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• July/August 1969 • Vol. 8 No. 3

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AS OUR LAB SEES IT

ELECTRONICS IN THE NEWS

SWEET AND SIMPLE

THE REGULARS

☆ Cover Highlights

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July/August 1969 Vol. 8/No. 3

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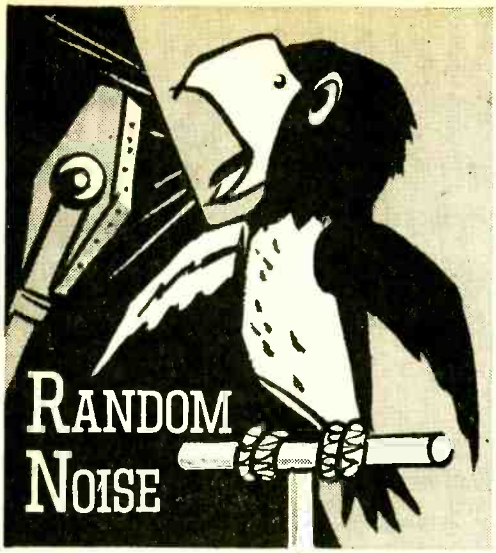
ELEMENTARY ELECTRONICS is published bi-monthly by Science & Mechanics Publishing Co., a subsidiary of Davis Publications, Inc. Editorial, Business and Subscription offices: 229 Park Avenue South, New York, N.Y. 10003. One-year subscription (six issues)—$4.00; two-year subscription (12 issues)—$7.00; and three-year subscription (18 issues)—$10.00. Add $1.00 per year for postage outside the U.S.A. and Canada. Advertising offices: New York, 229 Park Avenue South, 212-OR 3-1300; Chicago, 520 N. Michigan Ave., 312-527-0330; Los Angeles: J. E. Publishers' Rep. Co., 8380 Melrose Ave., 213-653-5841; Atlanta: Pirnie & Brown, 3108 Piedmont Rd., N.E.; 404-233-6729; Long Island: Len Osten, 9 Garden Street, Great Neck; N.Y., 516-487-3305; Southwestern advertising representative: Jim Wright, 4 N. 8th. St., St. Louis, 314-CH-1-1965.

Second-class postage paid at New York, New York and at additional mailing office.



By Julian M. Sienkiewicz, Editor

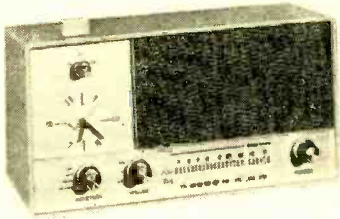
After a magazine has gone to bed (that's publishing talk), this editor sometimes thinks about the importance of schedules and deadlines. Facing up to an exacting timetable is not an occupational hazard solely for the publishing world. An important case would be the past Apollo 8 timetable.

Space officials recently completed their analysis of the data from the Apollo 8 round trip to the moon. Here are some of the interesting facts they have uncovered.

Apollo 8 began in style by lifting off the pad less than two-thirds of a second late, and its Pacific splash-down was only eleven seconds behind time. During its descent to earth orbit, every one of the engine's ignition and cut-offs of the three Saturn 5 booster stages was within 4 seconds or less of the flight plan. The third stage re-ignited only 0.9 seconds late to send the spacecraft toward the moon, and shut down exactly on time, having pushed the three astronauts to a speed scarcely one-fifth of one percent off target. That's good shooting!

On the outbound trip to the moon, four mid-course corrections were scheduled, but so accurate was the trajectory, that the first was not even necessary until more than two hours past its set time, and the second and third corrections were not needed at all. Correction number four was used to provide a trivial change of two feet per second, though space officials said it, too, could have been dispensed with if desired. The spacecraft's service propulsion system was fired three times around the moon, and each burn was accurate to the second. The latitude of the three home-bound mid-course corrections were not needed at all; re-entry speed was precisely as planned. *(Continued on page 8)*

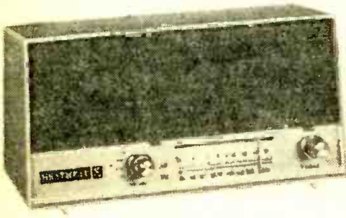
New Kits For Home And Hobby...



NEW
Kit GR-58
47^{95}*

Heathkit GR-58 Solid-State AM/FM Clock Radio

An easy way to get up . . . choose news & weather on AM or the bright sound of FM music. AFC for easy FM tuning. Use "Auto" position for only radio, or the "Alarm" setting for alarm & radio. The clock-controlled accessory AC socket will even perk coffee for you in the morning. The "Snooze" button turns off the alarm for 10 minute periods until you move the function switch . . . lets you wake up gradually. Easy circuit board construction. For an easy way to get up, order yours now. 8 lbs.



NEW
Kit GR-48
39^{95}*

Heathkit GR-48 Solid-State AM/FM Table Radio

An ideal table radio for any room in the house. All solid-state circuitry delivers the same excellent sound as the GR-58 above, but without the clock and alarm functions. An Automatic Frequency Control position on the mode switch locks that FM station in and makes tuning easy. Designer-styled avocado green cabinet with matching grille cloth. Fast, simple circuit board construction. 5 lbs.

NEW
Kit IG-28
79^{95}*

Heathkit IG-28 Solid-State Color-Bar—Dot Generator

The new Heathkit IG-28 is the most advanced instrument of its type available . . . at any price. Computer-type integrated circuitry eliminates divider chain adjustments and instability — no flutter, jitter or bounce . . . ever. Delivers 12 patterns — standard 9x9 dots, cross-hatch, vertical & horizontal lines, color bars & shading bars . . . plus the exclusive Heath "3 x 3" display of all patterns . . . plus a clear raster so necessary for purity adjustments. Also features variable front panel tuning for channels 2 through 6, front panel sync output, two front panel convenience outlets, variable positive or negative video output, built-in gun shorting circuits and grid jacks and vectorscope display capability. 8 lbs.

NEW
kit SB-500
179^{95}*

Heathkit SB-500 2-Meter Transverter

The new SB-500 allows owners of Heathkit models SB-101, SB-110A, HW-100 and the SB-301/401 combination to operate on 2-meters without having to buy a complete new rig. It gives complete, reliable SSB & CW facilities from 144 to 148 MHz and features a husky 50 watts output, fast, easy tuning and a 0.2 uV receiver sensitivity. A built-in meter monitors final plate current or relative power. Internal relays eliminate cable changing when switching from LB gear to the SB-500. Step up to "2" now, with the SB-500. 19 lbs.

NEW
Kit GD-28
59^{95}*

Heathkit GD-28 8-Track Cartridge Tape Player

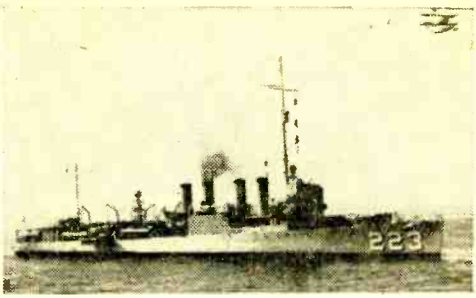
The new GD-28 is an ideal addition to any home music system. Plays pre-recorded tapes through any system with a Tape Recorder, Tuner or Auxiliary input. Just push in the 8-track stereo cartridge . . . it starts and changes tracks automatically . . . even shows which track is playing. Changes tracks instantly with the front panel switch too. Goes together quickly on one circuit board, and the playing mechanism is preassembled & adjusted. Attractive wood-grained polyurethane cabinet included. Order yours now. 10 lbs.

Continued from page 5

Back here on earth, you and I have to face the problems of everyday commutation. Many Americans check their railroad timetables to discover that the train they need to get to work on time in the big city leaves the station at 6:34 a.m. Bucking traffic all the way they drive to the station's parking lot in time to race up to the platform and—*wait!* The train is not there and the reason is totally unknown to the commuter. It could have been that the train had arrived five minutes earlier and left without waiting for its normal complement of passengers from that station. It could be that the train will be ten minutes late, or fifteen, or twenty, maybe an hour—who really knows? Or it could be that the train was lifted from service because of mechanical trouble and no replacement has been sent down the line to gather up the sleepy passengers waiting for the early morning 6:34.

In our great age of moon shots, computers, communications, etc., you would expect that the American railroads would be able to maintain a commuter service that would certainly be dependable. I wonder if there are any publishing firms on the moon looking for an electronics editor.

Pueblo, c. 1926. In the March/April issue of ELEMENTARY ELECTRONICS we ran a very interesting story on "The Strange World of Paid Shortwave Listening." In the story we had mentioned that the United States Navy had realized the value of monitoring the airwaves. By 1926 it had a listening station on the 4th floor of the American Consulate in Shanghai, China. This listening post, armed with shortwave regenerative receivers, could not pick up the transmissions from Japanese warships at sea. Several of these sets were installed aboard the U.S.S. McCormick and that autumn the ship became the first floating monitoring post. Thus, was born the first electronic spy ship. The McCormick secretly eavesdropped on Japanese fleet exercises without the latter knowing what was taking place. Fortunately, we were able to obtain an old photograph of the old U.S.S. McCormick.



Here's the U.S.S. McCormick during Pacific fleet war games prior to World War II. Note the bi-plane with float flying overhead. (U.S. Navy photo)

The photo shows the block numerals "223" painted on her side, a number she proudly carried around the world several times. Although she was a fourstacker and sported open gun mounts both forward and aft, she was one of the most advanced destroyers for her day.

This Editor believes that the Navy should have stuck to war ships as listening posts rather than equipping inferior merchant ships to do the same job. Even the old four-stacker McCormick could have given a better account of herself off the North Korean coast than did the Pueblo. This is not a reflection on the crew, but rather the type of ship used for spy surveillance. For some reason, a foreign country somehow expects an armed man-of-war to be well equipped with sensitive listening devices that can hear and see what the foreign nation does not want it to hear and see. These armed ships are usually left alone. But, give this snooping power to an unarmed merchant ship, and Terry and the Pirates somehow come to real life and a sad ending.

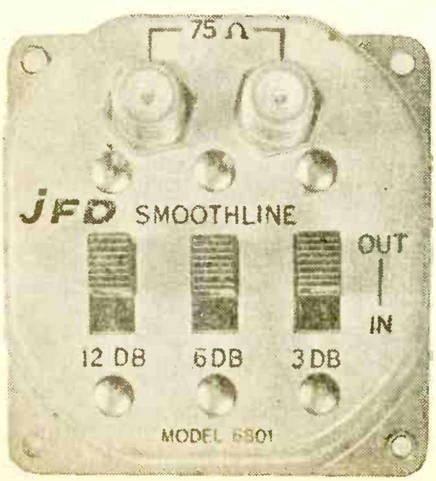
Editor's Laugh-in! In our last issue Mr. George Caisse of Levittown sent in some humorous news flashes which tickled this Editor and many readers who took the time to write in to tell us so. Well, George's fickle pen has struck again and here are some of the idio-items.

- Hollywood—America's most famous octal, the man who played Heathkit in "Withering Herz," Rumbling Dodo, verified the fact today that he and his wife were separated. He confessed responsibility for the marital breakdown. Dodo told her "You look like a ferrite!" whereupon she gave him the gate. It's been twenty years from the first day emitter. "I'm solder, but wiser," he reported.
- Philadelphia—Flip-Flop Flip-Flop, an oscillator operator, suddenly went berserk watching television after he downed Anode Fashioned at the Epoxy Grille here. Five shots rang out in rapid succession, then he drank the last shot and diode.
- Houston—A surprise police raid at an alleged T-pad here netted the son of a famous judge and several micro Waves in μ-skirts. One girl was immediately released as innocent—there was general agreement that she was a square Wave. At the hearing, Patrolman Righteous testified that he heard one Wave say that she needed to "get in contact with my connection to get a fix" for a forthcoming birthday calibration! "Let her stator case," said the magistrate. "Your honor," she said, "the officer had no right to radar apartment." Said the magistrate to the arresting officer, "You made a complete mesh of this case." ■

Hey, readers! ELEMENTARY ELECTRONICS *is your magazine, and Hey, Look Me Over is your department. We'd like to know what you think of our new products column. Send your comments to the Editor,* ELEMENTARY ELECTRONICS, *229 Park Ave. So., New York, N.Y. 10003, % Hey, Look Me Over.*

Variable Attenuators for MATV

A new line of fixed and variable attenuators designed specifically for 82-channel cable-powered MATV systems is shown here from JFD. Model SL-6801 is variable from 0 to 2 dB in 3 dB steps. "F" type connectors are used for input and output and attenuation is set by means of heavy duty slide switches. Models SL-6803, SL-6806, SL-6812, and SL-6820 are fixed at attenuations of 3, 6, 12, and 20 dB respectively. All models pass uhf as well as vhf,



JFD SL-6801 & SL-6803 Attenuators

providing uniform attenuation across the entire TV-FM spectrum. They also pass AC and DC power for cable powering applications. The SL-6801 variable attenuator is priced at $22.50 and the fixed attenuators go for $5.95 each. Write to JFD Electronics Co., 15th Ave. at 62nd St., Brooklyn, N.Y. 11219.

Now Hear This in the Romper Room!

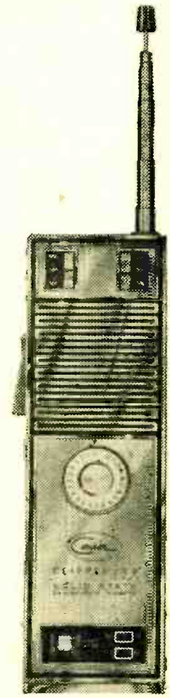
Ampex has brought out a series of children's stories on micro cassettes that are fool-proof, even in the hands of babies. There are 22 titles in this kiddy series, from "Puff, the Magic Dragon" to "Little Red Riding Hood" to "Pinocchio" and so on. Each li'l cassette holds up to eight minutes of recorded material on each side, and they go for $1.98 each. For a catalog of more than 1300 cassette selections from Ampex Stereo Tapes, write Ampex Corp., 2201 Estes Ave., Elk Grove Village, Ill. 60007.

Ampex Stereo Tapes Golden Records Micro Cassettes

"Man, dig that crazy beep!"

Hand-Held and 23 Channels!

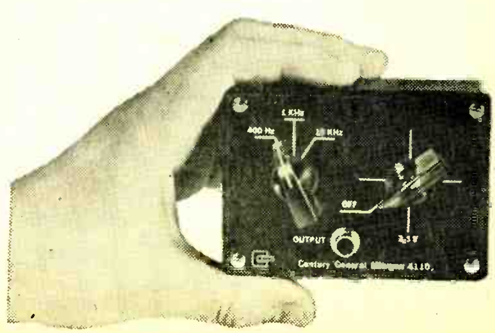
Here is the Clipper 23, the first walkie-talkie capable of transmitting and receiving on all 23 CB channels. Courier's Clipper 23 has full 5-watt power with an effective inland range of 10 miles, depending on terrain. Over the water operation increases the range. This all solid-state unit is said to give excellent voice reproduction through a 2¾-in. PM dynamic speaker. All crystals are included. Signal clarity is enhanced by variable squelch, a built-in range expander and an automatic noise limiter. Jacks are included for PA systems, external earphone/speaker, antenna, microphone and power connection. Priced at $159.95. Clipper 23 comes with a leather carrying case. With an AC power supply recharger you can use it as a base station. Write for more information from Courier Communications, Inc., 439 Freylinghuysen Ave., Newark, N. J. 07140.



Courier Clipper 23 CB Transceiver

Vest Pocket Gen

Putting out three stable tones (400 Hz, 1 kHz, 10 kHz), the Minigen 4110 measures a weensy 2⅞ x 4 x 1⅝ in., weighs a mere 7½ oz. The solid-state audio generator's 10-kHz tone is convertible to 5 kHz by slight internal modification. The output is continuously varia-



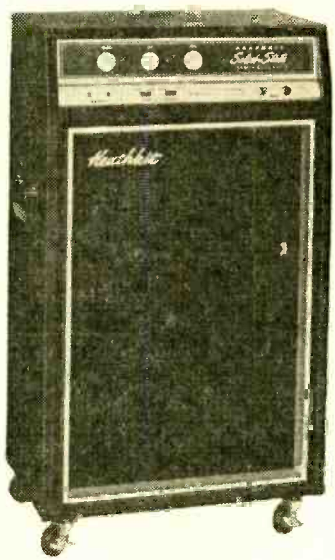
Century General Minigen 4110 Audio Generator

★★★★★★★★★★★★★★★★★★★★★★★★★★★

ble 0 to 2.5 volts. Priced at $14.95, Minigen 4110 comes with probe and standard 9-V transistor battery. For more information write to Century General Corp., 90 Broad St., New York, N.Y. 10004.

Stand Back for Big Boomer

To fill out their line of guitar and organ amplifiers in kit form, the Heath Co. introduces the TA-38, an all solid-state bass guitar amplifier. The new amplifier will deliver 100 watts rms into its two 12-in. speakers. Peak power rating is 240 watts. They claim the amplifier/speaker combination cannot be blown, due to



Heathkit TA-38 Bass Amplifier

its circuit design and choice of speakers. The speakers have 6¾-lb. of magnet assemblies between them. The TA-38 has two bass inputs, volume, bass and treble controls, and *DEPTH* and *PRESENCE* switches all mounted on the front panel, as are the on/off and hum-minimizing line reverse switches. Unit is housed in a ¾-in. thick pressed-wood cabinet covered with black vinyl and has removable locking casters. The TA-38 sells for $225.00, and you can write for more specs to the Heath Co., Benton Harbor, Mich. 49022.

Tunable Tipped Tenna

The Racer 4 and Racer 6 mobile antennas have a stainless steel tip incorporating a tuning device. Tuning is accomplished by adjustment of the tip length for minimum SWR. The tip is then locked into place. The fiberglass shafts are white with a printed checkered flag pattern at the base; the Racer 4's is 48 in., the Racer 6, 72 in. The chromeplated threaded

Avanti Racer 6 Mobile Antenna

brass ferrule can be installed on any standard mounting bracket. Frequency range is 26.6 to 27.3 MHz, power handling capability is 100 watts. Racer 4 sells for $10.25, Racer 6 is $11.25. The lady is priceless. Write to Avanti Research & Development, Inc., 33-35 W. Fullerton Ave., Addison, Ill. 60101.

Looking for a Left-Handed Monkey Wrench?

This 24-page catalog of hard-to-find tools could be a big help with your construction projects. All kinds of tools are available from the Brookstone Co.; for instance, electronic pliers, sensitive drillers, precision tools, unusual solders, miniature files, riflers, endless hacksaw, etc. These all have detailed descriptions and applications and are only available by mail. For the catalog, send 25¢ to Brookstone Co., 96R River Rd., Worthington, Mass. 01098.

Brookstone "Hard-To-Find Tools"

Transceiver Mit Pluses

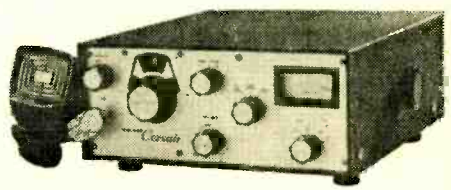
The new Galaxy GT-550 is a 5-band single-sideband transceiver designed for either mobile or fixed station use by amateur radio operators. Compact (11¼ x 12⅜ x 6-in.), lightweight (17 lb.), yet it has 550 watts SSB power, 360 watts CW. The GT-550 is priced at $449. Accessory-wise, you can have the LA amplifier for $495, the RF console at $69, the remote VFO at $75, and the speaker console at $19.95. Other optional accessories are: AC power supply, mobile power supply, phone patch, CW

Galaxy RF Console, GT-550 Transceiver, Speaker Console

filter, VOX accessory, calibrator, mobile mounting bracket, floor-board adapter. For a free brochure on the complete line write to Galaxy Electronics, 10 S. 34th St., Council Bluffs, Iowa 51501.

Two Transceivers in One

The Tram Corporation, makers of the Titan II Citizens Band base station, have now produced a mobile unit, the Corsair. The Tram people state that the Corsair's complete AM capability plus an excellent single-sideband receiver and a double-sideband-suppressed carrier transmitter make all other CB equipment absolete. The Corsair is compatible with any unit



Tram Corp. Corsair Transceiver

now on the market. Its built-in Collins mechanical filter cuts interference from adjacent channels down 90 dB or even better. There's a noise blanker/noise limiter which reduces ignition interference. The unit draws a maximum of 1.5 amps of current while transmitting and 300 milliamps while receiving. Very compact, 4 x 9 x 8 in., it's easily installed in cars, boats, aircraft. Price of the Corsair is $415.00. For more specs write to Tram Corp., Lower Bay Rd., Box 187, Winnisquam, N. H. 03289.

23 Channels by Messenger

Latest in the E.F. Johnson line of Citizens two-way radios is the Messenger 123, featuring full 23-channel operation at new low prices. Power input to the final amplifier is the maximum 5 watts for FCC type acceptance. The 123's receiver has 0.4-μV sensitivity with sharp filtered 7-kHz selectivity. There's a noise limiter, and the all solid-state circuitry is fully temperature-compensated to operate from −22°F to +140°F. Other features: variable squelch control, automatic volume control, a

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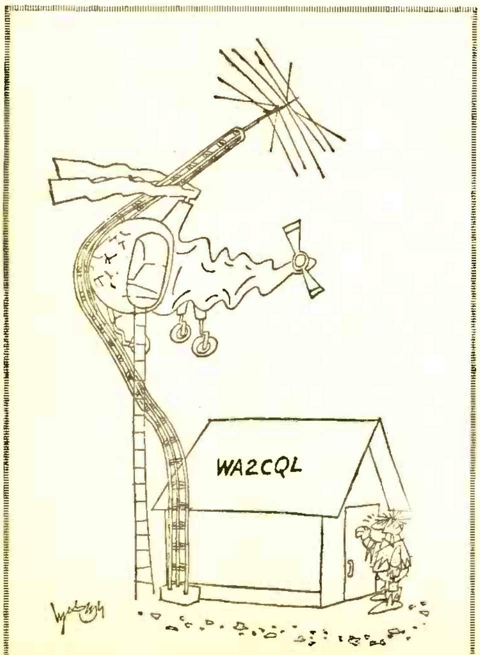
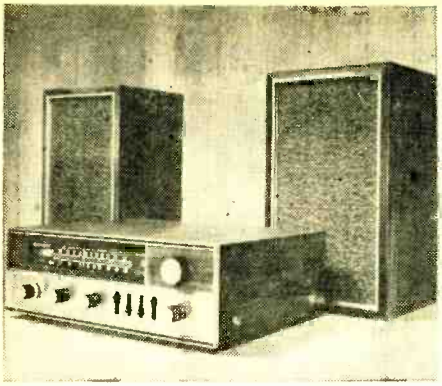
E.F. Johnson Messenger 123 Transceiver

meter that monitors incoming signal strength and transmitter output power. For under-the-dash snugness, the Messenger 123 measures 2½ x 6⅜ x 8¾ in., weight is only 5 lb. The whole line of Johnson accessories is available for the 123, including base station adapter. Price is $169.95. For more information write to the E. F. Johnson Co., 299 10th Ave. S.W., Waseca, Minn. 56093.

You Can't Beat the System!

This stereo system—a receiver and pair of speakers—employs an FET (field effect transistor) in its tuner section for better sensitivity and less cross modulation. Kenwood's KS-33 has an automatic stereo/mono mode silent switching circuit with stereo light indicator, and an illuminated pinpoint tuning meter. In the amplifier section, a 4-position program source selector permits *AM, FM, AUTO, PHONO,* and *AUX*. There are four pairs of input ter-



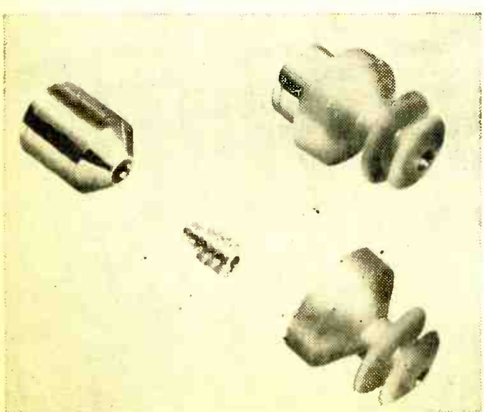


Kenwood KS-33 Stereo Receiver System

minals for *MAG, AUX, TAPE REC,* and *TAPE PLAY*. Output is 30 watts. All this, including cabinet, is $199.95, and there's a two-year warranty on both parts and labor. Write for more dope to Kenwood Electronics, Inc., 3700 S. Broadway Pl., Los Angeles, Calif. 90007.

Rock Heads, Before It's Too Late!

Cutdown on those damaging decibels! Research has shown that the sound level on dance floors and near the bandstand averages 100 dB and often peaks at higher than 120 decibels, which is lots higher than the safe industrial noise level of 85 decibels. Someone had to do something and the Sigma Engineering Co. did. Their Le Sonic Ear-Valv is not an ear plug, it's a sonic filter that screens and blocks out the harmful sound energy. The Ear-Valv has a sound-actuated mechanism that acts as an auxiliary to the human ear's protective mechanism. Damaging noises are filtered out while harmless level sounds pass through unaltered. This intricate device costs only $3.95 the set, and



Sigma Engineering Le Sonic Ear-Valv

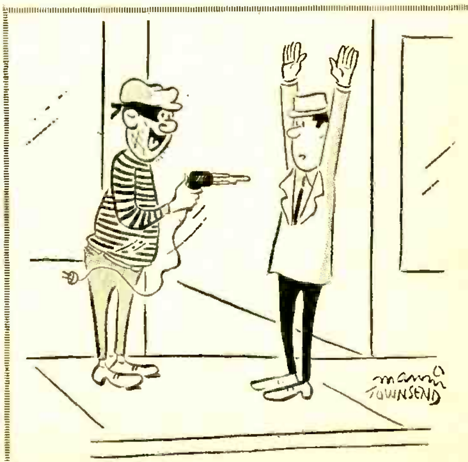
all rock musicians and buffs should write to Sigma Engineering Co., 11320 Burbank Blvd., N. Hollywood, Calif. 91601 for more data.

Too Lazy to Hold the Phone?

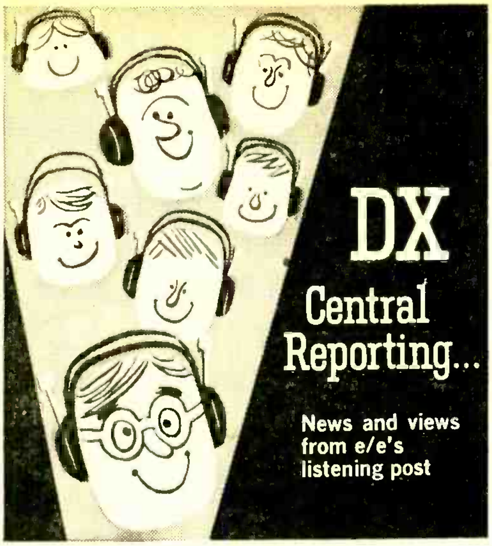
The Knight-Kit KG-205 Telephone Amplifier has many uses and requires no electrical connection to the phone. A suction cup mount on the pickup attaches itself instantly to any telephone. The solid-state circuit amplifies telephone sound to room level for hands-free conversation and

Knight-Kit KG-205 Telephone Amplifier

group listening, and it's a nice little device for the hard-of-hearing. Easily assembled with basic tools, the KG-205 is equipped with volume control and *on/off* switch. It's priced at $6.95 with 9-volt battery and step-by-step instructions. Write for Sales Book No. 283, free from Allied Radio Corp., 100 N. Western Ave., Chicago, Ill. 60680. ■



"Oh, that kid again. He's always pulling those practical jokes!"



DX Central Reporting...

News and views from e/e's listening post

by Don Jensen

What's going on in Central America? For years, this underdeveloped umbilical of mountain and jungle between the hemisphere's continents was something of a broadcasting backwater. Save for some government outlets, progressive missionary stations and a handful of successful private operations, shortwave broadcasting in the six republics—Guatemala, Panama, Honduras, Nicaragua, El Salvador and Costa Rica—was pretty anemic.

But something strange is happening. First, it was Germany's Deutsche Welle that announced plans for a powerful relay in Guatemala or El Salvador. Though bogged down, latest word from Cologne is that the project's still alive. No one's saying just when construction will begin, however.

Then, early last year, one of the financially solvent Central Americans, *TIRICA*, Costa Rica's La Voz de la Victor, did a crazy thing. It dropped all commercials! Coming up with a mysterious pair of new transmitters, one million watts on 625 kHz., and 50 kw. on 9,615 kHz, it began airing nothing but music and station identifications.

Sporadically, these tests have continued, but recently, some political programs have been heard, lending credence to stories that *TIRICA* is about to follow the murky path trod by the CIA's secretly-supported stations, Radios Americas and Libertad.

Last fall, it was Radio Nacional de Quetzaltenango that popped up with an apparently new and potent transmitter. This Guatemalan had languished for years on 11,700 kHz., its 500-watt transmitter infrequently heard by SWL's. Suddenly, everyone was hearing it testing with English announcements.

Why this minor government-owned station in provincial Quetzaltenango—a city best known to Guatemaltecos for its breweries—should "up" its power and play around with international programming remains a puzzle.

The latest enigma is Radiodifusora Nacional de Nicaragua, which returned to the air a couple of months ago after a shortwave absence of about 14 years. The Managua station, using at least one 100-kW transmitter, seemingly is in search of a frequency and has been heard on 5,935 and 11,875 kHz.

So far, its programming is nothing special, just the usual domestic fare, Spanish announcements, time checks and slogans, plus plenty of Latin rhythms and old American recordings. Why, then, the expensive new equipment to cover a country no bigger than Arkansas?

There's nothing to indicate these intriguing little mysteries are connected in any way, but the nagging question remains—What IS going on in Central America?

Ship's Doctor. When Dr. Guido Guida died in Rome, February 19, at the age of 72, he left behind an unusual legacy to all men who go down to the sea in ships—the International Radio Medical Center.

Since 1935, the service has provided medical advice by shortwave radio to ships around the world. Each year, the Italian-based operation handles an average of 8,000 radio calls from ships at sea seeking medical help. It also assists persons on isolated Mediterranean islands who need aid.

Before his death, Dr. Guida, whose training was received at the University of Rome, recalled the beginnings of the unique radio doctor service.

"In those days," he said, "I used to have a radio operator sleeping in my apartment and conducted the operation from there."

Dr. Guida sent notices explaining his free service to the shipping lines and furnished medical manuals, written in layman's language, to ship's officers. Initially, the International Radio Medical Center was used mostly by Italian vessels, but soon it was accepted almost universally by ships of other nations.

Today, the costs are underwritten by private and governmental sources around the globe. Medical expertise is provided by teams of volunteer doctors always on call.

A ship needing help radios *MEDRADCRIM*, a code call that has priority over all other radio traffic except SOS, and reports details and symptoms to the center. Physicians on duty study case history sheets of the sailors being treated for illness or injury and their advice on medication or treatment is then radioed back to the vessel.

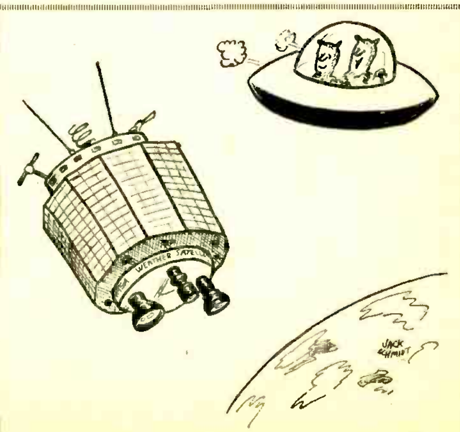
The center is housed in a villa in the suburbs of Rome, having outgrown its offices in the city in 1963.

DXers report hearing the center's station, IRM, transmitting an identification "marker" in International Morse Code during the early evening hours on a number of shortwave frequencies, including 6,384, 8,685, 12,770 and 17,035 kHz.

If your code ability isn't up to par, tape record the signal at "fast" speed, play it back at "slow," and copy down the di's and dah's. Listen for a running series of "V's" (. . .–) and the station's Morse identification, IRM (. ./ .–./– –).

Bandsweep. 890 kHz.—dawn patrollers on the broadcast band are finding the Dominican Republic's HIPJ, Radio Continental, in Santo Domingo, with a strong signal at 1010 GMT sign on. 6,195 kHz.—on the other half of Hispanola island, the French-speaking veteran, Radio Haiti is stronger than usual during the early evening hours. 7,065 kHz.—a good catch in the volatile Middle East is Radio Iran, in Persian around 0230 to 0330 GMT. 7,286 kHz.—the usual damn-yankee tirades are heard mornings from 1200 GMT, in English, on this new Hanoi frequency. 9,525 kHz.—Zulu's back in town! Radio RSA, South Africa can be heard with Zulu programming to Southern and Eastern Africa at 0400 GMT sign on. 11,825 kHz.—Machinegun-speed drumming and French lingo news are aired nightly by Papeete, Tahiti after 0600 GMT. 11,948 kHz.—one of the toughest countries to log in Latin America is Paraguay. Radio Encarnacion is audible now during the early evening. 16,342 kHz.—an interesting, non-broadcast type station is this outlet of the New China News Agency, with slow, dictation speed in Chinese for newspaper editors in provincial Red Chinese cities. ■

(*Credits:* Jerry Starr, Ohio; A. R. Niblack, Ind.; Bill Berghammer, N. Y.; Bob Palmer, Wash.; Gregg Calkin, N. B., Canada; National Radio Club; American SWL Club; North American Shortwave Association)



"Let's show 'em some hurricane pics!"

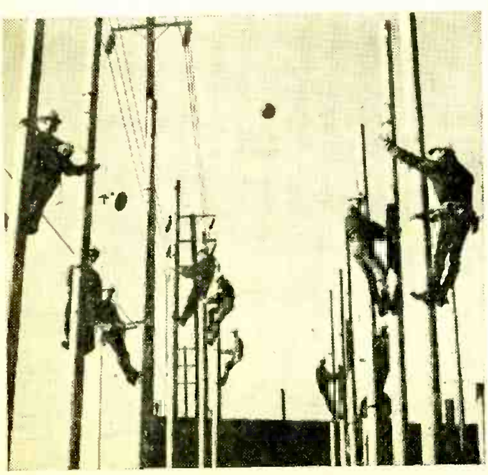
Higher Education

The dark sphere hurtling through the California air is neither bird nor missile: it's just an ordinary basketball being tossed from man to man in a "school in the sky," here.

Playing catch is an important part of the curriculum for these 12 young men who are students in a pole-climbing school run by General Telephone & Electronics Corporation. By passing the basketball around their "classroom" 25 feet in the air, the novice climbers gain confidence in working at heights and develop the agility they'll need to "walk the stick" without mishap.

Anyone who misses an easy catch or drops the ball must climb down and retrieve it—and the same penalty awaits the thrower of a bad pass. These errors benefit the entire class by providing additional climbing practice.

The five-day course teaches the California



School can be fun as the pole climbers have discovered. Simple game of catch in the sky builds confidence.

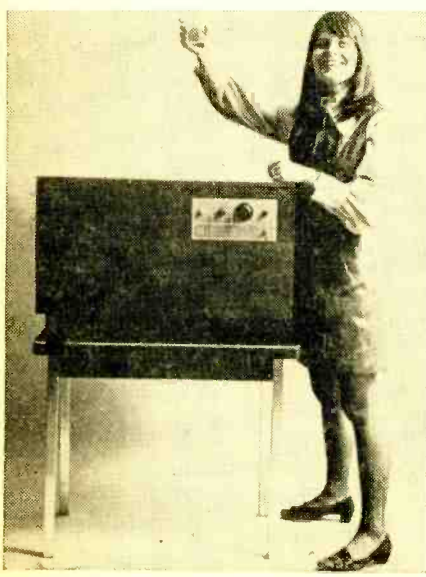
company's new installer-repairmen, linemen, and cable splicers how to ascend, work atop the pole, and descend—and do everything safely. Instructors drill the men in use of their safety belts and boot "gaffs"—the sharp spikes they jab into the wooden pole for climbing. To "graduate," pupils have to pass a rigorous test that demonstrates their proficiency in all aspects of the aerial art.

Clear Water

A new type of water purification system utilizing ozone has been developed for the millions of homeowners, farmers and small commercial businesses who derive their water from the 15-million wells in America and other private sources. Many of these wells contains undesirable impurities and as time goes by the situation gets worse.

Ozone reportedly oxidizes from water harmful pollutants such as sulphur, bacteria, virus, and many other kinds of impurities. It is also reputed to keep pipes and plumbing free of blackening and damaging corrosion, and it eliminates the tastes and odors of sulphur and other unpleasant substances. Ozonator Corporation of Batavia, N. Y., creators of the system, also maintains that water purified with ozone contains no residual taste or odor that is the case with conventional chlorine or other chemical equipment.

Ozone is an activated oxygen molecule, formed when air is charged by electricity. It is familiar in nature as that fresh smell after a lightning storm. Ozone is unstable, and when bubbled through a household water supply it readily combines with and oxidizes existing impurities.



The new Ozonator water purifier, which can be installed in just a few hours, produces pure water for homes, farms, and small businesses by using ozone to oxidize sulphur, algae, bacteria, viruses, and other problem impurities.

Ozone's purification properties have been known for hundreds of years. Paris and many other cities in France and Germany have used ozone to purify municipal water since the early 1900's. Until the development of the Ozonator Corporation system, however, ozone was too expensive to produce for application to household water purification.

Ozonator Corporation reports the purifier to be completely automatic and self-regulating. There are no chemicals to add or replace, no backwashing is necessary, and it is unconditionally guaranteed. Since air and electricity are the only raw materials, there is a minimum of maintenance. The Ozonator unit is compact, easy to install, and operates inexpensively from standard household electrical outlets.

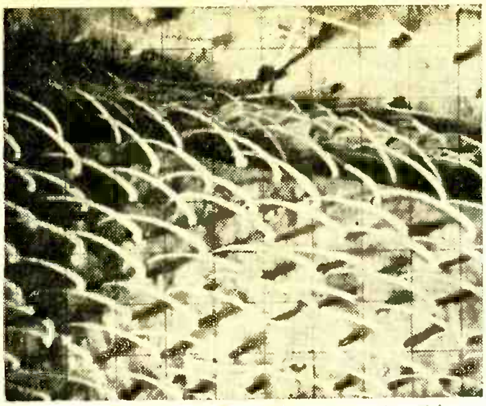
Speck of News

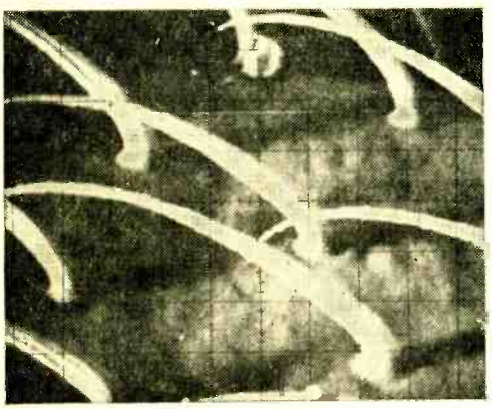
Chemists and biologists now have a powerful new electronic instrument that helps them make analyses more amazing than those of Sherlock Holmes and his fabled magnifying glass. The new instrument, called an "electron probe microanalyzer," looks and works like an electron microscope. It can greatly magnify small objects—for example, it can make the hairs on the wings of a housefly look like a field of waving grass. But Philips Electronic Instruments developed the microanalyzer to answer a common, perplexing laboratory problem: how to determine the chemical composition of a speck of material so small that thousands could rest on a single grain of table salt?

To solve this problem, Philips took advantage of an electronic phenomenon that recently made the nation's TV viewers move back a bit from their TV sets: X-rays. Whenever an electron beam strikes a substance, the impact of the electrons cause the substance to emit X-rays. Each basic element—for example, iron, carbon, and the phosphorous of a TV screen—emits its own special X-ray wavelengths when struck. The strength of these rays depends upon the strength of the electron beam that stimulates them.

The X-rays emitted when an electron beam "paints" a picture on a TV screen are usually very weak and harmless, and serve no useful purpose. But in the Philips electron probe microanalyzer, a powerful electron beam is carefully focused onto an unknown speck of material. The resulting X-rays can "fingerprint" the composition of the speck being analyzed—if they can be "unscrambled."

Although unscrambling invisible rays sounds





Two views of hair on a fly's wing as reproduced by a Philips 4500 electron probe microanalyzer operated in the scanning microscopy mode. Lower magnification is 140 times life size, and higher magnification is 575 times life size.

difficult, most grammar-school students have seen an experiment which shows how easily it is done. In the experiment, the teacher shines sunlight through a triangular glass prism, separating the scrambled white light into separate wavelengths which the human eye sees as red, orange, blue, etc.

In the Philips microanalyzer, the scrambled X-rays emitted by the unknown speck pass through a crystal of lithium fluoride, rare-earth cousin of the material in cavity-fighting toothpastes. The fluoride crystal separates the X-rays like the glass prism separates light wavelengths.

As the crystal is rotated by a motor, the separate bands of X-rays strike a counter tube that resembles the kind carried by uranium prospectors. A computer connected to the crystal motor and the tube records what angles radiation passed through the crystal to strike the counter tube, and which did not. It compares the data it has collected with information collected on all known elements. When its analysis is done, the computer's teletypewriter delivers a printed report on all elements of which the tiny, invisible speck was composed.

Definitely not a tool for the basement experimenter, the complete Philips system costs about $100,000—without the computer. But for medical researchers trying to determine the composition of a new drug or metallurgists trying to develop high-strength metals of the future, the months of research it can save is more than worth the microanalyzer's price.

Credit Card Cop

Harried retailers and their customers can look toward rapid sales with a new credit-card authorizing system that tells a clerk within one second whether to authorize a purchase or call for help. The need for such systems has increased with the number and misuse of credit cards in recent years. Losses have grown to almost *three per cent* of total sales for many department stores. And in the end, the honest customer suffers: prices have increased to cover lost merchandise and the salaries of enlarged credit-office staffs, and during busy seasons, the credit verification for even a moderate purchase may take a quarter hour or more.

A promising solution to these problems is a new credit-authorizing system called "Creditmaster," developed by Digital Data Systems Corp., Pennsauken, N. J. It consists of a sales-counter card reader about the size of a desk telephone, and a computerlike processor and credit-office console.

When a customer hands a clerk a credit card, she places it in her card reader and presses a series of buttons. Twenty microcircuits inside the reader immediately translate the card number into an electronic signal for transmission

"Julian saved every back issue of Elementary Electronics!"

Kenrick Stephenson, engineering vice president of Digital Data Systems, examines circuit board of new credit-card authorizing system he developed to help department stores eliminate losses from fraud and bad debt. The circuit board contains 20 of the latest Texas Instruments micro-circuits, space-age devices which take just a few millionth of a second to translate a 12-digit credit card number into an electronic signal.

over a wire to the central processor. Within 1/30th second, about 500 more of the tiny electronic circuits inside the processor search its memory for information on that account, and flash it back to the clerk.

Tiny lights on her card reader, hidden from the customer's view, indicate what the central processor has found. There are four possibilities—the card is good; the card is good but the size of the purchase of status of the account requires a phone call to the credit office; the card is listed as lost or stolen and the store detective should be called; the card number doesn't make sense, indicating clerical error or a possible counterfeit card.

The Digital Data System's equipment uses integrated circuits (ICs)—inch-long electronic components that contain the equivalent of up to several hundred separate transistors and other parts within each tiny package. Developed a decade ago by Texas Instruments to reduce the size and failure rates of complex aero-space computers, ICs have steadily decreased in price to the point where they are now far cheaper than the larger, older devices they replace.

"By using complex, low cost TI integrated circuits, we were able to quickly design a credit authorizing system even the smallest department store issuing credit cards could afford," explains Kenrick O. Stephenson, vice president of engineering, and one of Digital Data System's owners. "These ICs include many new types classed as 'medium scale integration,' each of which replaces two or more prior-generation integrated circuits."

The new integrated circuits greatly reduce engineering time, saving the first Digital Data customers the high engineering costs that used to be amortized over the first year or so of equipment production.

In the case of the clerk's card reader, for example, Texas Instrument engineers completed drawing up the circuit diagram at 4 p.m. one afternoon, and had a working prototype by 7 p.m. the same evening. Thanks to ICs, development time is now limited only by the creative process, not the assembly of the test circuit. While the engineers could have designed a credit card authorizing system using transistors rather than ICs, the equipment would have been impractical. With transistors, the equipment would have been too big, too expensive to build, and a nightmare to troubleshoot. If an IC fails, it's cheap enough to throw away—but if a whole printed-circuit board full of transistors failed, too much money would have been tied up in it to toss it out.

While designing the system, it was decided that the final circuitry would have to be absolutely fail-safe. At no time could obvious breakdown occur, tipping off prospective defrauders that the system was inoperative.

Digital Data System's equipment has an emergency bypass switch to protect the store in the event of a breakdown. This switch permits clerks to continue inserting credit card into their counter units; however, all cards will be determined "valid" until the malfunction is corrected. Even the clerk will be unaware that the cards actually aren't being checked by the central processor. ■

"I learned new earth words today, 'Stick 'em up!' "

"The winning of a Pawn among good players of even strength often means the winning of the game," wrote World Champion Jose R. Capablanca. And this is particularly true of many modern masters who thrive on winning one early in the game and nursing it along to victory in the ending. But this is easier said than done. Great precision and perfect technique are sometimes required. And sometimes even that, as in my second example, is insufficient.

First, the Lucena Position. This setup was analysed by Lucena, a Spanish theorist, late in the Fifteenth Century, and is basic to an understanding of the Rook and Pawn vs. Rook endgame. White can only win by freeing his King (by "building a bridge") and queening his Pawn.

Black

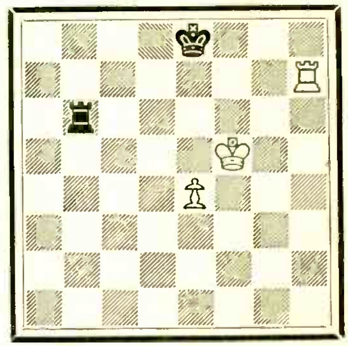
White

1	....	R-R6	5	K-N6	R-N8#
2	R-B4!	R-R8	6	K-B6	R-B8#
3	R-K4#	K-Q2	7	K-N5	R-N8#
4	K-B7	R-B8#	8	R-N4	

And White wins.

Second, Philidor's Drawn Position. Andre Philidor, France, World Champion 1747-1795, knew this setup could not be won by White, despite his Pawn advantage. Black only needs to post his King on the queening square of the Pawn, keep his Rook on the third rank until the Pawn reaches its sixth rank, and then go to the eighth rank and check and check and check.

Black



White

1	P-K5	R-QR3	4	K-K5	R-K8#
2	P-K6	R-R8!	5	K-Q6	R-Q8#
3	K-B6	R-B8#			

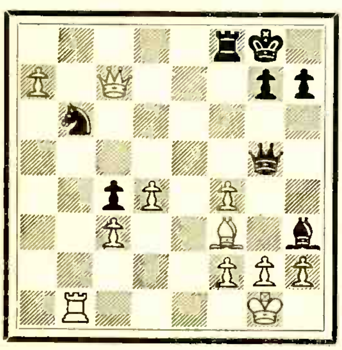
And so on and on. If the King leaves his Pawn to evade the checks then the Rook attacks the Pawn and wins it or forces the King back to its defense.

Game of the Issue. El Gran Cubano, chess machine, lightning-chess wizard, combinative genius, endgame virtuoso, exponent of simple chess—these were some of the sobriquets bestowed on Jose R. Capablanca, World Champion from 1921 to 1927. Capa, whose name and fame were known to millions who barely knew the moves, was born in Havana, 1888. He learned to play at the tender age of four (which explains how chess became his "mother tongue"), won the championship of Cuba when only twelve, swamped U. S. Champion Frank J. Marshall by 8-1 in their 1909 match, finished first and second, respectively, in the great tournaments of San Sebastian, 1911, and St. Petersburg, 1914 (he now had an appointment to the Cuban Foreign Office), won seven more tournaments during the next seven years, and then defeated Dr. Emanuel Lasker in the 1921 title match with four wins, fourteen draws, and no losses. As reigning champion, two more notable firsts were added—London, 1922, and New York, 1927. But defeat, disappointment, and disillusion came in 1927—he lost the title to Dr. Alexander Alekhine by 15½-18½. The spell was broken, the aura of invincibility dispelled. Several more tournament victories were racked up, among them such great ones as Moscow, 1936, and Nottingham, 1936, and a 6-4 match triumph was registered against future World Champion Dr. Max Euwe of Holland, but the world title was never regained.

Capablanca was supreme in combinations, position-play, middle-game, endgame, and he had an intuitive grasp of all the essentials. He received the First Brilliancy Prize for the following game against R. Spielmann (Black) in the 1927 New York Tournament. A Queen's Gambit Declined, it is cleancut, logical, "simple," and is considered "the classical Capablanca game."

1	**P-Q4**	**P-Q4**	**14**	**N-Q2!**	**P-N4**
2	**N-KB3**	**P-K3**	**15**	**Q-R5!**	**N-K5**
3	**P-B4**	**N-Q2**	**16**	**NxN**	**PxN**
4	**N-B3**	**KN-B3**	**17**	**P-QR4!**	**Q-Q4**
5	**B-N5**	**B-N5**	**18**	**PxP!**	**QxB**
6	**PxP**	**PxP**	**19**	**BxP**	**R-N1**
7	**Q-R4**	**BxN#?**	**20**	**PxP!**	**R-N4**
8	**PxB**	**0-0**	**21**	**Q-B7**	**N-N3**
9	**P-K3**	**P-B4?**	**22**	**P-R7**	**B-R6**
10	**B-Q3**	**P-B5**	**23**	**KR-N1!**	**RxR#**
11	**B-B2**	**Q-K2**	**24**	**RxR**	**P-B4**
12	**0-0**	**P-QR3**	**25**	**B-B3**	**P-B5**
13	**KR-K1**	**Q-K3**	**26**	**PxP**	**Resigns**

Position after 26 PxP



Why did Black resign? Because he is behind four Pawns for a piece, his Queen, Bishop, and Knight are en prise, and because the Queen Rook Pawn is about to queen. Here is the analysis—

A. If 26 . . . . QxP 27 QxQ, RxQ 28 RxN, R-B1 29 R-N8 and White makes a new Queen.

B. If 26 . . . . Q-N3 (other Queen moves lose too) 27 RxN, Q-B7 28 QxBP# K-R1 29 PxB wins.

C. If 26 . . . . RxP 27 RxN, RxB 28 R-N8# (or 28 P-R8=Q#) R-B1 29 QxBP# K-R1 (29 . . . . Q-Q4 and 30 . . . . B-K3 delay it two moves) 30 RxR mate.

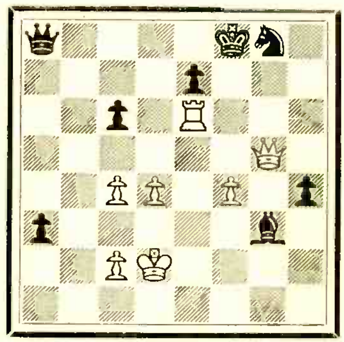
D. If 26 . . . . N-Q4 (26 . . . . N-R1 27 QxBP# K-R1 28 PxQ wins) 27 QxP, Q-N3 28 BxN# K-R1 29 R-N8 wins.

A well-nigh perfect game by the Great Cuban.

End Game Study #5

By K. A. L. Kubbell

Black



White

White to Play and Win.

This composition by a famous Russian, noted for his realistic positions, was awarded First Prize in "64" in 1925. It features an unexpected sacrifice and a "quiet" move. Don't struggle to find the solution. Just play over the score and notes and enjoy the beauty of it.

1 R-N6 **N-B3**
2 Q-R6# **K-B2**

If 2 . . . . K-K1 3 Q-R8# K-B2 4 R-N7# K-K3 5 QxQ wins.

3 RxN#! **PxR**

If 3 . . . . K-N1 4 Q-N5# K-R2 5 R-R6 mate.

4 Q-R7# **K-K3**

If 4 . . . . K-B1 or 4 . . . . K-K1 5 Q-R8# wins the Queen.

5 P-B5# **K-Q3**
6 P-B5# **K-Q4**

7 Q-N8#!! . . . .

Unexpected—to say the least!

7 . . . . **QxQ**
8 K-Q3! . . . .

A "quiet" move—with a roar!

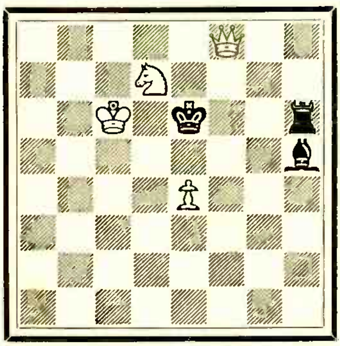
8 . . . . **Any**

Black can make any move—with the Queen (it has no checks), Bishop, or Pawns —and White's reply will be the same.

9 P-B4 mate

Problem 19
By H. Weenink
Op de Hoogte, 1918

Black



White

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

This one is by a famous Dutch composer and has a "Grimshaw" theme (Walter Grimshaw, an English problemist of the Nineteenth Century) which illustrates interference.

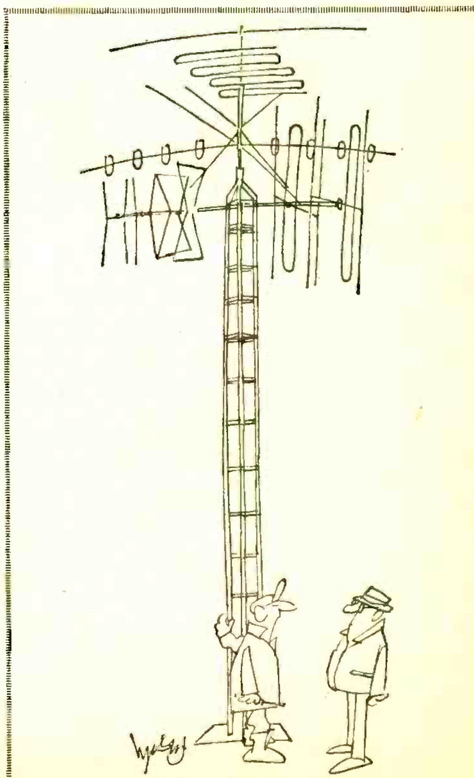
Solution to Problem 18: 1 K-N3.

Solution to Combination #1:
1 R-B8# RxR (if 1 . . . KxP 2 RxR wins) 2 QxP#!! KxQ (if 2 . . . . K-B2 3 P-N8=Q## wins) 3 PxR=N# K-N2 4 NxQ and White wins with his two passed Pawns. So it was a Knight fork which did it after all! Very slick.

News and Views. PFC Charles W. Powell won the 1968 Armed Forces Worldwide Chess Championship with an 11-1 score. Second and third prizes went to two other Army players, SP4 Michael Sienkiewicz, 10½-1½, and SP5 Walter R. Cunningham, 10-2.

A new series of annual matches has been arranged between the Manhattan and Marshall Chess Clubs. The first one was won by Manhattan, 8-6, with Grandmaster Robert J. Fischer scoring on first board against Dr. Anthony Saidy of the Marshalls. Dr. Karl Burger, Manhattan, won the Brilliancy Prize for his win over Malcolm Weiner, and Fischer and Arthur Bisguier (against James Sherwin, Marshall) shared the Best Played Game award. Mr. Milton Pauley, a Director of the Manhattan and of the American Chess Foundation, has contributed a trophy and cash awards for these matches.

The 70th Annual U.S. Open Chess Championship will be held at the Hotel Lincoln, Lincoln, Nebraska, August 10-22. There is a $5000 Guaranteed Prize Fund (the largest one ever offered in a U.S. Open) with a $1500 1st Prize, plus Trophy. And there will be prizes for Expert, Classes A, B, C, D, and E, Unrated, Women, and Junior. The Entry Fee will be $25 plus United States Chess Federation membership. All are invited. ■



". . . I'll listen to anything . . ."

LITERATURE

ELECTRONIC PARTS

★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!

★2. Now, get the all-new 512-page, fully illustrated *Lafayette Radio* 1969 catalog. Discover the latest in CB gear, test equipment, ham gear, tools, books, hi-fi components and gifts. Do it now!

★5. *Edmund Scientific's* new catalog contains over 4000 products that embrace many interests and fields. It's a 148-page buyers' guide for Science Fair fans.

★4. *Olson's* catalog is a multicolored newspaper that's packed with more bargains than a phone book has names. Don't believe us? Get a copy.

★7. Before you build from scratch, check the *Fair Radio Sales* latest catalog for electronic gear that can be modified to your needs. *Fair* way to save cash.

8. Get it now! *John Meshna, Jr.'s* new 46-page catalog is jam packed with surplus buys—surplus radios, new parts, computer parts, etc.

1. *Allied's* catalog is so widely used as a reference book, that it's regarded as a standard by people in the electronics industry. Don't *you* have the 1969 *Allied Radio* catalog? The surprising thing is that it's free!

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.

★106. With 70 million TV and 240 million radios somebody somewhere will need a vacuum tube replacement at the rate of one a second! Get *Universal Tube Co.'s* Troubleshooting Chart and facts on their $1.50 flat rate per tube.

10. *Burstein-Applebee* offers a new giant catalog containing 100s of big pages crammed with savings including hundreds of bargains on hi-fi kits, power tools, tubes, and parts.

11. Now available from *EDI (Electronic Distributors, Inc.)*: a catalog containing hundreds of electronic items. *EDI* will be happy to place you on their mailing list.

6. Bargains galore, that's what's in store! *Poly-Paks Co.* will send you their latest eight-page flyer listing the latest in available merchandise, including a giant $1 special sale.

CB—AMATEUR RADIO—SHORTWAVE RADIO

102. No never mind what brand your CB set is. *Sentry* has the crystal you need. Same goes for ham rigs. Seeing is believing, so get *Sentry's* catalog today. Circle 102.

146. It may be the *first—Gilfer's* speciality catalog catering to the SWL. Books, rigs, what-nots—everything you need for your listening post. Go *Gilfer*, circle 146!

100. You can get increased CB range and clarity using the "Cobra-23" transceiver with speech compressor—receiver sensitivity is excellent. Catalog sheet will be mailed by *B&K Division of Dynascan Corporation*.

141. Newly-designed CB antenna catalog by *Antenna Specialists* has been sectionalized to facilitate the picking of an antenna or accessory from a handy index system. Man, *Antenna Specialists* makes the pickin' easy.

130. Bone up on the CB with the latest *Sams* books. Titles range from "ABC's of CB Radio" to "99 Ways to Improve your CB Radio." So Circle 130 and get the facts from *Sams*.

107. Want a deluxe CB base station? Then get the specs on *Tram's* all new Titan II—it's the SSB/AM rig you've been waiting for!

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.

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.

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.

111. Get the scoop on *Versa-Tronics'* Versa-Tenna with instant magnetic mounting. Antenna models available for CBers, hams and mobile units from 27 MHz to 1000 MHz.

45. CBers, Hams, SWLs—get your copy of *World Radio Labs'* 1969 catalog. If you're a wireless nut or experimenter, you'll take to this catalog.

101. If it's a CB product, chances are *International Crystal* has it listed in their colorful catalog. Whether kit or wired, accessory or test gear, this CB-oriented company can be relied on to fill the bill.

103. *Squires-Sanders* would like you to know about their CB transceivers, the "23'er" and the new "SS5." Also, CB accessories that add versatility to their 5-watters.

TOOLS

78. Scrulox square recess screws pose no problems for the serviceman who carries either of *Xcelite's* two new Compact Scrulox screwdriving sets in his pocket or tool box—Bulletin N467 explains all.

118. Secure coax cables, speaker wires, phone wires, etc., with *Arrow* staple gun tackers. 3 models for wires and cables from 3/16" to 1/2" dia. Get fact-full Arrow literature.

ELECTRONIC PRODUCTS

44. Kit builder? Like wired products? *EICO's* 1969 catalog takes care of both breeds of buyers. 32 pages full of hi-fi, test, CB, ham, SWL, automotive and hobby kits and products —do you have a copy?

144. Hear today the organ with the "Sound-of-Tomorrow," the Melo-Sonic by *Whippany Electronics*. It's portable—take it anywhere. Send for pics and descriptive literature.

42. Here's colorful 116 page catalog containing a wide assortment of electronic kits. You'll find something for any interest, any budget. And *Heath Co.* will happily send you a copy.

128. If you can hammer a nail and miss your thumb, you can assemble *Schober* organ. To prove the point, *Schober* will send you their catalog and a 7-in. disc recording.

12. *C. B. Hanson* new Automatic Control records both sides of a telephone call automatically—turns off automatically, too! Get all the details —today!

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ELEMENTARY ELECTRONICS ETYMOLOGY

By Webb Garrison

Matrix

▲ Probably from *mater* (mother), Roman cattle and horse breeders used *matrix* to name a pregnant animal. Later the term came to designate the womb, whose initial swelling was a signal of motherhood to come.

Preserved unchanged for many centuries, the Latin term for "womb" was employed by English physicians before the 16th century. In his pioneer translation of the New Testament (1526) William Tyndale wrote that *"Every man chylde that first openeth the matrix shalbe called holy to the lorde."* (Luke 2:23).

Passing from speech of anatomists to that of artisans, the old word seemed just right to designate a mould. For when metal is cast, the mould serves as the "breeding place" for the finished product. Type-founders, in particular, found matrix technology to effect great savings of time.

Long abandoned by obstetricians and animal breeders but still a vital term in many industries, *matrix* seemed just the right label for an entirely new device: a logical network in the form of a rectangular array of intersections of input and output leads. Adopted in the infancy of information storage and retrieval technology, the name has clung to increasingly sophisticated devices—many of which serve as encoders and decoders.

In more than symbolic form, the matrix served as an electronic womb by means of which the binary computer was brought to full term.

Quasar

▲ More than 30 years ago Karl Jansky of Bell Laboratories reported that he heard radio signals coming from outer space. At the time, few scientists took him seriously. A few considered his report to be a hoax; most thought he had misinterpreted data.

But confirmation came from so many sources that radio astronomy was born. After World War II, advances in radar technology increased the sensitivity of radio telescopes. Using huge new ones, it was shown that most radio signals from space originate in distant galaxies.

About 1960, scientists at Cambridge University began to pin-point extremely strong impulses that seemed to come from faint stars. Logic said that such sources of electromagnetic waves simply had to be vastly smaller than galaxies; yet magnification showed them to be very bright. One of them was estimated to give out as much radiation as 10 thousand billion suns.

Such "broadcasting stations in space" were considered to be neither ordinary galaxies nor stars of a kind familiar to us. So pioneer investigators evaded precision by coining the name "quasi-stellar radio source." Abbreviated to *quasar*, the term masks many mysteries. Sources of the signals from "out yonder" are now thought to be as far as 8 billion light years away, receding from our galaxy at speeds up to 153,000 m.p.h. Riddles linked with them have helped re-open debate about the origin and nature of the universe.

Log

▲ Since the beginning of open-water navigation, sailors have sought to measure speed of ships. No effective device was in use before the 15th century, though.

In the decades just before Columbus' voyage to the New World, artisans perfected a new instrument. Its vital component was a thin wooden quadrant 5 or 6 inches in radius, loaded with lead on the arc so that it would float point up. Though it bore only a superficial resemblance to a section from the trunk of a small tree, the gadget looked more like a log than anything else.

Lines from the four corners of the log were attached to a log line that was knotted at regular intervals. The number of knots drawn from the log reel showed the ship's speed in knots per hour with surprising accuracy.

A careful master made certain that his speed was frequently recorded in a log-book, along with other important circumstances. In time it became traditional that a well-kept log should reveal, in sequence, all major events of a voyage. From sailors' talk the name for a tabulated summary drifted into the mechanical world and came to name the "diary" of an engine's care, fuel consumption, and performance.

Having been firmly established as a colorful synonym for a detailed chronicle, it was easy for "log" to enter the speech of pioneer radio enthusiasts who kept careful records of time and circumstances surrounding every broadcast. Today the thickness and precision of a ham operator's *log* is a source of pride almost as important as the size and accuracy of a sailing-master's record of his ship's voyages.

elementary
Electronics

DXers
Why not the moon?

By Don Jensen

On its pad at the Kennedy Space Center's launch complex 39 stands a huge Saturn V three-stage rocket, poised on the threshold of the Century's greatest adventure! Any day now the 36-story-high rocket will have hurled the Apollo 11 spacecraft into the Florida sky with an ear-rending roar. Sixty-nine hours, 47 minutes and 5.5 seconds later, a pair of astronauts should climb from a spider-like contraption and become the first humans to set foot on the surface of the moon. Whenever the Apollo astronauts begin their historic odyssey, the eyes of the world will be on them. Television coverage, relayed worldwide by communications satellite, will have given viewers from Ashtabula to Zurich a front row seat during the key moments of the lunar flight. These moonshot reports, via TV, may be AOK for the average Joe—after all, the "telly" networks *do* do a pretty good job of hitting (Continued Overleaf)

the highlights. But why settle for half the action when the full, behind-the-scenes drama of Apollo 11 can be heard on shortwave? The only trick is knowing how and where to tune. And that, Alfie, is why we're here!

Moon Shot's Beginning. But before getting down to the real nitty gritty of moon flight DXing, let's frame the picture with a little background data.

The countdown for Apollo 11 really began back in 1961, when President John F. Kennedy gave NASA, the National Aeronautics and Space Administration, the task of putting men on the moon before the end of the decade. During the past eight years, more than a quarter of a million persons have worked toward this goal.

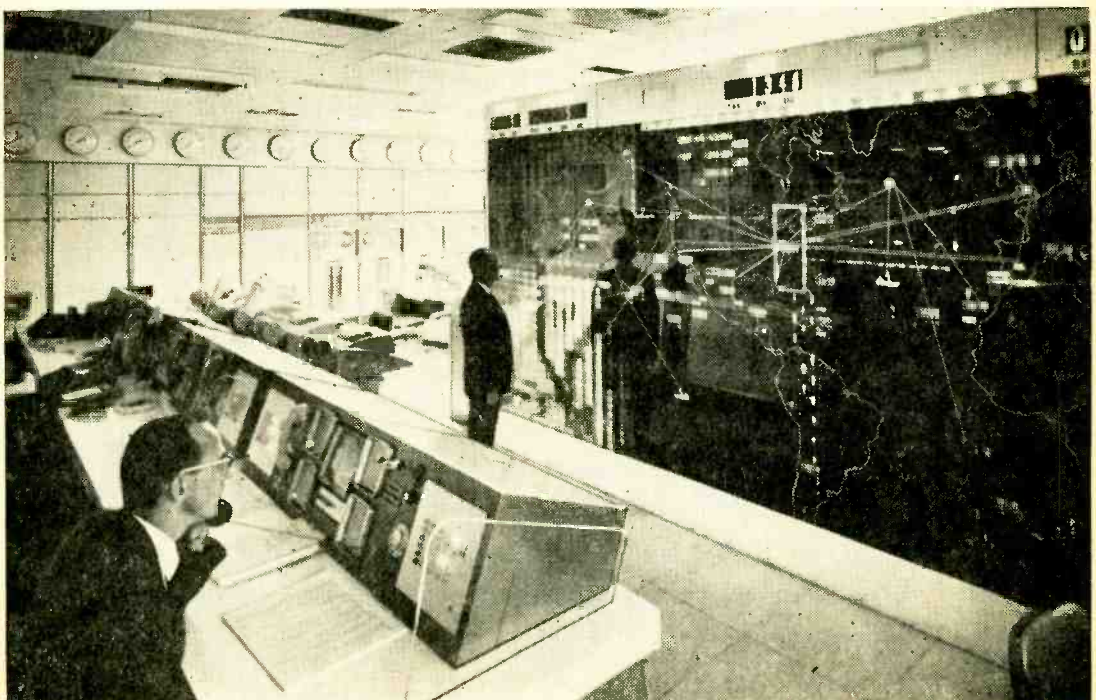
Mercury, Gemini, and earlier Apollo missions have set the stage for the big one this summer, when astronauts Neil Armstrong, Michael Collins, and Edwin "Buzz" Aldrin Jr. lift off.

NASA's split-second flight plan calls for sending a five and a half ton command capsule, a 15-foot service unit, and a weird-looking lunar excursion module, nicknamed Rosemary, on the 240,000 mile trans-lunar journey.

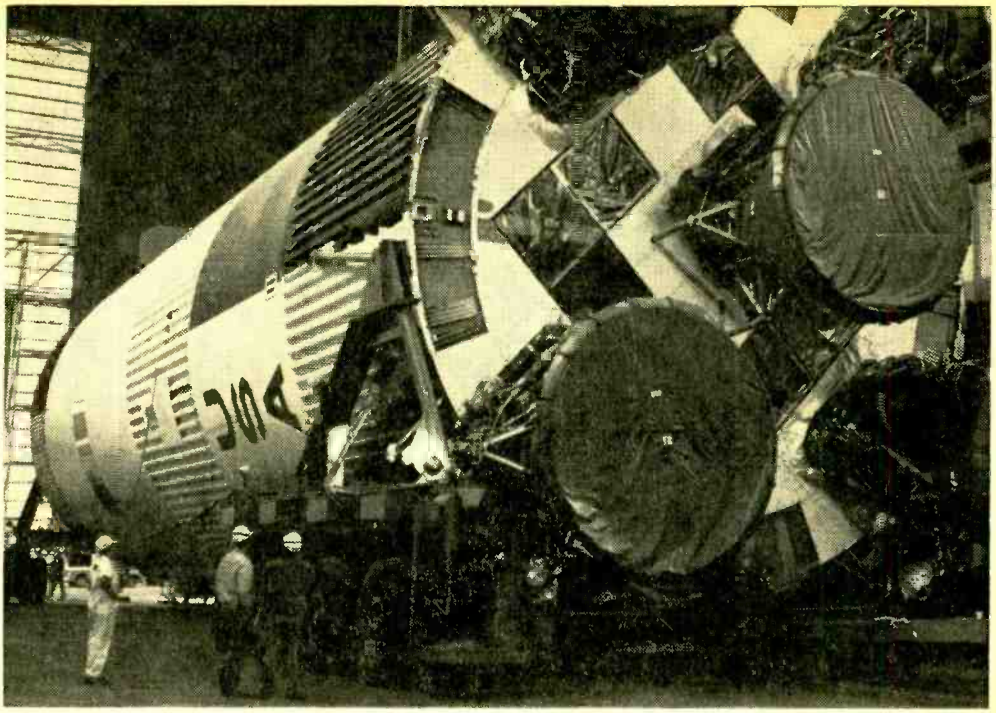
The moon landing itself will be Rosemary's baby, with Armstrong and Aldrin, in all probability, making the shuttle trip. Their task will be to explore the "lurrain" for three hours while Col. Collins keeps the command craft in orbit some 60 miles out. Then, eight days after leaving Cape Kennedy, the trio is scheduled to splash down in the Pacific.

Much of the mission's success should be credited to the thousands of civilian and military personnel who man the most extensive and expensive—would you believe, $600 million — communications complex ever assembled.

Total Communications Facilities. Apollo communications facilities demonstrate a model in redundancy, and deliberately so. Super High Frequency and Ultra High Frequency channels are backed up by satellite relays, landline links, undersea cables, and, of course, shortwave radio. These back-up systems are NASA's guarantee that one way or another, vital communications will be maintained.



Inside NASCOM (NASA Communications Network) Control Center. NASA Communications Director and Communications Systems Managers direct flow of mission information from console positions at left. NASCOM status board (right) indicates on-line, backup, and alternate routes for mission support.



At Cape Kennedy, S-1C booster for Apollo 11 is shown after being erected atop its mobile launcher in Spaceport's Assembly Building. Though Apollo 8 circled moon some ten times last December, no landing was attempted. Apollo 11, in contrast, is first in series bearing name to be capable of placing men on moon.

Tracking, telemetry, television transmission, and voice command circuits between Apollo 11 and Earth are handled by NASA's Manned Space Flight Tracking Network. MSFN has space stations three deep at Goldstone, Calif.; Robledo, Spain; and Honeysuckle Creek, Australia; each with an 85-foot diameter tracking antenna. Other stations at 14 locations around the globe use 30-foot dish antennas. Four specially-equipped ships and a half dozen or so jet aircraft complete the MSFN.

This vast chain utilizes the S-band, frequencies between 1500 and 5200 MHz., in the SHF and UHF ranges. Other frequencies are in the Very High Frequency spectrum, including an important voice channel on 296.8 MHz.

These frequencies, of course, are far beyond the tuning range of the average SWL's receiver. But there is one transmitter aboard Apollo 11 you might try for, particularly if you do your DXing from the West Coast or Hawaii.

Operating on 10,006 kHz., a dual 20-watt single sideband-five watt AM transmitter is used only during the landing and recovery phases of the flight. After the scorched space vehicle plunges back through the Earth's atmosphere into the Pacific, this unit provides long distance direction finding signals and voice communications during rescue operations.

But moonshot monitors will find most of their targets among several other communications systems. These stations, belonging to NASA's Communications Network (NASCOM), the manned spacecraft recovery forces, and the private communications corporations providing press coverage, operate mostly on shortwave frequencies you can tune.

SSB Predominant. Most of these stations use single sideband, a transmission mode that offers more efficient use of transmitting power and band space. But SSB has one drawback for the DXer—the voices tend to come out sounding a bit like Donald Duck.

This should be no problem for experienced SWLs or those with high priced communications receivers specially designed for SSB tuning. But even if your set is more modest you can tune these stations if it has a beat frequency oscillator.

Carefully tune to the signal's strongest point, flip on the BFO—some sets label the switch "CW"—and adjust the control until

e/e DXing THE MOON

speech is more or less intelligible. If your receiver has an RF gain control, back it off slightly to improve voice quality. It's a bit tricky, but a couple of hours practice before the Apollo 11 launch are all that's needed, and the amateur bands are full of SSB stations to practice on.

While the near and deep space trackers handle the up-down links between the capsule and Earth, the job of tying all the MSFN stations together belongs to NASCOM. Upwards of 50 other NASA facilities around the world are also joined by this radio chain. Where possible, cable, landline and satellite relays are used; elsewhere, NASCOM uses high frequency shortwave.

Radio circuits operate between Goddard, London, Madrid, Johannesburg, Perth and Tananarive. There are NASCOM facilities at Cairns, Australia; Pretoria, South Africa; Kano, Nigeria; Tangier; Manila; Bermuda; Hawaii; Canton; Wake; Canary Islands; and, of course, Cape Kennedy. At Balboa, Canal Zone, a relay serves NASA teams at Quito, Lima, and Santiago in South America. Shortwave connects tracking stations on Antigua and Ascension Islands. DXers may hear other NASCOM land-based transmitters, or a series of seagoing and airborne units.

There are three ships designed to supplement MSFN coverage during earth orbit and trans-lunar insertions. USNS Vanguard, Redstone, and Mercury are identical, enlarged T-2 class tankers of World War II vintage. A fourth vessel, USNS Huntsville, is a converted Liberty ship which handles reentry tracking duties.

The Vanguard, located in the Atlantic (49° W, 28° N), communicates via Bermuda, Antigua and the Cape; on Indian Ocean station (38° E, 18° S), the Redstone maintains contact with Ascension, Perth,

APOLLO 11 COMMUNICATIONS FREQUENCIES (kHz)

	Nascom Network—to MCC-Houston, via Goddard S.F.C.				
Ascension Island	6,752	7,919	11,634	12,140	20,286
	20,454	20,700			
Balboa, Canal Zone	9,132.5	10,242.5	15,925	17,682.5	20,727.5
Canary Islands	8,119.5	13,423	13,447.5	13,527.5	20,450
Canton Island	10,897.5	16,440			
Cape Kennedy	5,775	7,675	7,833	8,260	12,140
	13,170	13,878	14,585	14,896	17,390
	18,330	20,475			
Honolulu	9,212	10,410	12,212	13,175.5	20,390
London	6,970	7,480	8,005	9,157.5	10,792.5
	10,798	13,555	13,595	13,620	14,887
	18,127.5	18,130.5	18,580		
Kano, Nigeria	9,440	13,905	15,870	18,335	21,845
Perth, Australia	9,200	10,950	13,580	14,939	
Sydney, Australia	10,165	13,500	19,465		
Tananarive	7,690	9,865	10,270	11,430	12,275
	20,990				
Tracking Ships	6,787	7,898	8,176	10,648	11,514
	14,896	17,643	18,635	18,660	22,857
	Recovery Network—Also ± 5 kHz. from listed frequencies				
Atlantic	4,690	4,739	5,718	6,708	6,693
	6,694.5	6,702	8,980	8,985	9,006
	11,205	11,252	13,227	13,237	14,676
	15,016	15,021	15,051		
Pacific	6,693	6,694.5	6,805	15,016	15,085
	17,386				
	Press Communications				
RCA-New York	9,095 (WEP69)		13,900 (WES33)		15,982.5 (WES25)
	15,987.5 (WES75)		16,015 (WER46)		18,960 (WES58)
RCA-San Francisco	6,845 (WMF36)		10,190 (WM150)		13,645 (WMH23)
Shipboard links	6,890	9,460	10,390	13,915	18,150


Though Russians ostensibly bring their astronauts down on dry land, U.S. still prefers to rely on sea for so-called splashdown. At right above, frogmen prepare to leap from hovering helicopter into warm waters of tropical ocean. Main task of frogmen is to attach flotation collar to capsule (see photo at left).

Hawaii and Manila. In the Pacific, both the Mercury (174° E, 8° N), and the Huntsville, farther south, supply data via Honolulu, Guam, Wake and Sydney, Australia.

Supplementary duties are assigned to a group of ARIA tracking aircraft, Air Force JC-135 jet planes which fly over-water patterns during the launch and recovery phases.

The threads of this worldwide web, routed through subswitching centers, all lead to Building 14 at the Goddard installation in Maryland. Here, the message flow is directed automatically by landline to the Manned Spacecraft Center in Texas.

Separate Spacecraft Recovery Network. Separate from NASCOM is the spacecraft recovery network, a joint venture involving the military services and NASA's Landing and Recovery Division. Though basically a Navy show, an Air Force major general sits beside the NASA mission director in Houston and serves as liaison between the Department of Defense and the civilian agency.

Sharp-eared DXers will soon find that there are really two recovery operations invoked in Apollo 11. Navy Task Force 130 covers the prime target in the Pacific, while Task Force 140 is responsible for retrieving Astronauts Armstrong, Collins and Aldrin in the event a mission abort forces an Atlantic splashdown.

Headquarters for the Pacific Recovery Force is at the huge Pearl Harbor naval base. During space flights, about 1500 Navy, Air Force and Army personnel are assigned to the command. Navy units come from the First and Seventh Fleets, Air Force men and planes are assigned from the Pacific Aerospace Rescue and Recovery Center at Honolulu's Hickam AFB, and a limited number of soldiers are transferred from Army posts on Hawaii.

The key station is Pacific Radio at "Pearl." Other shore operations include Navy PACMISRANFAC transmitters on Eniwetok and Kwajalein, and Air Force Rescue and Recovery stations at Andersen AFB, Guam, and Kadena AFB, Okinawa, and on American Samoa.

Afloat, Too! Task Force 130 includes about a half dozen Navy vessels, from carrier-size on down, with supporting SH-3 Sea King helicopters and Air Force HC-130B Hercules rescue planes. At this writing, the Navy hasn't announced its ship assignments—over 200 different vessels have participated in Mercury, Gemini and Apollo flights so far—but almost a sure bet for the Pacific team is the USS Arlington.

The Arlington began her Naval career as the small aircraft carrier Saipan in 1946. In 1966, she was converted to a communications ship, with highly sophisticated electronic gear and antennas. She was renamed the Arlington, in honor of Radio Arlington, one of the Navy's first wireless stations. She can provide full communications capability for the fleet at sea.

In the Atlantic, TF-130's twin, Task Force 140 will deploy for possible rescue operations in case of an emergency. East coast focal point is Building SP-71, at the Norfolk Naval Air Station. Since November 1967,

e/e DXing THE MOON

all space flight recovery operations scheduled for the Atlantic Command Area have been directed from the Recovery Control Center at Norfolk. Communications with fleet ships, regular naval stations on the eastern seaboard and Puerto Rico and other recovery facilities are routed through RCC.

Four transmitters at Cape Kennedy, remotely controlled from Texas, are "patched" into the system. These stations are heard with the identifier "Houston" call. In addition, Air Force Eastern Test Range Command facilities at Bermuda, Antigua and Azores, and stations at Lajes AFB, Azores will be used.

Main station in this shortwave network, dubbed Atlantic Chief, is located at Norfolk. The rest of the stations in this net are called, collectively, the Atlantic Tribe. Circuits connect the whole recovery system with NASA's Texas space center.

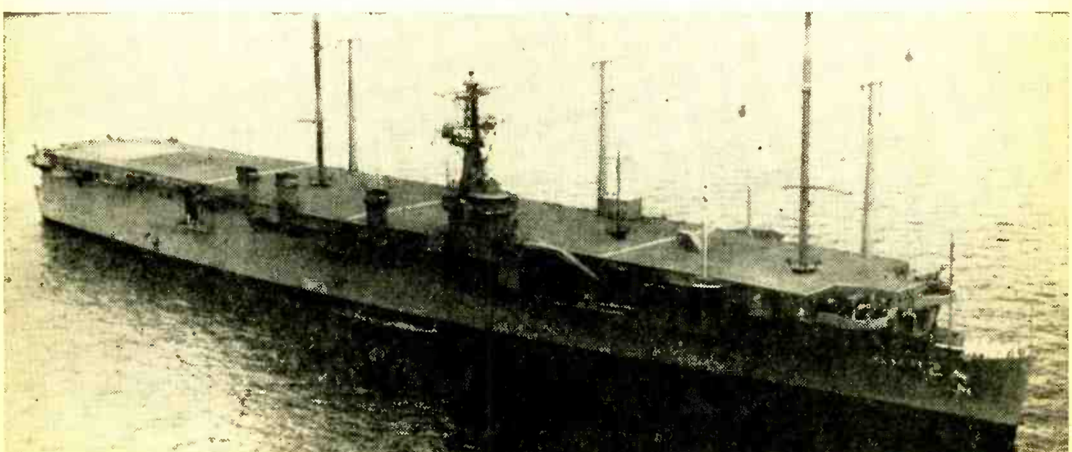
Likely to be included in TF-140 is the USS Francis Marion. A 564-foot, converted attack transport, she originally was launched as the Prairie Mariner 15 years ago. Like the Arlington, she is equipped with the latest in radio gear. Once called the fastest amphibious assault ship in the Navy, the Francis Marion was converted to a radio command post only last year.

DXers can tune the seagoing, airborne and shore-based outlets of the recovery forces as early as a week before liftoff, when TF-130 and 140 stations will be activated.

(Continued on page 93)

APOLLO VOICE IDENTIFIERS

AIR BOSS	Voice call of rescue aircraft commander
ATLANTIC CHIEF	Key Atlantic recovery station, Norfolk, Va.
ATLANTIC____	Atlantic recovery station, eg., Atlantic Surgeon (medical), Atlantic Leader (on primary recovery ship), etc.
CROWN	White House ID, heard with post-flight presidential call
HONO	NASCOM, Honolulu
HOUSTON____	Recovery stations at Cape Kennedy, controlled from Houston, eg., Houston Recovery, Houston Surgeon, etc.
IVANHOE	Navy Communications Station NAM, Norfolk, Va.
PACIFIC RADIO	Key Pacific recovery station, Pearl Harbor, Hawaii
PUERTO RICO RADIO	Navy Communications Station NAU3, Ft. Allen, P.R.
PEASOUP	NASCOM, London
PHOTO 1, etc.	Navy photo helicopter
RECOVERY 1, etc.	Sea King recovery helicopters
____RELAY	Pacific recovery shore stations, eg., Kwajalein Relay, Eniwetok Relay, Singapore Relay, etc.
RESCUE 1, etc.	Voice call of ARRS rescue aircraft
____RESCUE	Land-based stations of Air Force Rescue and Recovery Service, eg., Lajes Rescue (Azores), Kindley Rescue (Bermuda), Naha Rescue (Okinawa), etc.
TOPHAND	Navy Communications Station NSS, Annapolis, Md.
TOREADOR	Navy Operational Radio, San Francisco, Cal.



U.S.S. Arlington (originally the Saipan) is likely to see service when Apollo 11's men return from moon.

Dig Those Campus Cops

by Skip Bradford

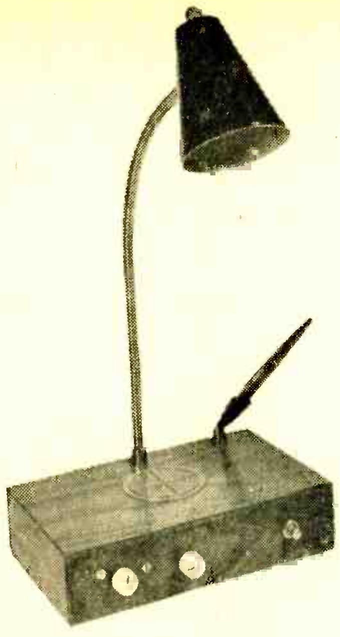
Remember last Spring, when college campuses across the nation went wild? In fact, remember *every* Spring when this happened? Time was when Springtime meant that a young man's fancy gently turned to thoughts of love; but today from Columbia to Berkeley, our erstwhile Romeo seems predisposed to tar-and-feathering the Dean of his local college for any number of reasons dear to his heart.

During these periods, the colleges' campus police forces are operating in full swing on a 24-hour basis. Extra men are often assigned to patrol the ground, manage crowds, rescue professors. The dispatcher at the campus police radio communications station is about as busy as a one-armed juggler and can be heard at all hours with instructions to the patrol officers on campus. The mobile units reporting in are also quite active as they relay back to headquarters vivid descriptions of the wild antics which rule the crowds. Often there is an animated exchange of communications between base and mobiles when a barricade or building-assault is underway.

If you have a VHF receiver or converter you can be part of the inside story when the fun-time hits your local campus each year. Or, you might like to listen all year long as the campus police go about their normal duties of raiding pot parties in the dorms, checking the parking lots each night for couples who ought to know better, witnessing draft card barbecues, and other such vital public safety tasks.

We've put together a directory of the call-signs and frequencies used on the campuses

(Continued on page 96)



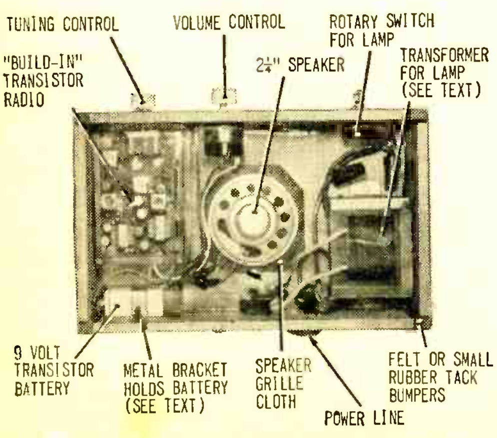
Desk Top 3-in-1 Project

Put this transistor radio/ desk pen/hi-intensity lamp on your desk in just hours

by Art Trauffer

How nice it is to have an uncluttered desk, and yet have such conveniences as your personal transistor radio (to be one up on the news, market reports, sports events), to have your desk pen handy, and to have enough light to see what you are signing with the pen. You can enjoy such luxuries by completing our weekend project. All we have done is to locate the components and developed the plans to build a beautiful walnut case (one that anyone should be proud to have on his desk) in which to house them.

The 6-transistor radio is all ready to play, factory-wired, and housed in a protective clear plastic box so that this module can be easily mounted in the walnut desk cabinet. High intensity desk lamps are always on sale; you can buy the least expensive one for this project since you will not be using anything but the gooseneck, shade, and bulb socket, transformer and *on/off* switch. Except for the decor of the housing most high intensity lamps are all similar. As for the pen, inexpensive desk pen holders and desk type ball point pens are procurable at stationery supply or hobby shops. Before tackling the part of the project that taxes your skill with tools, purchase all of the materials required (see Parts List) so the project will not be suspended temporarily for lack of materials.



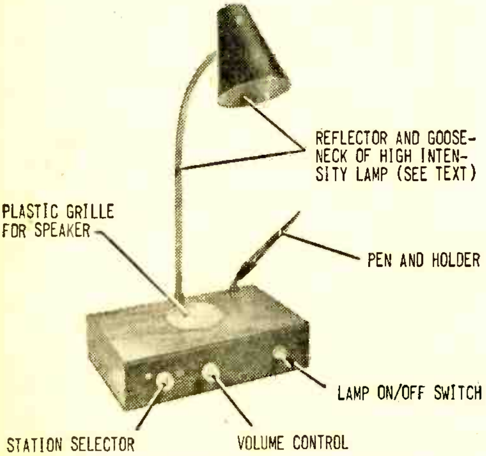
Locating components. Separate lamp transformer and radio as much as possible to reduce heat damage, hum pickup, and power-line interference.

Making the Cabinet. We made the cabinet from five pieces of black walnut wood, ¼-in. thick. You can, of course, use any wood you wish in order to match the decor of the room. All pieces are straight cuts and require no special cabinet-making skills to cut and fit together. We assembled the cabinet by gluing, and tacking together (with thin wire brads) the various pieces of wood and then sanded them. Sanding the exposed edges to round them off makes a very professional looking finished product. Before putting on the final finish it is best to cut and drill the wood so that the polished wood will not be marred.

The speaker for the radio is supplied separately in a plastic case. Remove the speaker, being careful to protect the cone until the speaker is remounted in your new wood cabinet. Pare down the plastic speaker case so that the protective grille will be just thick enough to be flush with the top surface when inserted into the circular hole cut in the wood cabinet. The diameter of the hole should be just large enough (approximately 1¾ in.) to insert the plastic grille so that it will fit snugly. You should cement it in place with Elmer's glue or GE's RTV cement. You may prefer to mount the plastic grille on top of the wood in which case the diameter of the hole should be about ¼-in. smaller. The plastic grille can be cemented in place or held there with small wire brads. If you use brads drill the plastic grille before fastening it, to prevent cracking. Drill all of the other holes required for the radio and high intensity lamp.

At this point stain the wood in the desired color and when the stain is dry polish the cabinet by rubbing the cabinet with linseed oil, or if that is not readily available use lemon oil furniture polish.

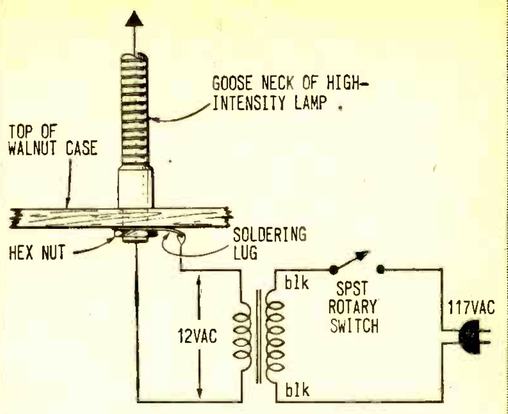
Mounting the Components. Cement a piece of netting over the underside of the grille to keep dirt from falling onto the



Surface mounted plastic grille will cover ragged wood cutout. Grille can be mounted flush in wood top if circle cutter is used to cut out hole.

speaker cone, then cement the speaker to the cabinet, taking care not to use so much cement that the porosity of the grille cloth is reduced.

Next mount the lamp gooseneck to the top of the wood cabinet. Make certain that



PARTS LIST FOR THE 3-IN-1er

1—Built-in transistor radio kit (Radio Shack 12-1150 or equiv.) includes 6-transistor radio chassis in plastic box, separate speaker, volume control and switch and knobs
1—Battery 9-volt (Eveready 216 or equiv.)
1—Desk-type pen complete with holder (stationer or hobby shop)
1—High intensity lamp (see text)
Misc.—Hardware, wire, solder, solderless connectors, soldering lug, rubber feet, stain, sandpaper and cement (GE-RTV or Elmer's Glue)
Black walnut wood (or other wood) for wooden cabinet
1—Piece 8 x 5 x ¼ in.
2—Pieces 8 x 2 x ¼ in.
2—Pieces 5 x 2 x ¼ in.

a large soldering lug is fastened under the nut that holds the gooseneck in place.

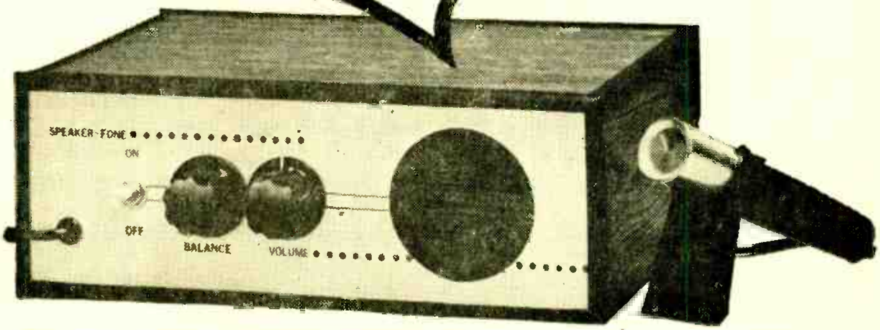
Mounting The Radio. The radio, complete in its plastic protective case is then mounted in the wooden cabinet. It is held in place by two 6-32 flat head machine screws approximately ⅜-in. long. By drilling holes into the plastic protective case that have a smaller than clearance diameter it is possible to thread the plastic cabinet, and, therefore no nuts will be needed to hold the assembly tightly in place. Make certain that the screws are long enough to extend through the plastic to assure a full threaded bite but not too long so that they could damage the printed circuit board of the receiver. The shaft for the tuning condenser extends through the front of the wood cabinet far enough to permit tightening of the tuning knob on the condenser shaft. We did not use a dial scale. However, if you prefer, why not design one that is both utilitarian and meets your artistic tastes.

The volume control and switch are sep-

(Continued on page 97)

Build SPEAKER-FONE

The telephone intercom that doesn't hang you up!



By Herb Friedman, W2ZLF

The currently popular status symbol for a big tycoon is the loudspeaking telephone (our Speaker-Fone). It is a gadget that lets Mr. Big Business carry on a bi-directional conversation in his office without having to hold a telephone instrument or operate a talk-listen transfer switch. He can count his money, change clothes for a night on the town, or seduce his secretary while carrying on a telephone conversation. Another application for Speaker-Fone allows a group of people to participate in a phone call. The incoming transmission is heard in the room through its speaker while its microphone picks up comments from anyone in the room and Speaker-Fone transmits it back into the phone line.

Both reception and transmission are accomplished without the necessity to operate switches or hold a telephone instrument—the user simply sits back and listens and talks, while the equivalent of operating a talk-listen switch is accomplished automatically in the Speaker-Fone.

Expensive? Commercial units are, but by taking advantage of the latest ICs and a few inexpensive, readily available components you can build one for well under $25 that will perform as well as the most expensive commercial models presently available.

If you have no need for a Speaker-Fone, how about a no-hands, switchless intercom for the office, home, or shop? It's basically the same device—and is less than expensive to build. It lets you listen to transmission from, and talk to, remote locations from wherever you may be in the room, without having to favor the microphone or operate transfer switches.

How It Works. The Speaker-Fone works by taking advantage of signal cancellation inherent in a phase splitter. For simplicity, the term "line" will refer to the telephone line (or intercom line) connected to the Speaker-Fone.

Output from the microphone is fed into IC1, an Op Amp (see p. 45) serving as a microphone preamplifier. IC1's output, at pin 13, is coupled through C5 to transistor Q1, which functions as a phase splitter. Q1's collector resistor of 560 ohms (R8) is essentially equal to the emitter impedance consisting of resistor R9, 560 ohms, and the AC impedance of T1's primary. Therefore, when signal voltage is applied to Q1's base the amplified output appears essentially equal in amplitude, but of opposite phase, at both the collector and the emitter. The

e/e SPEAKER-FONE

signal voltage at Q1's collector is 180° out of phase with the signal voltage at the emitter. Meanwhile, the current through Q1 also flows through T1's primary, inducing a signal into T1's secondary, which, in turn, feeds the signal to the line through R12, R13, and R14—a pad having approximately 6 dB attenuation.

Phase Splitter. So far we have described how the microphone signal is fed into the telephone line, but since there would be one loud howl if the mike signal should feed through to the input of the speaker amplifier, how is the mike signal kept out of this amplifier, which consists of transistor Q2 and IC2? The answer lies in the function of the phase splitter. Remember the signal at the collector is 180° out of phase with the emitter. The collector signal is coupled through C6 to one side of balance control R10 and the emitter signal is coupled through C7 to the other side of R10. At one point of the setting of R10's wiper, the collector signal is exactly equal to the emitter signal, and the two cancel each other because they are exactly 180° out of phase. Therefore, at this balance point, no signal voltage appears at R10's wiper, which is connected to the volume control (R11) feeding signal to the speaker amplifier.

When a signal from another Speaker-Fone appears on the line, a voltage is induced from the secondary of T1 to its primary. This voltage then appears at Q1's emitter, the top of R9, where it is fed through C7 to R10. But since there is no corresponding out-of-phase signal voltage at Q1's collector, the signal is not cancelled at R10 and it is fed through to the speaker amplifier. (In practice a small signal can be detected at Q1's collector but it is not nearly strong enough to cancel the emitter signal in R10.)

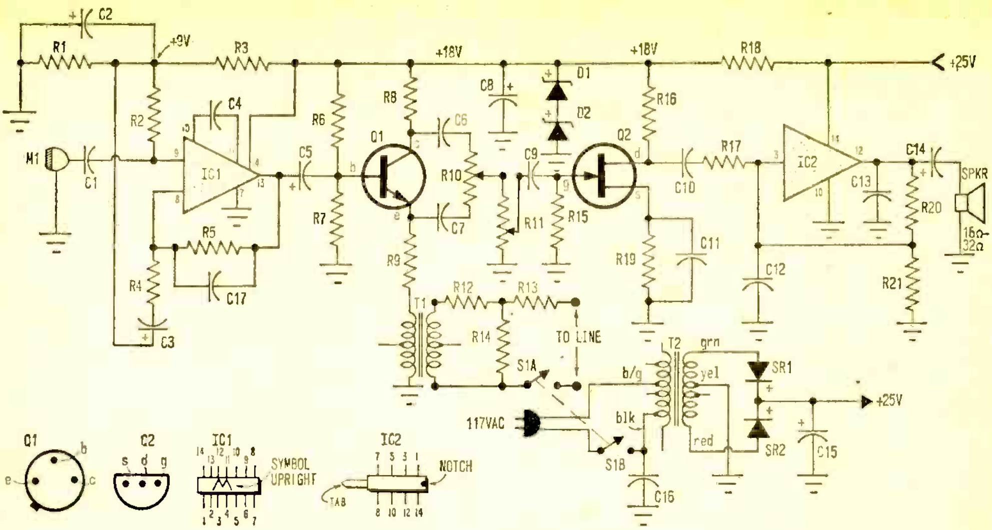
Therefore, by using a phase splitter (Q1) the microphone can transmit to the line

PARTS LIST FOR SPEAKER-FONE

C1—0.25-uF, 75-V ceramic capacitor
C2, C6, C7—50-uF, 15-VDC electrolytic capacitor
C3—10-uF, 15-VDC electrolytic capacitor
C4—680-pF ceramic disc capacitor
C5—1-uF, 50-VDC electrolytic capacitor
C8, C15—2000-uF, 15-VDC electrolytic capacitor
C9—0.01-uF, 100-V ceramic disc capacitor
C10—0.1-uF, 75-V ceramic disc capacitor
C11-50-uF, 6-VDC electrolytic capacitor
C12, C13—0.05-uF, 75-V ceramic capacitor
C14—160-uF, 25-VDC electrolytic capacitor (see text)
C16—0.002 uF, 500-VDC ceramic disc capacitor
C17—47-pF ceramic disc capacitor
D1, D2—9.1-V Xener diode (Motorola HEP-104 or equiv.)
IC1*—Integrated circuit stereo amplifier (Motorola MC1303P)
IC2*—Integrated circuit 1-watt amplifier (General Electric PA234)
M1*—Dynamic microphone, 50,000 ohms (Piezo 106)
Q1—2N1306 transistor (see text)
Q2—FET (Motorola MPF-103 or equiv.)
R1, R3—4700-ohm resistor
R2, R5—See text (note: author used 100,000-ohm for both R2 and R5)
R4, R19—1000-ohm resistor
R6—22,000-ohm resistor
R7—10,000-ohm resistor
R8, R9—560-ohm resistor
R10—10,000-ohm linear taper potentiometer (Mallory U-20 or equiv.)
R11—100,000-ohm audio taper potentiometer (Mallory U-41 or equiv.)
R12, R13, R18—150-ohm resistor
R14—680-ohm resistor
R15, R20—1-megohm resistor
R16—15,000-ohm resistor
R17, R21—100,000-ohm resistor
(All resistors 1/4, 1/3 or 1/4 watt, 10%)
S1—Dpdt toggle switch (Lafayette 99-6162 or equiv.)
SP1*—2 3/4-in. round, 16-32-ohm voice coil impedance speaker
SR1, SR2—Silicon rectifier, 50-PIV, 500 mA or higher (Lafayette 19T5001 or equiv.)
T1—500/500-ohm telephone line transformer (Lafayette 33T8553 or equiv.)
T2—Low voltage rectifier transformer (Allied 54E4732 or equiv.)
1—9 x 6 x 3-in. FLEXI-CAB cabinet**
Misc.—Keystone G pattern perforated board, hardware, wire, solder, etc.

* Following components are available from Custom Components, Box 352, Alden Manor, Elmont, N.Y. 11003:
IC1—MC1303L integrated circuit stereo amplifier, $6.00 each
IC2—PA234 integrated circuit 1-watt amplifier, $3.00 each
M1—Piezo microphone type 106, $6.95 each
SP1—2 3/4-in. round speaker, 32 ohms, $2.50 each
Above prices include postage and handling within the U.S.A.
For shipment to Canada add $1.00
New York State residents add sales tax

** FLEXI-CAB cabinets are available from Bell Educational Laboratories, Hauppauge, N.Y. 11787



Speaker-Fone schematic. All components mount on perfboard, save those in power supply and on front panel. As explained in text, commercial amplifier can be used to replace all components between C9 and speaker.

simultaneously while the speaker amplifier is monitoring an incoming signal from the line.

Phase Shifts. If T1 is of very high quality, all signals appearing at Q1's collector will be exactly 180° out of phase with the emitter signals. In practice, the lower quality transformer that was selected for T1 introduces a phase shift, which counteracts the Q1 shift of 180°, and so only 40 dB to 60 dB of cancellation can be obtained through balance control R10 before the system starts to howl at high frequencies. This means that you cannot use a transformer of lower quality than the one specified in the Parts List. The T1 specified will introduce some phase shift, but it will allow an adequate listening level before the howl starts. Attempting to increase the speaker volume to a "shout" will produce howling. Using a more expensive T1—with less high frequency phase shift, will allow a higher speaker volume. However, the T1 specified is satisfactory for home and office use.

Input Op-Amp. Input amplifier IC1 is one half of a Motorola MC1303P "Stereo Preamplifier," which is actually an assembly consisting of two independent operational amplifiers. Without getting bogged down in Op-Amp theory, IC1 is an amplifier whose gain is equal, essentially, to the ratio of R5 and R4. This permits the amplifier gain to be easily changed to match the mike you use by just changing resistor R5. (More on this later.) The reason an MC1303P is used—even though only one of the Op-Amps is used—is that, similar to 2N109, 2N217, and 2N274 transistors, the MC1303P is almost goof-proof—it's difficult to damage it and almost impossible to destroy its operation completely.

An Op-Amp normally requires a power supply that provides both positive and negative power above and below a common or ground. Since Q1, Q2, and IC2 utilize a single-ended positive voltage supply with negative at ground (and no center tap) we have made provision to operate IC1 from a single-ended power source by providing a power supply voltage divider with a center tap (R1 and R3) to develop the positive and negative voltages it needs. The voltage at the R1-R3 junction is exactly one half the IC supply of 18 V applied to pin 14 of IC1. Note also that both R2 and C3 are connected to the R1-R3 junction. In the event you have difficulty in the operation of the microphone preamp, check for the split in supply voltage at R1-R3, for if the voltage on either side of the center tap of R1-R3 is not exactly equal, and of opposite polarity, the IC won't amplify. If C3 would be returned to ground (the chassis) the IC may or may not work, depending on normal leakage current of C3—so throw out the rule book: C3 is connected to R1-R3, not to ground.

Output Op-Amp. The monitor amplifier section consists of Q2 and a 1-watt IC power amplifier IC2. Q2 raises the level of the signal on the line to the input level needed by

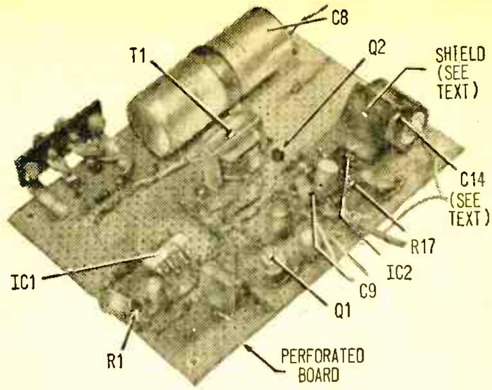
IC2 to produce a maximum output of 1 watt. As a precautionary measure, make certain that speaker SP1 is between 16 and 32 ohms. If it is less than 16 ohms, IC2 breaks into oscillation and self-destructs (this tidbit of information is not supplied in the IC2 data sheet).

The schematic (see previous page) shows Speaker-Fone using Q2 and a pad of approximately 6 dB between T1 and the line. The pad is used so that the balance control can be adjusted correctly before connection to the line. If the pad isn't used the line affects R10's adjustment quite severely, and might require frequent readjustment. Normally, you balance R10 once and that's it.

When operated as a Speaker-Fone the mike gain must be held down to limit the signal level so that it will not overload the telephone line. To accomplish this R2 and R5 should be 100,000 ohms (R4 always remains 1000 ohms). R2 is changed because, for proper op-amp operation, R2 must equal feedback resistor R5. If you need slightly more gain, increase R5 to 220,000 ohms and change R2 to 100,000 ohms.

A switchless intercom can handle more level, and can have a greater incoming line level than a Speaker-Fone since you are not restricted to level limitations, as is the case when using telephone lines. You can increase mike sensitivity considerably by changing both R5 and R2 to 1 megohm. Also, since the line level will then be very high, Q2 and the 6-dB pad may be eliminated. To adapt the unit to function as a switchless intercom, delete C9, R15, R16, R19, C11, and Q2. Connect the wiper of R11 to C10. Similarly, since the pad R12-R13-R14 is not needed and the line can be connected to T1 primary directly, R12, R13, and R14 may be deleted.

Power Supply Regulation. Two Zener diodes, D1 and D2 are used instead of a single 18-V Zener because the HEP units specified are more easily obtainable than other 18-V Zeners. The Zener diode regulation for IC1 and Q1 and Q2 is necessary since the voltage variation created by the class-B amplifier in IC2 will affect the performance of IC1. Make certain that the Zener diodes are correctly polarized. The end marked with a white band connects to the positive supply voltage.



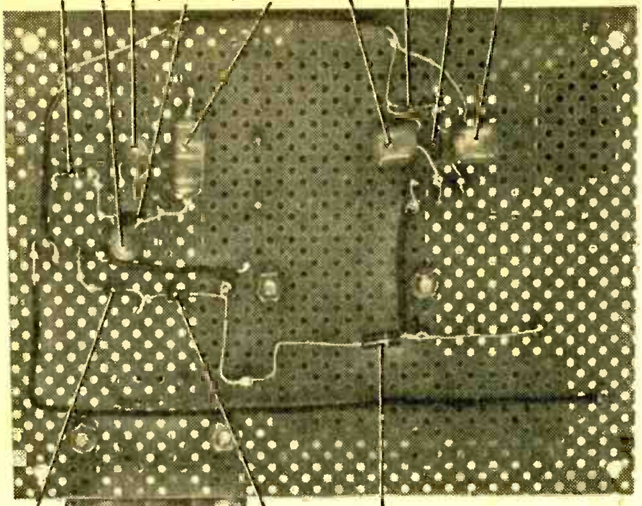
Perfboard assembly is mounted on bottom plate of cabinet using 1/4-in. standoff washers between board and cabinet. Heat sink (identified as "shield" above) must be soldered to tab on IC2.

Construction. For a better display of the important components the photographs show the switchless intercom model but include the telephone line pad (R12-R13-R14) for the Speaker-Fone, mounted on the circuit board. Q2 and its circuit components can be placed virtually anywhere on the board as it takes up very little space and its location is not critical.

The model shown is housed in a very attractive cabinet. The sides and top are prefinished in wood grain and the front panel is stainless steel. It's all supplied knockdown, and you assemble the cabinet with the supplied plastic corner pieces. Because the sides, front panel, top, bottom, and back are insulated by the corner pieces, you must connect the front panel and the bottom plate to the circuit ground for proper shielding. Also, for a more rigid assembly, it is recommended that corner pieces be cemented in place with a silicon adhesive, such as GE's RTV.

The front panel provides only sufficient space for a speaker no greater than 2¾-in. in diameter, which will deliver adequate sound level for home or office. Higher sound level will require a larger speaker, and, for noisy locations, we suggest at least a 5-in. speaker and, of course, a larger cabinet. Round speakers should be cemented to the cabinet with RTV; speakers with corner mounting holes are secured with bolts.

All of the electronics circuitry, with the exception of the power supply (T2, SR1, SR2, C15, C16), and the front panel components, are mounted on a 4 x 5½-in. section of perforated board. This allows the unit to be mounted in any suitable cabinet.



To avoid parts jam on top of perfboard, place as many components as possible on its underside. Wire parts flat against board.

(Use Keystone type G-pattern board as the extra "holes" makes for easier assembly.) Push-in terminals provide the tie points.

IC1 is secured by the push-in terminals used for tie points. The connections made to IC1 terminals 8 through 14 are all on one side. To avoid crowding, use terminals on the other side of IC1 only at terminals 1 and 7 (1 is not wired, 7 is ground).

IC2 is mounted in this same manner, using push-in terminals only where the IC2 terminals are connected in the circuit. Be very careful when mounting IC2 as it can be easily mounted upside down and one then is not aware that terminal connections have been reversed. The tab and the terminals are not on the center-line between top and bottom of IC2; the terminals are closer to one surface than the other. Proper orientation of IC2 places its terminals closer to the mounting board than to the top of the IC case. If you locate the tiny notch, as shown in the drawing, you won't go wrong. A ¾-in. square heat sink must be soldered to the tab. A small section from a tin can will suffice; pre-tin the heat sink and solder it to the tab of the IC2 very quickly. The tab can be bent up at right angles to the board to prevent its shorting to other components.

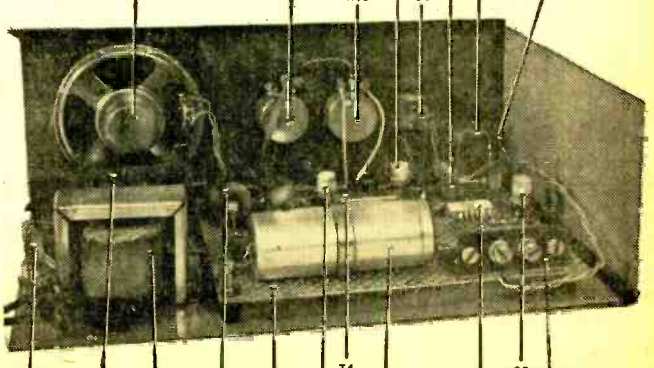
If a speaker less than 3 in. in diameter is used, C14 can be 160 *u*F. If a larger speaker is used, C14 should be increased to 250 *u*F (though you may be satisfied with response when using a 160-*u*F C14).

Transistor Q1 can be just about any npn silicon or germanium type with a Beta of 75 to 150 (100 recommended). At most, you may have to change R6's value slightly for proper biasing.

The ground system of the circuit must be connected to the cabinet base. The front panel is grounded to the circuit-board ground by using shielded cable between R11 and the board. Fold over the grounded terminal of R11 to its case and solder. Solder the shield to this point and the other end of the shield to the board's grounding system.

One final note: the unit won't work if capacitor polarities are reversed. Make certain all capacitors shown in the schematic as polarized electrolytics (indicated with a "+") are correctly installed.

Installation. If a Speaker-Fone is to be used as a switchless intercom simply connect two or more units to a pair of wires stretched



Completed Speaker-Fone, with panel and one side in place. Power-supply components are at left; perfboard assembly is at right.

between the locations of the units. For use on a telephone line, connect Speaker-Fone to the talking pair. If your phone installation uses two telephone wires (talking and ringing on the same pair), simply connect the Speaker-Fone to the two wires. If you have three telephone wires locate the two used for talking (these are generally internally connected in the phone to terminals indicated "L1" and "L2"). If you have a plug-in type phone installation, you can plug in the loudspeaking telephone without having to make permanent connections between the Speaker-Fone and the phone line.

The circuit is so designed that the pad makes it self-limiting, holding the transmission below the maximum authorized telephone line signal level.

Operation. With the unit on the bench, not connected to the line, apply power by turning S1 *on*. Position the microphone near the speaker and slowly advance volume control R11. When the unit breaks into acoustic feedback (howling) adjust balance control R10 until the howling stops. Turn off power and connect the unit to the line. When S1 is *off* the unit is automatically disconnected from the line by S1A.

Call a friend on the phone (or on the intercom) and then turn the unit *on*. If it breaks into howling readjust balance control R10.

Always turn the Speaker-Fone *on* after you have completed dialing another phone and the party at the other end has answered, as the unit will disable the dialing if it is turned on first. Phones can be answered by simply turning the unit *on*—there is no need to lift the phone handset. Intercoms are permanently connected. A switch can be used to short the microphone for privacy so the other station can call, but not eavesdrop on your office.

Special Note on Microphones. The microphone should be a dynamic type. A crystal or ceramic one can be used only if R2 is 1 megohm. When R2 is less than 1 megohm, a crystal or ceramic microphone is loaded down, resulting in severe loss of low frequency response. Also, the relatively smooth frequency response of a dynamic microphone generally provides less sensitivity to howling, which permits higher speaker levels to be used.

Commercial Amplifiers. Though the construction details feature an IC power amplifier, keep in mind that a commercial printed circuit amplifier, such as sold by Lafayette Radio and Radio Shack, can be substituted for the entire shop-built amplifier assembly consisting of Q2 and IC2. This will replace all circuit components between C9 and the speaker. The pre-fab amplifier can be mounted directly on the perforated board in place of Q2 and IC2. The wiper of R11 will then connect to the input of the commercial amplifier.

Since these amplifiers require a 9-volt power supply, either of the following options may be used. You may either drop the existing 25-volt supply to 9 volts with a Zener diode or use a 9-volt battery for the commercial amplifier. In the event you utilize a battery it is not necessary to use power transformer T2 (rated at 100 mA) as there will be no need for the extra current drawn by the class B output in IC2. You may substitute the 35 mA model for T2. This is listed in the Allied catalog just ahead of the 100-mA T2 specified. ■

Earthbound Hi-Flyer

First general aviation trainer tailored to the pocketbook of a student pilot, Link's new GAT-1 flight trainer is a plane with a difference—it never gets off the ground! Designed for use with most any 117- or 230-VAC outlet, the GAT-1 is intended to teach students flying skills while they remain smack in the middle of the classroom. Yet every dial, switch, indicator, and control handle is operational in this plane that does all but one thing planes are supposed to do: *fly!* ■

By Lars Jorgensen

introducing... OpAmp

A ready-to-go amp with a zillion applications the little OpAmp can fill most any bill you have in mind

Just as a child builds houses and castles by adding one toy block to another, so too will the electronic engineer in the 1970s design all types of electronic equipment by adding one block to another. But he won't be using toy blocks—he will use operational amplifiers—the basic building blocks of electronics.

The operational amplifier, or OpAmp, is considered a basic electronic circuit building block because, just as is the case with the child's block, the OpAmp becomes whatever the designer wants it to be in a circuit. For example, the OpAmp in the triangle above serves as a low- or high-gain AF amplifier, a line amplifier, a preamplifier, an oscillator, a mixer, a modulator, a multivibrator, a detector, etc. You name it and the OpAmp can do it within the limitations of the device's bandwidth.

Certainly you can always arrange a group of discrete components to do any of the above-mentioned jobs, but what makes the OpAmp unique and important is that in addition to the OpAmp itself, just a few additional components are required to fabricate a complete module. Circuit functions are changed by changing the value of just some of the external components or the way they are connected.

Goodies Do Come in Small Packages. When the OpAmp is an IC, rather than discrete components, the entire OpAmp is in a small package (as in the photo above), and the external associated components for a given circuit may number four or five. Changing the value or connection of only one or two of these components completely changes the OpAmp's function. The OpAmp is not a new development that has evolved from the availability of ICs. OpAmps, predating these new IC types, were wired packages of discrete components that afforded no savings in cost. However, the IC OpAmp certainly has tipped the scales the other way. These new units cost but a fraction of what the older ones did, both in dollars and in space requirements. Progress surely pays dividends—collect yours by using OpAmp.

Easy Does It. Another advantage of OpAmp is that without having to make yards and yards of calculations you can be fairly certain of the end results, within broad limits. As an example, suppose you wanted to construct a microphone preamplifier having 60 dB of gain (1000 ×). You would have to calculate all the constants of many discrete components associated with two or three transistors and/or FETs—and you'd still have to breadboard the circuit to iron out the bugs. But, using an OpAmp the only calculation would be:

$$Gain = R1/R2$$

and since R2 would be known, your total effort would be to calculate the proper value for R1 and connect it into the circuit.

Does it all sound too easy? If we were to delve deeply into OpAmp theory you'd have another 100 pages or so to read. But OpAmps are available predesigned with certain characteristics, such as input impedance, gain, bandwidth, overload voltage, etc., clearly specified. All that is required of the experimenter is for him to select the few components needed for his particular application. Particularly for the newcomer to electronics, practical application of the OpAmp can be easily handled. As long as you know what result to expect from your connections of the components, you can get started on OpAmp applications immediately. The how and why can come later.

AC, DC or Both. The schematic of a typical OpAmp is shown in Fig. 1. We could go into differential inputs, constant current sinks, split outputs and all the other technical terms that are impressive. But, in all probability most of this terminology would be meaningless to the experimenter and hobbyist. What is important, as noted in Fig. 1, is the absence of coupling capacitors. The OpAmp is DC coupled, and its output is self-center tapped. The OpAmp can handle either AC, DC or both simultaneously, and the output is normally at DC ground potential. As it is usually powered by a bi-voltage power supply as shown in Fig. 2, the OpAmp's output can be set to the center tap or ground potential and usually is in experimenter's applications.

Input Polarity Controls Output. Observe in Fig. 2 that the OpAmp has separate inputs indicated as positive (+) and negative (−) respectively. The input impedance of the device is the internal impedance between these two inputs. The input polarity determines what the polarity will be at the output when a voltage is applied to the input. The positive input is non-inverting, and the output voltage will have the same polarity as the input voltage. The negative input is inverting, therefore, the output voltage will be 180° out of phase with the input voltage. Keep this point in mind, as we'll come back to it later. Knowing this fact at this point will help you to understand the workings of the OpAmp.

Differential input is a term that you will run across frequently as you work with OpAmps. It means that the amplifier responds to the *difference* in voltage between the input terminals which may be either AC or DC. If a 1.5-V battery is connected across the input terminals the difference voltage is 1.5 V. It doesn't matter to which input the positive battery terminal is applied, the difference voltage will still be 1.5 V. The output voltage of the amplifier, the voltage between the amplifier output terminal and ground, is equal to the open loop gain of the amplifier times the differential voltage. If the open loop gain is 1000, and the differential input voltage is 1 millivolt, the output voltage is 1 *mV × 1000 or 1 volt.*

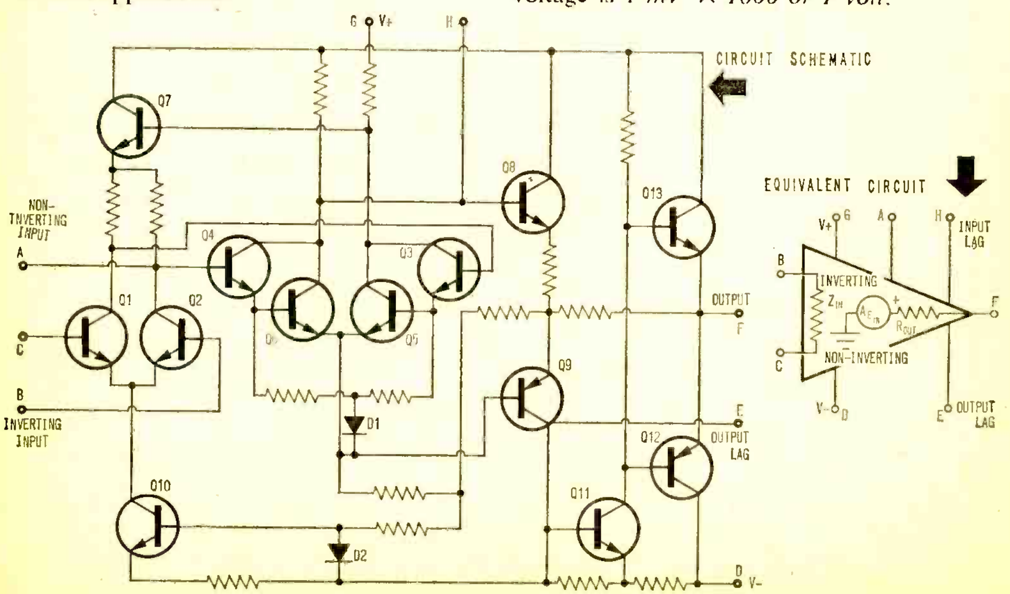


Fig. 1. Schematic and equivalent circuit of IC operational amplifier. Since device is DC coupled, it can be used for both AC and DC amplification. Output can be either in phase or out of phase with input signal.

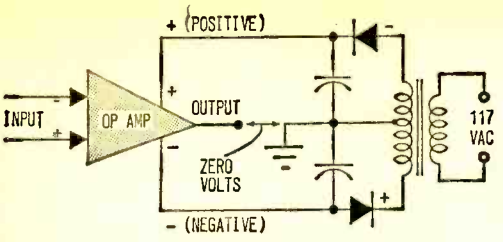


Fig. 2. OpAmp boasts two inputs: inverting input indicated as "—" and non-inverting input indicated as "+". DC output from power supply is half total supply voltage and of two differing polarities.

Open Loop—Closed Loop. Open loop gain refers to the gain of the OpAmp, or any amplifier, as rated by the manufacturer. Open loop gain or maximum gain, is achieved by connecting the amplifier as shown in Fig. 3A. Closed loop gain refers to the gain of the amplifier after a feedback network has been connected from its output to its input. Fig. 3B indicates how negative feedback is derived by connecting amplifier output to the inverting (−) input. If the amplifier should include both negative and positive feedback, which is unusual in experimenter's circuits, the closed loop gain will be the total resultant gain of the device. It is easy to calculate the closed loop gain. Essentially, it is derived by dividing Rf by Rb1 (where Rf = feedback resistance and Rb1 = its associated bias resistance—see Fig. 3B).

When the loop is closed, which occurs

A

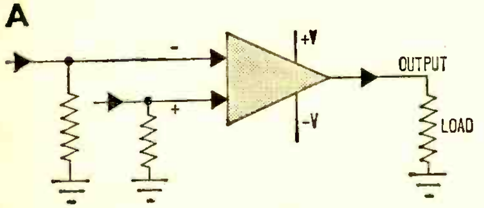
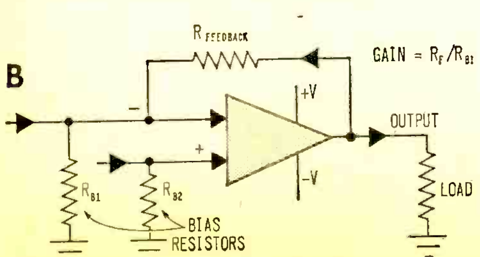


Fig. 3A. Open-loop gain results when amplifier is connected as shown and is maximum gain available. Fig. 3 B. Closed-loop gain is device's gain after feedback has been applied; it's equal to Rf/Rb.

B



when feedback is applied, the inverting (−) input bias resistor becomes part of a feedback voltage divider consisting of Rf in series with Rb1. It can be shown mathematically that, when the input signal is applied between the inverting input and ground, the closed loop gain equals Rf/Rb. When the input signal is applied between the non-inverting (+) input and ground, the closed loop gain equals Rf/Rb+1. Since the factor of +1 is generally insignificant, we can consider that, for experimental use, the closed loop gain is as previously stated. If Rb is 1000 ohms, and Rf 1 megohm, as shown in Fig. 3B, the closed loop gain will be equal to 1 megohm/1000 ohms or 1000. This is equivalent to gain of 60 dB, since gain in dB equals 20 log voltage gain. Regardless of the linear OpAmp used, resistors having these values will always produce the same gain if the amplifier's open loop gain is greater than the closed loop gain. It is not possible to get a closed loop gain higher than open loop gain. For example, an Rf/Rb ratio that produces total gain of 60 dB for one amplifier will not produce 60 dB gain in another amplifier if the latter has a gain of only 50 dB.

Bear in mind that regardless of whether it is an open or closed loop unit, the OpAmp output voltage will be in phase with the non-inverting (+) input and out of phase with the inverting (−) input. For example, assuming the OpAmp in Fig. 3B has a gain of 1000, if 1 millivolt is applied across the input, with the positive voltage connected to the non-inverting (+) input, the output voltage to ground will be +1 volt. If we reverse the input (−) the output voltage to ground will be −1 volt.

Offset Voltage.—What Is It? An important consideration is the offset voltage, which usually refers to the inherent differential voltage, but can also mean a desired DC input voltage difference.

In normal operation, if both inputs are grounded through a resistor, and no input voltage is applied, theoretically the output voltage should be equal to the ground voltage. In actual practice there is a small inherent difference voltage, called the offset voltage, which naturally produces a slight output voltage. If you specifically wanted a quiescent output voltage other than zero you would apply a DC potential to the inputs through a bias resistor and this voltage would be called the operating offset voltage. *(Continued overleaf)*

e/e DISCOVERING OP AMPs

We will spend some time on offset voltage since understanding it will help you trouble shoot experimental projects. In normal linear amplifier operation a zero offset voltage is essential so that output voltage to ground will be zero. This affords the most flexibility in audio and RF circuits. If the output voltage is at zero, the output signal can swing equally to both positive and negative sides of the power supply. For example, if the supply is a +15 V, −15 V (total 30 V) unit, the signal could swing 15 V peak either side of ground (zero output voltage) or 30 V peak-to-peak. But if an offset voltage caused the output voltage to be +10 V under no-signal conditions, the output voltage could only swing +5 V before overload. So for most operations the offset voltage should be as close to zero voltage as is possible.

Taking Advantage Of Offset Voltage. However, for specific applications, offset voltage can be applied deliberately. For example, assume a 30-millivolt peak pulse must be amplified to 30 volts peak. Obviously, this can't be accomplished with zero output voltage and a +15 V, −15 V supply, as the maximum possible swing is only 15 V in either direction. Therefore, by applying an offset voltage that drives the output voltage to −15 V, this leaves a full 30 volts available for a 30-V output voltage swing, and when the 3-*u*V peak signal is applied the output voltage can swing the full 30 V from −15 through zero to +15 volts.

Therefore, you can see the offset voltage can be an advantage or disadvantage, depending on the type of signal with which you are working.

Beware Of Offset Voltage. An important point to keep in mind about offset voltage is, that for zero output voltage the DC resistance path from both inputs to ground must be identical. An OpAmp's input is a transistor, and as all transistors require a bias current, which, though quite small (measured in microamperes), nevertheless does exist. Since the bias current flows through the bias resistor it produces a voltage drop across the resistor. If the resistance paths to ground for the two inputs differ, the voltage drop across the resistors will differ, and the voltage at the OpAmp's inputs will be different. You will have an offset voltage condition. So, as a general rule, the DC path from both inputs to ground must be identical to avoid an unwanted offset voltage.

OpAmp As An AC Amplifier. Bear in mind that the resistance for the OpAmp's inputs includes the entire resistance associated with each input. For example, in Fig. 3B the 1-megohm Rf resistance in series with the output circuit resistance is also in parallel with the 1000-ohm bias resistor. Since feedback resistor Rf alone is greater than 10 times the bias resistor it can be ignored but you will run across many circuits where Rf is an appreciable part, or all, of the DC resistance, and it must be taken into account.

A practical example of the Rf factor is in the tape-head equalized preamp shown in Fig. 4. Since the amplifier is intended for a relatively high input impedance, an 820 k resistor is used for the positive input bias

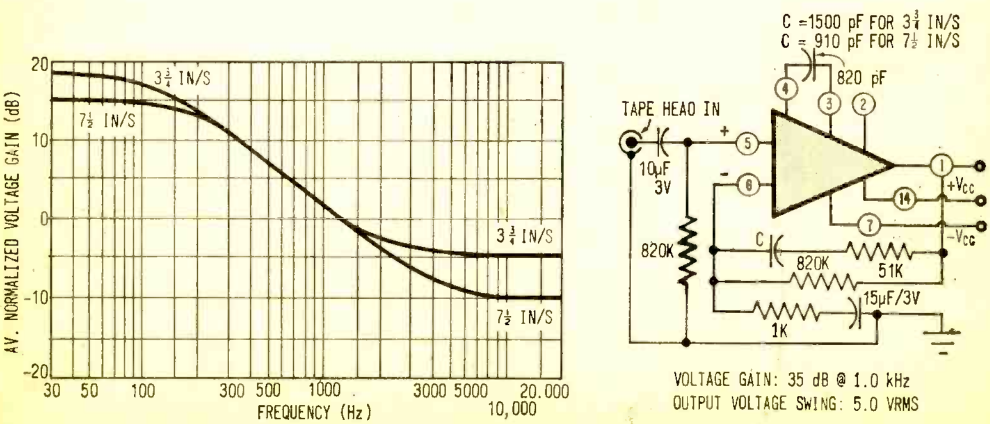


Fig. 4. Circuit for NAB-equalized tape-head preamp using Motorola MC1303L preamplifier. Only one channel is shown here—second channel utilizes other half of IC and is wired exactly the same.

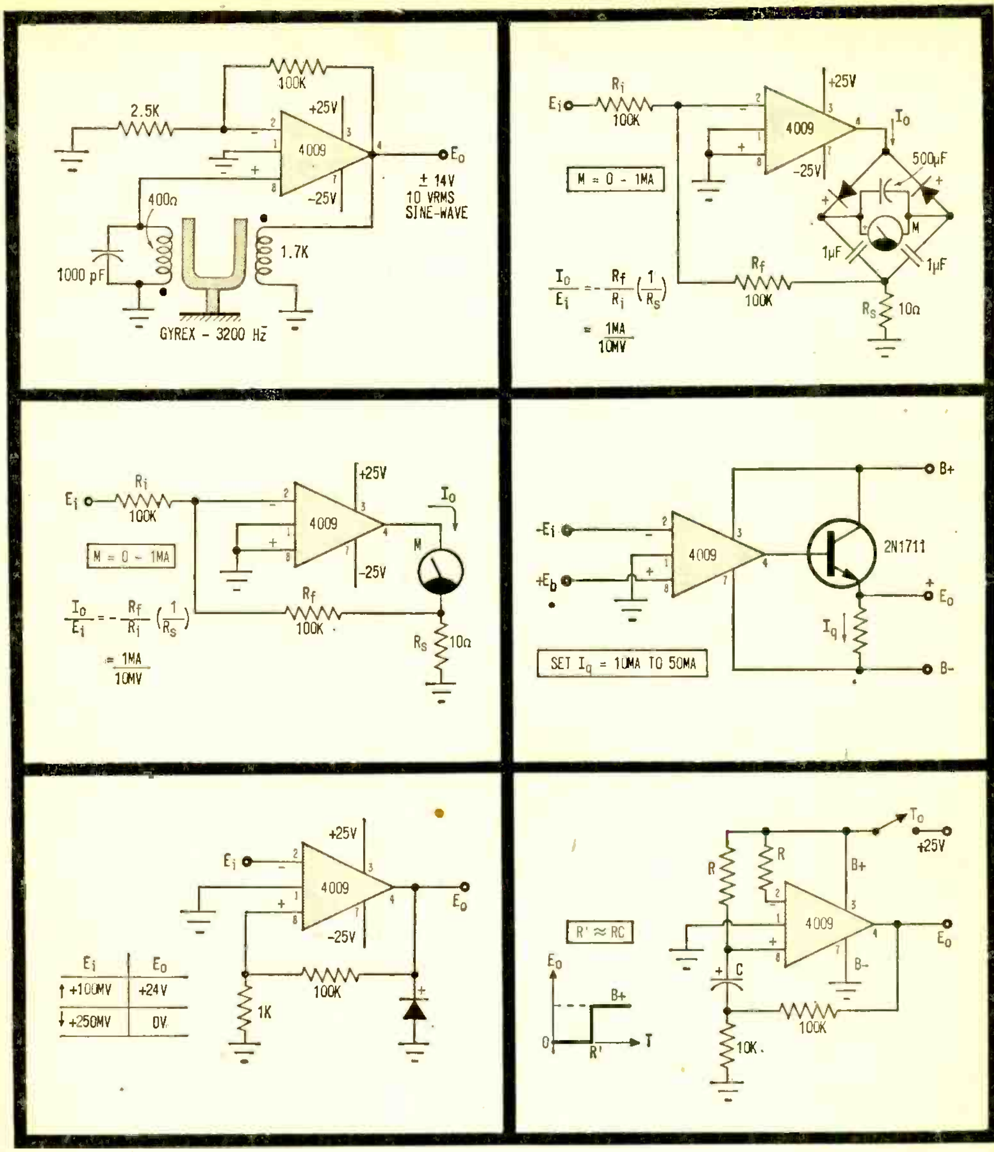


Fig. 5. Six circuits using 4009 OpAmp, available from OpAmp Labs, 172 S. Alta Vista Blvd., Los Angeles, Calif. 90036 for $10.00 ea., postpaid. Circuits, from left to right, are 1) tuning fork oscillator, 2) AC millivoltmeter, 3) DC millivoltmeter, 4) DC medium-power amplifier, 5) Schmitt trigger, 6) fast turn-on timer.

resistor. Now an identical 820,000-ohm resistor in the negative input, which will be used for frequency equalization, is going to result in extremely large feedback resistors. Instead, we use a 1000-ohm negative input load (no longer bias) resistor and isolate it from ground with a 15-uF capacitor. While there is no DC path to ground, the capacitor provides an AC path so that the 1000-ohm resistor can be used for the AC feedback. To provide the equal negative input bias resistance we then connect an 820,000-ohm resistor between the negative input and the output. Since the output is at ground potential both inputs "see" the same resistance value to "ground" and there is no offset voltage. The 820,000-ohm input resistor, in combination with the parallel RC series circuit, produces the proper equalization.

OpAmp As A DC Amplifier. In the previous example you have seen the application of the OpAmp as an AC amplifier. If you go through the calculations you will find that the AC gain at mid-frequency is determined by the 820,000-ohm resistor and it is identical to the DC gain, again from the formula: Gain = Rf/R bias. By the way, the Motorola MC1303L used in the previous example has a slightly different configuration from the usual OpAmp but is one of the best devices available for the experimenter as it behaves like an OpAmp and with reasonable care is indestructible.

So now we have two practical uses for the OpAmp: a) as a DC amplifier and b) an AC amplifier. By connecting the OpAmp to eliminate the input-blocking and negative input capacitor, the OpAmp can be used for simultaneous DC and AC amplification if you allow for a developed offset voltage.

You're Just Getting Your Feet Wet. This article should provide enough information to get you started on your own experiments, and enough help to get you started building and servicing OpAmp circuits. You must keep in mind that an offset voltage determines the output DC voltage and only AC requires DC isolation of the feedback path bias resistor. Then you should not have too much difficulty calculating and building your own circuits. The only problem you may have is with stability, and you should take precautions to prevent the entire circuit from oscillating. Many OpAmps have a frequency response that extends well into RF, and just as in any RF circuit, sloppy wiring will cause self-oscillation. Use standard RF wiring techniques, a lot of point-to-point grounds and a 0.1-uF bypass capacitor from each side of the power supply to ground, connected directly at the OpAmp leads, and you'll greatly reduce the possibility of instability.

Going Beyond AC and DC. Once you get beyond the audio and DC experiments why not give some oddball circuits a try? In Fig. 5 we show a number of useful circuits that are easy to build and easy to understand. All circuits are designed around an OpAmp Labs type 4009—but you can try them with any OpAmp, though you may have to change a few parts values to get them going. One tip to help you when working with oscillator circuits is to concentrate on feedback to the positive (+) input, as shown in the Wein bridge oscillator. If you remember your basic theory you will recall that negative feedback reduces gain while positive feedback drives the amplifier towards oscillation until there is sufficient positive feedback to sustain oscillation (same idea as in a receiver Q-multiplier). So, if you can't get an oscillator to start oscillating, make certain you have sufficient positive feedback. Quite often, the same OpAmp circuit will combine both negative and positive feedback, as in the Wein bridge oscillator, and too much feedback will prevent oscillation. The solution then is to increase positive feedback. If this isn't always possible, try decreasing negative feedback.

Why Is OpAmp a Building Block? This is a question you should know the answer to at this point. The reason for its being called a building block is that a complete operating entity can be assembled by stacking together several OpAmps. Let's look at a receiver as a practical example. Long before OpAmps were available, receiver design often required several engineers. One designed the front end, another an IF amplifier to match the front end output; perhaps another for the audio amplifier and finally a technician to connect them all together and iron out the bugs. More modern components generally required one engineer and a technician to de-bug the set. Again the design was circuit-to-circuit, so that one circuit matched another.

(Continued on page 95)

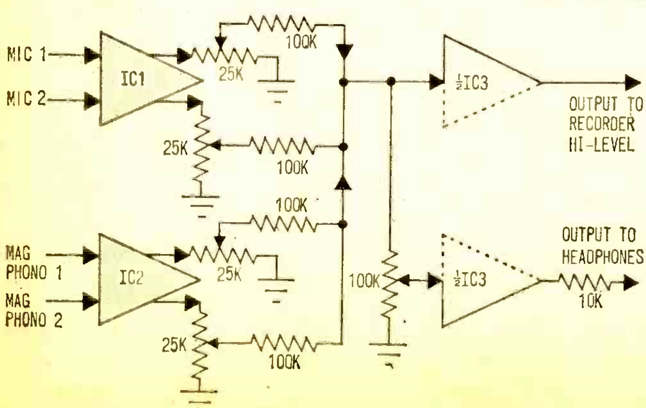
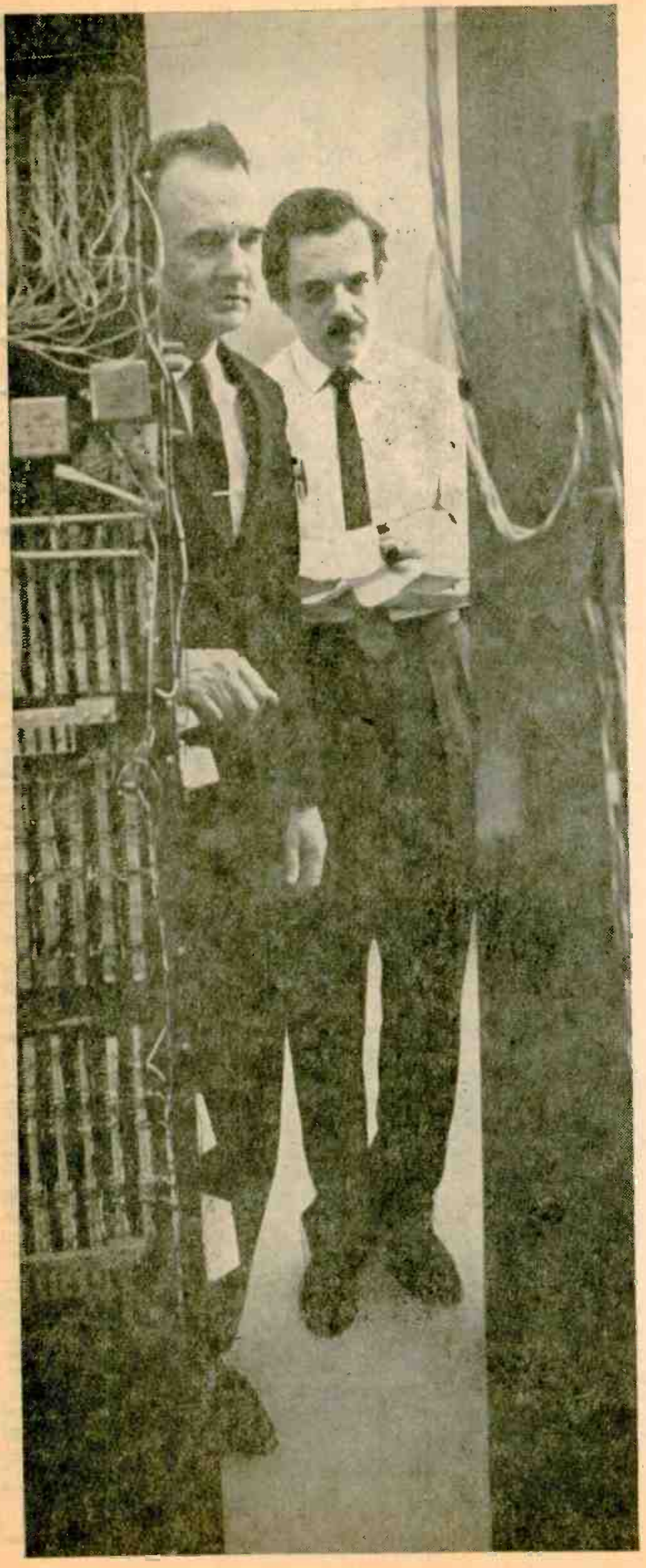


Fig. 6. Just for fun, try designing your own 4-channel mixer using Motorola's MC1303L stereo preamplifier IC. Block diagram gives basic info—you supply all details.



THE TEACHER'S ASSISTANT CAN BLOW A FUSE

Computers are replacing flesh-and-blood assistants as students strive to keep pace with technology

Everyone is concerned by the overcrowding of classrooms created by a shortage of qualified instructors and the population explosion. Good teachers who are harassed by existing classroom conditions and have an honest desire to provide all students with the best education possible, welcome any assistance, be it more teaching staff or modern scientific teaching aids. The electronic computer may provide a good portion of the help needed to relieve the extra load and also can be used to improve and expand the teaching curriculum.

These conditions are not exclusive to the highly populated urban areas in the United States. The Canadian government has initiated a study program to determine the applicability of the use of computers to assist educators.

A long-range program has been launched by the National Research Council of Canada to increase the productivity of Canada's educational process through the use of computer-aided teaching systems. The extensive program, undertaken with the cooperation of educational bodies, industry and government, is being conducted by the Information Science Section of NRC's Radio and Electrical Engineering Division and is being directed by J. W. Brahan and W. C. Brown.

(Continued overleaf)

Facts and photos courtesy
National Research Council of Canada

e/e TEACHER'S ASSISTANT

Printout from computer lesson. Student's entries appear at left, computer's instructions and comments at right. Due to impersonal nature of computer, student is in pure learning situation.

```
HELLO
         PLEASE TYPE YOUR NAME.
JW BRAHAN
         WHICH COURSE WOULD YOU LIKE TO STUDY TODAY?
GE01
         THIS UNIT CONCERNS FRUIT FARMING. A BOOKLET
        OF MATERIALS RELATED TO A TYPICAL NIAGARA
        PENINSULA FRUIT FARM HAS BEEN PROVIDED.
        AS YOU PROCEED, FOLLOW DIRECTIONS CLOSELY
        AND ANSWER ONLY AFTER CAREFUL CONSIDERATION.
        YOUR PURPOSE IS TO ACCURATELY VISUALIZE
        THE MANY ASPECTS OF FRUIT FARMING. ANSWERS
        SELDOM REQUIRE MORE THAN TWO WORDS.

         BEFORE PROCEEDING, SKIM THROUGH ALL MATERIALS
        PROVIDED.

         USING AN ATLAS, LOCATE GRIMSBY, ONTARIO.

         HAVE YOU LOCATED GRIMSBY?
NO
         PERHAPS THE FOLLOWING WILL HELP.
         A PLACE MAY BE LOCATED BY FINDING THE PLACE
        NAME IN THE INDEX OF THE ATLAS AND NOTING
        THE SYMBOLS WHICH FOLLOW THE PLACE NAME.
        FIND RENNES, FRANCE IN THE INDEX.

         WHAT ARE THE SYMBOLS (NUMBER, LETTER, AND
        NUMBER) FOLLOWING THE NAME?
30D3
         GOOD
         THE 30 REFERS TO THE PAGE ON WHICH YOU
        WILL FIND RENNES, AND THE D3 REFERS TO THE
        GRID SQUARE. CAN YOU NOW LOCATE RENNES?
        (YES OR NO)
YES
         WELL DONE.
         NOW, LOCATE GRIMSBY, ONT. STATE THE PAGE
        AND GRID NUMBER TO SHOW THAT YOU CAN.
16D3
         SUCCESS IS YOURS!
         TO WHAT DOES THE 16 REFER? (PAGE OR GRID
        SQUARE)
PAGE
         GOOD
         TO WHAT DOES THE D3 REFER?
GRID SQUARE
         WELL DONE.
         THE INDEX SYMBOLS, THEN, TELL YOU WHERE
        TO FIND A PLACE NAME ON A MAP. ARE YOU NOW
        ABLE TO LOCATE GRIMSBY?
YES
         WELL DONE.
```

Need More Education. Mr. Brown, Head of the Section, says the educational facilities of most countries are being subjected to ever-increasing demands as automation spreads and daily life becomes more complex. Not only are the formal school systems being required to provide a higher level of education for an increasing number of students, but there is a growing requirement for retraining of workers as their jobs are made either obsolete or more complex by the introduction of automation.

Demands also are being made for increased adult-education facilities as a result of the increased leisure time available to the worker as his productivity increases. This all points to a shortage of competent teachers in the very near future and an increasing work-load for those already involved.

Industry has made use of modern technology to increase industrial productivity. Application of the same kind of modern technology through use of the digital computer offers a means of increasing educational productivity to meet the growing demands on educational facilities.

For Teachers and Students. Mr. Brown emphasizes that computer-aided teaching systems will not replace teachers but will relieve them of time-consuming routine tasks making it possible for them to give more attention to the problems of individual students. A carefully designed system can tailor lessons to the needs and the learning rate of the individual student, it can challenge the gifted, enrich the curriculum of the superior student, provide the more repetitious instruction needed by the slow learner and afford the special facilities needed for the disadvantaged and those confined through illness. Only a small percentage of a student's time will normally be occupied in this conversational computer mode; much of the learning period will be occupied with tutorials and discussion groups under the teacher's guidance.

No Classroom Ridicule. A major advantage of such systems is that a computer is impersonal and impartial. Students are not subject to class ridicule if they give an incorrect answer and the computer can be programmed to provide statements in greater depth until a point is clearly understood and tested.

How Computers Can Help. The NRC

(Continued on page 98)

W.C. Brown (left) and J.W. Brahan seated at small switching computer. Unit permits information transfer between students and central computer.

Everything comes up both bigger and rosier with a push-pull circuit at the helm

PUSH-PULL CIRCUITS

When Detroit automakers want more horsepower, they build bigger engines. When Boeing thirsts for more thrust, it goes for jumbo jets. But when a radio engineer wants more watts he may not reach for tubby vacuum tubes or tremendous transistors. Chances are he'll consider an electronic version of the Volga boatmen —*push-pull*. It's nearly the standard circuit in the output stages of hi-fi receivers, public-address amplifiers and radio transmitters. There are good reasons for the choice.

Two at the top of the list are *more* power with *less* distortion. These qualities become especially troublesome whenever the designer wants to increase the power in an output stage. He can connect a pair of tubes in a parallel, but as power output rises, so does distortion. Yet if those tubes are connected in push-pull, not only is much distortion cancelled out, but more than twice the output power becomes available.

That's not all! Push-pull operation offers other benefits. In a transistor portable it reduces idling current drawn from the battery. It can also slash the size of an output transformer in a hi-fi rig. It performs exotic tasks in some circuits, like cancelling the radio carrier in a single-sideband transmitter. To see how push-pull does it all, consider its basic layout. *(Continued overleaf)*

By Len Buckwalter, K1ODH

PUSH-PULL

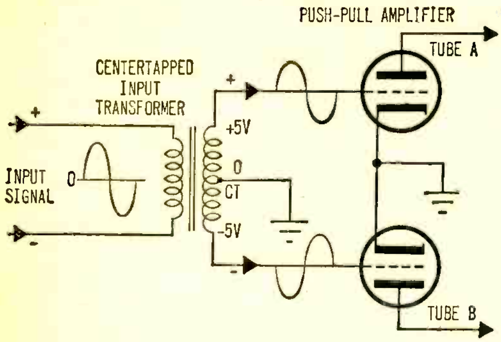


Fig. 1. Centertapped transformer splits signal into two equal and opposite parts, causing inputs to tubes A and B to be 180-deg out of phase.

See-Saw Circuit. Push-pull's underlying idea is to operate a pair of amplifiers in see-saw fashion. To start the action, the input signal to the stage must be split into equal and opposite parts. One method to prepare the signal is with a centertapped input transformer, as shown in Fig. 1. The signal (audio, video, RF, etc.) is applied to the transformer and, because of the centertap, it divides into two parts at the secondary winding. The voltage at the centertap is considered zero since that point is connected to ground. Voltages at the ends of the secondary winding, however, appear opposite in polarity.

Now, to apply input voltages to the grids of the push-pull amplifier! If it's assumed that Tube A, for the moment, is receiving a positive-going signal, that tube experiences an *increase* in plate current. Tube B, on the other hand, now receives a negative grid signal, so its plate current *decreases*. The circuit derives its name from this action: you can say that Tube A is "pushing" while Tube B is "pulling." As the input signal reverses polarity, so will tube action.

Next, examine what these tube currents produce at the output, as shown in Fig. 2. Note that again there is a centertapped transformer. Since the centertap is connected to the power supply (B+), this is considered a zero or electrical ground point for signal (not power-supply) voltage. It means that each tube in the push-pull partnership contributes an amplified output across the transformer primary. And at any given instant the two output signals are equal and opposite. When these components appear at the secondary winding of the transformer, however, they combine and add for the total output power.

So push-pull boils down to a process of splitting a signal to be amplified, feeding its parts to each tube for amplification, then joining the outputs for an *additive* total. But the circuit does much more than that in the process.

One + One = Three. Push-pull circuits can be driven harder than conventional (single-ended) amplifiers with less output distortion. Fig. 3 shows why. To obtain good fidelity in an amplifier, like the Class A type shown in Fig. 3, there must be a continuous flow of plate current, even when no signal is applied. This ensures that all parts of the input signal are amplified equally. Plate current is made to flow continuously by setting the proper value of negative bias at the tube grid. But the price paid for *high fidelity* in the circuit is *low efficiency*. Much power is wasted in the form of heat due to constant plate current.

In the push-pull circuit, though, it's possible to drive tubes into a highly distorted region, achieve high operating efficiency—but not suffer severe distortion at the output. The answer to this apparent paradox is illustrated in Fig. 4.

First, grid bias on the tubes is raised to a sufficiently negative point to cut off any idling plate current. This causes each tube to conduct current only when the input signal drives its grid into the positive region. When the signal is negative, tube plate current is cut off or highly distorted. Recall, though, that in a push-pull operation one tube increases current as the other tube decreases. This partnership enables one tube to operate in a faithful, or linear, fashion while the other is driven into a distortion region.

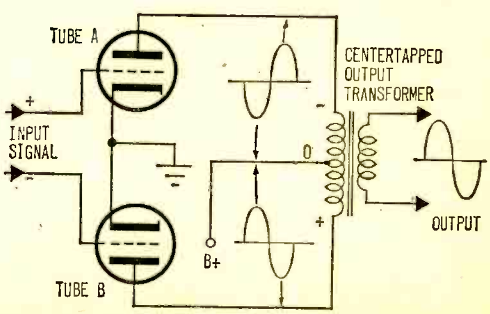


Fig. 2. Centertapped transformer again comes into play at output of push-pull stage. But this time transformer combines rather than splits signals.

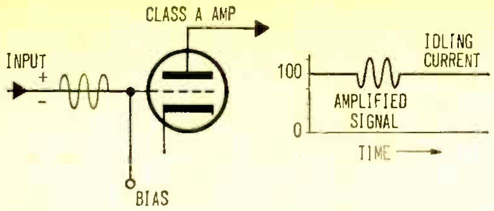


Fig. 3. Single-ended amplifier, while offering good fidelity, is inefficient, since plate current must be allowed to flow at all times.

On the next half-cycle of the input signal, the tubes switch places . . . so the input is correctly reconstructed at the amplified output. The big advantage in this arrangement is lower plate dissipation in the tubes. Since the tubes operate at high negative bias, each conducts only when it receives a positive-going grid signal. Each tube works part-time, so the designer can drive them hard and obtain good operating efficiency (due to less heat). He knows he can obtain more than twice the power from a pair of tubes in push-pull as compared to two tubes connected in parallel.

Harmonics. Another important benefit of push-pull is the treatment of harmonics. These are signal multiples which produce distortion in the output. As we've seen, an input signal is split so that it's equal and opposite in both input and output transformers. This is a 180-degree phase difference which must be maintained so the split signals can combine and add in the output. Any other phase difference is apt to cause losses through voltage cancellation in the transformers. This is exactly what happens for all *even*-numbered harmonics (2nd, 4th, etc.) in a push-pull amplifier. Such harmonics create bucking voltages which disappear as they clash in the output. The hi-fi engineer exploits this circuit quirk to reduce listener fatigue caused by harmonic distortion. And in a ham transmitter, there'll be fewer harmonic signals to interfere with television sets. But more power and less distortion are not all the benefits of push-pull.

More Pluses. Your transistor portable probably has a push-pull output for reasons which have little to do with high fidelity. The circuit can reduce drastically the amount of current drawn from the battery. Since the transistors are biased to about cutoff, they draw current only according to the loudness of the program. This arrangement eliminates the continuous standby drain of the conventional amplifier. Another attraction of the push-pull circuit is that the output transformer can be made smaller. When current runs through a conventional audio transformer, it tends to magnetize the iron core and reduce transformer efficiency. This doesn't happen in the push-pull transformer since there are two opposite current flows (from each amplifier toward the centertap). The net result is the cancelling of any DC magnetizing effect on the core. What's more, if an AC power supply is poorly filtered, it may not produce annoying hum on the signal. As in harmonic cancellation, hum voltage tends to be bucked out in a push-pull stage.

What's Wrong? Push-pull also has certain disadvantages. For one, it requires twice the input voltage to drive two amplifier grids. Then, the push-pull stage is preceded by some method of splitting and phasing the input signal. Another wrinkle is that the amplifiers are subject to "cross-over" distortion. But the advantages of push-pull are so great that manufacturers willingly pay the price to overcome push-pull's liabilities. Let's consider the special circuitry needed to make a push-pull stage operate properly.

Phase Inverter. To feed the push-pull final of a radio transmitter, a designer can use the simple arrangement already shown in Fig. 1. There is an input transformer with a centertap to split and phase the signal. The method isn't costly since the transformer for RF is only an air-wound coil. But when the circuit operates at audio frequencies, the transformer becomes costly if fidelity is important. For this reason, hi-fi circuits almost always use a tube or transistor to provide the same action. The stage, as shown in Fig. 5, is the "phase inverter."

It uses the phase-inverting action which occurs through a tube like the one in Fig. 5.

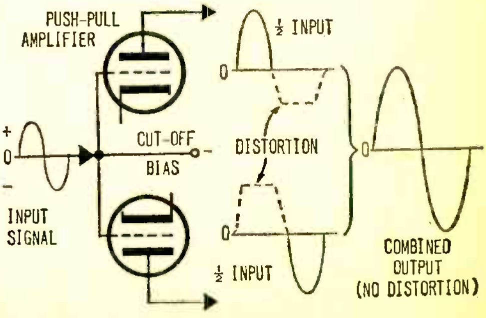


Fig. 4. Because two halves of signal are combined at output, push-pull circuit can be biased to cutoff to realize efficiencies as high as 50%.

e/e PUSH-PULL

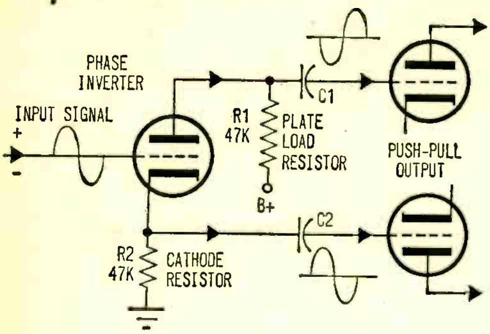


Fig. 5. Like centertapped transformer of Fig. 1, tube (or transistor) also can serve as signal-splitter. This is one of many possible circuits.

If an input signal is applied to the phase-inverter grid, and the signal is going positive at this time, there is an *increase* in plate current through the tube. This causes a *drop* in voltage at the plate (see top of plate resistor R1). When this voltage is tapped by a coupling capacitor (C1), it is negative-going. This action has turned the original positive signal upside down—a phase reversal of 180 degrees.

Meanwhile, the same plate current is coursing through R2, the cathode resistor. The polarity at the top of R2, however, is the same as the input signal (positive). This part of the output is applied through a coupling capacitor to the lower grid of the push-pull stage. The two resistors, as you can see, are the same value so the push-pull input voltages will also be equal and opposite. Phase inverters of this type are not only economical, but accurate in phasing and low in distortion.

Solid, Too! With the transistor take-over from vacuum tubes in audio and low-power RF equipment, push-pull also goes solid-state. A basic stage of this type is shown in Fig. 6. As in the vacuum tube version, an input signal is split and inverted before feeding the amplifier inputs (transistor base elements in this case). Since these transistors are *pnp* types, only when the input signal goes negative will a transistor collector conduct current. Thus, upper and lower transistors share the amplifying burden. Each contributes half the power in the output transformer, as in the earlier circuits.

But there is one fault in this arrangement. Transistors do not amplify in a perfectly true, or linear, fashion at all signal levels. This is especially troublesome during small signal currents. It causes "cross-over" distortion, as plotted in Fig. 6. Note the flattening of the waveform where the curve drops toward zero. This is the cross-over point, where one transistor stops conducting and the other one takes over.

Engineers cure cross-over distortion in transistor stages by introducing a small amount of continuous current flow. This is done by applying a slight amount of bias, as shown in Fig. 7, so neither transistor is ever completely cut off and thrust into the critical, low current area of operation. Since the transistors are never totally cut off, the continuous current does reduce circuit efficiency and increases battery drain in portables, but the effect is small and usually worth the reduced distortion. As shown in Fig. 7, resistors R1 and R2 form a voltage divider which taps a small amount of negative voltage from the power supply. This potential is applied to the transistor bases and a continuous flow of collector current is assured.

Free Push-Pull. Anyone who's studied vacuum tubes knows that current flow is one way: electrons boil off a hot filament and fly to a positive plate. But transistors will push current flow in either direction. If a semiconductor is a *pnp* type, like the ones in Fig. 6, an increase of negative voltage on the base raises collector current. In an *npn* transistor this is reversed; a positive base signal raises collector current. This dual nature of transistors easily makes possible a

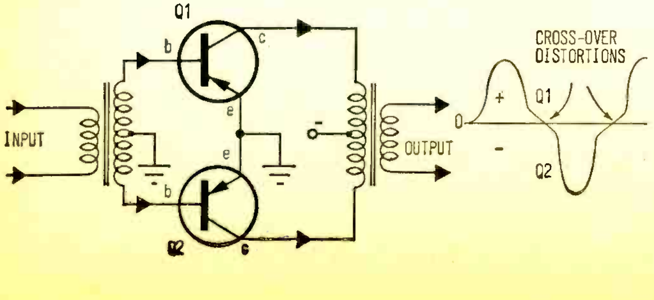
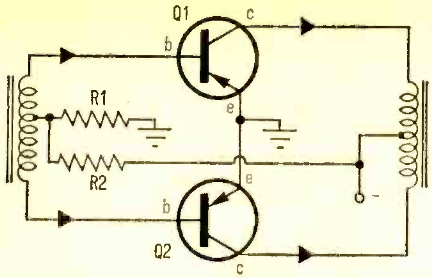


Fig. 6. Due to nature of transistor action, solid-state push-pull circuits can display appreciable distortion, particularly at low signal levels. Curves at right of simplified circuit here reveal nature of so-called cross-over distortion.



simplified, solid-state push-pull circuit.

The arrangement, known as "complementary symmetry," is shown in Fig. 8. There are two transistors which are electrically identical except that one is *pnp*, the other is *npn*. An input signal to be amplified is simultaneously delivered to both transistor bases. If the signal at this instant is negative, it produces a current flow in the top transistor (*pnp*) and a decreasing flow in the lower semiconductor. When the signal reverses on the next half-cycle, all polarities change to the opposite sign. The result is the same as that described for earlier push-pull circuits; each amplifier contributes half the output signal. This circuit, however, does it without a phase inverter or centertapped input transformer. As shown in the diagram, there are two collector currents flowing in the same direction. It is now possible to connect a loudspeaker in place of the load resistor without benefit of a centertapped transformer.

Other Pushes. When speaking of push-pull it almost always refers to output stages of an amplifier. But the idea is also applied to a number of other circuits. With a slight modification, designers come up with a useful item known as a "push-pull multiplier." It's found in radio-frequency amplifiers to efficiently boost *even* harmonics (2nd, 4th, etc.) of a fundamental frequency. This would be useful in a ham transmitter, for example, where bands are assigned in harmonic relationship. A low-band signal can be multiplied and transmitted at some higher frequency. Consider how it operates.

The push-push circuit starts with the same input circuit described earlier, as shown in Fig. 9. There is a centertapped input transformer to divide the signal into equal and opposite components. The big difference is how the outputs are wired. Note that the two tube plates are directly connected in a *parallel* arrangement. When the top tube is driven with a positive grid signal, as shown, there is an output current flow. Then, the

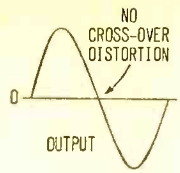
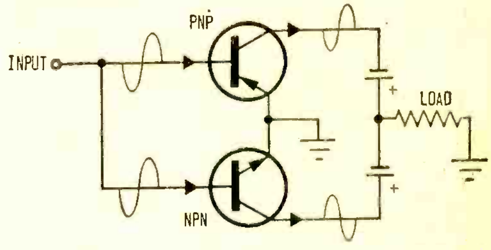


Fig. 7. Adding biasing network to circuit of Fig. 6 tends to kill cross-over distortion.

Fig. 8. Complementary-symmetry circuit needs neither input nor output transformers.



input signal alternates and goes negative, cutting off the top tube. But because of the centertapped input transformer, a positive signal is delivered to the lower tube, which now conducts. The total effect is push-push—there is an amplified signal at the output during positive and negative halves of the input. This action doubles the frequency.

A cousin to push-push is the common full-wave power supply found in a goodly portion of electronic equipment. As shown in Fig. 10 the power transformer operates on AC current from the line which alternates at 60 Hz. But the transformer secondary winding has a centertap which causes the rectifier diodes to conduct current during both positive and negative excursions of line voltage. Since the diodes are connected together in parallel on the output side, the total effect is like that of the push-push circuit. The output voltage "ripples" at 120 Hz—twice the 60-Hz line alternation. It explains why hum from a poorly filtered power supply is usually 120 Hz, not 60. The supply circuit is not only a rectifier, but a *frequency doubler* as well. *(Continued overleaf)*

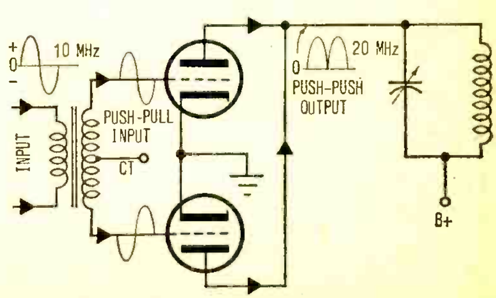


Fig. 9. Circuit of push-push frequency doubler, which converts 10-MHz input to 20-MHz output. Parallel L/C combo of output is tuned to 20 MHz.

One of the more exotic application of push-pull circuitry is in sideband transmitters. As you may recall, a conventional AM signal consists of three components: the steady radio carrier, plus upper and lower sidebands which carry the signal intelligence. Although a carrier is needed to create sidebands within the transmitter, it may be discarded before transmission. A circuit to produce sideband signals is the balanced modulator shown in Fig. 11. If we start with the radio carrier (a continuous signal) we see that it's introduced as a push-push signal to the tube grids. This is aided by the center-tapped input transformer. But observe the output at the tube plates and you'll note a parallel, or direct, connection. This means that any signals developed in push-pull at the grids will collide in the output. The action —signal cancellation—eliminates any steady carrier signal in the output, which is the desired result.

Next, the sidebands are created. If you examine the tube screens, you'll see they're connected to a push-pull audio transformer. Again there'll be cancelling of the output signal, since audio is applied in push-pull, and destroyed in the parallel output. But there's an important upset within the tubes as someone speaks into the transmitter

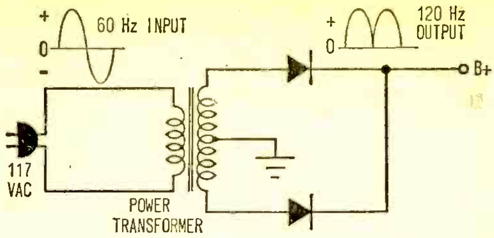


Fig. 10. Like frequency doubler of Fig. 9, common full-wave rectifier also acts as doubler, since 60-Hz input appears as 120 Hz at output.

microphone. Audio voltage on the screens *unbalances* the tubes as "seen" by the radio carrier. The unbalance now allows the radio carrier to slip through to the output. The electronic trick is that the carrier is permitted through the unbalanced tubes *at an audio rate*—another way of saying the carrier is being modulated. The significant factor is that neither *steady* carrier nor audio occur in the output, but the *modulated* signal can appear. That modulated signal consists of the two sidebands. If transmitted in that form, it's a double sideband signal, or if one sideband is removed later, it is single sideband. It's all made possible by the magic of push-pull.

Look Back. Now you've had a basic lesson in what push-pull circuits are all about. A healthy dose of electronics was served up. It would be best if you now reviewed what you have read and learned. We gave you the push, now *pull* with us. ■

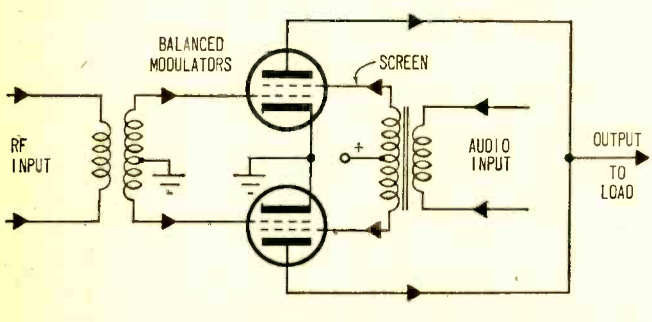
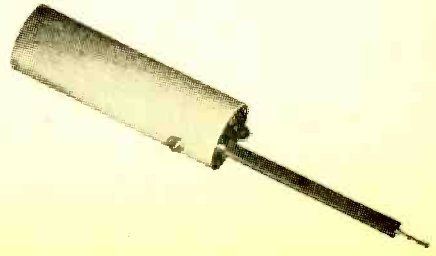


Fig. 11. Unusual hookup of balanced modulator accounts for lack of carrier in double sideband signal. Both sidebands are present in output of this circuit, but one can subsequently be removed for true single sideband operation.

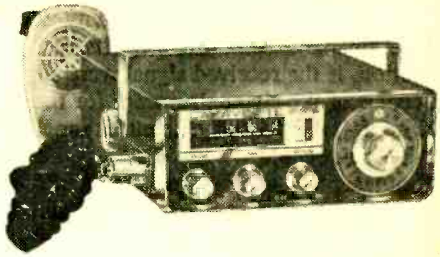
A Signal Injector For All Reasons



Among the handiest trouble shooters in electronics is the lowly signal injector. Handy as any is a dandy new kit just announced by Allied Radio. Dubbed the KG-644, the all-solid-state unit is completely portable, completely self-contained, and produces a signal rich in harmonics for tracing audio, RF, and IF circuits.

The injector comes complete with four penlite cells and is supplied in easy-to-build kit form. Price of the Knight-Kit KG-644: $4.95. ■

LAFAYETTE TELSAT 150
Solid State CB 2-Way Radio Plus VHF Police and Fire Monitor Receiver



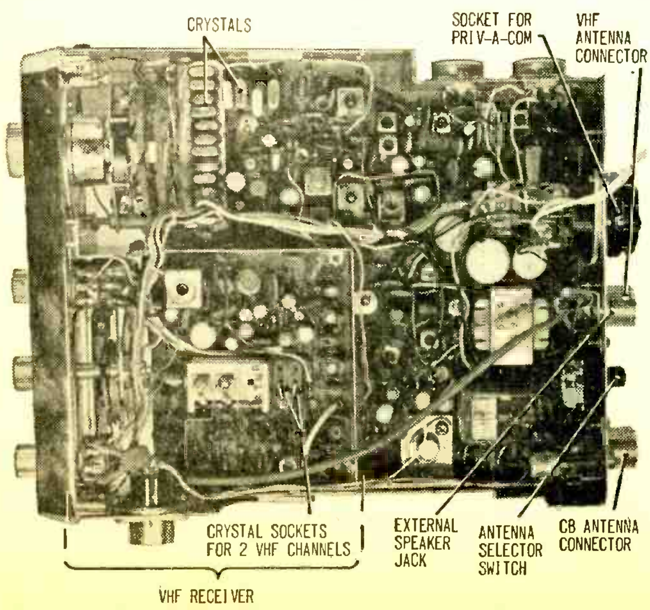
Lafayette Radio has always been at least one jump ahead of the CBers' needs. And with their Telsat 150 combination CB transceiver/police-fire receiver they just about wrap up every need of the active CBer in a relatively inexpensive package priced at $199.95.

The Telsat 150 combines two separate communications functions in a single standard transceiver cabinet: that of a 23-channel crystal-controlled CB transceiver and an FM vhf receiver, tunable from 150 to 174 MHz. In addition, two crystal-controlled, fixed frequency receiving positions are provided for the vhf band. The crystals are optional equipment, and are priced at $5.95 each (specify frequency when ordering).

Equipment Features. The CB section includes a double-conversion receiver using a small mechanical filter in the second conversion. A frequency synthesizer facilitates transmission and reception on all 23 channels. To provide the space required to house the vhf receiver in a standard mobile CB cabinet, all superfluous circuits not directly associated with communications quality have been eliminated. For example, there is no S-meter, PA output jack, PA switching or Delta tuning. The only frill, if it can be considered a frill, is an external speaker jack.

Two coaxial antenna jacks and a mode switch are provided. With the switch in the CB position one of these jacks is connected to the CB antenna and the remaining jack is connected to an independent vhf antenna. When the switch is set to the common mode both jacks are connected together so the CB antenna can serve both for CB reception and transmission as well as reception of vhf signals. The common mode switch position does not affect CB performance. Vhf performance is affected only to the extent that best results are obtained when an antenna is cut for a specific operating frequency.

Performance. The overall CB receiver performance is quite good. Sensitivity measured 0.7 μV for 10 dB S+N/N (signal plus noise to noise). Adjacent channel rejection checked out at 41 dB, and while 41 dB is by no means super-sharp, it is about the limit *(Continued overleaf)*



Telsat 150's guts are packed with no space left over. Liberal use of ceramic filters, ICs and other mini-components keep unit's size and weight down. Note all crystals in place—that's $$ saved.

of selectivity when no means are provided for fine tuning. Greater selectivity would reduce sideband response, with its resultant distortion, if the received signal were slightly off center of the channel. Except for the true DX hound, 41 dB of adjacent channel sensitivity is adequate.

Input signals as high as 10,000 uV, the equivalent of a very strong signal, did not overload the front end.

Audio quality is extremely good—in fact, considerably better than usually found in a solid-state transceiver. No doubt this is due to an obviously beefed-up output amplifier. There is enough available power output to overcome most any ambient noise level with extremely clean speaker volume.

With a DC power input of 13.6 V, the equivalent of battery voltage when the engine is running, the transmitter delivered 3.5 watts output to a 50-ohm load. An external loading adjustment is provided for adjustment of optimum output into any normal CB antenna. Modulation sensitivity through the microphone checked out to be −21 dB average sensitivity, with notably low distortion until the automatic 90% modulation limit was reached.

Limiting is very effective, with a rounding, rather than squaring, of the waveform that keeps the limiting distortion to a minimum, even when shouting into the microphone. Again, we attribute the excellent modulation to the beefed-up audio system.

About That VHF Receiver Package. The vhf receiver, which is crowded into a small area, appears at first glance to be a "throw-in" feature. However, it proves out to be a first-class performer.

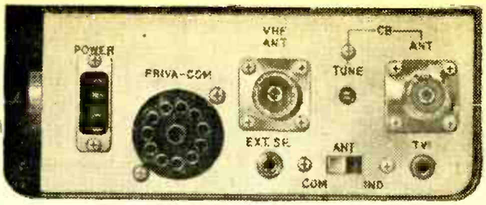
The vhf receiver has three stages of ceramic coupled IF amplification followed by the latest RCA IC designs for the limiter, detector and low level audio stage. Since we didn't have a schematic or instruction manual available at the time the tests were conducted, we couldn't locate an AFC (automatic frequency control) circuit. There must be either an AFC, or one heck of a stable local oscillator, as the variable tuning is rock-steady. A front panel switch selects either variable tuning or two crystal-controlled fixed frequency positions. The crystal sockets are located inside the cabinet and are accessible only by removing six cover screws.

The vhf receiver is completely independent of the transceiver up to the FM output, at which point it shares the transceiver's audio system.

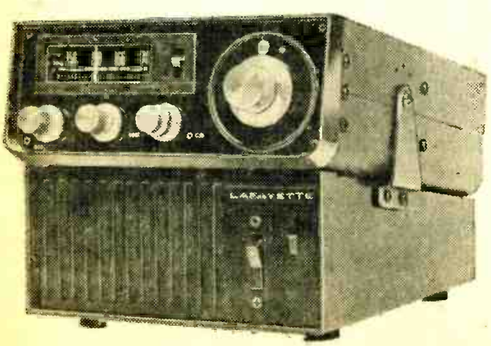
The overall performance on vhf is somewhat astounding. Sensitivity checked out at 1 uV and image rejection was better than 35 dB down. We could not measure the selectivity because of instrument limitations, but a good indication of its selectivity is that it completely separated the crowded New York City police frequencies, which is something that we cannot do with other vhf receivers in the $200 range. The overall audio response is surprisingly good, easily surpassing that of any other consumer-type vhf receivers we have used and even better than some of the commercial equipment used by the New York city police and fire departments. In short, the vhf performance is very impressive.

Primary Power. Telsat 150 is powered by 12 VDC with a *negative ground.* Either a 117-VAC power pedestal or a battery pack can be used as the power source—both are

(Continued on page 98)



You wouldn't fully realize the buy the Telsat is until you peek at its flip side—the rear apron looks like a control panel. Note antenna inputs for CB and VHF—actually wired in parallel. 11-pin socket connects optional selective-call unit.

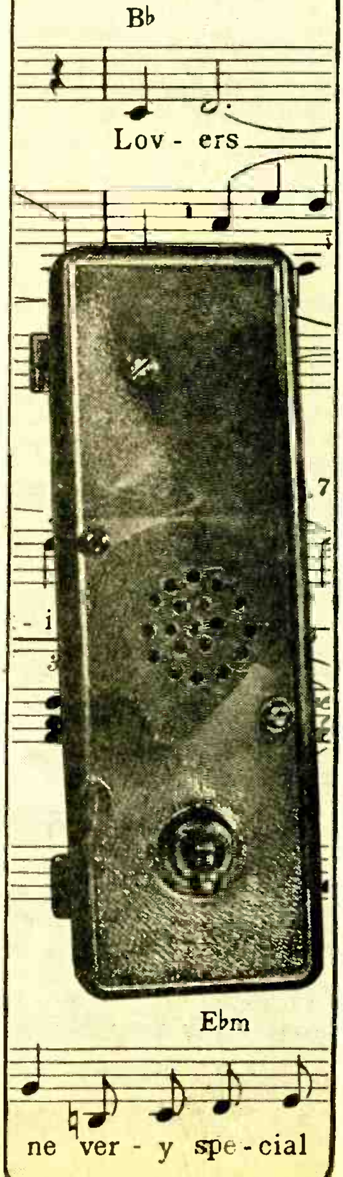


Put your Telsat 150 on a pedestal—Lafayette's HB-502A AC power supply serves as a base while powering rig from 117-VAC line.

CHEAPY BIPPY

Convert a CPO into a modern metronome for less than $5.00

By Steve Daniels WB2GIF



Is there a budding musical genius in your life who just can't keep time but who has nevertheless pestered you for a metronome? So when you shopped for one at the local music shop you discovered that conventional spring-driven pendulum types are expensive, delicate, and susceptible to shock and vibration. And then a brilliant thought crossed your mind.

Why not use a variable low-frequency transistor oscillator and speaker? You probably have all of the components required in your parts box, and using them would overcome the mechanical deficiencies and high cost of a commercial metronome.

How about using that code practice oscillator that was discarded a few months ago? It has enough output to drive a small speaker at its self-generated audio frequency. True, its output frequency is higher than the timing rates of a metronome. But with a change in a component or two it should be possible to lower the original frequency to the desired timing rate and also to make the timing rate variable through the desired range. All that is necessary is to change the time constant of the oscillator so that feedback occurs at a much lower frequency.

Modifications to CPO. Most pre-fabricated CPO modules (we used Lafayette's 19T1513) are designed around the circuit in the schematic diagram (see next page). Remove the small capacitor in the module and replace it with a 10-uF, 6-V electrolytic (C1).

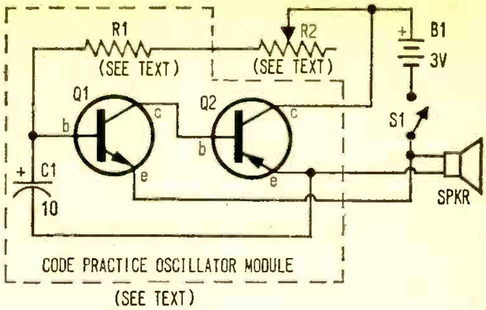
Next, remove the resistor in the module and temporarily replace it with a potentiometer (approximately 200,000 ohms) to be used as a variable resistance. This is an easy way to determine a new value of fixed resistance (R1) to replace the resistor just removed. The combination of capacitor C1 and resistor R1 estab-

(Continued overleaf)

lishes the time constant of the oscillator feedback circuit. A 10,000-ohm fixed resistor and 100,000-ohm potentiometer, for R1 and R2 respectively, produced a suitable range in the module we modified. These values may not necessarily be correct for the module you use.

At this stage connect the module to a battery and speaker. The oscillator will be running at a slow rate, indicated by a clicking sound in the speaker. Vary the potentiometer until the clicks heard in the speaker are equal to the slowest desired time rate. Once this rate is reached remove the potentiometer from the circuit, taking care not to disturb its setting. Measure the value to which it was set with an ohmmeter and select a fixed resistor that has a resistance as near in value to this measurement as possible. Permanently solder in the selected fixed resistor as the replacement for the original R1.

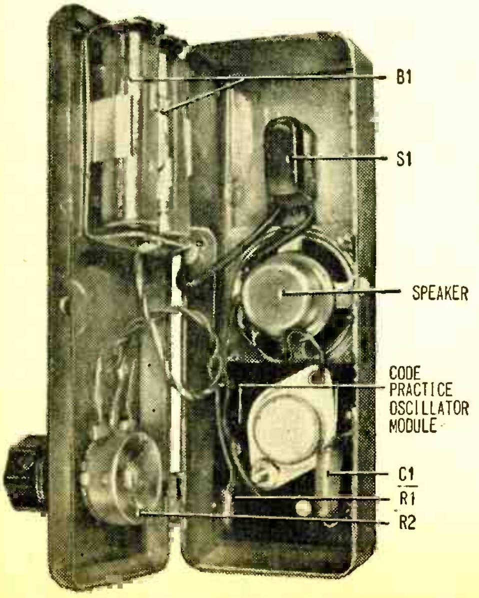
The final step in the modification is to provide a means to vary the rate of timing between the lowest and highest required counts. This becomes the electrical equivalent to physically moving the pendulum weight up or down its supporting arm in a conventional metronome. The addition of R2 to the circuit provides this timing control.



Circuit of Cheapy Bippy is simplicity itself, even with modifications outlined in text. Value of resistor R1 is determined experimentally and establishes slowest time rate; potentiometer R2 makes it possible to increase rate as desired.

Viola! A Metronome! Once the modification has been completed you are ready to complete the assembly. Install the module, speaker, battery holder, power switch and timing control in a plastic box having a hinged or removable cover, to provide easy access when it is necessary to change the batteries. Put markers on an arc around the knob to serve as calibration indicators.

What to do with your newly made metronome? Easy. Bestow it on that budding musical genius we mentioned earlier and hope for another Jack Jones or Petula Clark in the making. Bring it out at your next party and watch those bar-dragging choristers take on life and zip. Or, for kicks, try syncing it with WWV. ■



PARTS LIST FOR CHEAPY BIPPY METRONOME

B1—Two penlight batteries (Eveready 915 or equiv.)
1—Battery holder (Lafayette 34T5006 or equiv.)
C1—10-uF, 6-V electrolytic capacitor (Lafayette 99T6006 or equiv.)
1—Miniature code practice oscillator (Lafayette 19T1513 or equiv.)
R1—See text
R2—See text
S1—Spst toggle switch (Lafayette 34T3309 or equiv.)
SPKR—8-ohm miniature speaker, 1 1/2-in. diameter cone (Lafayette 99T6035 or equiv.)
Misc.—Plastic box with hinged lid—minimum inside depth 1 1/4-in., hardware, hook-up wire, etc.

Metronome's components can be installed in most any case or box you happen to have on hand. Here, housing is rectangular plastic box with hinged lid. Speaker is mounted dead center, CPO module at bottom.

e/e TEST GEAR

CENTURY GENERAL
Solid-State, Self-Powered Audio Test Center

Century General's Audio Test Center is a battery-powered, transistorized signal tracer small enough to carry in your tool box, that is specifically intended for trouble-shooting solid-state equipment. Typical of most service grade signal tracers, it includes both a very high gain audio amplifier and an RF detector for troubleshooting RF circuits, such as found in AM transistor (or tube) radios. An additional feature, not found in other signal tracers, is an AF oscillator, at a fixed output frequency of approximately 1 kHz, having adjustable output.

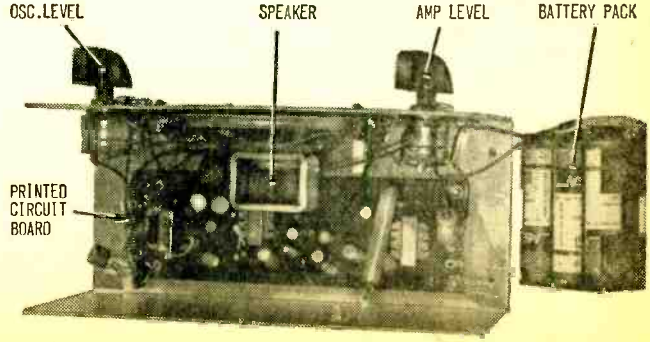
The Audio Test Center is housed in a compact 7 x 3½ x 3½-in. cabinet with front panel tilted up for easy use. The probe, supplied as an accessory with the Test Center, is connected to the various test facilities of the Center via front-panel mounted jacks.

Numerous Tests Possible. Input jacks are provided on the front panel for RF signal tracing (includes a diode detector) as well as low and high gain inputs to the internal amplifier for testing microphones.

Output jacks, also front-panel mounted, are provided for connecting an oscilloscope (500 ohms) to monitor signals from the output of the internal amplifier and speaker; and also feeding the output from the built-in 1-kHz (approx) oscillator for gain and output level measurements of any audio equipment being tested. Separate level controls, input to the signal tracing, and oscillator output, allow either circuit to be used or adjusted independently of the other.

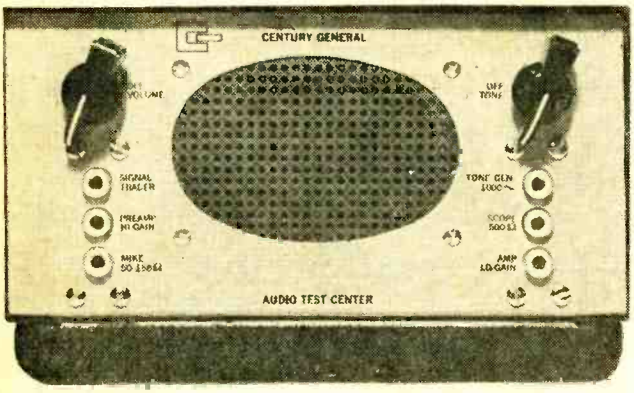
Excellent Internal Amplifier. The basic component of the Audio Center is a high-gain amplifier module having a rated output level of 200 milliwatts. This module originally was designed, and presently is used as a low level montoring or line amplifier in broadcast stations. Hence, as you can assume, its response characteristics are excellent, with notably low distortion. The high gain input can bring a 1-mV input signal up to a roaring speaker output, and is particularly useful for checking tape heads or magnetic pickups. The so-called low gain input actually provides only 7 dB less gain than the high gain input. The microphone input will handle any low impedance microphone from 30 to 250 ohms impedance. High impedance microphones can be tested by connection to either the low or high level input jacks.

Small Speaker-Big Volume. The sound level from the built-in speaker in typical signal tracing applications can be made quite high before objectionable distortion sets in. This loud volume, in comparison to the rated 200 mW output power, is due primarily to



Heart of CG's Audio Test Center is a high-gain amplifier designed as a low-level monitor or line amplifier. Oscillator is piggy-backed on amp's output transformer.

the good response and efficiency of the speaker, which, though small, can handle relatively large power without break-up.



Century General Audio Test Center provides very high gain audio amplifier and RF detector for signal tracing audio and low-frequency RF circuits. Unit includes 1 kHz adjustable output oscillator for signal injection; amplifier and oscillator circuits can be used simultaneously or independently. Built-in speaker is centered on front panel amid clearly marked knobs and jacks that offer user the utmost in simplicity for test setups and operation anywhere.

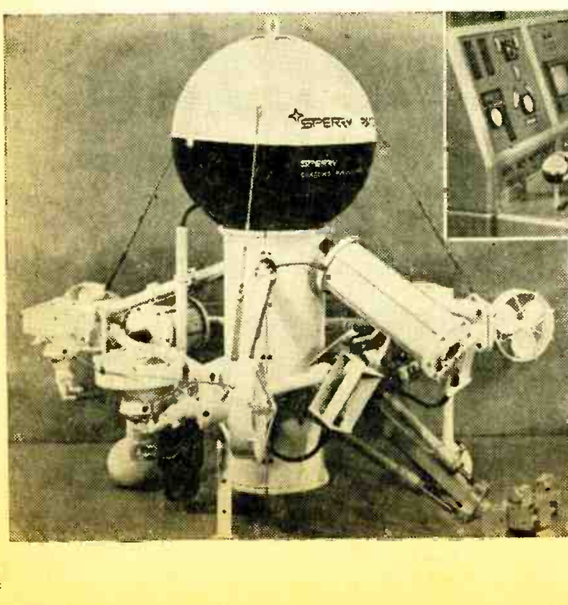
The Audio Center can be used as a preamplifier from any input and produces a 1-V output, available at the scope output jack. Though more than 1 volt output can be obtained, the distortion becomes excessive above 1 volt output level.

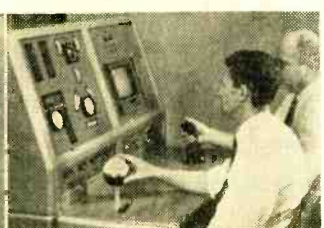
The internal 1-kHz oscillator can deliver up to 1-volt output, adjustable from zero to full output, depending on the setting of the level control. Though the waveform is not of very low distortion comparable to that delivered by a high-quality audio signal generator, it is about equal to the waveform produced by service grade RF-AF generators and is more than adequate for all trouble-shooting needs.

Due to the fact that the Audio Center is battery-powered (by 6-AA penlight batteries) there is no common AC power line connection possible through ground leakage, therefore no noise is injected via the ground when working on transistor radios, which is common with line-powered signal tracers.

The Century General Audio Test Center, priced at $48.00, is supplied complete with batteries and test probe. For additional information or direct order write to Century General Corp., 90 Broad St., New York, N.Y. 10004. ■

Meet A Modern Sea Monster: The Mini Sub

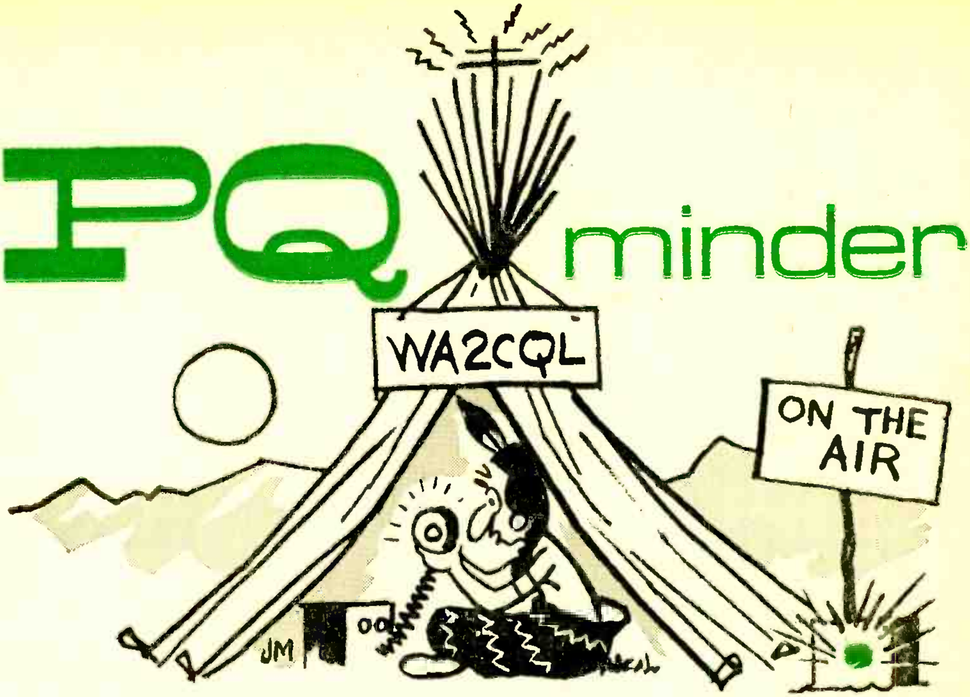




Looking like a fat-headed mechanical monster, prototype of Sperry Rand's WORKSUB can be adapted to most any task. Control console (inset) governs unit's every action.

Put a man in a submarine, and cost and complexity rise faster than Moby Dick. But make that same sub unmanned and remote-controlled, and chances are you can turn it into a veritable workhorse of the deep. So went the thinking at Sperry Rand which came up with the prototype pictured at left. Packing its own power supply, the mini sub also incorporates CCTV to tune its operator in on what's going on at depths to 2000 ft. ■

PQ minder



A flashing red light may be the barbed wire you need for privacy!

by Steve Daniels, WB2GIF

Ever been on the verge of a real DX catch or making a delicate adjustment on a project, or just reading a most absorbing article in ELEMENTARY ELECTRONICS, when all of a sudden a buddy drops in, glad-handing you with an earth-shaking pat (?) on the back: "HIYA OM!! HOWZIT GOIN'?" Your DX catch is lost, or your adjustment is disrupted, and/or your train of thought is lost.

Take heart, friend! Our PQ Minder, mounted on the door of your operations center, will cause guests to think twice before barging in too quickly. The PQ Minder is a transistorized flasher with a bright red warning light that a fellow would have to be color blind to miss! To prevent prying fingers from playing around and turning it *off*, it incorporates a magnetic proximity switch whose location only you know.

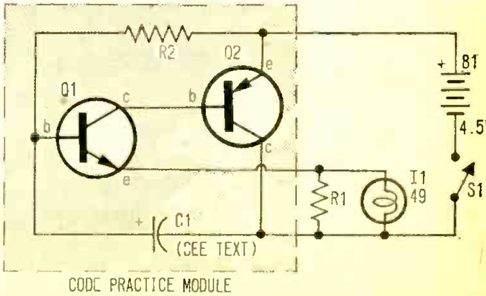
Building It. Start with the code practice oscillator module. Cut out the little disc capacitor that is connected between the base of Q1 and the collector of Q2. Replace it with a 25-μF electrolytic rated at 6 volts or better (C1). Be sure that the positive end goes to the junction of R2 and the base of Q1. This is the only modification required for the board. A number 48 or 49 lamp in parallel with a 10-ohm, ½-watt resistor is connected in place of the speaker shown in the diagram that comes with the module.

Power is supplied by three penlight cells mounted in the battery holder at the bottom of the case.

Mount the pilot lamp assembly in one end of the plastic box. Fasten the battery holder and the CP module inside the box to the 4 x 2½-in. plastic face.

The Mystery Switch. Mount the reed switch inside the box on the end opposite to the pilot lamp assembly. Cut its terminals short so that the switch will fit snugly into the end of the box. Fasten to this end, out-

(Continued on page 97)

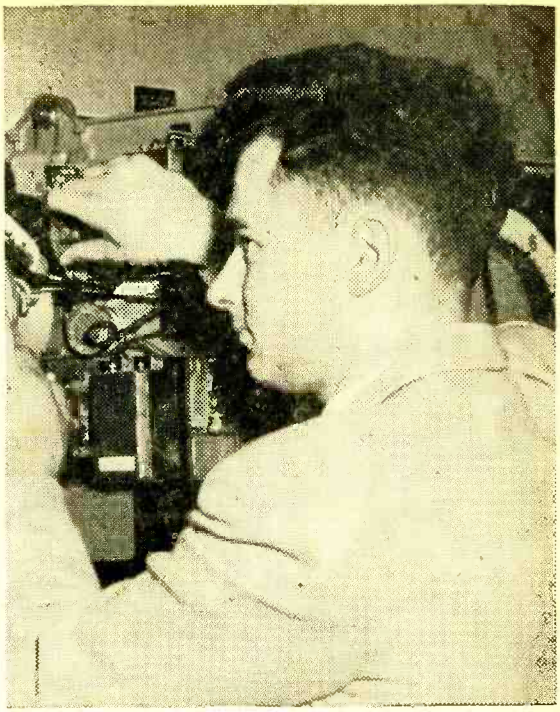


Just four parts outboarded from a Lafayette module are all that is needed to make our PQ Minder.

With his NRI home training

as a solid base for success, graduate W. Gerald Kallies of Elliott Lake, Ontario, Canada, has branched into three different areas of Electronics. He is in charge of the complete Electronic automatic control system at Rio Algom Nordic, Ltd., a uranium mining company. Also, he handles operations at CKSO-TV, a satellite station in Elliott Lake, and he owns Gerol TV Sales & Service, which grosses $60,000 a year.

How did Gerald Kallies launch his career? While a high school senior, he faced the fact that college was beyond his financial reach. So he wrote to ten Electronics training schools. He chose NRI. Why? Because, he says, it appeared to be complete training with no short cuts . . . because courses were offered at very reasonable prices . . . and because he was convinced NRI would take a personal interest in him. The results of his training speak for themselves.



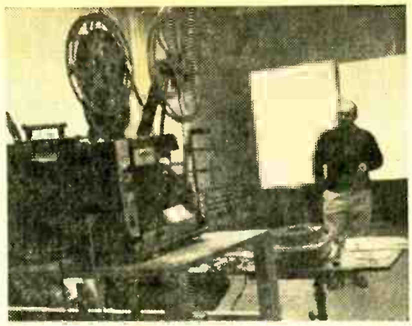
Experience Counts Most in Color TV Communications Electronics

Psychedelia

Man probably painted his first picture after dipping a finger in a mud hole and dabbing the walls of a cave. What he dabbled is a bit of pre-historic history (?!!), but history it remains. Since those ancient Flintstone days, tools have become a trifle more sophisticated. Rembrandt took up brush and pigments; Michelangelo swung a hammer and chisel. And, ignoring Mondrian for the moment, computers today create works of art formed by x's and o's on an electric typewriter. Could these trends mean the machine is making the artist obsolete?

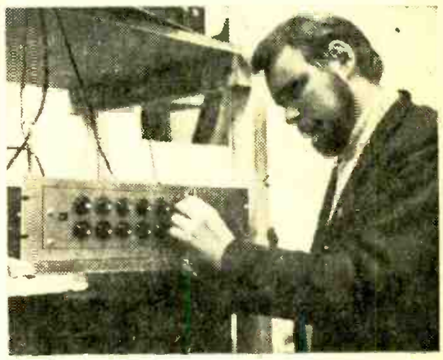
By the beard of Da Vinci, there's hardly a

Breadboard circuits (above) are introduced early in course, but more sophisticated circuitry comes later in game. At right, students learn to use tape recorders, mike mixers, switching devices, many of which were donated by leading electronic firms.



Led by Laurence Warshaw (above), who is also consultant to Metropolitan Opera and on faculty of Hofstra University, class does just about everything worth doing.

Goes to School



chance. As art becomes more technical—and technology more artistic—there are signs that the twain shall meet. And meet they already do—in one instance at least. For twice a week at New York University comes a mind-boggling mix of a course called Intermedia Workshop.

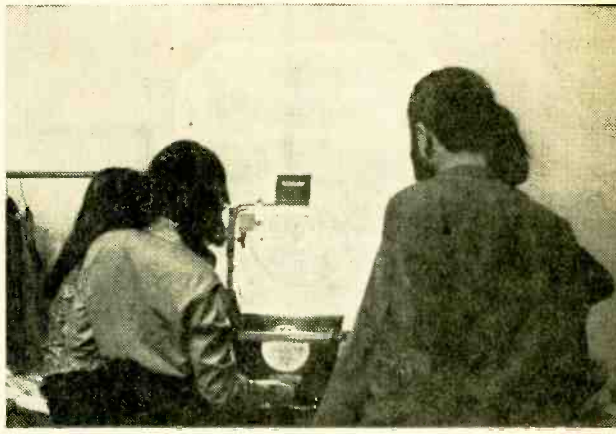
There, students of an engineering bent discover that light is not only electromagnetic radiation, but also a tool to paint with. Creative souls make scientific discoveries. They find, for example, that a switch controls an electrical current between a battery and a buzzer. Likewise, they stumble onto the fact that colored

Assistant instructor Bob Demchuck (above) demonstrates Agastat programmer to class. Unit can take up to 17 inputs, feed 17 different speakers.
At left, student Bill Colish demonstrates homebrew theremin which produces unusual audio effects at wave of hand.

e/e PSYCHEDELIA

Lights and their effects on various materials are one of favorite subjects of students' studies. They work with mirrors, photocells, polarizing films, also investigate what happens in terms of color and spatial effects when light is cast on multitude of plastics.

Life is rough unless you know what you're looking for, though students do—when and if they see it.

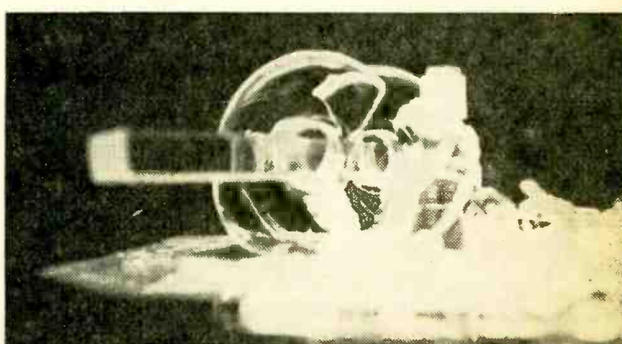


lights also flicker. And as the 15-week program progresses, the division between art and science is, hopefully, eradicated.

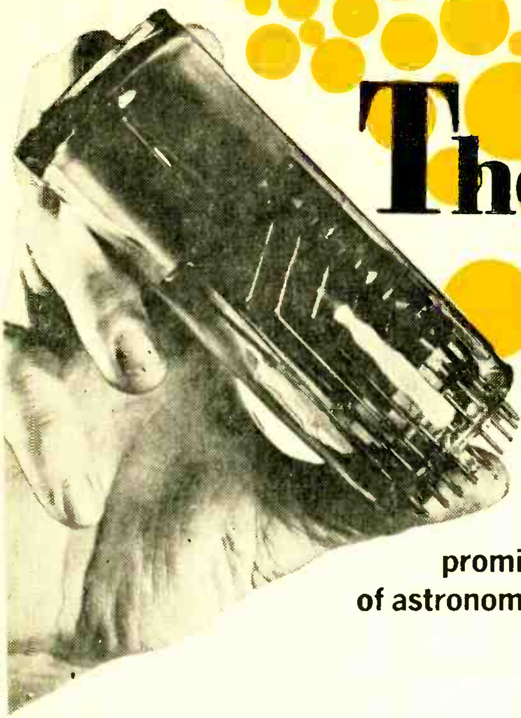
The course is conducted by Laurence Warshaw, himself a kinetic artist, who wants his students to break out of the usual confines of two-dimensional canvas or three-dimensional sculpture. As our photos show, Warshaw teaches his students to explore the creative possibilities of time, space, sound, light, motion (kinetics), and other media.

If they succeed, they may well surpass the two reigning examples of contemporary technical artistry—the juke box and the pinball machine. And if they fail . . . Well, let's face it. Does anyone of substance ever really fail at things artistic?

—*Len Buckwalter, K1ODH* ■



Psychedelia incarnate is this weirdo of weirdies, beautifully (?) illuminated by heaven-knows what.



The Golden Cascade

Discover how a mere handful of glass, metal, and chemicals promises new insights on the mysteries of astronomy, atomic structure, and life itself.

By Jorma Hyypia

The kamikaze projectile had been traveling through outer space for a hundred years. Now the end was near. Silently, it crashlanded right on target. But the waiting intelligence personnel were ready. A few of them felt the impact and passed on the warning. Soon there were a hundred, then a thousand, finally millions of couriers speeding to one central intelligence center to verify that the destructive landing had occurred. The data was recorded and decoded, and men here on earth had a little more intelligence data about one of those strange outer-space worlds called pulsars.

These alien pulsar worlds are fascinating and mysterious, but they pose no threat to mankind. Man's real enemies are still here on earth. Another intelligence team awaits the arrival of a stray *kamikaze projectile* originating at the scene of carnage. It arrives, and the intelligence network is instantly alerted. More data, more decoding, and man learns a bit more about one of his most vicious enemies—the cancer cell.

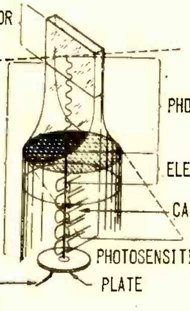
An Ultra-sensitive Detector. This intelligence network we are talking about is an electronic device called a photomultiplier. To be sure, it's not a colorful James Bond, and the only female likely to be intrigued by this special agent is a white-smocked lab technician. A photomultiplier is, after all, just a handful of glass, metal, and chemicals, yet it can see things that cannot be detected by the human eye, or by the largest of optical telescopes or microscopes.

Take those pulsars, for example. Only because astronomers have been able to detect pulsating radio signals emanating from them (reason why they were named pulsars) are these stars known to exist. Scientists have determined that they also emit light, but such feeble light that optical telescopes are useless. However, it can be detected by a sensitve photomultiplier, which needs only a few photons of light, the basic particles of light, to generate a revealing electrical signal that can be detected with electronic instruments.

Chemical changes that take place in human cells also release light energy. But again, the light is so weak that ordinary optical instruments cannot detect it. A modern photomultiplier can, however, do the job.

If the photomultiplier can detect just the few photons originating in a human body cell, it can as easily detect photons produced by chemical changes in a plant cell. This means that photon-transported intelligence may finally help in pinning down the mechanism by which green plants convert sunlight into food.

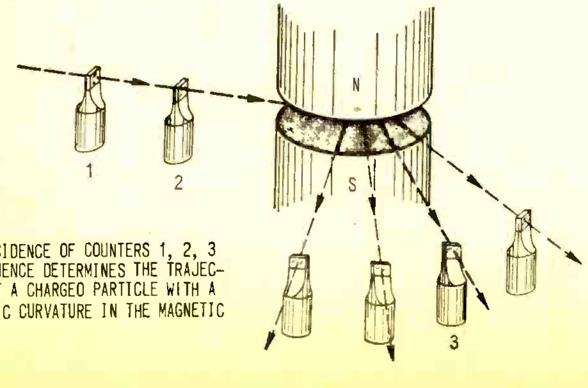
Basic Principle of Operation. An atom-smasher tears atoms apart and sends the particles speeding to a target, where electrons are ripped off the target atoms by such sub-nuclear bullets as gamma rays, neutrons, and other energy-charged particles. Often this action releases light energy. Photomultipliers can convert these very weak, extremely short-duration light pulses into electrical pulses of much greater energy that can be recorded by electronic counters. Photomultipliers not only show that a target collision has occurred, but can also reveal the trajectories of the particles. Photomultiplier scintillation counters can detect the passage of a fact particle at speeds greater than one-ten-millionth of a second. They also can reveal, with a precision of one-billionth of a second, whether or not two particles arrive at a given place at the same time. Such atomic ballistics studies are of paramount importance to those concerned with probing the atom's fundamental properties.



Photomultipliers Assist Lasers. Applications for lasers, that now require the use of photomultiplier detector circuits, include laboratory measuring instruments, range-finding equipment, satellite tracking radar, special communications systems and high resolution radar for satellite docking. When and if more general laser communications systems are developed, photomultipliers will, almost certainly, be incorporated into the laser optical receivers.

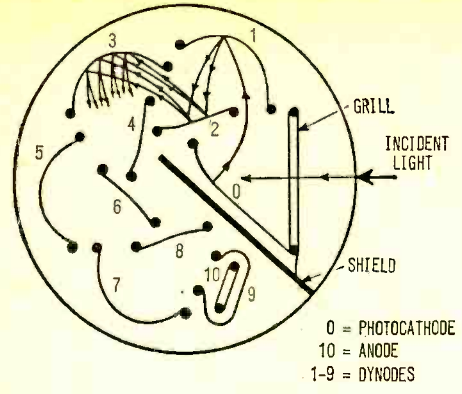
They Measure Space. Photomultipliers are also vital components of many satellite-borne scientific instruments that gather all kinds of information concerning outer space. For example, they have been used to measure the vertical distribution of ozone in the earth's atmosphere. This is done by recording the extinction of light at satellite sunset (or the reverse at sunrise) as the layers of atmospheric ozone absorb the sunlight. While one photomultiplier looks at the sunset, another will be aimed straight down into the earth's atmosphere to measure the earth's ultraviolet albedo (the light the earth reflects that is proportional to that which falls on it). Other satellite-borne instruments utilizing photomultipliers measure such phenomena as ultraviolet radiation, Cerenkov radiation, particle scintillation, and solar radiation. Still others are used for positron detection, micrometeroid detection, and the spectral analysis of starlight.

The actual, as well as the potential, applications of photomultipliers are almost endless. More down-to-earth uses include spectrophotometry, general photometry, colorimetry, flying spot scanning, hydrogen flame detection, X-radiation detection, and a host of industrial control applications. No list can



A COINCIDENCE OF COUNTERS 1, 2, 3 IN SEQUENCE DETERMINES THE TRAJECTORY OF A CHARGED PARTICLE WITH A SPECIFIC CURVATURE IN THE MAGNETIC FIELD.

Energetic particles such as gamma rays produced by nuclear disintegrations cause scintillations in crystals of certain kinds. Photomultiplier, integrated with scintillation unit, converts light flashes to measurable electrical pulses. Light energy is very nearly proportional to gamma-ray energy; and since photomultiplier exhibits linear response, electrical pulse heights provide direct measures of gamma-ray energy.



Circular-cage dynode configuration—one of first developed—is still used in many photomultipliers. It is compact and exhibits good electron collection time between stages, good transit-time spread.

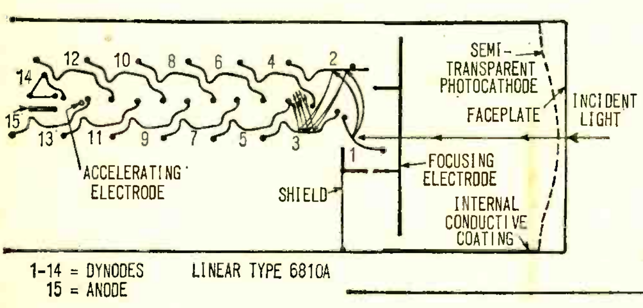
be complete because the uses of this remarkably versatile device continue to increase.

Super Sleuth. Most detection problems are being solved by a whole family of photomultipliers. All are based on the same theoretical principles, but individual units differ in physical design, light sensitivity, and other characteristics.

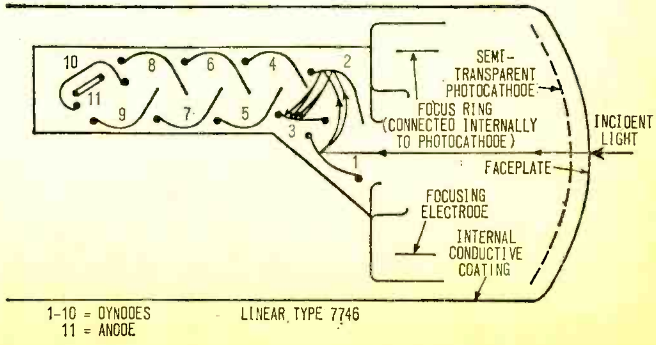
As sensitive as these devices are, they haven't been able to cope fully with some of the tougher detection problems. There has been a real need for one that might be called a super sleuth photomultiplier. In late 1968 RCA announced the completion of the development of a photomultiplier that "could revolutionize studies of DNA, pulsars, atomic particles and photosynthesis." This detector may not be the ultimate in photomultiplier design, but it is clearly a big step toward that goal.

RCA engineers believe that the new detector will be of great help in mapping the structure of the DNA molecule on which all life is based. The new detector should also be powerful enough to catch the very small amount of light believed to emanate from invisible pulsars (radio stars). This detector may prove to be a boon in two other important research areas: atomic physics, and the study of biochemical processes produced in living cells.

How They Work. Many different types of photomultiplier tubes that are now commercially available all work on the same basic principles. Each tube has, near its top, a light-collecting target called the photocathode. At the opposite end of the tube is the final anode signal collector. Stacked between the photocathode and this collector anode are a number of specially prepared targets called dynodes; most commercial photomultipliers have nine or ten such stages, and some may have as many as fourteen. Although signal amplification depends, theoretically, on the number of such stages, it should not be assumed that a count of stages per se will provide a true indication of the relative amplification attainable with any one type of photomultiplier tube. Many



So-called Rajchman linear-dynode system requires complex dynode shapes. Since focusing fields keep electron stream near middle of dynode structure, large number of dynode stages can be used.

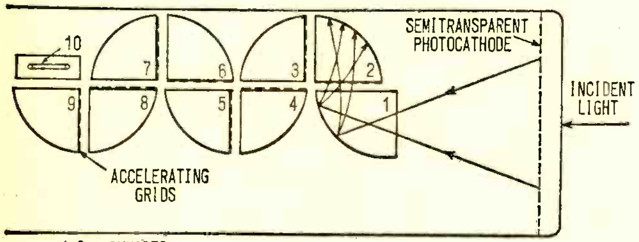


Though similar to Rajchman system, linear or 'in-line' type of dynode configuration is inherently simpler. Note lack of accelerating electrode in front of anode in dynode array.

other factors influence the signal amplifying characteristics of them.

When a photon strikes the photocathode target, electrons are knocked off the surface of the cathode. These electrons are electrostatically directed to the first dynode. The photocathode should of course have the highest possible quantum efficiency, meaning that it should release as many electrons as possible, per unit of incident light energy expended.

Chemical composition of the cathode determines the number of electrons that can be liberated. Most known substances emit electrons if bombarded by the right kind of electromagnetic radiation, but all substances have a threshold incident light frequency below which no emission is possible.



Box-type dynodes are efficient electron collectors, though there are some signal losses to grids that separate boxes. Transit-time spread characteristics are not outstanding, largely because box types lack good focusing properties.

Sodium and a few other metals will release electrons when activated by visible light. However, most pure metals fail to respond until light at wavelengths in the ultraviolet region, or still shorter wavelengths, is employed. Red light is a very poor electron blaster, green is better, and blue is still better. Ultraviolet light is more efficient than any visible wavelength. X-rays and gamma rays exhibit the most pronounced effects and will, in fact, hurl electrons out of any substance.

Pure metals are of negligible importance as photocathodic materials. By far the largest number of tube types utilize a mixture of cesium and antimony, to which may be added potassium, and sometimes both potassium and sodium. A few photocathodes are made from cesium and bismuth, or from cesium, oxygen and silver for infra-red applications. Where high red sensitivity is required, a complex mixture of silver, bismuth, oxygen and cesium is used. Empirical formulations such as these have been found to be much more efficient electron emitters than are pure metals.

Cascade of Splashes. A kind of electron splash occurs when primary electrons, produced by the action of light on the photocathode, strike the first dynode—the first of a number of secondary emitters. The splashed-out electrons are greater in number than those causing the splash. They now become "primary" electrons that are beamed to the next dynode where they create a still bigger splash. And so the splashes continue, from one dynode to the next, each splash producing larger numbers of free electrons. Thus each primary electron initially produced by the photocathode is multiplied into many millions of electrons before the growing electron cascade is at last captured by the terminal anode collector. Modern photomultipliers provide a very wide choice of current amplification characteristics, ranging roughly from factors of 10,000 to at least as much as 85 million.

As in the case of photocathodes, dynodes are also coated with various empirical chemical formulations to make them good electron emitters. Of the ten to twelve dynodes used in a typical photomultiplier, the first dynode is most important because it is the one receiving the weakest electrical signal, the electrons originating from the photocathode.

The electron emitter coating on many dynodes is a cesium-antimony compound very much like that used on some photocathodes. Other mixtures, containing such elements as beryllium and magnesium, are also used.

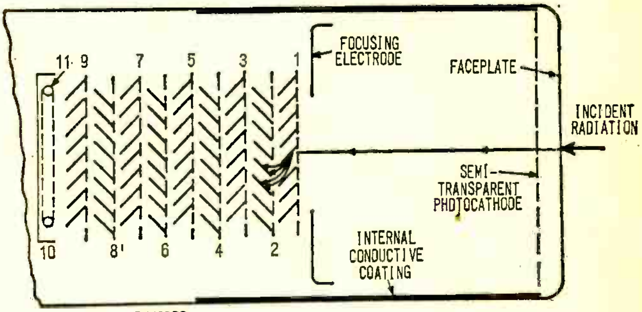
New Material Increases Sensitivity. The remarkably improved performance claimed for the new RCA photomultiplier tube is attributed to the discovery of a more efficient dynode emitter material, gallium phosphide. RCA claims that this material is a better secondary electron emitter than any other now in use.

"For an applied field of 600 volts, for example, gallium phosphide will multiply one primary electron into an average of 30 secondary electrons. By contrast, the best conventional materials produce an average of only five secondary electrons. Furthermore, increasing the voltage will raise this ratio still further in the case of gallium phosphide. In fact, secondary emission gains greater than 100 from gallium phosphide have been measured. Conventional materials, on the other hand, have intrinsic limits that are ten times lower."

"For this reason, a gallium phosphide dynode in the first amplifier stage makes it possible, for the first time, for a photomultiplier to discriminate between light-producing phenomena that generate one, two, three, four, five or more primary electrons."

plete defiance to all laws of energy and matter conservation. Not so. You could make even the coin multiplier work, but only by first loading the machine with a reserve of at least 80 million pennies, before inserting the triggering coin. To create an electron bonanza with a photomultiplier tube, you also must load it with an electron reserve that can provide an accelerating potential.

Each time an electron splash occurs, the released secondary electrons must be energized by an accelerating potential applied to the dynodes by means of a voltage divider network. Otherwise the system would poop out before it got started. You might say that the accelerating potential is the agent that carries the electron "snowball" to the top of each dynode "hill" so that it can roll down and hit the next target with enough impact



Venetian-blind systems are space savers, and more dynodes can easily be added. Transit-time spread tends to be large because this type of focusing leads to rather low value of electric field at emitting surfaces.

"This, in turn, should make it possible, in electrical terms, to 'see' details of nuclear, astronomical, and biological events never before witnessed."

In this prototype tube only the first dynode is coated with gallium phosphide; other dynodes are coated with a conventional copper-beryllium compound.

Electronic Jackpot. Considering the total multiplication factor that can be achieved, even with more conventional photomultipliers, it would seem that here, at last, is a development that can make a great deal out of next to nothing, a return of tens of millions of electrons for every single electron knocked off the photocathode. Just think! Suppose you could invent something comparable that would use coins instead of electrons; put a penny in at the top, and draw 80 million pennies ($800,000) out of the bottom within a fraction of a second! So who would need Las Vegas or Monte Carlo?

Obviously, something appears to be wrong. The photomultiplier seems to work in com-

to create a bigger snowball. To expect the snowballing to take place without the aid of the accelerating potential would be like hoping that a real snowball placed at the bottom of a snowy slope would roll to the top of the hill by itself.

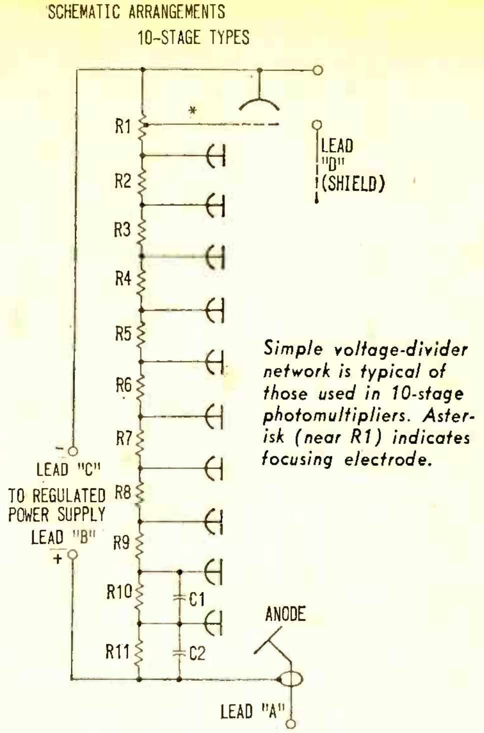
In general, the practical working potential of a typical dynode is in the order of 100 volts. The supply voltage between the anode and cathode must be in the range of 1000 to 5000 volts in order to provide adequate potential for each dynode by means of the divider network.

Up to a point, the number of secondary electrons produced at each dynode increases as the accelerating potential is increased. But there is a limiting factor. The faster the primary electrons move, the deeper they penetrate the dynode emitter before knocking out secondary electrons. Deeper secondary electrons must work harder to reach the surface of the dynode and still have enough energy to attain the needed escape velocity. There is, then, a threshold accelerating voltage for any given dynode system. If this threshold voltage is exceeded, the concentration of secondary electrons will begin to diminish.

Transit Time. Many performance characteristics must be taken into consideration when a photomultiplier tube is to be selected for any given job. Perhaps the most obvious criterion is that the tube has the proper spectral sensitivity, and that it has an adequate multiplication factor.

Transit time and *transit time spread* are two closely related characteristics that are especially important if the tubes are to be used in such applications as scintillation counting of energetic particles produced in atom-smashing experiments. Transit time is a measure of the speed with which the signal multiplication process is completed, covering the period from when the light first strikes the photocathode to the instant that the resulting anode pulse reaches its peak. The related transit time spread represents the greatest delay between anode pulses; the spread is caused by secondary electrons that differ in their energies and directions.

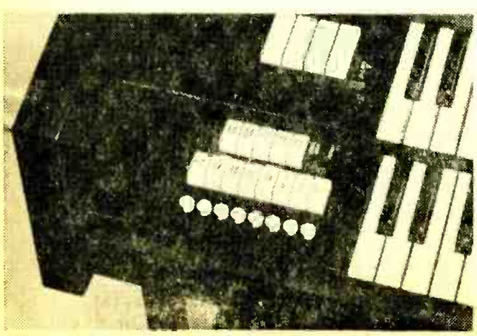
The anode-pulse rise time is also a significant factor. This indicates the time it takes an output pulse at the anode to go from 10 percent to 90 percent of its peak value. There are, also, certain interference factors that must be considered. Perhaps the most important of these is the so-called dark current, a noise producing electron flow inherent in any photomultiplier tube even when the photocathode is not being activated by light rays.



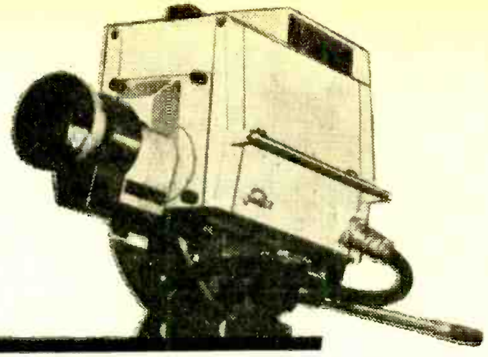
Simple voltage-divider network is typical of those used in 10-stage photomultipliers. Asterisk (near R1) indicates focusing electrode.

The modern photomultiplier is truly one of the most remarkable scientific intelligence agents yet devised. Its phenomenal sensitivity, at least on a pound for pound basis, is perhaps unmatched by any other single instrument man has yet invented. When one considers how much scientific information would most assuredly be almost out of man's reach, except for the development of the photomultiplier, the electron-cascade begins to look more and more like a golden cascade-of-knowledge. And it's all done with a mere handful of glass, metal, and chemicals. Remarkable! isn't it? ■

SIZZLE CYMBAL/RIM SHOT/CRASH!



Time was when it took a ton-and-a-half of electronics to fire up much of anything, least of all what's now known as electronic percussion. But electronic percussion we now have—and in punier than pint-size dimensions—thanks to the magic of this stuff called solid-state. In fact, the Conn Organ Corporation now offers a built-in, completely electronic percussion unit as standard equipment on four of its organs. Thirteen percussion effects are available: five from the pedal section, eight from the accompaniment keyboard. Among them: a sizzle cymbal, a rim shot, even a snare-drum roll. ■



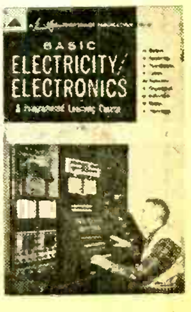
e/e's BASIC COURSE IN ELECTRICITY & ELECTRONICS*

PART IX

TELEVISION TRANSMITTERS

WHAT YOU WILL LEARN. In this part you will learn how a television transmitter develops both picture and sound signals. You will gain more knowledge about antennas and the problems of sending electromagnetic waves through the atmosphere. In the following part to appear in the next issue of ELEMENTARY ELECTRONICS, you will also become familiar with how a television receiver converts electronic signals into picture and sound reproductions. Learning the basic principles of television transmitters and receivers is no more difficult than learning the principles of radio. The basic electronic principles are the same for both.

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



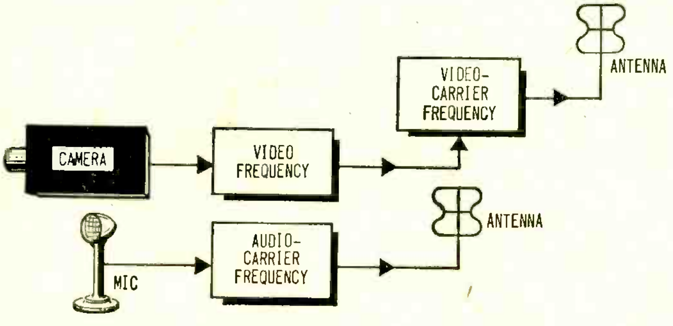
THE TELEVISION TRANSMITTER

There is actually very little difference between radio and television transmitters. As you recall from the last issue, the functional block diagram of a radio transmitter contains a microphone, an audio-frequency section, a carrier-frequency section, and an antenna. A television transmitter has more operations to perform than a radio transmitter. Its functional block diagram, therefore, contains more sections. The functions of the two transmitters are quite similar.

Functional Block

The radio transmitter has the single problem of putting sound on a carrier. The TV transmitter must modulate two carriers: one with sound, and the other with *video* (picture).

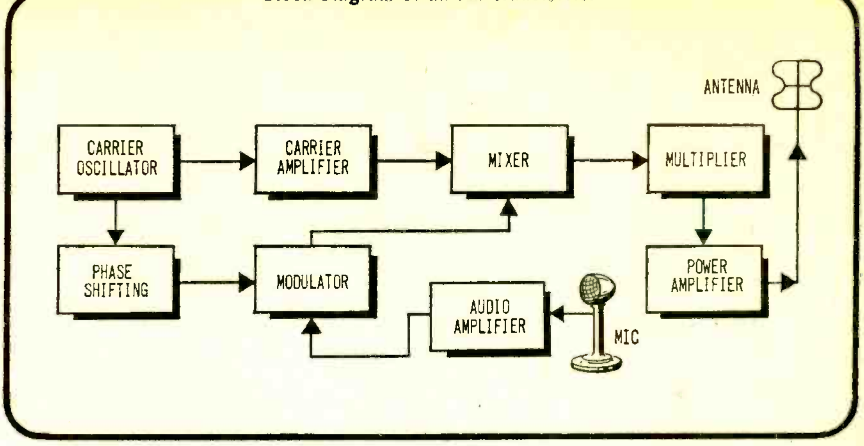
TV Transmitter Functional Block Diagram



Video-Frequency Functions. The only difference between the functional blocks of a radio transmitter and a TV transmitter is the addition of a *video-frequency* function in the TV transmitter. The audio-frequency section is in a separate channel which sends a weak picture signal to the video-frequency section to be amplified. The output of this section is a *video* frequency (higher than audio) used to modulate a *very high frequency* (VHF) generated in the carrier block. Superimposing the video (picture) on the carrier is done by amplitude modulation, the same process used in an AM radio transmitter.

Audio-Frequency Functions. A microphone feeding a signal to the audio-frequency section is shown at the bottom of the illustration above. The sound signal from this microphone is amplified and used to frequency-modulate a separate carrier. This modulated carrier is then fed to an antenna. In effect, there are two transmitters for TV—one for transmitting the picture and the other for transmitting the sound. In practice, a single antenna is usually used to transmit both carriers.

Block Diagram of an FM Transmitter



Q1. **The sections of a functional block diagram of a radio transmitter are a microphone, ----- ----------, ------- ---------, and antenna.**

Q2. **Sound in an AM radio transmitter is placed on the carrier as a(an) ---------- ----------; in a television transmitter, it is done by ---------- -----------.**

Q3. **An audio frequency modulates a sound carrier; a(an) ----- frequency modulates a picture carrier.**

Q4. **The outputs of the ----- --------- and ----- ---------- blocks of the sound transmitter are fed to the modulator.**

Your Answers Should Be:

A1. The sections of a functional block diagram of a radio transmitter are a microphone, *audio frequency, carrier frequency*, and antenna.

A2. Sound in an AM radio transmitter is placed on the carrier as an *amplitude modulation;* in a television transmitter, it is done by *frequency modulation.*

A3. An audio frequency modulates a sound carrier; a *video* frequency modulates a picture carrier.

A4. The outputs of the *phase shifting* and *audio amplifier* blocks of the sound transmitter are fed to the modulator.

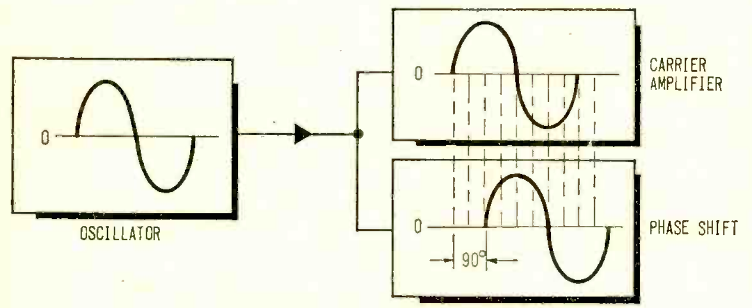
THE TV AUDIO TRANSMITTER

As previously stated, a TV audio transmitter uses the frequency modulation method. In the preceding chapter, you learned that *FM* is a process in which the frequency of a carrier is varied in accordance with the amplitude of an audio signal.

Audio Modulation of the Carrier

The oscillator in an *FM* transmitter, as in any other transmitter, develops a constant frequency at a uniform amplitude. The output of the oscillator is simultaneously fed to a carrier amplifier (where it is increased in amplitude) and to a phase-shifting circuit. A single cycle is shown in the oscillator block below. The same cycle appears in the output of the carrier amplifier. The corresponding cycle in the phase-shifting circuit shows that the signal has been shifted (moved) to the right a quarter of a cycle. This is called *phase shifting.*

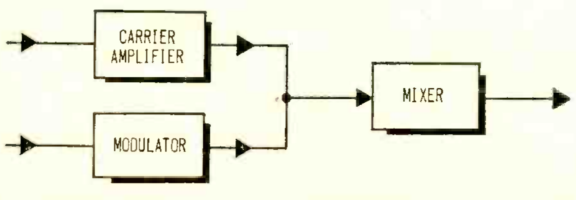
Phase Shifting Illustrated



The starting, maximum positive, return-to-zero, maximum negative, and ending points occur one quarter of a cycle later in the lower block than they do in the upper block. Since there are 360° (one way of designating the period of a sine-wave cycle) in a complete cycle, the lower waveform has been shifted in phase by 90°.

Modulator. Amplified sound signals from the audio amplifier and the phase-shifted carrier frequency meet in the modulator. The result of the meeting is a modulated output with an amplitude that varies in accordance with the amplitude of the audio, but still phase-shifted a quarter cycle.

Phase-Shifted Audio and Carrier Joined in Mixer



Mixer. This circuit mixes the outputs of the carrier amplifier and the modulator to produce a variable frequency. This new signal is the carrier frequency changed by an amount determined by the amplitude variations of the audio. If the two inputs to the mixer had been in phase, this frequency variation of the carrier could not have occurred. Since equivalent points of the two waveforms are changing at different times, the audio variations of the modulator signal either add cycles to or subtract cycles from the constant frequency of the carrier. When the audio content of the modulator frequency goes positive, it causes a corresponding decrease in frequency of the carrier. When the audio content goes negative in its cycle, the carrier frequency increases a proportionate amount. The output of the mixer then is the basic carrier changing in frequency in accordance with the amplitude of the original sound.

Q5. The frequency of any transmitter is generated in a(an) ---------- circuit.

Q6. The phase-shifting circuit changes the phase (starting point) of the sine wave a(an) ------- of a cycle, or -- degrees.

Q7. Modulation occurs (before, after) power is amplified.

Q8. The audio frequency is placed on the carrier by ------ to and ----------- from the carrier cycles.

Your Answers Should Be:

A5. The frequency of any transmitter is generated in an *oscillator* circuit.

A6. The phase-shifting circuit changes the phase (starting point) of the sine wave a *quarter* of a cycle, or *90* degrees.

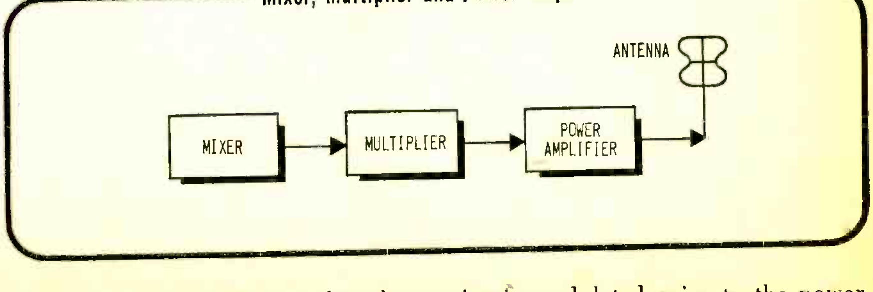
A7. Modulation occurs *before* power is amplified.

A8. The audio frequency is placed on the carrier by *adding* to and *subtracting* from the carrier cycles.

Amplifying the Modulated Carrier

Multiplier. The purpose of the multiplier stage is to amplify and increase the frequency of the modulated carrier. In some transmitters, several such circuits may be required. In addition to raising the amplitude of the carrier to that which is required for transmission purposes, multiplying the frequency also makes the modulated variations more pronounced. Those portions of the audio signal having higher amplitudes cause a wider variation of the carrier frequency than do those portions having lower amplitudes.

Mixer, Multiplier and Power Amplifier

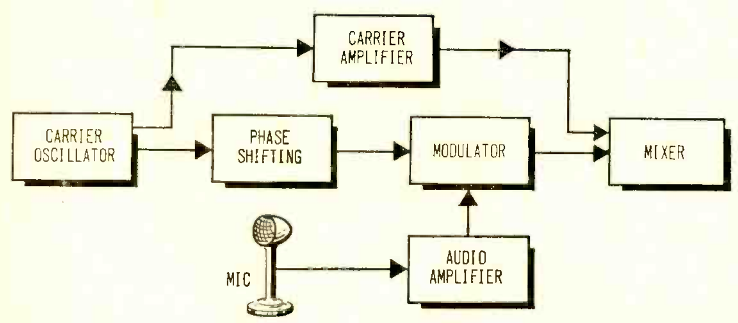


Amplifier. You will note that the carrier is modulated prior to the power amplifier stage. In amplitude modulation it is necessary to superimpose the audio in the final power stage, which is usually at very high power. Since the final amplifier of the audio-frequency section must have a power output that is close to 50% of that of the carrier amplifier, tubes and other parts must be large and expensive. In FM, the entire modulated carrier is raised to the correct power level in a single stage, making the *FM* transmitter more economical in this respect than its *AM* counterpart. The output of the power amplifier goes directly to the antenna.

Audio Transmitter Review

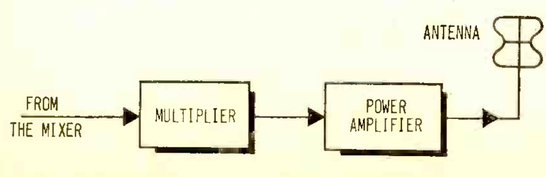
Sound from a television studio is added to the carrier wave by frequency modulation. The block diagram below shows the transmitter portion which mixes the two frequencies.

Audio Added to the Carrier



The *oscillator* generates a stable frequency which is simultaneously fed to an *amplifier* and a *phase-shifting* network. The phase-shifting stage shifts the frequency by a quarter of a cycle. The carrier and the shifted signal are no longer in step. The amplified audio from the microphone is mixed with the out-of-phase signal in the *modulator*. The output of the modulator is a series of sine waves that vary in amplitude in accordance with the amplitude of the original sound.

The Modulated Carrier Is Fed to the Antenna

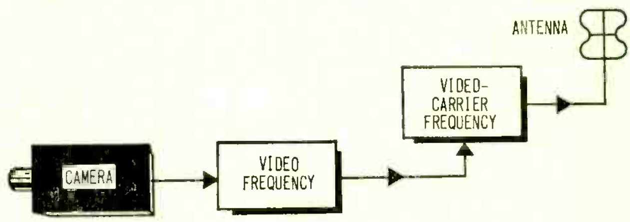


The outputs of the carrier amplifier and the modulator combine in the *mixer*. The output of the mixer is a signal that varies in *frequency* according to the *amplitude* of the modulating signal. The FM signal is then multiplied in frequency several times and increased in power by the stages shown below.

TV VIDEO TRANSMITTER

A brief summary of what happens in the TV video transmitter might be helpful before its stages are discussed.

Functional Block Diagram of the Video Transmitter



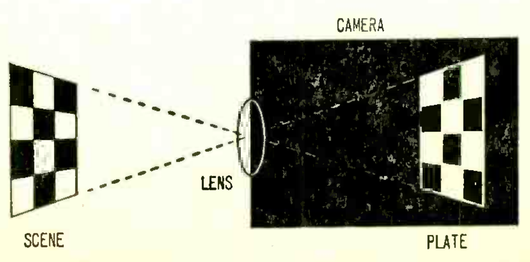
In the video-frequency section, video signals from the camera are amplified and fed to the final power amplifier of the carrier-frequency section. Here, the carrier is amplitude-modulated by the video.

Camera

There are several different types of TV cameras. The *iconoscope*, *image dissector*, and *image orthicon* are examples. The latter is the type most frequently used in TV broadcasts. Although the manner in which they accomplish their purposes differs, their basic operating principles are the same.

The camera, much like its photographic counterpart, deposits a scene through a lens on a plate within the camera. Light rays from all parts of the scene are focused through the lens, reproducing the image on the plate. If the plate were a photographic negative, the light rays would excite deposits of light-sensitive materials in proportion to the intensity of light, varying from white through shades of gray to black.

Optical Camera Operating Principle



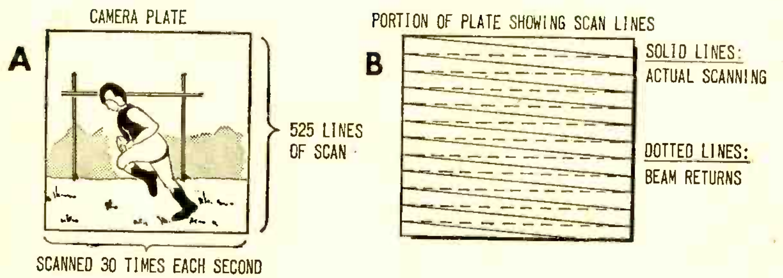
A similar process occurs in a TV camera. The light-sensitive plate receives a picture of the scene. Tiny areas on the chemically treated plate are thereby electrically charged in proportion to the light intensity of that part of the scene.

Scanning

A very narrow beam of electrons is moved back and forth across the plate from top to bottom. The beam samples the intensity of the charge in each of the tiny areas. The amount of each charge indicates whether that portion of the scene is black, white, or some shade of gray.

As shown in part A above, the plate is *scanned* (movement of electron beam) in a sequence of 525 lines from top to bottom. A complete scan of the plate (525 lines each time) is made 30 times each second. The same procedure is dupli-

Details of Electron Beam Scanning



cated on the screen of your receiver. In a TV receiver with a 17-inch screen, the electron beam in the picture tube travels across the screen at the rate of approximately 13,000 miles per hour.

Part B shows how this scanning is accomplished. The beam moves across the plate in the camera from left to right, sampling the intensity of each tiny area it passes. At the end of the line the beam is *blanked* (shut off) and returned to the left side of the plate to start the next line. The beam is turned on again and samples the second line. This process is continued until the bottom of the plate is reached. The beam is blanked and returned to the upper left-hand corner to start scanning again. When the beam is on and moving from left to right sampling the intensity on the plate, it is said to be *scanning*. When it is shut off and being returned to a new starting point, it is retracing.

Q9. The video is placed on the carrier by ---------------------.

Q10. The image plate is ------- by an electron beam.

Q11. How many lines does the beam trace each sound?

Q12. How many times a second is the beam blanked?

Your Answers Should Be:

A9. The video is placed on the carrier by *amplitude modulation.*

A10. The image plate is *scanned* by an electron beam.

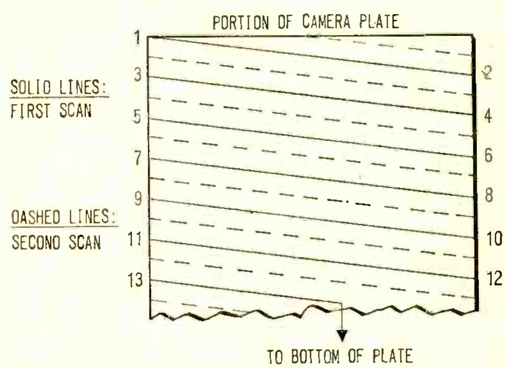
A11. *15,750 lines per second.*

A12. It is blanked at the end of each line, *15,750 times each second.*

Interlaced Scanning

Because of problems in controlling the beam and of noticeable flicker to the viewer when *line-by-line scanning* is performed, the beam is caused to scan every other line.

Details of Interlaced Scanning



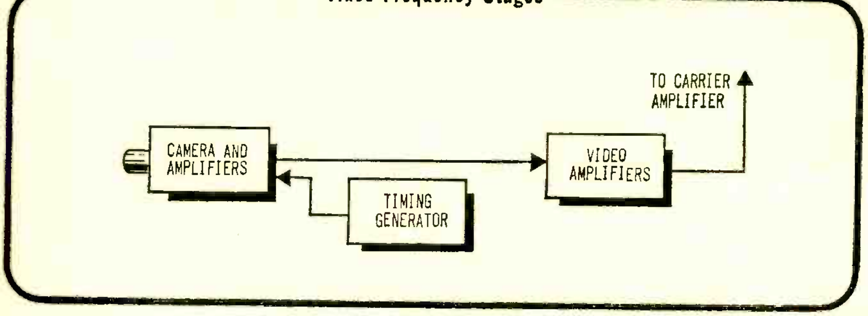
As the illustration shows, the first scan starts at line 1, samples the charged areas, and is retraced to line 3. This action continues to the bottom of the plate, scanning the odd-numbered lines. When it reaches the bottom, the beam returns to the top of the plate and scans the even-numbered lines. Each scan, top to bottom, requires 1/60 of a second. To scan the entire plate, the beam requires two passes, which takes a total time of 1/30 of a second. On the receiver screen a new image is being presented on every other line 60 times a second, a line-tracing frequency that cannot be noticed by the eye. If it were being done at the rate of 30 times a second, the eye might be able to see the changes, which would be recognized as a flicker. This process of scanning every other line is called *interlaced scanning.* The camera thus identifies the light and dark areas of a scene and converts this information to currents and voltages that change in proportion to the light intensity.

Timing Generator

The timing of the scanning events is very critical. The beam of electrons must begin at a precise point near the top of the camera plate and scan every odd-numbered line in 1/60 of a second. The electron beam must be blanked out precisely at the end of every line and at the end of the *field.* A complete scan of all the odd-numbered lines (or even-numbered lines) is called a field.

When the odd-numbered field has been completed, the blanked beam must be returned to a new position at a precise time to begin scanning the even-numbered field. Each action and position of the camera beam must be followed precisely by similar action in your TV receiver at home. The stage in the TV transmitter that establishes this precise timing is known as the *timing generator*, sometimes called the *blanking* or *synchronizing* stage.

Video Frequency Stages



The timing generator in the preceding illustration feeds pulse waveforms to the camera tube. The amplitude and timing of the pulses are such that they *synchronize* (cause all events to take place at precise time intervals) scanning, blanking, retracing, and positioning of the electron beam. The same timing pulses (for synchronizing the same events in the receiver) are fed, with the amplified video, to another stage of video amplifiers. From this point the entire signal—video and timing pulses—is passed to the final amplifier of the carrier for modulation purposes.

Q13. ---------- scanning skips very other line.
Q14. By this method, a line on the receiver screen is changed -- times a second.
Q15. Scanning is synchronized by a(an) ------ ----------.
Q16. What is contained in the video-output amplifiers?

Your Answers Should Be:

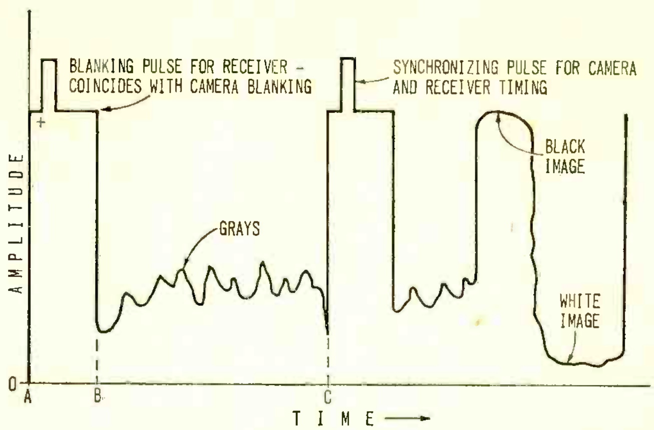
A13. *Interlace* scanning skips every other line.
A14. By this method, a line on the receiver screen is changed *60* times a second.
A15. Scanning is synchronized by a *timing generator*.
A16. *Video and timing pulses.*

Video Modulation

The video and timing pulses are placed on the carrier frequency by amplitude modulation. The process is similar to the method used by AM radio stations.

Video Signals. As you have learned from the preceding discussion, a video signal contains a great deal of information. A series of video waveforms is shown below. Remember that a waveform contains only two dimensions—amplitude and time.

Complete Video for Two Scanned Lines

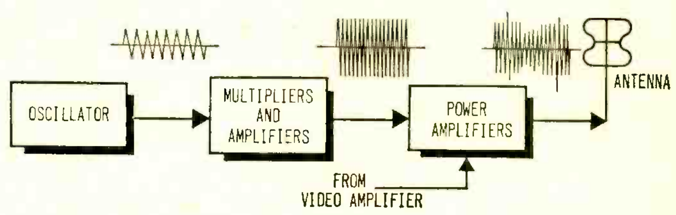


Carrier Frequency. The carrier-frequency section is similar to the same circuits in a broadcast radio transmitter. (See the diagram shown immediately below.)

The oscillator generates a continuous and constant frequency. The output of the oscillator is increased in frequency and amplitude by the multiplier and amplifier sections. In the power amplifier, the carrier is raised to the desired power level required by the station, and is amplitude-modulated by the video signal.

For VHF (very high frequency—channels 2 to 13), the frequency of the carrier is between 54 and 216 megacycles. For UHF (ultra high frequency—channels 14 to 83), the carrier is between 470 and 890 megacycles. Transmission of signals at these frequencies is quite different from that for the lower radio frequencies. High frequencies have short wavelengths. A *wavelength* is the time duration, or length, of one cycle. The higher the frequency of a signal, the shorter is its wavelength.

TV Carrier Frequency



Q17. The image scanned by the camera is changed into a(an) ----- frequency.

Q18. A video signal has ---------- and ---- dimensions.

Q19. In the diagram on the preceding page, a full video cycle is from (A to B, B to C, A to C).

Q20. The beginning of a scanned line on the receiver screen coincides with (A, B, C).

Q21. Using the same letters, the electron beam is retracing between time _____ and time _____.

Q22. A black image appears on a (more, less) positive voltage than a shade of gray.

Q23. During retrace time in a video cycle, two pulses appear. What are they?

Q24. How many cycles are shown in the figure above?

Q25. VHF has (shorter, longer) wavelengths than UHF.

Q26. A TV video signal is --------- modulated.

Your Answers Should Be:

A17. The image scanned by the camera is changed into a *video* frequency.

A18. A video signal has *amplitude* and *time* dimensions.

A19. In the diagram, a full video cycle is from *A to C.*

A20. The beginning of a scanned line on the receiver screen coincides with *B.*

A21. Using the same letters, the electron beam is retracing between time *A* and time *B.*

A22. A black image appears as a *more* positive voltage than a shade of gray.

A23. During retrace time in a video cycle, two pulses appear. They are *blanking* and *synchronizing* pulses.

A24. *Two cycles* are shown in the figure.

A25. VHF has *longer* wavelengths than UHF.

A26. A TV video signal is *amplitude* modulated.

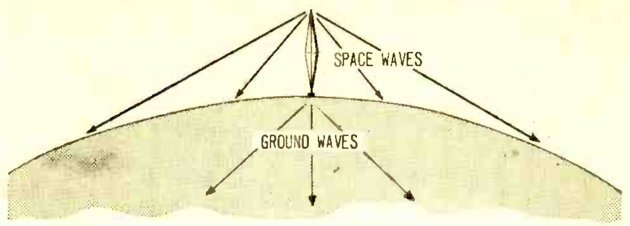
TELEVISION TRANSMITTING ANTENNAS

An antenna, as you recall, develops an electromagnetic field around itself when current is passing through it. Current flows back and forth through an antenna in accordance with the rise and fall of the carrier-waveform frequency and amplitude.

Television Wave Propagation

Since the wavelength of a TV carrier is shorter than that of a radio-broadcast carrier, the length of the TV antenna is correspondingly shorter. There is also a difference in the way short and long wavelengths travel through space.

Radiated Long Waves

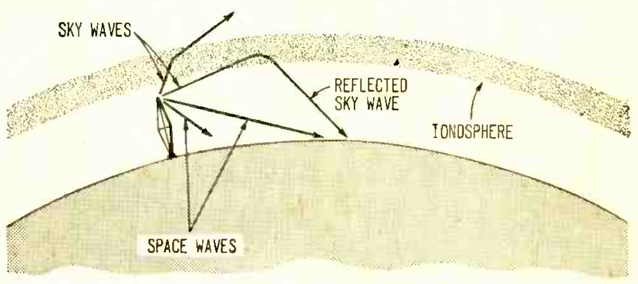


The diagram illustrates the *propagation* (travel of electromagnetic radiation) of long waves as they radiate from the antenna of a commercial radio station. The frequency is between 535 and 1605 kilocycles. The radiated energy has a *space wave* that travels essentially in a straight line. Low frequencies also have a *ground wave* that hugs the ground until the radiated power decreases so much with distance that reception is no longer possible.

The short wavelengths of a television transmission depend on a different method of wave propagation.

High frequencies radiate a space wave and a *sky wave*. Both of these waves travel essentially in straight lines. To receive a space wave, the receiving antenna must be within line-of-sight of the transmitting antenna. If the receiving antenna is beyond the horizon, the space wave (if it still retains sufficient power) passes over it.

Radiated Short Waves



Sky waves, also traveling in a straight line, head out into space. When the sky waves are 50 to 75 miles out, depending on the time of day, they encounter the *ionosphere*, a layer of charged particles that cause the short-wave radiations to bend. Waves that enter the ionosphere at a sharp angle are bent back to earth. At an angle close to 90° (perpendicular), the bending is not enough for the signal to return to earth, so it continues to travel toward higher altitudes. If they are of sufficient power, reflected sky waves can sometimes be picked up by receiving antennas.

Q27. TV frequencies have ----- and --- waves.

e/e Basic Course

Q28. --- waves may be reflected by the ionosphere.
Q29. TV radiations are (short, long) waves.

Your Answers Should Be:

A27. TV frequencies have *space* and *sky* waves.

A28. *Sky* waves may be reflected by the ionosphere.

A29. TV radiations are *short* waves.

WHAT YOU HAVE LEARNED

1. Television transmitters and receivers, like any other electronic equipment, consist of circuits designed to accomplish specific functions. Although there are a large variety of circuits, they all operate in accordance with a basic concept—the effect that voltage, current, and electronic components have on each other. These basic effects can be used to analyze any circuit, providing the student understands the underlying principles of each.
2. A television transmitter consists of two sections. One section uses a camera to scan a scene, and a group of circuits to modulate a carrier frequency with the image. The other section takes the output from a microphone and uses it to modulate a second carrier frequency.
3. Sound is superimposed on its carrier by frequency modulation. The procedure is one in which the frequency of the carrier varies in accordance with the amplitude of the sound—decreasing during the positive portions of the audio cycle and increasing during the negative portions. The FM carrier is then amplified to the required power level and fed to the antenna.
4. Video is obtained from the camera as it scans a scene with an electron beam, one line at a time. The video signal, with the addition of blanking and synchronizing pulses, is amplified and then used to modulate the picture carrier frequency. The amplitude-modulated carrier is raised to a specified power level and then fed to the antenna.
5. Video and sound carriers are of a high frequency and therefore have short wavelengths. These travel through the atmosphere as either space or sky waves. Short space waves travel on a line-of-sight path and cannot be received beyond the horizon. Sky waves enter the ionosphere where their paths are bent by an amount depending on the angle of entry. If the entry angle is small, the sky wave returns to the earth and can be received.

NEXT ISSUE: PART X
Understanding Television Receivers

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.

DXing The Moon

Continued from page 32

Commercial Communications' Role. Private communications firms, like American Tel. and Tel., Western Union, ITT, and overseas, the Spanish CTNE and Australian telephone systems, also have a role in the lunar mission. Some of these corporations lease facilities and services directly to NASA. Others, like COMSAT, handle satellite relay transmissions for the space agency and for the major television networks.

On the shortwave frequencies, SWLs should tune for the RCA Communications, Inc., stations at Rocky Point, Long Island, and at Point Reyes, near San Francisco. These point-to-point stations are used by the broadcasting networks and press audio services for feeding correspondents' reports from the recovery ships to the mainland.

RCA-San Francisco transmitters use call letters WMF, WMH, and WMI, followed by pairs of numerals; Rocky Point stations carry calls WEO, WEP, WER, and WES, plus two number identifiers. These calls, however, are seldom, if ever, announced. Occasionally, you'll hear two letter/four digit identifications, such as KL8444. These belong to the shipboard ends of the press circuits.

The list shows many wavelengths to be used by the various shortwave services during the Apollo 11 flight. Since not all of these are in use at the same time, you'll have to skip around to find where the action is.

For openers, though, you might try the NASCOM network on 14,861 kHz., which has been one of the busiest during recent space missions. Good bets for the recovery network are the frequencies clustered around 6693 and 11,205 kHz. Or, for Pacific Radio, try 15,016 and 15,088 kHz. The Atlantic Tribe pitches camp around 15,051 kHz.

Sorry—No NASA QSLs. Will the Apollo stations verify? Officially, NASA says it provides no "ham" services whatsoever—another way of saying, "Sorry, boys, no QSLs!" But things aren't quite that bad. A few DXers have managed to get verifications for NASCOM reception during earlier space shots.

No guarantees, but if you're willing to risk a six-cent stamp, try writing the NASCOM Communications Director, NASCOM Control Center, Building 14, Goddard Space Flight Center, Greenbelt, Md. 20771. Reports for stations identifying as "Houston"

Houston, Tex., will continue as center of NASA operations during Apollo 11 flight. Here, Dr. Robert Gilruth (left) and George Low view picture of Earth televised when Apollo 8 was some 200,000 miles away.

(Continued from previous page)

may be sent to Landing and Recovery Division, NASA Manned Spacecraft Center, 2101 Webster-Seabrook Rd., Houston, Tex. 77058. And, occasionally, some benighted technician at one of the remote NASA sites will answer SWL letters if you can "fudge" an adequate address.

Navy and Air Force recovery net stations often will QSL. Pacific Radio reports should go to Communications Officer (Apollo 11), Navy Terminal Post Office, FPO San Francisco 96610. Atlantic Chief reports go to his counterpart at the Manned Spacecraft Recovery Force, Atlantic, RCC, Bldg. SP-71, Naval Air Station, Norfolk, Va. 23511.

To help you "make up" suitable addresses for other military stations in the recovery network, here are a few APO-FPO Zip codes: Puerto Rico, FPO N.Y. 09550; Antigua, APO N.Y. 09552; Bermuda, APO N.Y. 09560; Eniwetok, FPO S. F. 96625; Guam, FPO S.F. 96630; Saipan, FPO S.F. 96636; and Okinawa, FPO S.F. 96670. For seagoing stations, write in care of the ship's radio officer, APO New York 09501; or FPO San Francisco 96605, for Pacific fleet stations.

Reports to the RCA Communications stations usually result in QSLs if sent to either 135 Market St., San Francisco 94105, or 66 Broad St., New York City 10004.

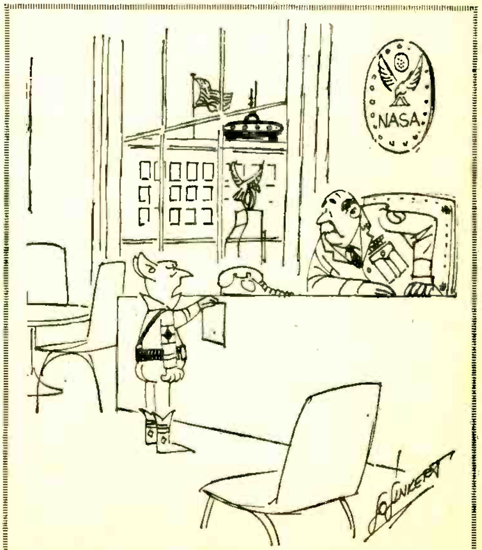
The forthcoming Apollo 11 mission *is* a gigantic, awesome business, but don't let that scare you off. Amid all the mind-boggling, technological marvels, the human element still persists.

Want proof? One SWL moon tuner overheard this Mission Control instruction during a recent space flight. . . .

"Move your suit control valve back down to the first black scribe mark below the little red one." Bet ya never heard that on your boob toob! ■

APOLLO GLOSSARY

AFB	Air Force Base
AIS	Apollo Instrumentation ships
AOS (IOS, POS)	Atlantic (Indian, Pacific) Ocean ships; NASA's tracking vessels, USNS Vanguard, Redstone, Mercury and Huntsville
APO	Armed Forces Post Office
ARIA	Apollo Range Instrumentation Aircraft, airborne tracking stations aboard JC-135 jet planes
ARRS	Aerospace Rescue and Recovery Service aircraft, airborne rescue stations aboard HC-130 Hercules planes
COMSAT	Communications Satellite Corporation
CTNE	Compania Telefonica Nacional de Espana
FPO	Fleet Post Office
GUMDROP	Code word for Apollo command module
ITT	International Telephone and Telegraph Corporation
JPL	Jet Propulsion Laboratory, Goldstone, California
MCC	NASA's Mission Control Center, Houston, Texas
MSFN	Manned Space Flight Tracking Network, responsible for spacecraft to Earth communications
MASCOM	NASA Communications Network, responsible for ground communications between MSFN stations and MCC
PACMISRANFAC	Navy's Pacific Missile Range Facilities
PRS (SRS)	Primary (Secondary) Recovery Ship
RCC	Recovery Control Centers, recovery network headquarters
SPIDER	Code word for Apollo lunar module, also known as Rosemary, LEM, LM
USB	Unified "S" band communications, also used to designate upper single sideband transmissions
USNS	United States Naval Ship



"I'm from the Extraterrestrial Law Enforcement Committee—I'm here to serve a space-littering warrant!"

Discovering OpAmps

Continued from page 50

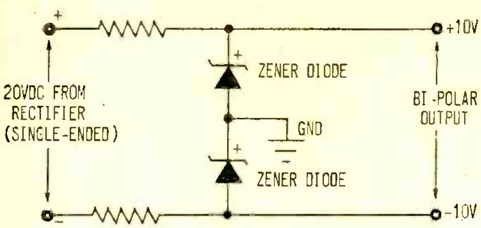


Fig. 7. Getting bi-polar output for OpAmp circuitry may pose problems, but solutions are easier than you might expect. One is to toss in a couple of Zeners: input is single-ended; output, bi-polar.

But with OpAmp design each circuit becomes a separate building block that will mate with any other block—just as toy blocks can be mated. Let's assume you build a front end for a receiver, you know the desired output voltage and the required matching impedance. You then select an off-the-shelf OpAmp for the IF amplifier having the required input impedance (no matching problem), add a tuned circuit and a resistor in the feedback loop to establish the circuit's resonant frequency and gain, and once again, before the circuit is built, you know the output voltage and impedance. For the AF amplifier you select an OpAmp having the required impedance, add the correct feedback resistor for the desired gain and your amplifier is complete. This is possible because an OpAmp can produce either high or low power out, and a single OpAmp can provide the entire voltage gain and power output stages of the AF section of your receiver.

You can take the same building block approach with other circuits. Each circuit function can be designed as a building block, the entire circuit being achieved when they are all connected together.

Let's Experiment. Here's a useful building block project you may want to try. Starting with a Motorola MC1303L stereo preamplifier, in building block fashion, design a 4-channel mixer/amplifier in which: two channels are for mikes, two for magnetic phono or tape head inputs, and having a high level output. Try this approach, one MC1303L will be used for the two mike channels, one for the two equalized channels for magnetic phono pickup or tape head, and one half of an MC1303L as the output amplifier, with the half remaining as an amplifier for a VU meter or headphone monitor amplifier. Fig. 6 is a block diagram to get you started—from there on you're on your own. However, because locating a bi-polar power supply can be an Excedrin headache, we'll help you out with the power supply.

Bi-Polar or Single-Ended. A bi-polar supply is, as we have previously discussed, a power supply that produces an equal voltage either side of the center tap or ground, since the center tap is generally grounded. Using a power transformer single-ended secondary, as in Fig. 7, you can provide a zero voltage point, or phantom-ground by connecting two Zener diodes across the rectified output of the supply. The junction of the two Zeners serves as the ground, or center tap. The major problem with this arrangement is that you must select the correct series resistor and each half of the supply will be a half-wave rectifier. Also, this requires a fair amount of filtering, achieved either through large, expensive capacitors or a capacity-multiplied transistor regulator.

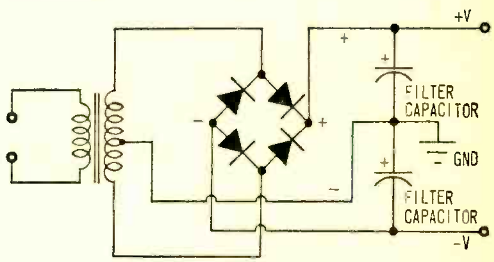


Fig. 8. Even cheaper way to achieve bi-polar output is to combine bridge rectifier with center-tapped power transformer. Full-wave output is easy to filter, ideal for most OpAmp circuits.

An alternative approach is shown in Fig. 8 above. Using a power transformer having a split-secondary (center tapped) and a bridge rectifier, you produce a center-tapped supply with full-wave rectification on both sides, which requires much smaller filter capacitors.

The more popular power source is a single-ended power supply having positive and negative output leads—generally either side may be grounded. By connecting two 4700-ohm resistors across the supply, the junction of the resistors becomes the center tap (ground) and each side of the supply will provide output voltages of opposite polarity with respect to the center tap or ground. ■

Campus Cops

Continued from page 36

of leading institutions of higher learning throughout the country. Most of these stations are licensed by the FCC in the Police Radio Service, while others turn up in Business and Local Government radio services. The stations marked with an asterisk (*) are known definitely to be used by campus police; the others are licensed to the institutions indicated and we can only guess that they are specifically used for police purposes.

CAMPUS STATIONS THROUGHOUT THE NATION

City	Institution	Call	MHz
	Alabama		
Univ.	Univ. Ala.	......	33.14
	Arizona		
Tempe	State U.	KBY500	155.49*
Tucson	Ariz. U	KO1249	155.25*
		KO1249	155.67*
		KCN226	155.76*
	Arkansas		
Fayettev.	U. Ark.	KJG643	27.265
	California		
Berkeley	U. Calif.	KMC290-1	155.85*
Los Angeles	U. Calif.	KMF741	155.79*
Los Angeles	USC	KLE314	151.775
		KDM746	151.805
San Francisco	U. Calif.	KMJ964	27.235*
		KMG226	155.55*
San L. Obispo	Caltech	KMG999	155.49*
Stanford	Stanford U.	KCN729	463.25
	Connecticuit		
New Haven	Yale	KB1613	27.470
		KFQ950	27.470
	District of Columbia		
Wash.	American U.	KJ0579	151.745
Wash.	Georgetown U.	KJ1224	151.685
Wash.	Howard U.	......	154.57
	Florida		
Coral Gables	U. Miami	KDK833	151.865
Gainesville	U. Fla.	KIE831	155.37*
N. Tampa	S. Fla. U.	KCQ233	158.85*
Tallah.	Fla. State	KIK314	155.31*
	Georgia		
Athens	U. Ga.	KBK849	154.86*
Atlanta	Ga. Tech.	KBM399	155.58*
	U. Ga.	KLK624	453.05
Augusta	Med. Coll.	KFN598	154.86*
Statesboro	Ga. Southern	KJ1426	39.68*
	Illinois		
Chicago	Loyola	KJT621	27.245
		KEW683	27.265
	U. Chicago	KAR202	463.95*
	U. Ill.	KSJ236	155.37*
		KSJ236	155.43*
DeKalb	N. Ill. U.	KCW738	155.37*
Evanston	Northwestern	KES741	151.865
Macomb	W. Ill. U.	KDN537	155.37*
Normal	Ill. State	KDN588	155.25*
	Indiana		
Bloomington	Ind. U	KSF261	156.21*
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Notre Dame	Notre Dame	KFX482	151.865
W. Lafay.	Purdue	KSB412	155.37*
		KSB412	156.21*
Terre Haute	State U.	......	30.84
	Iowa		
Ames	State U.	KAJ316	37.10*
		KAJ316	37.26*
Iowa City	State U.	KBD918	37.26*
	Kansas		
Manhattan	State U.	......	33.14
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Orono	U. Me.	......	42.98
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		KDY664	35.90
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Rio Piedras	U.P.R.	KAS626	155.07*

Desk Top Project

Continued from page 38

arated from the radio chassis. It should be mounted in the front of the cabinet so that it will be roughly midway between the radio dial knob and the high intensity lamp *on/off* rotary switch.

Next Comes The Lamp. The transformer from the high intensity lamp we used had two mounting brackets fastened to it. We placed the mounting screw for the pen holder through the hole in one of these brackets and used a machine screw to fasten the other bracket to the wood cabinet.

Finally mount the desk pen holder to the top of the wood cabinet. The holder is normally supplied with a mounting screw and/or nut. Position may be either left or right of center, whichever location you prefer, near the rear edge of the cabinet. To protect the desk top surface either place tack-type small rubber bumpers or cement 1/4-in. squares of felt or sponge rubber to the bottom of the assembled desk unit.

Wiring the Assembly. The only hooking up required for the radio will be connections to the volume control and switch, the 9-V battery and the speaker. The schematic diagram details the hook-up for the high intensity lamp.

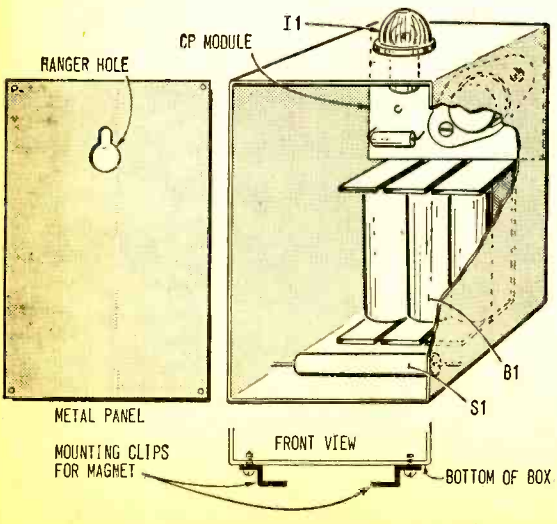
The photographs show the placement of the various components and the handsome appearance of the finished product. You will be very proud of this desk unit. ■

PQ Minder

Continued from page 65

side the box, two metal clips to provide a slip-in holder for the magnet assembly. Paint the mounting clips and magnet assembly the same color as the plastic box so that the magnet will not be noticeable. Idea here is to foil any attempt by a passerby to shut off the flashing lamp, since he will now be unlikely to see the magnetic switch.

Bore a hole in the metal panel which now becomes the back of the box, making it easy to hang the gadget on a nail or hook on the door. After mounting, wire all components in accordance with schematic. ■



PQ MINDER PARTS LIST

- B1—Three penlight cells (Lafayette 99T6258 or equiv.)
- C1—25-uF, 6-volt electrolytic capacitor (Lafayette 34T8429 or equiv.)
- I1—Lamp assembly (holder, Lafayette 99T6339 or equiv.; bulb, Lafayette 32T6621 or equiv.)
- Q1, Q2—Part of code practice module
- R1—10-ohm, 1/2-watt resistor
- R2—Part of code practice module
- S1—Magnetic proximity switch (Lafayette 34T4401 or equiv.)
- 1—Code practice oscillator (Lafayette 19T1513 or equiv.)
- 1—4 x 2 1/2 x 1 3/8 in. plastic box (Lafayette 99T8078 or equiv.)
- Misc.—Hardware, wire, aluminum for slide clips, solder, etc.

Teacher's Assistant

Continued from page 52

program is concerned with the problems involved in the application of the digital computer as an aid to teaching. It will include the assessment, and subsequent development where necessary, of input and output equipment, information storage and retrieval methods and the system's programming required to make computer-aided teaching effective at all educational levels.

"It should be clearly understood," Mr. Brown says, "that our plans include no work on curriculum content—that is strictly a matter for the educational authorities. Likewise the evaluation of the system as it evolves will be under the direction of competent educators."

Efforts will be concentrated on the development of terminal equipment and of specialized computer facilities such as random access audio and video storage and on the writing of control programs. The aim is to provide a system which effectively communicates with the student and which can be used easily by the teacher in preparing instructional programs and in monitoring and updating their presentation. Natural language commands, and not complex computer notations, permit the teacher to communicate easily with the system.

John Humphries, engineer, and Martha Symonds, mathematician, at student terminal. Photo on screen is slide-controlled by computer to supplement material provided to student on typewriter.

Participation. The research program will require the active participation of industry and educators if success is to be achieved. Initial discussions of cooperative projects with industry, government and educational bodies have been encouraging and committees are being set up to assist in the guidance of such work in Canada. ■

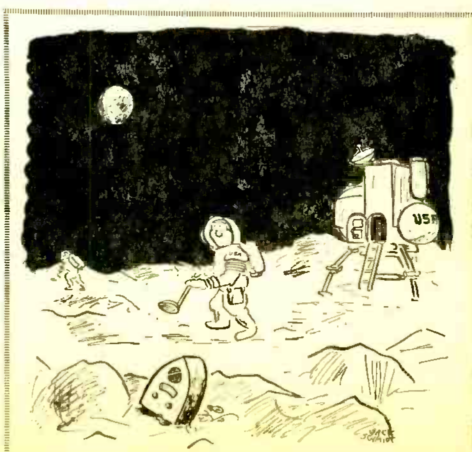
Lafayette Telsat 150

Continued from page 60

available as optional accessories. A prewired rear apron socket permits direct connection of an external selective calling device.

Operation. The Telsat 150's mode of operation is established via the CB channel selector. When the selector is set to the red dot position the vhf receiver is turned *on* and a lamp that illuminates the tuning dial indicates the vhf mode has been selected. Control of vhf squelch is independent of the CB squelch, permitting both squelch levels to be preset and not disturbed when switching from CB to vhf operation.

Summing Up. The Telsat 150 is an outstanding buy for the active CBer, particularly the CBer involved in REACT or other emergency team operation. The vhf receiver sets a new high level of performance for consumer vhf equipment, as does the CB transmit and receive audio quality. The overall CB performance is very good, and we would suggest the Telsat 150 be given first consideration when looking for new CB equipment. For additional information write to Lafayette Radio, Dept. DK, 111 Jericho Tpke., Syosset, N. Y. 11791. ■



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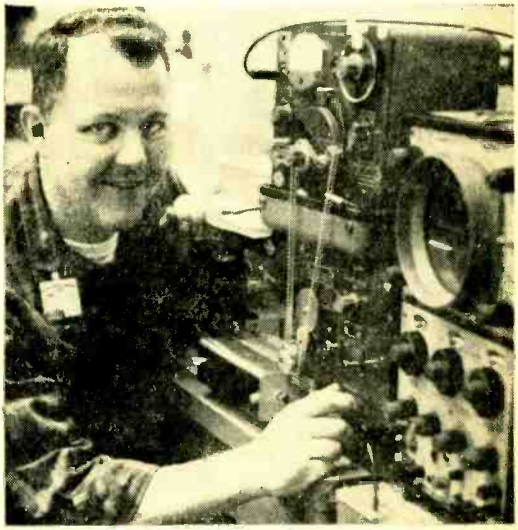

Harry Remmert on the job. An Electronics Technician with a promising future, he tells his own story on these pages.

By Harry Remmert

AFTER SEVEN YEARS in my present position, I was made painfully aware of the fact that I had gotten just about all the on-the-job training available. When I asked my supervisor for an increase in pay, he said, "In what way are you a more valuable employee now than when you received your last raise?" Fortunately, I did receive the raise that time, but I realized that my pay was approaching the maximum for a person with my limited training.

Education was the obvious answer, but I had enrolled in three different night school courses over the years and had not completed any of them. I'd be tired, or want to do something else on class night, and would miss so many classes that I'd fall behind, lose interest, and drop out.

The Advantages of Home Study

Therefore, it was easy to decide that home study was the answer for someone like me, who doesn't want to be tied down. With home study there is no schedule. I am the boss, and I set the pace. There is no cramming for exams because I decide when I am ready, and only then do I take the exam. I never miss a point in the lecture because it is right there in print for as many re-readings as I find necessary. If I feel tired, stay late at work, or just feel lazy, I can skip school for a night or two and never fall behind. The total absence of all pressure helps me to learn more than I'd be able to grasp if I were just cramming it in to meet an exam deadline schedule. For me, these points give home study courses an overwhelming advantage over scheduled classroom instruction.

Having decided on home study, why did I choose CIE? I had catalogs from six different schools offering home study courses. The CIE catalog arrived in less than one week (four days before I received any of the other catalogs). This indicated (correctly) that from CIE I could expect fast service on grades, questions, etc. I eliminated those schools which were slow in sending catalogs.

FCC License Warranty Important

The First Class FCC Warranty* was also an attractive point. I had seen "Q" and "A" manuals for the FCC exams,

*CIE backs its FCC License-preparation courses with this famous Warranty: graduates must be able to pass the applicable FCC License exam or their tuition will be refunded in full.

and the material had always seemed just a little beyond my grasp. Score another point for CIE.

Another thing is that CIE offered a complete package: FCC License and technical school diploma. Completion time was reasonably short, and I could attain something definite without dragging it out over an interminable number of years. Here I eliminated those schools which gave college credits instead of graduation diplomas. I work in the R and D department of a large company and it's been my observation that technical school graduates generally hold better positions than men with a few college credits. A college degree is one thing, but I'm 32 years old, and 10 or 15 years of part-time college just isn't for me. No, I wanted to *graduate* in a year or two, not just *start*.

If a school offers both resident and correspondence training, it's my feeling that the correspondence men are sort of on the outside of things. Because I wanted to be a full-fledged student instead of just a tagalong, CIE's exclusively home study program naturally attracted me.

Then, too, it's the men who know their theory who are moving ahead where I work. They can read schematics and understand circuit operation. I want to be a good theory man.

From the foregoing, you can see I did not select CIE in any haphazard fashion. I knew what I was looking for, and only CIE had all the things I wanted.

Two Pay Raises in Less Than a Year

Only eleven months after I enrolled with CIE, I passed the FCC exams for First Class Radiotelephone License with Radar Endorsement. I had a pay increase even before I got my license and *another* only ten months later. I'm getting to be known as a theory man around work, instead of one of the screwdriver mechanics.

These are the tangible results. But just as important are the things I've learned. I am smarter now than I had ever thought I would be. It feels good to know that I know what I know now. Schematics that used to confuse me completely are now easy for me to read and interpret. Yes, it is nice to be smarter, and that's probably the most satisfying result of my CIE experience.

Praise for Student Service

In closing, I'd like to get in a compliment for Mr. Chet Martin, who has faithfully seen to it that my supervisor knows I'm studying. I think Mr. Martin's monthly reports to my supervisor and generally flattering commentary have been in large part responsible for my pay increases. Mr. Martin has given me much more student service than "the contract calls for," and I certainly owe him a sincere debt of gratitude.

And finally, there is Mr. Tom Duffy, my instructor. I don't believe I've ever had the individual attention in any classroom that I've received from Mr. Duffy. He is clear, authoritative, and spared no time or effort to answer my every question. In Mr. Duffy, I've received everything I could have expected from a full-time private tutor.

I'm very, very satisfied with the whole CIE experience.

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Perhaps you too, like Harry Remmert, have realized that to get ahead in Electronics today, you need to know much more than the "screwdriver mechanics." They're limited to "thinking with their hands"...learning by taking things apart and putting them back together...soldering connections, testing circuits, and replacing components. Understandably, their pay is limited—and their future, too.

But for men like Harry Remmert, who have gotten the training they need in the fundamentals of Electronics, there are no such limitations. As "theory men," they think with their heads, not their hands. For trained technicians like this, the future is bright. Thousands of men are urgently needed in virtually every field of Electronics, from two-way mobile radio to computer testing and trouble-shooting. And with this demand, salaries have skyrocketed. Many technicians earn $8,000, $10,000, $12,000 or more a year.

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