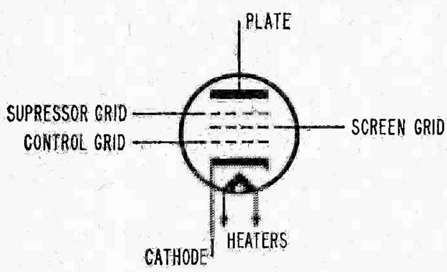


A. INTERELECTRODE CAPACITANCE

B. SYMBOL FOR TETRODE

Pentodes. The fifth element in a pentode alleviates another problem encountered in vacuum tubes—the problem of *secondary emission.* Many of the electrons making up the plate current strike the plate with sufficient velocity to release other electrons from the plate material and bounce them back into the space between the screen grid and plate.

Symbol For Pentode



The fifth element of the pentode is called a *suppressor grid.* This element is usually connected internally to, and has the same potential as, the cathode. In other words, the suppressor grid is negative with respect to the plate. Spacing between the turns of wire of the suppressor grid is wide enough for plate current to pass through, but yet sufficiently close enough to repel the negative secondary electrons back to the plate.

Q7. ––––––––––––– ––––––––––– between the plate and grid of a triode causes signal distortion.

Q8. The fourth element of a tetrode is called a ––––––––––.

Q9. The screen grid bypasses the distorting feedback voltage to –––––– through a capacitor.

Q10. The –––––– symbol is an indication of a common connection to a wire or chassis for several components.

Q11. Electrons that bounce off the plate due to current flow are called ––––––––– –––––––– electrons.

Q12. The ––––––––––– grid of a pentode repels electrons back to the plate.

Q13. The ––––––––––– grid is tied to the cathode.

Your Answers Should Be:

A7. *Interelectrode capacitance* between the plate and grid of a triode causes signal distortion.

A8. The fourth element of a tetrode is called a *screen grid.*

A9. The tetrode bypasses the distorting feedback voltage to *ground* through a capacitor.

A10. The *ground* symbol is an indication of a common connection to a wire or chassis for several components.

A11. Electrons that bounce off the plate due to current flow are called *secondary emission* electrons.

A12. The *suppressor* grid of a pentode repels electrons back to the plate.

A13. The *suppressor* grid is tied to the cathode.

VACUUM-TUBE CIRCUITS

There are thousands of different vacuum-tube circuits. No one could hope to learn how each circuit works by memorizing their operating details. However, you can analyze how they work by applying the principles of electricity and electronics. You have already acquired most of the fundamental principles, but not at the depth required to be an expert. See if you can apply some of these principles to the circuits that follow.

Full-Wave Vacuum-Tube Power Supply

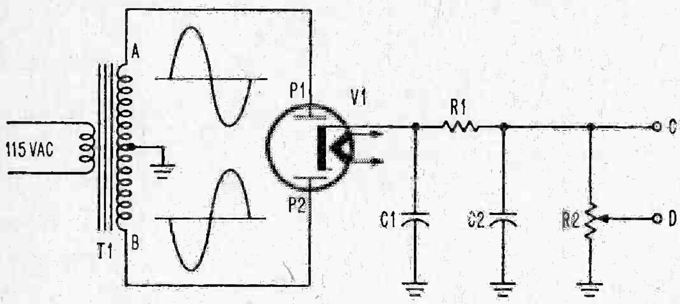
The circuit on the next page performs a rectification function—it rectifies alternating current into smoother direct current.

Transformer T1 steps 115 volts AC up to the value desired on the secondary winding. Each terminal of the secondary is connected to a separate plate of the *twin diode* V1. The secondary winding of the transformer is *center-tapped* to ground.

C1, R1, and C2 form the filter network. By storing a charge during each AC half cycle, and discharging slowly through the resistors, the capacitors smooth out the ripple in the pulsating DC. R2 is a bleeder resistor that provides selected DC voltages for vacuum tube circuits.

Note that C1, C2, and R2 each have one side connected to ground. The ground symbol indicates a common connection for all components terminated in this manner.

A Full-Wave Power Supply



The principle of a center-tapped transformer winding is the manner in which AC voltages appear on either end of the winding. The first half cycle appearing at point A is positive with respect to ground. This makes the center tap more positive than point B, or point B is, in effect, swinging in a negative direction.

When point A is positive, point B is negative. Plate P2 is cut off, but P1 conducts. Current travels through the upper half of the secondary to ground, up through R2 (charging the capacitors on the way) through R1, and then to the cathode. The top of R2 is positive with respect to ground. Point C is positive to ground as is point D. However, point D is at a lower value.

When point A swings negative, point B swings positive. What then happens in the filter network is exactly the same as discussed in the preceeding paragraph.

Q14. When a negative half cycle is developed from point A to ground (P_1, P_2) conducts.

Q15. With current from cathode to P_2, current flows through R_2 from (top to bottom, bottom to top).

Q16. When current leaves P_1, it will enter R_2 at the (top, bottom) and leave at the (top, bottom).

Q17. When P_2 conducts, C_1 will charge by storing excess electrons on the (top, bottom) plate.

Q18. The vacuum tube in the circuit is a ----- -----.

Q19. The voltage at point A would be measured from point A to ------.

Q20. If the voltage output at the top of R_2 is 200 volts, what will be the voltage at point D if the top is 3/5 of the resistance above ground? *(Continued on page 89)*

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Continued from page 86

Your Answers Should Be:

A14. When a negative half cycle is developed from point A to ground, *P2* conducts.

A15. With current from cathode to P2, current flows through R2 from *bottom to top.*

A16. When current leaves P1, it will enter R2 at the *bottom* and leave at the *top.*

A17. When P2 conducts, C2 will charge by storing excess electrons on the *bottom* plate.

A18. The vacuum tube in the circuit is a *twin diode.*

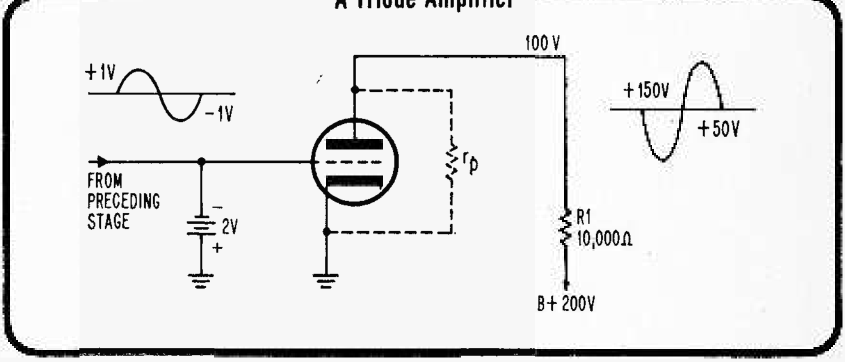
A19. The voltage at point A would be measured from point A to *ground.*

A20. 3/5 of 200 is *120 volts.*

Triode Amplifier

The circuit below is that of a triode amplifier. The B+ voltage of 200 volts is obtained through the load resistor from the power supply. The control grid has a fixed bias of −2 volts. Since there is a common connection through ground, the grid is two volts negative with respect to the cathode.

A Triode Amplifier



With this bias, plate current is 0.01 amp (10 ma). The cathode-to-B+ path contains R1 and r_p as resistances in series. R1 is the load across which the voltage for the next circuit is developed; r_p is a variable resistance existing between cathode and plate. This variable resistance is known as the *plate resistance.* When plate current increases, r_p decreases; when plate current decreases, r_p increases.

With 0.01 amp flowing, there will be a 100-volt drop across R1 ($E = IR$). Since B+ is 200 volts, there will be a 100-volt drop across r_p ($200 - 100$). This is the same as saying that the voltage from plate to cathode is 100 volts.

The AC signal on the grid swings one volt positive. Added to the −2-volt bias voltage, the grid is now at −1 volt with respect to the cathode. Plate current increases to 0.015 amp. The drop across R1 is now 150 volts, leaving 50 volts across r_p. A change of 1 volt on the grid has changed the plate voltage from 100 volts to 50 volts.

When the AC signal swings one volt negative, grid bias becomes −3 volts. Plate current decreases to 0.005 amp. The voltage drop across R1 is now 50 and across r_p, 150. Once again a change of 1 volt on the grid has caused a change of 50 volts on the plate. This means that the gain of the tube is 50.

Q21. When plate current increases, r_p ----------.

Q22. Gain of an amplifier is determined by dividing the change in -------------- by the change in ------------.

Your Answers Should Be:

A21. When plate current increases, r_p *decreases.*

A22. Gain of an amplifier is determined by dividing the change in *plate voltage* by the change in *grid voltage.*

WHAT YOU HAVE LEARNED

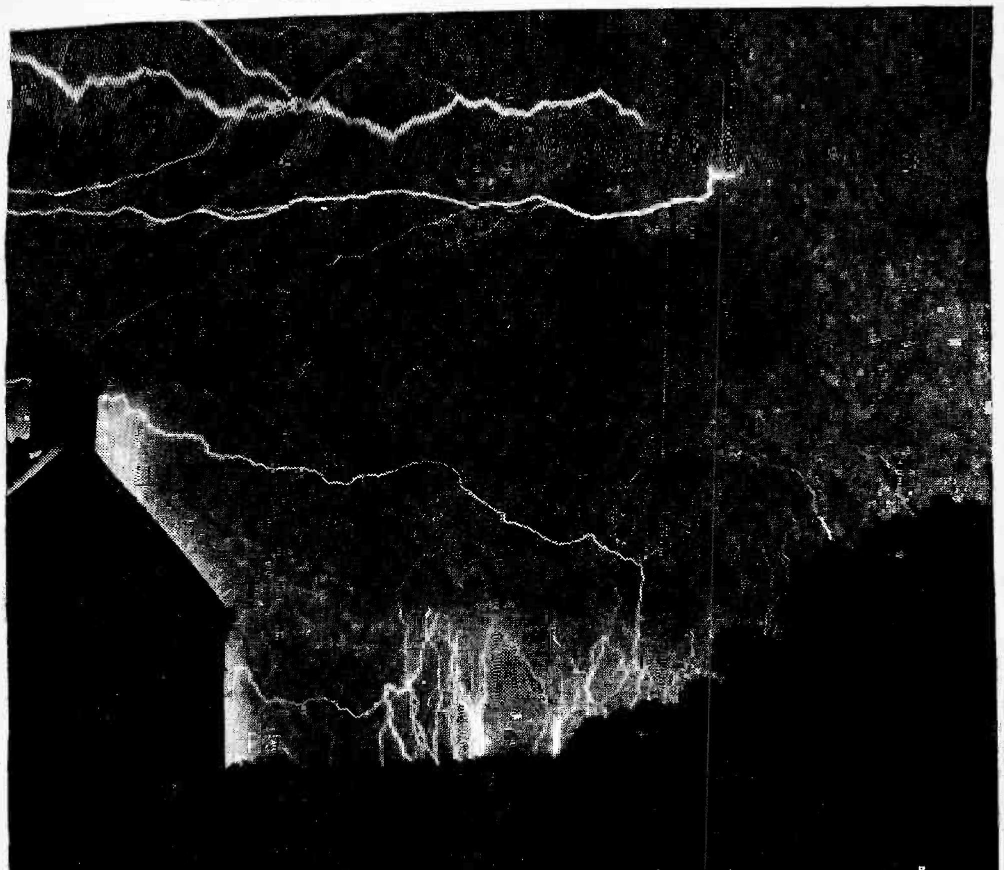
1. A diode has two active elements—a cathode and a plate. When heated, the cathode emits electrons. The plate draws current when it is more positive than the cathode.
2. A triode has a cathode, plate, and control grid. The control grid regulates the amount of plate current. A small change in grid voltage causes a large change in plate current and voltage.
3. The additional grid in a tetrode is called the screen. It eliminates the distortion effects of interelectrode capacitance.
4. A pentode has a suppressor grid that returns secondary electrons to the plate.
5. The ground symbol indicates a common wire or chassis for all components terminated to ground.
6. A full-wave vacuum-tube power supply uses a twin diode and a transformer center-tapped-to-ground secondary as input voltage.
7. Varying plate voltage varies plate current until the limit of plate-current saturation is reached.
8. Varying cathode temperature varies the supply of available electrons and therefore plate current. Maximum electrons will be available at cathode-temperature saturation.

NEXT ISSUE: PART VI—Understanding Basic Circuit Actions

This series is based on material appearing in Vol. 1 of the 5-volume set, BASIC ELECTRICITY/ELECTRONICS, published by Howard W. Sams & Co., Inc. @ $19.95. For information on the complete set, write the publisher at 4300 West 62nd St., Indianapolis, Ind. 46268.

L REPORT:

HUNDERSTORM in a DOUGHNUT



Generating power at home where it is used will bring an end to major regional blackouts!

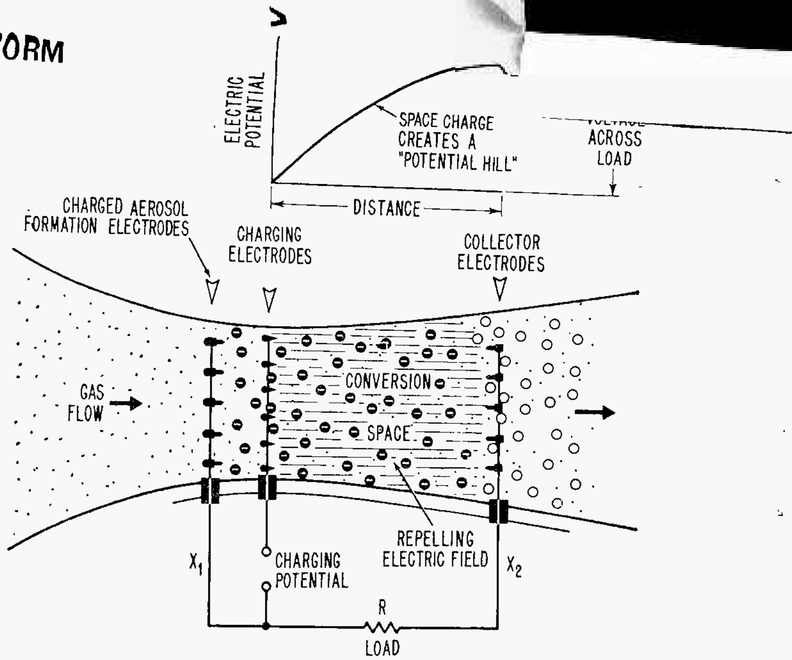
By Jorma Hyypia

Problem. If you had to, how would you generate the electric power needed to operate all the electrical devices in your home *without* using batteries, fuel cells, or generators requiring magnetic fields and moving parts?

Answer. Tap the electric power in a bottled thunderstorm.

Nonsensical as it sounds, you may someday add a grapefruit-size "doughnut" to your furnace in order to make all your own electric power by utilizing the same natural phenomena that produce lightning from water droplets in the clouds. At least so believe Alvin and Mortimer Marks, president and vice president respectively of the Marks Polarized Corporation of Whitestone, New York. These inventors aren't just talking theory; they have already put together a Charged Aerosol Heat-Electric Power Gene/e THUNDERSTORM

Imitate nature to get an ETD generator. You need a gaseous environment, suspended water droplets, and a charging device. In nature, these are, respectively, air, clouds, and turbulence. But instead of random thunderstorms, you have to bottle controlled discharges for a stable, continuous supply of electricity.



erator that really *works*!

You had better believe they are serious. *You* and other taxpayers of the nation have already underwritten this project to the tune of some $650,000—the amount of money already sunk into the Marks research project by the United States Navy.

Moreover, the progress made by the Marks brothers has inspired other research groups to work on similar devices. As Alvin Marks puts it: "Our 35 years of pioneering work on the charged aerosol generator is coming to fruition and has inspired many others to enter this field. A group at Wright-Patterson Air Force Base established a facility for the study of the charged aerosol generator. They have scaled up a device similar to that of Marks to produce a thousand watts at one million volts. Their work independently corroborates Marks' work."

Curtis-Wright Corporation, partially supported by the U. S. Air Force, has also been working on the charged aerosol generator. And Foster-Wheeler and Gourdine Systems have been awarded a contract by the Office of Coal Research of the Department of the Interior to engage in similar research. Clearly, millions are being invested into the development of this unique power source, and many researchers apparently are convinced that the Marks idea is anything but a tempest in a teapot.

Delayed Development. Although the Marks brothers call themselves "pioneers" in the development of *electrothermodynamic* (ETD) power generation, they point out that the basic principles involved were discovered about 125 years ago. Why, then, did we not have this power source long ago? Because a number of other important scientific discoveries had to be made before the principle of heat-to-electric power could be put to practical use.

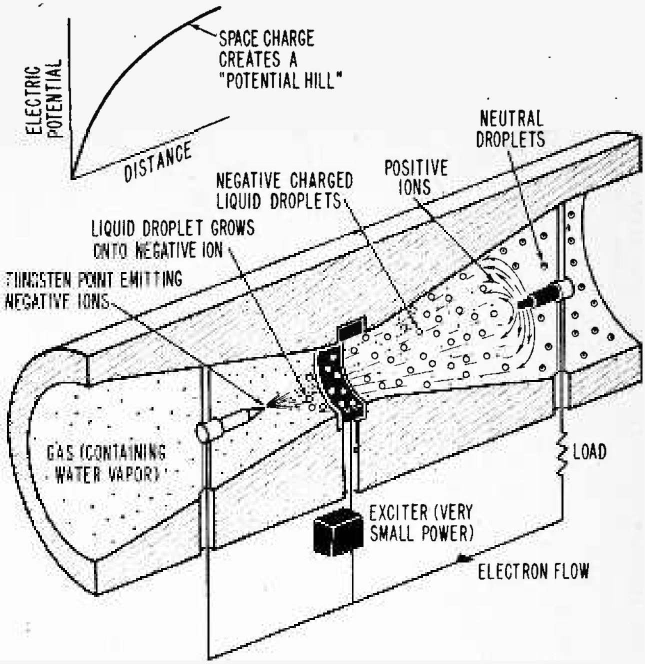
Meanwhile, the generation of electric power proceeded faster along a long "detour"—the familiar heat-to-mechanical-to-magneto-to electricity route that is the basis of our modern power generation system. It is now time to get back on the shorter heat-to-power route.

In 1842, Englishman William George Armstrong described the primitive electrohydrodynamic steam generator shown in the accompanying illustration. Large condensed water droplets, charged by friction, were carried by a steam jet to a collector electrode. Sparks having a potential difference of several million volts, at very small current, were produced.

Later, other scientists discovered other relevant phenomena. Von Helmholtz and Richarz, in 1890, described the condensation of steam in the presence of ions. In 1914, Zeleny produced charged aerosol droplets from a liquid surface exposed to a strong electrical field. In 1924, Millikan established the elementary charge of the electron. In 1932, Pauthenier and Moreau-Hanot studied the charging of small metallic and dielectric spheres in electrical fields, while at the same time Vollrath utilized the frictional charging of silica dust in an electric generator capable of producing an output of 260 kilovolts at 80 microamperes.

Alvin Marks began his experimental and

Helium under pressure flows through torus and is activated by aerosol jets. Thus, two elements of system—gaseous environment and droplets—are obtained. When water droplets are charged by external source, gaseous flow propels them to discharge electrodes. This liquid aerosol can be formed by either condensation or electro-jet methods (see text).



theoretical studies on the conversion of heat to electric power in 1932, and subsequently obtained patents describing the use of submicron charged liquid particles in a moving gaseous system. Before looking at the Marks generator in more detail, it might be well to examine briefly the "thunderstorm" phenomenon in which ETD power generation is related.

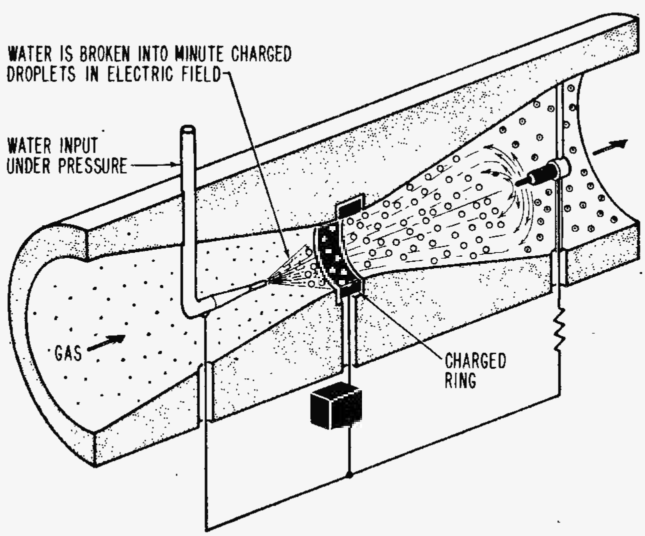
Bottling a Storm. Ever since Ben Franklin flew his kite, man has dreamed of tapping the enormous electrical power contained in storm clouds. Although this still remains a dream, knowledge acquired about the nature of atmospheric electrical disturbances has led to the very real possibility of creating and bottling *synthetic* electrical storms.

When warm, moist air near the ground flows upward into cooler air, the water in the air condenses to form clouds. Heat is released in the process to further increase the cloud-forming turbulence. As the storm cloud continues to develop, charged particles (ions) within the cloud separate into clumps of positive and negative charges. When the charge differences between clouds, or between a cloud and the earth become large enough, a lightning discharge occurs.

The elements vital to this natural electric generator are: a gaseous environment (air); small, suspended droplets of water (cloud); and a charge-building system (turbulence friction).

To make an ETD generator, it is necessary to bottle these same elements in such a way that the discharges will be controlled and continuous instead of intermittent as in the case of lightning.

Gas Flywheel. In the Marks generator,



In spite of externally applied electric field, input power is negligible compared to power output obtained from ETD system. Gaseous flow is continuous and silent. It is creation of space charge between electrodes which produces potential (hill) that causes aerosol particles to do work.

helium gas is contained in a doughnut-shaped bottle (torus) called a gas flywheel. Helium is used because it has very low conductivity and a high electrical breakdown strength. This gaseous system is set into motion by aerosol steam jets issuing at sonic velocity from spray bars. This provides two of the three necessary elements—a turbulent gaseous system, and water droplets.

The water droplets must be electrically charged by means of an external electric power source. Free ions are too small to be moved by the streaming gas, against the field; the gas molecules simply fly past the ions without materially affecting them. However, if the ions are "bundled" onto water droplets they can be moved along toward the discharge electrode because the water droplets are large enough to be dragged along by the moving gas.

The need for a secondary source of electric power to provide the necessary charge to the aerosol may seem like a drawback. However, the power requirement is small, and readily met with available generating equipment. Remember, we have a very similar situation in our automobiles, and think nothing of it. A battery is needed to start the engine; but thereafter the engine, working together with a generator, supplies much *more* electric power than could ever be obtained from the battery. There is enough generated power to fire spark plugs and operate the radio, lights, air conditioning, electric windows and other equipment as well as keep the battery *re-charged*.

In like manner, a small amount of electrical input enables the *ETD* generator to produce a relatively large amount of power—enough to supply a house or apartment building, depending on the size of the generator used.

Charging System. The Marks brothers have discovered that either a condensation or electrojet system can be used to simultaneously form and electrically charge the liquid aerosol (see diagrams).

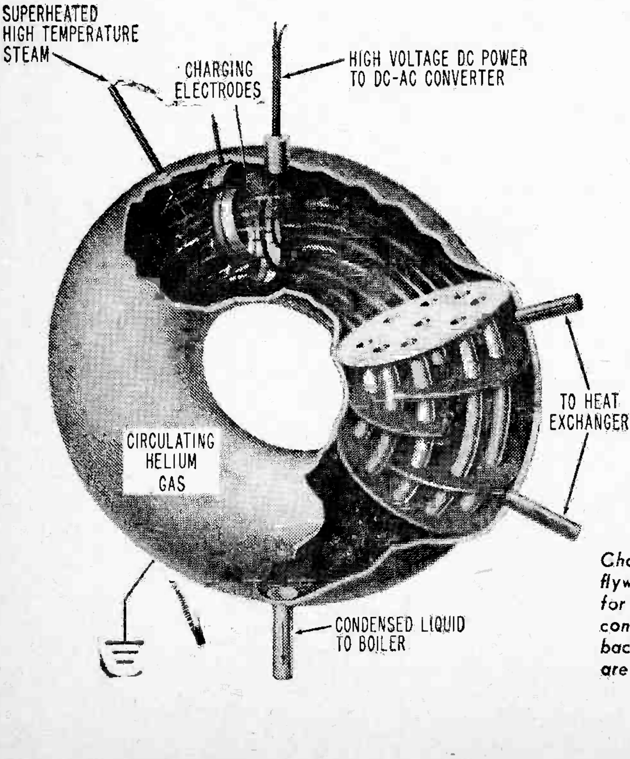
In the condensation system, a small diameter tungsten wire is exposed to an intense electrical field. As the incoming gas emerges from the nozzle, it is supercooled by sudden expansion; the gas condenses out the individual ions to produce a highly concentrated, charged aerosol.

In the electrojet system, a thin stream of water is forced under pressure through a small hollow needle; the jet is immediately subjected to both the motion of the gas in the flywheel and to an intense electrical field. The water particles break up into highly concentrated, charged aerosol.

In both systems the expenditure of input electrical power is "negligible" compared to the output of electrical power.

Power Transducer. The key to the functioning of the charged aerosol generator lies in the simultaneous formation and charging of the aerosol in a moving gas, and its subsequent utilization as a power transducer. Each incremental part of the charged aerosol exists for only about 15 microseconds, being discharged after moving downstream only a few millimeters.

The diagram showing a theoretical model of the sys-



Charged aerosol generator is simply a gas flywheel. There are no moving parts except for gaseous flow. Steam previously used is condensed by heat exchanger and sent back to boiler. Efficiencies up to 70% are possible.

tem helps explain how this heat-to-electric power transformation occurs. The liquid droplets, formed and charged at electrode X_1, give up their charge to a downstream collector electrode X_2. The collector is connected through a load resistor (R) back to the charging electrode. Heat-kinetic power is converted to electrical power in space between two electrodes.

The charged aerosol creates its own *space charge* which results in an electrical potential "hill" against which the charged particles do work in the generator to create the energy transformation. The process is reversible and can be used for an electrostatic pump.

Note that the device requires no mechanical moving parts, only gas in motion. Only an electrical field is used; magnetic systems are not needed.

Advantages. Efficient charged aerosol generators can be fabricated in sizes from about 1 kilowatt up into the multi-megawatt range. This covers the entire gamut of electrical power requirements.

An *ETD* system can have a high power density of 0.1 to 50 megawatts/m^2, a high power concentration of 1 to 1000 megawatts/m^3, and a high power to mass ratio of 10^3 to 10^5 watts/kg.

There are no moving parts aside from the gas and steam, hence the equipment is silent and reliable. Investment and maintenance costs are low.

Prototype equipment already tested indicate that an *ETD* system can convert heat to electricity with an efficiency in the order of 60-70%. In contrast, modern power plants convert only 35% of the heat derived from fuel into electricity, 65% of the heat energy is simply wasted. Marks believes that the charged aerosol generator may eventually make conventional turbo-generating equipment obsolete.

How Soon? This is the *big* question asked about the *ETD* system. It is a reality now. A full-size 10kw high-power generator, already built under Government contract, is now being tested at the Marks lab. So we can honestly say, "It's around the corner."

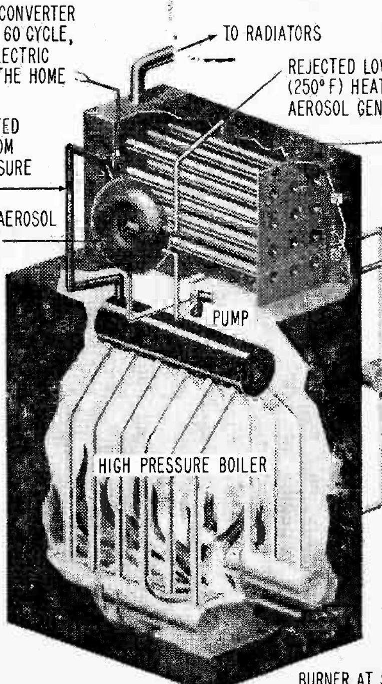
When will the generator reach the consumer market? That depends on how much money can be found to solve the remaining development problems. Says Marks: "If funds are made available, this device will be marketed in the near future instead of a decade or two."

According to Marks, very little initial capital will be required to generate electric power with an *ETD* system. Small electric generating units will be attached to family type heating units. Small businesses, cooperatives and other organizations (the armed services, for example) will be able to generate their own power at very low cost.

The man who has a bottled thunderstorm in his basement won't be groping about for candle stubs every time an electrical blackout occurs. His independent power system will go right on working.

If these predictions come true, not all the electrical storms will be inside the helium doughnuts. There will be plenty of turbulence, of a political-economic kind, within the conventional power generating industry.

But that's something that we, the consumers, won't have to worry about. We won't be holding the kite string. ■



Generator for electric power and heating. Doughnut shaped generator would be attached to a home heating unit. A small steam boiler and superheater could be used to drive generator. Rejected heat goes to radiators.

CB on the up and up

By Robert M. Brown

Here's how a 50,000-watt BCB station puts out traffic news from 5-watt CB

The highest operating Citizens Band two-way radio unit on the West Coast (and possibly the world) is operated by Seattle disc jockey Jim French of radio KIRO, a 50,000-watt AM station broadcasting at 710 kHz. The studio is located at the 580 ft. level of Seattle's well-known Space Needle. Citizens Band (CB) enthusiasts from the entire Puget Sound area have been reporting traffic snarls to Jim each morning now for almost three years. Sometimes the network does more than simply report traffic conditions.

"I once relayed a call from a man whose CB-equipped Mustang lost a front wheel," says Jim French, who operates under KIRO's CB callsign KRD-2355. "Additionally, we've summoned both the Washington State Patrol and an ambulance for a young woman who collapsed at the wheel as she drove onto the freeway."

"We've even helped follow a hit-run driver after he side-swiped a CBer in his car. The victim radioed the fleeing hit-run vehicle's position," Jim French continues, "while I relayed the information by telephone to the Seattle Police Department. Several other CB-equipped vehicles joined the chase and the culprit was apprehended within 10 minutes."

Service First. These incidents are only sidelights of the unique KIRO/KRD-2355 operation. Primary objective is to provide the radio station's audience—which numbers over 650,000 weekly—with the most accurate traffic information available. Twice daily Seattle's CB network swings into operation. First, during the six to 10 a.m. "The Jim French Show" and secondly, during "The Ron MacDonald Show," broadcast between three and five p.m.

With prompt coverage of traffic conditions a highly competitive and saleable broadcast commodity, there is surprising cooperation between KIRO and another Seattle station which employs a traffic control helicopter to provide on-the-air reports.

Additionally, the newsroom at radio KJR has a CB transceiver and, KJR supplies helicopter-reported traffic information to KIRO via CB. (Continued on page 104)

At height of morning rush hour, disc jockey Jim French reports an accident to Washington State Patrol. Four-car crash was seen by passing motorist equipped with 27-MHz CB transceiver. He radioed French direct over KIRO. Amphenol 650 transceiver is beneath clock—a commercial plays on turntable and goes over wire.

Yesterday's NEWS for Today's ELECTRONICS

By Marshall Lincoln, W7DQS

Looking for a new building material for your next construction project? It's no further away than your nearest newspaper office!

There's a bonanza of strong construction material waiting for you in the trash bin at any newspaper plant. The material is strong, easy to work with, and will *tin* easily, making it ideal when reliable, soldered connections are important. It can be used for chassis tops, front panels, and a wide variety of mounting brackets.

Though aluminum has long been a favorite construction material with electronics experimenters, it has the disadvantage of refusing to take solder easily. Most experimenters have grown used to using solder lugs to make ground connections to aluminum chassis brackets. However, many of us have wished for a material that could be soldered directly.

This material has been around for a long time, and its presence is felt whenever photographs appear in your paper. The material is all of the metal printing plates used by newspapers to reproduce photographs.

Most of these plates are scrapped after a day's press run, so you'll have no difficulty obtaining a handful for your next project. Newspapermen refer to the plates as *cuts*, since in forming the picture image on the plate, acid is used to cut into the metal.

The metal is a little thicker than aluminum, and heavier. But it drills and saws easily, so you'll have no trouble working with it. The edges and corners of the plates are rather sharp, but they can be rounded with a file. Best of all, the material has a high percentage of zinc, which makes for good soldering.

To the Plant. You can get these handy printing plates by going to the composing room or print shop of your nearest newspaper and telling the man in charge you'd like a few used cuts for workshop use. Once you have his confidence, he'll probably point to a scrap barrel and say "Help yourself."

In the barrel you'll find a batch of plates carrying photographic images which you'll recognize from recent issues of the paper. Each plate is the same size as the picture which appeared. To build small brackets you can use plates originally prepared for one-column photos. For larger brackets, subchassis, or even a complete chassis top, you'll probably need a three-, four-, or even a five-column wide plate. Occasionally, you may be lucky enough to find a cut running the full width of a page.

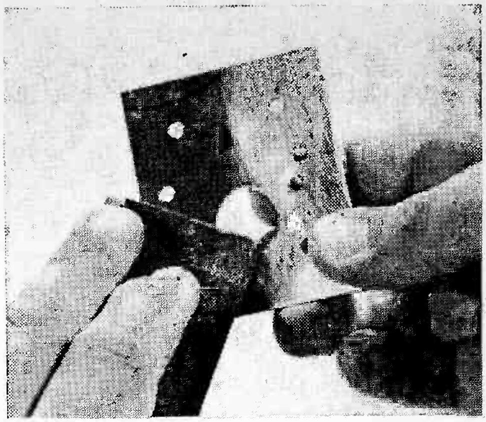
The side of the metal plate bearing the photographic image is rather rough and resembles fine-grade sandpaper. Look at it closely, and you'll see that the image is made up of thousands of tiny dots, all lined up in neat, evenly spaced rows. In dark areas of the picture these dots are rather large so they can pick up more ink and transfer it to the paper. In light areas of the picture, the dots are smaller so that they pick up less ink.

Rough and Ready. When you're mounting components on the plate, this roughness can work to your advantage by providing a surface that helps hold things in place without their slipping. The back side of the plate is smooth and probably has a coat of reddish-brown paint. If you need to make electrical connections on this side you can remove this paint easily with sandpaper. Also, the smooth side of the cut is the best surface for marking saw cuts and drill centers.

Our photos show a newspaper cut used to make a support bracket for a 2-meter ground-plane antenna. But the techniques described here can be applied to a variety of projects.

Cut the metal to the size you need with a hacksaw. File the edges smooth, and then round the edges and corners if necessary. Holes are drilled with ordinary metal cutting bits. The extra thickness of the metal plates makes it possible to countersink holes for flat-head screws. This is something that usually can't be done with the thin material often used for construction projects.

To get your cut to proper size for a construction project, mark off desired area with a sharp pencil and then go to work with a hack saw. Smooth side of cut makes good surface for marking saw cuts and drill holes. Use a square.



Prepare back surface of cut for soldering (or clamped connection) by using sandpaper to remove paint.

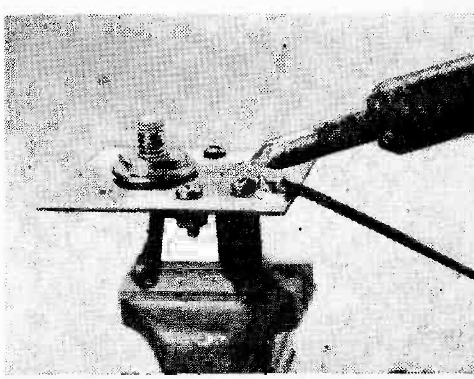
You should use coarse sandpaper to remove the coat of paint from the back of the cut if you intend to make any electrical connections on that side. This holds true whether the connections are soldered directly to the surface or to a mounting-lug and lockwasher combo.

Heat Aplenty. If soldered connections are made, you'll need a fairly large soldering iron to provide enough heat. Since the metal plate is heavy, it will conduct quite a bit of heat away from the area you wish to solder. For most projects you're likely to encounter, a 100- or 150-watt iron should do the job.

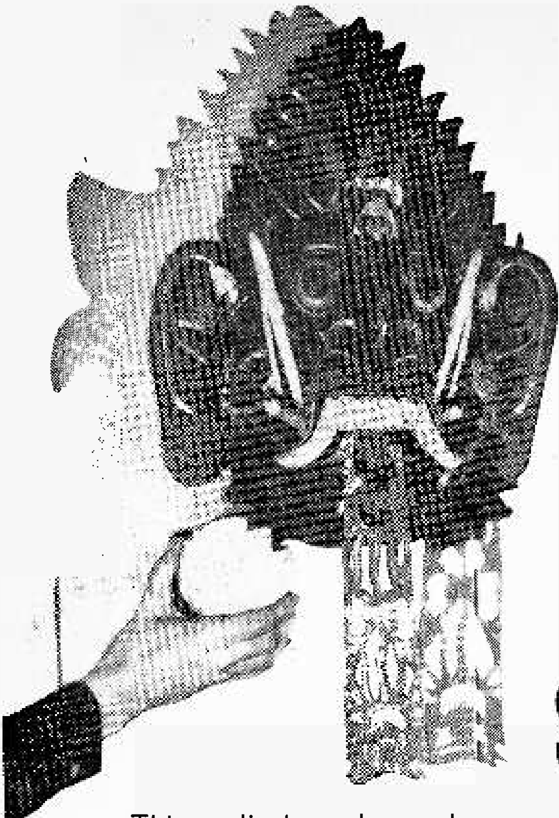
Be sure the iron's tip is well tinned so you get maximum heat transfer from the iron to the joint you're soldering. And keep the iron as close as possible to the area towards which you want solder to flow.

Plan your work so that you will make these solder connections early in the construction sequence, before very many com-

(*Continued on page 110*)



Use a large soldering iron to solder connection on cut. A large amount of heat is needed for smooth flow.



By Jorma Hyypia

FLYING SAUCER SPEAKER

This audio transducer changes any flat surface into a real super speaker for that total sound you've been waiting for

We all know that certain impossible things can't be done because common sense tells us so. But when someone comes along and does the impossible anyway, what do we say then? "Of course! It's so obvious! Why didn't someone do that long ago?"

A new device called the Rolen-Star audio transducer is a case in point. It replaces the speaker in any audio system but is not a speaker in itself. To convert it into a high-fidelity speaker system, you simply add one other component—a room wall, floor or ceiling. Any one of these structural elements will function as the driver diaphragm, taking the place of the paper cone of a conventional speaker. In fact, even a chair or the dining room table can be converted into a high-fidelity speaker!

Sceptical? Understandably so. The idea of a wall being used as the dynamic part of a speaker (not just as a baffle, mind you) seems too far out to be accepted on faith. In fact, you probably won't believe your ears the first time you turn on your hi-fi wall. At least I didn't—probably because my common sense was taking one awful beating.

I called in a young friend, an audio buff whose ear drums are several decades newer than mine and possibly more responsive to broad audio-frequency ranges. He cast a baleful eye at the unimpressive little flying saucer mounted on my living room wall as I dropped the stylus on a record filled with groovy highs, lows, plenty of percussion, and lotsa reverb. In a moment his baleful look was drowning in wild-eyed disbelief.

"What the heck was it?" he demanded. "Sounds like a hundred and fifty buck speaker, but it sure doesn't look like it!"

"It," I said, "is a $39.95 transducer that is making this whole wall vibrate like a speaker cone." He was convinced only after he had placed the palm of his hand on the wall to feel the unmistakable vibrations.

Admittedly, it's not much of a trick to make a wall vibrate. You can do that just by pounding it with your fist. But high-fidelity sound reproduction? Fantastic, but true.

(Turn page)

e/e SAUCER SPEAKER

Mounting procedure is simple. Just one bolt or a combination bolt-screw attaches to center of unit.

Rolen Electronics (328 Martin Ave., Santa Clara, Calif. 95050) claims a frequency response of 20 to 20,000 Hz ± 3dB for the Rolen-Star transducer. Listening tests tend to confirm these claims. Unquestionably, a plywood wall can out-woof and out-tweet many a quality speaker of conventional design. Of course, it's easy to accept the idea that a plywood wall might woof well, but it's the high-frequency response that really gets you. Triangles, chimes, and glockenspiels *shimmer* like dew drops in a Walt Disney cartoon landscape.

We aren't ready to assert that performance of the Rolen-Star exceeds or even matches that of every other sound reproducer on the market. We have not tested it against all the speakers available. But one thing is certain: it is the most versatile and easily installed high-fidelity reproducer you are likely to find.

Encapsulated Teaser. The electronic components of the transducer are completely sealed inside a tough Lexan polycarbonate plastic shell, making the unit completely weatherproof for outdoor use. But this very functional covering will exasperate the electronics fan who likes to open things up to see what makes them tick. Short of some destructive testing with a hammer and chisel, there is no safe way to peek inside.

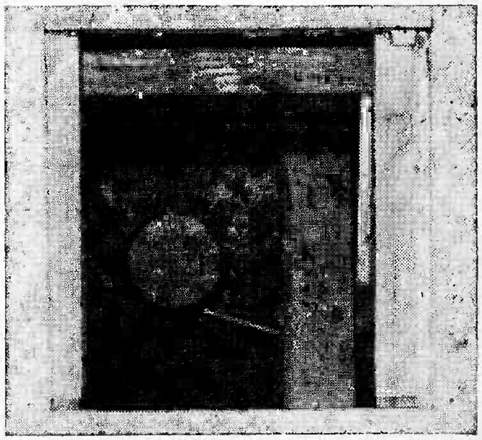
It's obvious that the transducer contains a strong permanent magnet. What else? The manufacturer isn't about to let you in on any trade secrets. As company president W. R. Bercaw put it: "We would like to keep it as mysterious as possible for the time being." Knowing full well that plenty of people (competitors) will gladly sacrifice a transducer to find out how it works, Bercaw adds this cryptic comment: "If someone did duplicate exactly what we have inside the shell, they still wouldn't get the same quality of reproduction." Why not? Bercaw just chuckles knowingly.

The 2-lb. transducer is 4 in. in diameter and 1¾ in. thick. It is fastened to a wall or other suitable surface with only one special bolt (or screw) provided with the unit. All you do then is connect your amplifier leads to two small contact lugs, and use the clips provided by the manufacturer. It couldn't be easier.

The transducer can convert electrical signals from almost any radio, TV, hi-fi or stereo set into mechanical vibrations that create an infinite number of standing waves on the surface to which the transducer is attached. The clear, dynamic sounds are projected in an omnidirectional pattern that eliminates the annoying sound-from-a-pipe quality of conventional speakers.

Power Requirements. You'll need a minimum of 1.5 watts for each transducer you want to operate. One watt per unit will suffice for soft background music. The maximum power handling capability is rated at 30 watts IHFM which means that you should be able to cover a couple thousand ft of area with just a single transducer.

Dynamic impedance is 8 ohms, passive impedance is 4.6 ohms. For peak efficiency, the usual impedance matching principles should be observed. The instruction booklet that comes with each transducer is unusually clear and detailed, giving full information about stereo as well as monaural hook-ups. It also covers such special conditions as multiple transducer installations requiring long wires and 70-V outputs.



Two room service with one transducer is obtained by mounting unit onto sub-flooring of room above.

Just watch that maximum power rating. The transducer should not be subjected to a greater output. Be particularly careful about overloading the transducer when you have it in your hand and are testing the vibrational characteristics of various mounting surfaces. The transducer is not excessively delicate, but any sound reproducer can suffer a ruptured cone or other damage if it's overloaded.

Mounting Surfaces. Sheetrock, plywood, wood paneling, and masonite surfaces all reveal excellent vibrational characteristics. I especially like the sound produced when the transducer is coupled to a plywood wall. Just be sure to mount the transducer *between* the wall studs and not over them. The best position is easily located by moving the transducer from one spot to another, while pressing it firmly against the wall.

You can place the transducer inside the wall, completely out of sight. If placed on the outer surface of the wall, the small unit is easily hidden with decorative, hollow objects such as exotic masks, clocks, etc. Such camouflage isn't really necessary though, because the transducers aren't eyesores in most places.

Other good mounting surfaces include acoustic tile, pressed wood, perforated board, plaster, and stucco. Plate glass is excellent provided there are no loose frames to create spurious vibrations. The Rolen-Star instruction booklet provides complete information about mounting the transducer on glass surfaces. The few construction materials you should avoid include stone, concrete, and brick. These do not vibrate properly.

Transducers attached to a ceiling can often be kept out of sight by installing the units in the attic. Another way to conceal the transducers is to attach them to the subflooring of a room—often readily accessible in the basement. Surprisingly, the sound is remarkably good even if it must pass through a carpet as well as two layers of flooring. This arrangement is great if you wish to service two rooms with one transducer.

Talking Furniture. Cabinets, tables, beds, and even chairs will produce high-fidelity sound if transducers are attached to them. Such applications not only solve installation problems in difficult areas, but offer some very unusual *musical decoration* possibilities.

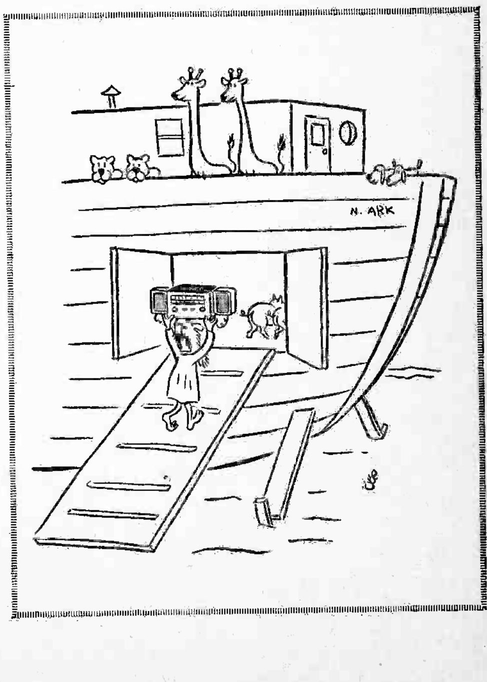
The versatility of the transducer is especially realized when planning stereo installations. All too often there seems to be no way of arranging a pair of cabinets in a room without drastically disrupting its design. This problem is eliminated because the transducers require no cabinets and take up no floor space.

Since the sound patterns are omnidirectional, they help to eliminate the hole-in-the-middle problem often encountered with widely spaced speakers. You will discover that you can sit or move anywhere in the room and still hear balanced stereo sound.

If possible, mount the two transducers on *opposite* walls. This orientation is said to yield superb stereo sound. However, you can get true stereo separation even if the transducers are mounted on the same wall, provided they are at least 8 ft apart. You can also use walls at right angles to each other.

The Great Outdoors. Since the transducer is completely weatherproof, you can put it in all sorts of places where conventional speakers would be unthinkable. Use them in patio ceilings and walls, in bath houses, or in the garage. They are excellent aboard boats, or even in automobiles and aircraft. The only precaution: spray waterproofing plastic onto the contact terminals to prevent corrosion if the transducers will be subjected to rain or snow.

For a really off-beat application, mount the transducer onto a sheet of marine plywood (at least 3 ft square) and float the assembly in your swimming pool. Then you can listen to Handel's *Water Music* while swimming underwater! ■



Photoelectricity

Continued from page 68

tered amplifier rather than by a pot, and the signal's output controls an SCR dimmer; it is not used directly.

Photoconductive cells can also serve as a replacement for the ignition points in an automobile. Such a system is sold commercially by Mallory. A light bulb is located inside the center of the distributor (see Fig. 16) and a photocell is located on the inside of the distributor shell. The rotor contains a number of holes—one for each lobe of the normal rotor—so that light can reach the photocell at specific instants as the rotor rotates.

The photocell functions as the tripping element for a conventional transistorized ignition. When light strikes the cell the ignition fires. Components are subject to less wear and critical adjustments are eliminated. Possible disadvantages such as bulb burn-out, and increased circuit complexity are overcome by design. Bulb life is greatly extended by use of a low operating voltage, while complexity is reduced by designing the entire high-voltage circuitry around the characteristics of the photocell.

One of the better known, and always impressive, applications of photoelectricity is the construction of a light-beam communicator. This device modulates light in the same manner that a radio transmitter modulates an RF carrier. Figs. 17 and 18 show the unit's transmitter and receiver, respectively. Only two points are critical. One is the choice of a lamp bulb. Most incandescent bulbs heat and cool too slowly to operate properly at frequencies above 50 to 100 Hz. However, the bulb specified operates up to 5 kHz.

The other critical factor is the choice of an appropriate photocell. CdS photoconductors are not recommended for this circuit because of their slow response times. But selenium photovoltaic cells or gas photocells respond rapidly enough to follow audio frequencies. With B2M photovoltaic cells, this communicator has a useful range of 50 ft.

Last but not least, Fig. 19 illustrates a device that automatically stops a tape recorder, and requires only the addition of a light source and photocell to the recorder. The control circuitry can be mounted elsewhere (to control AC power to the recorder) or can be mounted in the recorder case and used to control only the capstan motor.

When the tape is passing by the sensor, no light reaches the photocell and the power circuit remains closed. But when tape runs out, the light path from bulb to photocell is no longer blocked and the photocell trips the power circuit to turn the recorder *off*. Power remains *off* until the machine is reloaded.

A variation of this may be had by placing a strip of reflective tape onto the recording tape's non-oxide side and mounting photocell and light source side by side. When the reflective tape passes in front of the sensor,

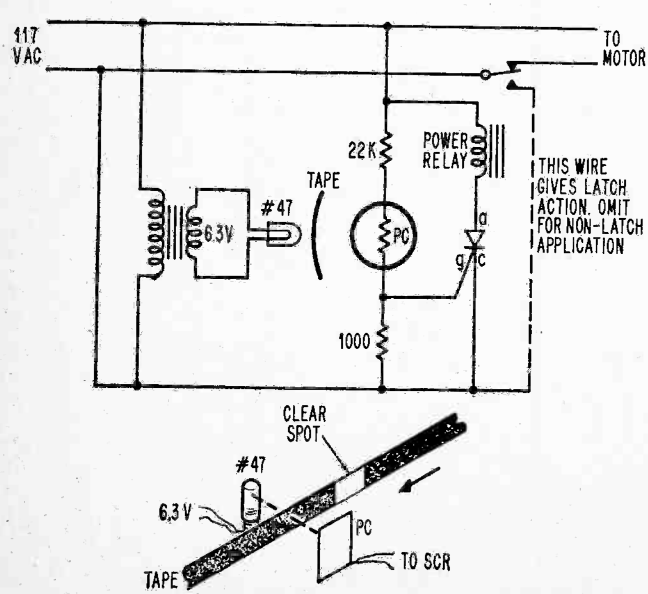


Fig. 19. Here's a simple automatic stop circuit for a tape recorder. The physical locations of the photoconductive cell and the lamp with respect to tape are shown below the circuit. Be sure to mask both bulb and cell so that no outside light triggers stop circuit. Alternative placements of bulb and photocell are discussed in text.

it will reflect light back to the photocell and trip the power circuit.

A second variation is achieved by mounting the sensor as shown in the drawing and scraping a clear spot at each end of a reel of tape. The spots should be about 6 to 8 in. from the end, so that they will allow light through to trip the circuit before the tape is completely unwound.

So much for the fascinating subject of photoelectricity! A more practical branch of electronics is hard to imagine, and it's all based on a storehouse that's found everywhere. ■

Rev Buster

Continued from page 40

To calibrate your tach, first adjust R10, the ×10 shunt resistor. Flip S3 to the 0-1000 rpm position, connect the calibrator, and adjust R5 (a temporary adjustment) until the meter reads exactly full scale (1.0 mA). Then flip S3 to the 0-10,000 rpm position and adjust R10 until the meter reads exactly 1/10 of full scale (0.1 mA).

Now decide which type of engine you want to calibrate for. For an 8-cylinder engine, flip S3 to 0-1000 rpm, and adjust R5 for a reading of 900 rpm (0.9 mA). For a 6- or 4-cylinder engine, set S3 at 0-10,000 rpm and adjust R5 for a reading of 1200 rpm (0.12 mA) or 1800 rpm (0.18 mA), respectively. The above procedures automatically calibrate both ranges.

The dwell meter is calibrated *before every application.* Touch the test prods together and adjust R9 for full-scale deflection. That's all! Note that your dwell meter is calibrated differently than most—it's calibrated directly in percentage of point dwell—0 to 100%.

The conventional calibration is in terms of *degrees of dwell.* This is because the distributor's points are closed for a specific number of degrees of the cam shaft's rotation. If the correct dwell figure for your car is listed in terms of degrees, just use the method described in the table below to convert to percentage. Consult your service manual for the correct dwell angle figure.

How to Figure Out Dwell Percentage

Number of cylinders into 360° (full shaft rotation) gives dwell and gap values for each cylinder.

4 cylinders = 90°
6 cylinders = 60°
8 cylinders = 45°

For instance, for a 6-cylinder engine, if dwell angle for your car were 36° (i.e., 36° dwell plus 24° gap equals 60° per cylinder), percentage would be 36/60, or 60%. This is a reading of 0.6 on meter.

NewScan

Continued from page 18

Public School 81 fourth grade students Willie Bacon and Evelyn Manero carry out lesson in spelling on new CBS Laboratories/Viewlex AVS-10 system. Portable electronic system is being used by the youngsters and 28 classmates in remedial reading program to see how well they can improve their reading skill.

frames synchronized with 18 minutes of audio material, are five inches in diameter and one-quarter inch thick. The system is the first to combine sight and sound onto a single cartridge and is expected to open a wide variety of applications for education, industry and the home.

A series of 300 lessons in alphabet recognition, spelling and word recognition, designed by the Reading Research Institute of Washington, D. C., is used in the program at P. S. 81 which began last March. These lessons include more than 5,000 response situations in teaching the student to spell and read words.

Results of the grogram to date show a steady improvement in reading skills. The average time in learning to read words—from monosyllables to polysyllables—is less than 25 hours. The system has been a motivational stimulant, because the child must operate it to learn. He has to look, he has to touch, he has to learn, and he is doing it with the essential senses. Reading improvement with AVS-10 program has been superior to the workbook because it provides both sight and sound. There also is constant reinforcement in the learning process. ■

CB on Up and Up

Continued from page 96

Motorist is one of CB traffic reporters who volunteer their services daily to help Seattle's commuters.

KIRO reciprocates by alerting the KJR helicopter of any important traffic snarls reported through the CB network. In this manner both stations improve their ability to alert motorists of dangerous conditions or time-consuming delays. It's good to know that broadcasters are good guys.

CB Has the Edge. How does the two-way radio communications network approach compare with the "flying reporter" technique used in other metropolitan areas?

"In Seattle," says Jim French, "the most certain method for covering the freeway traffic scene on a full-time basis seems to be by ground transportation. Reason for this is that winter rains, fog and occasional snow inhibit airborne reporting. For its insignificant cost, the CB system has proven to be practical and dependable. And it allows our listeners to get into the act, providing of course, that they are CBers.

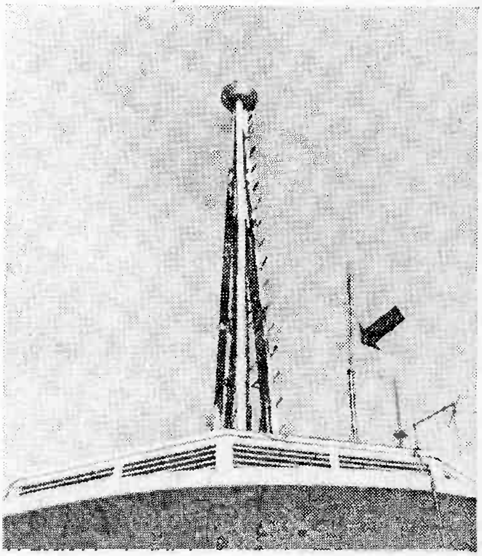
Approximately 40 work-bound mobileers report in with regularity, averaging about 15 on a daily basis. This number is more than adequate to cover those major arterials of interest to KIRO's commuter audience. Few participants can appreciate, however, what the Needle's elevation contributes to Jim's Amphenol 650 CB rig over typical mobile or base station installations. QRM is "unbelievable" at times, although a 20-mile radius can generally be depended upon even during rush hour periods.

"On an active morning or afternoon when we have extra heavy traffic," Jim continues, "it is fairly common for two or more CBers to hit their mikes and report simultaneously, often regarding the same traffic accident." Sorting them out is often difficult, especially since Jim French and Ron MacDonald operate alone without aid of an engineer in the studio booth.

Channel 9 Clears for KIRO. Before installing the Amphenol base unit, KIRO officials took a survey of area CB enthusiasts to determine which channel would be best for network operation. Overwhelmingly, those polled recommended channel nine.

What would on the surface appear a poor choice of operating frequency has worked out exceptionally well in service. According to the station, incidence of incorrect information from CBers has been minimal and—of particular interest to emergency monitoring people—casual conversation on channel nine has "dropped to almost nothing during high-traffic hours." Indeed, most Seattle area CB users are anxious to participate in the informal highway reporting network. Courtesy and consideration are the order of the day.

Interestingly, the KIRO/CB network approach, first of its kind in the nation, has done much to spur audience interest in Citizens Band radio communications. Both licenses and operator respect for emergency-use channels are definitely on the increase, reflecting the obvious public relations benefits of effective applications of CB communications. Hey! CBers are nice guys, too! ■



At elevation of nearly 600 ft, KIRO's 27-MHz signal has no trouble covering traffic network. Broadcast antenna is on tower; arrow points to CB skyhook.

Psychedelic Lights

Continued from page 35

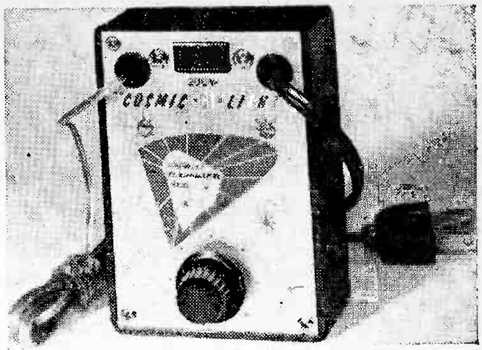
illumination; mid-tones activate a green light; while the high tones trigger blue. As music plays, sound mixtures generate a wide range of colors, with light patterns dancing with the tempo and pulsating according to audio frequency. The light patterns, though, are not confined to a screen, but projected over the room.

One model designed for youthful swingers is called the "Light Fantastic" (see photo). It's a small portable phono with a built-in AM radio. Atop the instrument is a plastic flower shaped like the horn of a vintage Victrola. Projected from the flower are revolving color patterns modulated by the music. Teenie-boppers will be able to buy the whole rig for $99 list. (They might sell you one if you're over 30, but you better bring a note from home.)

Considerably more sophistication is evident in the higher-priced Clairtone units. The president of the company told us they're aimed at store displays, fairs, and night spots, but they're basically for the home. The system begins with a "translator" (photo) which splits the musical program electrically into the three primary colors. It has brightness and tone controls for touching up the lighting effects while being driven by a low-level audio signal from the hi-fi rig. Cost of this unit is $149. (A deluxe version, at $199, adds some additional control functions, as well as a VU meter.) The translator is only one half the system.

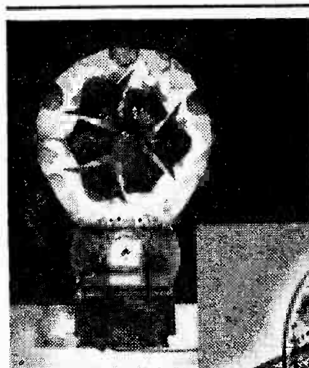
There are two ways to display the output of the translator as changing light patterns. One is a translucent globe which casts colors on its surface. Since it's done in a small area, it's akin to crystal-ball gazing in Technicolor. More fraught with psychedelic possibilities is the projector unit. This one will paint whole walls and ceilings with continuously moving light patterns. It has three 150-watt lamps with forced-air cooling and is tagged at $179. Thus for about $328 (at list prices) you can obtain a complete Clairtone system that'll add Op Art to Mozart, or make "Tea for Two" what Sir Lipton never flipped on.

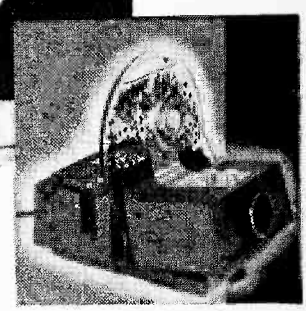
Solar Flare-up. So there's enough equipment starting to appear on the market to transform your home into a polychromatic palace. For anyone with an inventive turn of mind, the Edmund Scientific hardware provides raw material for experimentation. You can hang, shift and twist mirrors until you're blue (red and green) in the face. The system is open to endless modification.



Man, if you want the world flashing before your eyes, then dig CoSco's Go Light—it pulsates to music. Get all the facts from CoSco Research, Inc., 2803 N. Prospect, Colorado Springs, Colo. 80907.

A commercial unit, like the Clairtone instrument, is just the thing for timid adults—they can feel swingy, with never the risk of getting busted. There's even a new $19.95 gadget by Cosco (see photo) that'll help Granny rock a little faster. Attached to the hi-fi set, it simply pulses a lamp along with the music. What'll they think of next? How about a circuit to turn a color TV screen into a kaleidoscope—during the commercials, of course! ■



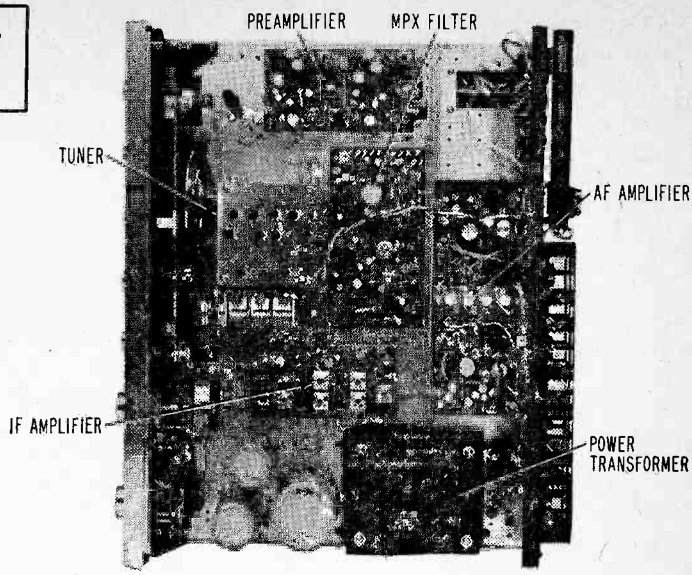


There's More

As we go to press we discovered, that Edmund Scientific Co. has come up with a Kaleidoscope Projector featuring a liquid color wheel. New unit projects non-repetitive, full-color, six-segment images on walls or screen. Write to Edmund for facts. ■

Lafayette LR-1500T

Continued from page 69



IF circuitry has 3 ICs for both AM and FM amplification. Besides the detector diodes, there are no other solid-state components in IF strip. The LR-1500T is packed with circuit boards. Each PC board has labels for all components, so that servicing is a breeze. Note 3-gang AM tuning capacitor below FM tuner.

—100,000 μV — failed to overload the front end. There was no cross-modulation or spurious frequency generation. The AM front end, typical of AM/FM receivers, is minimal, as is AM performance.

Three ICs (integrated circuits) are used for the IF amplifiers. These are of the stacked variety and provide for both the 10.7-MHz and 455-kHz IF frequencies. An AM/FM tuning meter comes with the unit, but performance on FM is not too reliable.

The output amplifiers are provided with an interesting protection device. In the event there should be a peak overload—caused by either turning up the volume control to exceed the rated power output, or by a noise impulse which overdrives the output stages—the amplifiers are disabled for a second or two, or until the volume level is reduced.

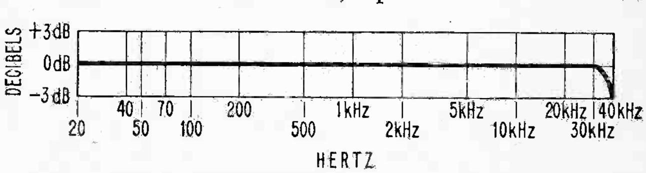
The protective circuits also function if speaker leads are inadvertently shorted, or if there is a protracted input overload such as with hum caused by an improperly connected input plug (no ground). Because of this overload protection, there are no individual fuses for the power transistors.

Performance. The response curves tell almost the entire story about the LR-1500T. Note in particular that the FM and FM stereo performance—through the tape input jacks—is essentially identical. The slight 2.5-dB loss at 15 kHz seems to be due to the pilot filter (used to avoid bias-beating when recording) and is typical of most late model receivers and tuners that employ really effective pilot signal filters. (It's pretty rough to filter out 19 kHz without losing something at 15 kHz!)

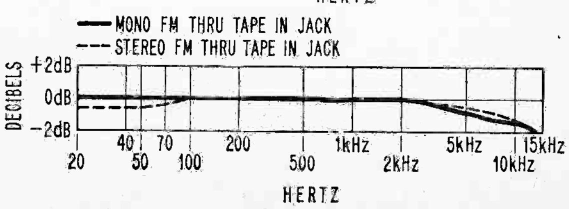
The rated IHF (Institute of High Fidelity) sensitivity for −30 dB hum, noise, and distortion checked out at 1.1 μV, with full 50-dB noise reduction at 3 μV. This is exceptionally good performance. Total hum and noise below a standard 1000-μV test signal was better than 60 dB down. Mono distortion at the rated test level was 0.38% total harmonic distortion, while the stereo distortion at 1 kHz was 0.78%—both better than claimed.

FM stereo separation at 400 Hz was 40 dB. At 15 kHz, separation measured better

Frequency response for amplifier. Both channels are driving and 0 db is equivalent to 50-watt output (at less than 1% total harmonic distortion) into an 8-ohm load. Response is flat to 30,000 Hz.



Receiver's frequency response is seen at right. This is for both mono and stereo FM. Signal is taken from tape input jacks. Performance for both modes is essentially identical, with only slight loss at higher frequencies.



than 15 dB. But since 15 dB was the limit of our stereo generator at 15 kHz, it could be even better.

The amplifier's frequency response at the rated sine-wave output of 50 watts into a load of 8 ohms (both channels driven) was absolutely ruler flat from 20 Hz to 30 kHz. The response falls rapidly, however, above 30 kHz. It is noteworthy that the distortion remained well below the rated 1% at full 50-watt output from 20 to 20,000 Hz (i.e., the limits of the distortion meter).

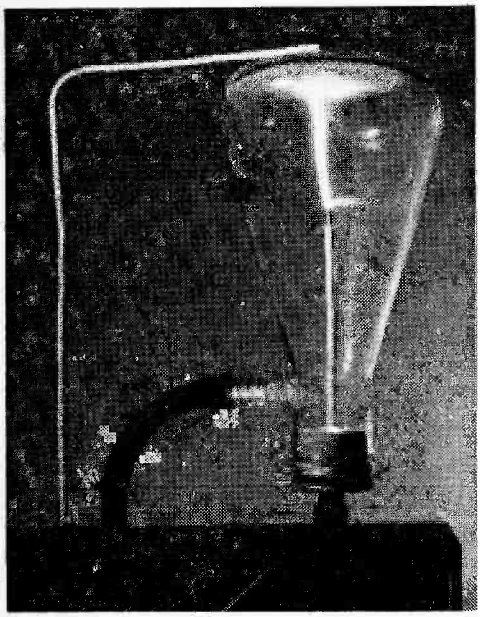
The response obtained with the high and low cut-off filters *in* was adequate. Note that the cut-off effect is not severe within the important frequency range of 50 to 7000 Hz. In fact, the high cut-off is somewhat less than that usually employed.

Summing Up. The LR-1500T's performance is outstanding. This, combined with its competitive price of $279.95 (including metal cabinet), makes it a best buy in high fidelity equipment.

For additional information write to Lafayette Radio Electronics Corp., Dept. CP, 111 Jericho Tpke., Syosset, N.Y. 11791. ■

Spark Spectaculars

Continued from page 78



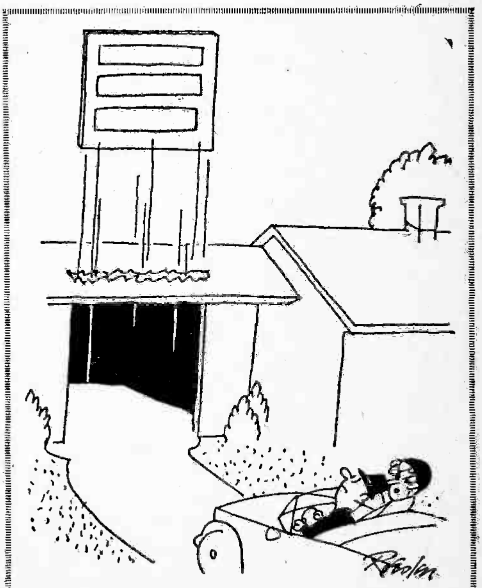
Filter flask should have thick walls and side tube if it is to be used for low pressure experiments. Vacuum pump is connected to hose at left. Second electrode touches bottom (inverted) and forms a ring.

Faraday Dark Space, positive striations, and negative cathode glow.

Incidentally, unusual vacuum demonstrations can be performed using certain types of laboratory glassware. A heavy-walled filter flask having a side tube is especially handy. Fit the mouth of the flask with a rubber stopper through which an electrode can be inserted. Then connect the vacuum pump to the side tube.

If the second electrode is formed into a ring resting on the bottom of the inverted flask, a conical discharge streamer is obtained. In our photo, the cone is narrow because the external electrode terminates in a ½-in. disc rather than a large ring.

To be sure, these experiments are only a beginning. Whether you go on to a 1-in. sparker or a high-power Tesla Coil (see ELEMENTARY ELECTRONICS, May/June, 1967), there are plenty more spectaculars just waiting for a showdown with your ingenuity. And should you arm yourself with a couple of college texts in chemistry and physics that have just gobs of information on this subject, you'll be blasting those sparks till doomsday. ■



"I thought you knew how to install a garage door opener!"

Miracle of the Platte

Continued from page 36

I thought of phoning our installation man and asking him to go with me. But no, it was Christmas Eve and he belonged with his family. I was single at the time. My only sacrifice consisted of breaking a date, and giving up a party which would probably be a brawl by midnight.

A mechanic from the garage across the street helped me load the bulky packing case and other paraphernalia into the back of the open sedan. And there I was, speeding up mountain grades on a narrow winding road, through snow-hushed pines. Not many habitations in those mounatins. Just a few summer cabins that had been boarded up for the winter. If the car had broken down, the consequences might have been serious. But I didn't think much about that.

The iron grey dusk of a winter evening darkened the valley when I coasted down the west slope, and followed the ice-fringed Platte north through meadows and rocky gorges. After turning, bumping, slipping along in frozen ruts for what seemed an endless time, wondering whether I had the directions right, I finally pulled up in front of a weathered, two-story building, with veranda all across the front. There was a rusty gasoline pump at the side, and several outbuildings—a barn, cattle shed, several primitive cabins for hunters and fishermen. I could hear the roar of the river as it plunged over giant boulders at the rear.

A white-haired man with leathery face and smiling grey eyes came down the steps, followed by a woman with a shawl around her shoulders, and two lanky young men.

"Did you think you'd never get here?"

"I was beginning to wonder," I said, with a sigh of relief.

"I'm Sam Barry—lots of sportsmen around Denver know me. This is my woman, Marthy, and my two sons, Joe and Sammy Junior. The boys'll help you carry your stuff into the dining room."

I could see through the windows that the rooms were lighted with kerosene lamps. No way to hook up a battery charger here. He'd just have to send the wet battery to Denver for recharging.

We eased the heavy console down to the ground, removed the packaging crate, and carried it up the steps and into the bare-looking dining room at the left of the entrance. The wall paper was a dingy blue with faded flower pattern. A long wooden table, obviously home-made, occupied the center of the room, with benches on either side. An oil-burning chandelier with glass pendants hung overhead. Extra chairs were placed around the walls. I felt as if I had stepped into the last century.

After we had placed the radio under the window at the end of the room, and unpacked the cartons containing wet and dry batteries, tubes and aerial assembly, I began putting things together. I wasn't too sure of myself. Our installation man usually handled all such work. Although I had watched him, and thought I knew just what to do, I would rather have had him there.

One thing worried me. In those days of battery-powered sets, and no network broadcasting, it was sometimes difficult to get reception in certain parts of the mountain country. The theory was that underground bodies of iron ore interfered.

I placed the batteries in the console, connected the terminals, inserted the tubes, and went outside with one of the boys to string an aerial wire from the barn to the main building. Then we hammered an iron rod into the frozen earth outside the dining room window to serve as a ground.

Meantime, people had begun arriving. By the time I was ready to test the set, there must have been thirty men, women, and children sitting on chairs and benches behind me, silently watching every move I made.

There were rough mountain people, shaggy heads, weathered faces, work-calloused hands, some of the men with untrimmed beards. They wore sheepskin coats, flannel shirts, overalls or blue jeans, and there was a faint barnyard odor in the room. The women wore dresses which were obviously not "store boughten", and the clothing of the children, some too large, some too small, indicated hand-me-downs. Good, plain, hard-working, God-fearing people.

Old Sam Barry hovered around, trying to help, but mainly succeeding in getting in my way. The set was finally hooked up, and I began twirling the three knobs, feeling for a station signal. Not a sound came from the twin speakers. The solemn eyes of my audience continued to bore into me from behind. All I could hear was the sound of breathing and the far-away tumbling of the river.

Adopting my most professional attitude, I rechecked every connection. Suppose the jolting of the car had broken loose some wire? Suppose we had hooked up the aerial in the wrong direction? Had I fastened the ground wire securely to the metal stake? What if there were a big iron ore deposit in that valley? I thought of the long, lonely drive over the ridges, and shuddered. How I wished that installation man had come with me!

I knelt in front of the console, turned the battery power way up, and began twiddling the knobs again. Glory be! . . a faint sound crackled through the speakers. I carefully retuned the set, and we heard the rolling tones of an organ, followed by a chorus of voices singing—"Oh Come All Ye Faithful."

There was a stir in the room. No talking—just the rustle of quickened attention. The voices of an announcer came on the air—"Des Moines, Iowa." I heard smothered exclamations around the room. Church music from hundreds of miles across the winter night! Instead of a salesman, they appeared to regard me as something of a magician. It was almost as if I had invented the radio myself.

Then the full realization came to me. This was more than a commercial transaction, much more than just a sale and a profit. This was a momentous occasion—a miracle to simple folks who lived in remote mountain meadows and valleys, and had no preparation for hearing music come out of empty air.

As the evening passed, reception got better. I tuned in several other stations—Calgary, and Shreveport, and Los Angeles. But they always asked me to go back to the Christmas hymns. Religion was a vital force in their scheme of things, and the church music enthralled them.

Mrs. Barry served me a generous dinner on a wooden table in a corner of the kitchen—chicken and dumplings, home-made biscuits and wild blueberry jam, buttered carrots and steaming black coffee. Sam wouldn't take any money for the meal, and insisted on filling up the gas tank of my trusty old Jewett car, no charge. He and his wife urged me to stay and celebrate Christmas with them. But I didn't belong there. These mountain folk would be ill at ease with a city man in their midst. After I left, dinner would be served family style, the fiddle and banjo would tune up, the party would get rolling.

My host and customer counted out the bills from his worn pocketbook. I gave him a receipt, some last minute instructions, and shortly after eleven was ready to leave. Someone had opened the door of the lobby on the other side of the hall, and I saw a huge Christmas tree, blazing with candles, trimmed with strings of popcorn, cranberries, chains of colored paper.

As I backed out of the rutty driveway, I could hear the immortal strains of "Silent Night" coming in from that blessed station in Iowa.

The mountains didn't seem so lonely, and the night didn't seem so cold. For I had played a part in bringing sacred music from the heavens, even as on that wintry night, centuries ago, the singing of angel choirs came to the ears of shepherds watching their flocks in the hills above Bethlehem. ■

Soldering Iron Control

Continued from page 49

776) and a 47½-watt "high heat" element (Ungar 4035) with thread-on tips. Most of the normal soldering jobs can be handled with a standard ⅛-in. chisel tip (Ungar PL-113), but if a larger tip is needed use a pyramid type (Ungar PL-116).

For work on integrated circuits or other extremely small components, a micro chisel tip (Ungar PL-113) or a pencil tip (Ungar PL-111) can be used. Also, remember that the gauge (size of the cross section) of the solder can be a factor when doing delicate soldering jobs. For this type of work 28-gauge soldier is most suitable. Selecting the right amount of heat for a particular job is only a matter of adjusting the control knob until you get a free flow of solder and a well-tinned connection.

When the soldering iron control is to be used as a motor speed control, lamp dimmer, or for some other application, remove the iron and plug the device to be controlled into J2. *SIC* is particularly useful in controlling the speed of electric drills and is also effective as a lamp dimmer. *SIC* provides a full range of control from no glow at all to full brightness.

Isn't this as good a way as any to brighten up your future? ■

DXing the Land of Thai

Continued from page 72

The Red transmissions are now heard sometimes by NA SWLs on 9423 kHz around 0800 EST.

A portable unit appeared on the Thai scene during August 1967 using the 843 kHz BCB channel with 50 kW, at Sakon Nakhon, east of Khan Kaen and near the Laotian border. This portable calls itself R. 909 in honor of Thailand's King Rama IX and the Buddhist year 2509. R. 909's assignment is to counter Peking's "Voice of the Thai People."

Probably R. 909 could be the 1963 vintage portable formerly located at Khan Kaen on the same frequency, possibly having returned to Thailand via Botswana where it is rumored that the British put it to use. Or it could be another mysterious unit which tested on 770 kHz July 20, 1966 at Sacramento, Califorinia with 50 kW and then, like the Khan Kaen unit, completely dropped from sight. Like we said, Thai radio broadcasting is chaotic. But, if you are lucky enough to log R. 909, reception reports can simply be addressed % the Ministry of Information in Bangkok.

Now you have enough poop to start pulling in Thailand. Careful tuning and a little patience may reward you with unusual DX thrills such as, "Etcetera, etcetera, etcetera"! ■

Yesterday's News Today

Continued from page 98

ponents are mounted on the zinc plate. The more components that are mounted, the more mass will be present to absorb some of the heat produced by the soldering iron heating element.

Angles To Suit. If you wish, you can bend these zinc plates to make right-angle or odd-angle mounting brackets, switch panels, switch or potentiometer supports, or subchassis units that mount at right angles to the regular chassis. Because of the thickness of the metal, you won't be able to make the sharp-cornered bends you see on manufactured chassis and utility boxes. However, a graceful curve can often produce a more pleasing effect than a sharp, right angle.

To bend a plate, mark the bend area with a pencil and clamp the plate in a vise. If the vise jaws aren't wide enough to grip the plate along the entire length of the desired bend, sandwich the plate between two wood blocks placed in the vise.

First, grip the plate firmly in your hands or between two more wood blocks, then slowly and forcefully bend it to the desired angle. Move slowly so you can see if the bend is developing just where you want it. If it isn't, loosen the vise jaws and move the zinc plate up or down as required to get the bend at the proper location.

Working with newspaper cuts has some advantages and some disadvantages when compared with other materials you're accustomed to using. But it's certain to prove a handy addition to your bag of tricks when you're building electronic equipment.

And besides, there's no other way for you to get a picture of a famous movie queen or recording star built right into your favorite project! ■

Bringing Up Junior

Continued from page 57

grams and electroencephalograms, appear on magnetic tapes, which are constantly examined by doctors and medical technicians. The continuous vigil of the Center's doctors and nurses is also maintained via closed circuit TV. Video tape recordings can be used for seminars and for training new members added to the hospital staff. An additional check that the babies are functioning well is an alarm which has been programmed to sound at the first sign of anything abnormal.

All treatment and procedures, including feeding, scalp and umbilical cord examinations and electroencephalograms, can be conducted without removing the infant from his incubator. But, undoubtedly, the most significant aspect of computerized incubators is that they enable infants to have the constant care and immediate attention, which, in many cases of premature birth, determine whether or not a baby will survive. Well, now it can be said—electronics is man's first nanny! ■

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Another reason two-way radio men earn so much more than radio-TV service men is that they are needed more often and more desperately. A home radio or television set may need repair only once every year or two, and there's no real emergency when it does. But a two-way radio user must keep those transmitters operating at all times, and *must* have their frequency modulation and plate power input checked at regular intervals by licensed personnel to meet FCC requirements.

This means that the available licensed experts can "write their own ticket" when it comes to earnings. Some work by the hour and usually charge at least $5.00 per hour, $7.50 on evenings and Sundays, plus travel expenses. A more common arrangement is to be paid a monthly retainer fee by each customer. Although rates vary widely, this fixed charge might be $20 a month for the base station and $7.50 for each mobile station. A survey showed that one man can easily maintain at least 100 stations, averaging 15 base stations and 85 mobiles. This would add up to at least $12,000 a year.

Be Your Own Boss

There are other advantages too. You can become your own boss—work entirely by yourself or gradually build your own fully staffed service company. Instead of being chained to a workbench, machine, or desk all day, you'll move around, see lots of action, rub shoulders with important police and fire officials and business executives who depend on two-way radio for their daily operations. You may even be tapped for a big job working for one of the two-way radio manufacturers in field service, factory quality control, or laboratory research and development.

How To Get Started

How do you break into the ranks of the big-money earners in two-way radio? This is probably the best way:

1. Without quitting your present job, learn enough about electronics fundamentals to pass the Government FCC Exam and get your Commercial FCC License.
2. Then get a job in a two-way radio service shop and "learn the ropes" of the business.
3. As soon as you've earned a reputation as an expert, there are several ways you can go. You can move *out* and start signing up and servicing your own customers. You might become a franchised service representative of a big manufacturer and then start getting into two-way radio sales, where one sales contract might net you $5,000. Or you may even be invited to move *up* into a high-prestige salaried job with one of the major manufacturers either in the plant or out in the field.

The first step—mastering the fundamentals of Electronics in your spare time and getting your FCC License—can be easier than you think.

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Get Your FCC License... or Your Money Back!

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Ed Dulaney is an outstanding example of the success possible through CIE training. Before he studied with CIE, Dulaney was a crop duster. Today he owns the Dulaney Communications Service, with seven people working for him repairing and manufacturing two-way equipment. Says Dulaney: "I found the CIE training thorough and the lessons easy to understand. No question about it—the CIE course was the best investment I ever made."

Find out more about how to get ahead in all fields of electronics, including two-way radio. Mail the bound-in postpaid reply card for two FREE books, "How To Get A Commercial FCC License" and "How To Succeed In Electronics." If card has been removed, just mail the coupon below.

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You begin by examining the various radio parts of the "Edu-Kit." You then learn the function, theory and wiring of these parts. Then you build a simple radio. With this first set you will enjoy listening to regular broadcast stations, learn theory, practice testing and trouble-shooting. Then you build a more advanced radio, learn more advanced theory and techniques. Gradually, in a progressive manner, and at your own rate, you will find yourself constructing more advanced multi-tube radio circuits, and doing work like a professional Radio Technician.

Included in the "Edu-Kit" course are Receiver, Transmitter, Code Oscillator, Signal Tracer, Square Wave Generator and Signal Injector Circuits. These are not unprofessional "breadboard" experiments, but genuine radio circuits, constructed by means of professional wiring and soldering on metal chassis, plus the new method of radio construction known as "Printed Circuitry." These circuits operate on your regular AC or DC house current.

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You will receive all parts and instructions necessary to build twenty different radio and electronics circuits, each guaranteed to operate. Our Kits contain tubes, tube sockets, variable, electrolytic, mica, ceramic and paper dielectric condensers, resistors, tie strips, hardware, tubing, punched metal chassis, Instruction Manuals, hook-up wire, solder, selenium rectifiers, coils, volume controls and switches, etc.

In addition, you receive Printed Circuit materials, including Printed Circuit chassis, special tube sockets, hardware and instructions. You also receive a useful set of tools, a professional electric soldering iron, and a self-powered Dynamic Radio and Electronics Tester. The "Edu-Kit" also includes Code Instructions and the Progressive Code Oscillator, in addition to F.C.C. Radio Amateur License training. You will also receive lessons for servicing with the Progressive Signal Tracer and the Progressive Signal Injector, a High Fidelity Guide and a Quiz Book. You receive Membership in Radio-TV Club, Free Consultation Service, Certificate of Merit and Discount Privileges. You receive all parts, tools, instructions, etc. Everything is yours to keep.

Progressive "Edu-Kits" Inc., 1186 Broadway, Dept. 528DJ, Hewlett, N. Y. 11557

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FROM OUR MAIL BAG

J. Stataitis, of 25 Poplar Pl., Waterbury, Conn., writes: "I have repaired several sets for my friends, and made money. The "Edu-Kit" paid for itself. I was ready to spend $240 for a Course, but I found your ad and sent for your Kit."

Ben Valerio, P. O. Box 21, Magna, Utah: "The Edu-Kits are wonderful. Here I am sending you the questions and also the answers for them. I have been in Radio for the last seven years, but like to work with Radio Kits, and like to build Radio Testing Equipment. I enjoyed every minute I worked with the different kits; the Signal Tracer works fine. Also like to let you know that I feel proud of becoming a member of your Radio-TV Club."

Robert L. Shuff, 1534 Monroe Ave., Huntington, W. Va.: "Thought I would drop you a few lines to say that I received my Edu-Kit, and was really amazed that such a bargain can be had at such a low price. I have already started repairing radios and phonographs. My friends were really surprised to see me get into the swing of it so quickly. The Trouble-shooting Tester that comes with the Kit is really swell, and finds the trouble, if there is any to be found."

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