50c

SEPT. 1966

Radio-Electronics

TELEVISION · SERVICING · HIGH FIDELITY

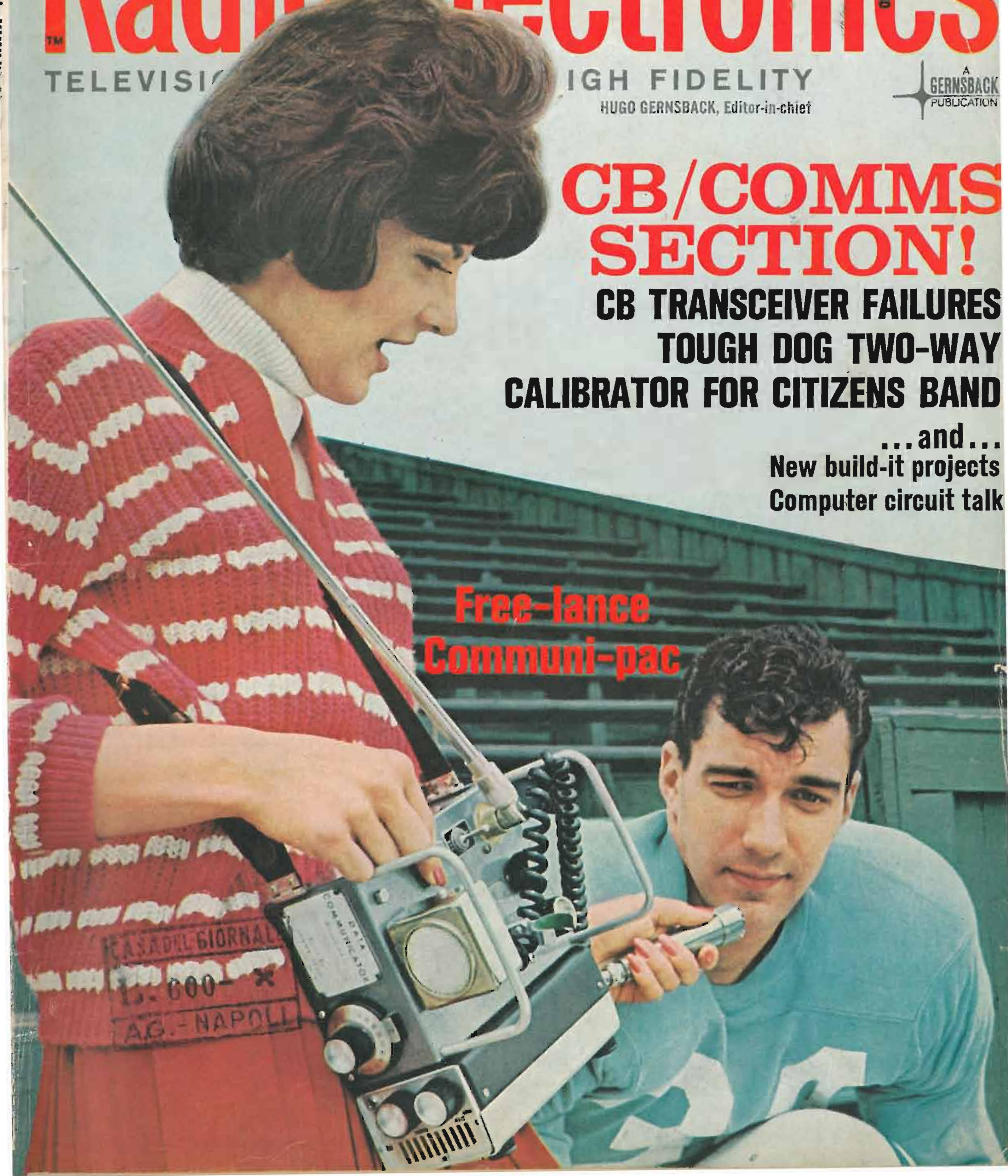
HUGO GERNSBACK, Editor-in-chief

A GERNSBACK PUBLICATION

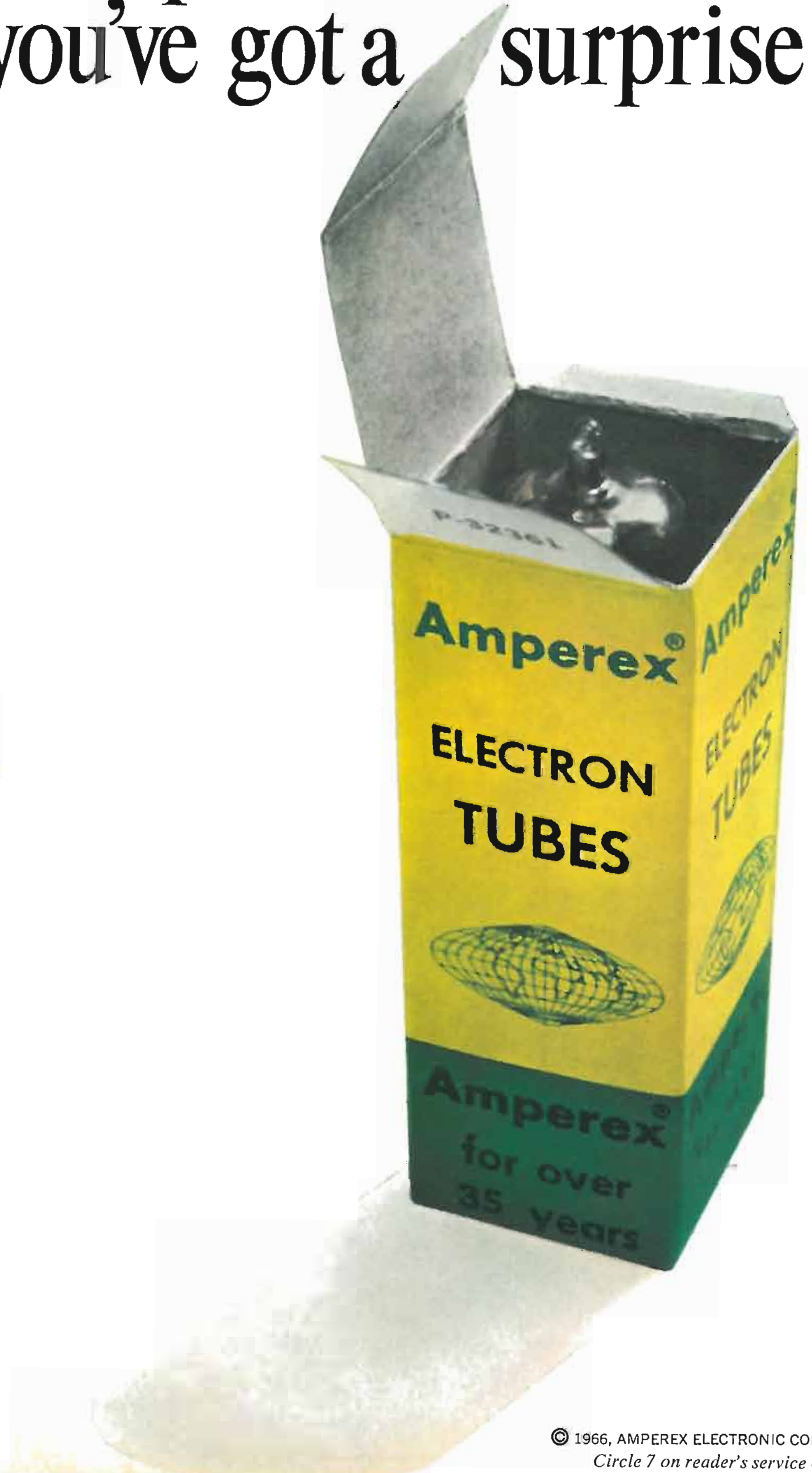
CB/COMMS SECTION!

CB TRANSCEIVER FAILURES
TOUGH DOG TWO-WAY
CALIBRATOR FOR CITIZENS BAND

...and...
New build-it projects
Computer circuit talk



If you think all replacement tubes are alike, you've got a surprise coming



Circle 7 on reader's service card

The ~~World~~ Universe of Communications

On the editorial page this month, in this our first CB & Communications Special, I planned to talk to you about the most spectacular communications event to date. No earth-shattering commentary, just a chat about how it was accomplished and what it might mean to your future and mine.

So I picked the most recent big event. But . . . no . . . that wasn't really the most important. The most important was . . . No, wait a minute . . . how about . . . ?

You get the idea. With so many events linked in one way or another to communications, how could I possibly pick out one that is the most important? Obviously, I couldn't.

The news media played up the triumph of Surveyor I, our "TV station" on the moon. Now, *there's* a TV show for you—live, from outer space! Not only did Surveyor manage a gentle landing, controlled by its own internal computer, but shortly set to work with its movable-mirror television camera telecasting back to earth thousands of sparkling pictures of the moon's surface. All through the 270°F temperature of the moon "day," the tough little moon photographer worked, and then settled into stillness to wait out the —280°F lunar "night."

Then, 14 earth-days later, when the sun rose again over the lonely lunar landscape, earth-based scientists sent out hopeful little electronic suggestions that Surveyor should wake up and look around again. And, with a slow but encouraging stretch of electronic muscles, Surveyor did wake up, healthy as ever, soaked up a hearty breakfast of solar energy to replenish its now-thawed batteries, and went willingly to work again pouring information about the moon down those telemetry and television beams to exulting scientists at receiving stations back on earth.

Then there's that other miracle of space communications—Mariner 4—which has become the earth's most traveled former denizen. Not satisfied with sending the world's first closeup pictures of Mars last year, this marvelous interstellar traveler obligingly sent back an answer to our most recent electronic question—sent it back from 749 million miles away in space. Talk about communications! It took more than 2 hours for the messages to make the round trip to Mariner and back.

All this activity in outer space overshadows less flashy happenings down here within a few hundred miles of earth. A worldwide system of communications is ready to serve the military. Navigation satellites are edging toward the launch pads. Some experts predict we'll have direct satellite-to-home TV in a few years; others deny it. (Rest assured; if we don't, the reason won't be technical.) And orbiting observatories are an accomplished but little publicized fact.

Right here on the solid earth, imaginative ways of multiplexing more messages on existing facilities are being put into operation. In labs, lasers are opening new avenues of speculation about handling the mounting volume of future communications traffic.

No spot is untouched by the innovators. New means for undersea communication are being tried out, while we're still finding new ways to send more messages over those old standby's, the undersea cables.

So, you see, I picked too broad—if not impossible—a subject. One short editorial can't cover it.

But, in working at it, I decided one thing I can pass along and hope will affect your future thinking about communications: No longer can any of us talk of, think about, or plan for *world* communications. From the briny depths of the ocean to yet-unfathomed reaches of outer space, we now must plan our communications systems in terms of the *universe*.

—Forest H. Belt

Radio-Electronics

SEPTEMBER 1966 VOL. XXXVII No. 9
Over 55 Years of Electronic Publishing

EDITORIAL

CB/COMMS SPECIAL SECTION

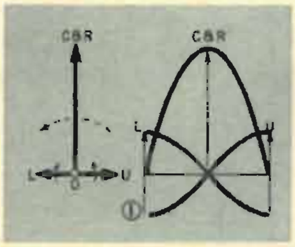
ELECTRONICS

AUDIO-HIGH FIDELITY-STEREO

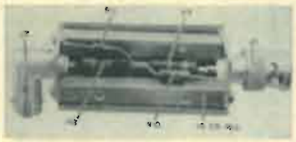
GENERAL

THE DEPARTMENTS

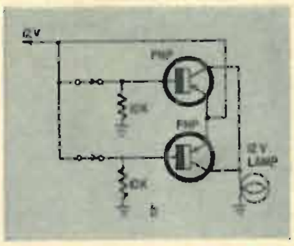
p 40—2-WAY TOUGH DOGS



p 48—PHASE MODULATION



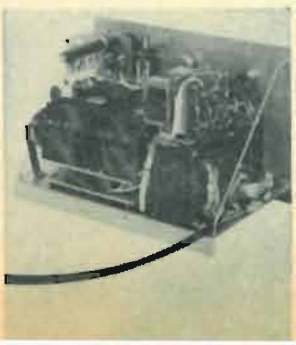
p 58—A UHF WATTMETER



p 46—COMPUTER LOGIC

p 54—QUAKE DETECTOR

p 59—A 5-AMP SUPPLY



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*COVER FEATURE

p 32—For interviews and for reporting, this multi-purpose gadget can make the life of the free lance easier. It can be built by almost anyone.

LASER COMMUNICATIONS

p 34—In outer space and for earthbound communications, the laser seems to be an answer to the expected congestion.

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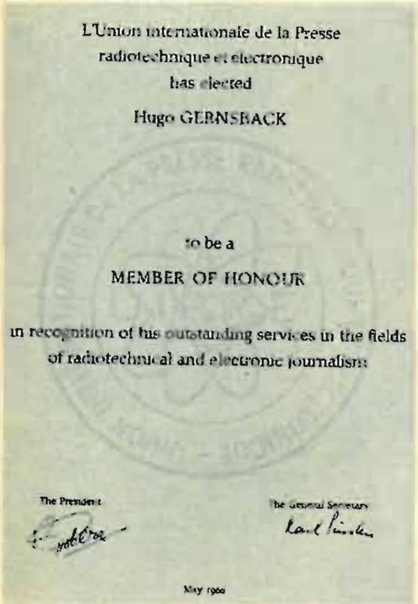
NEWS BRIEFS

HUGO GERNSBACK HONORED BY INTERNATIONAL PRESS GROUP

The International Union of the Radiotechnical and Electronics Press (L'Union internationale de la Presse radiotechnique et électronique) has elected Hugo Gernsback a Member of Honor of the association, "in recognition of his outstanding services in the fields of radiotechnical and electronic journalism."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of radiotechnical and electronic journalism

The President
The General Secretary

May 1966

Mr. Gernsback was notified of the honor in a letter by Eugene Aisberg, president of the Union, old-time friend, and publisher of five magazines in the field of electronics in France:

"Dear Friend Gernsback:

I am very happy to address you this witness of affection and admiration from your confreres of the world electronic press."

The Union is composed of editors of publications in the electronics field and includes leading publishers and editors in a large number of countries and languages.

TV DIRECT FROM SATELLITES NOT LIKELY, SAYS COMSAT HEAD

Dr. Joseph V. Charyk, president of the Communications Satellite Corp., does not believe that television broadcasts are likely to be relayed direct to homes from satellites. Instead, he thinks broadcasts will go from space to ground stations and then be distributed by existing television networks.

Direct satellite transmission would create a propaganda broadcast problem, and many governments might object to their citizens receiving material the satellites might broadcast. There would also be a serious economic problem, as existing television networks would probably object to any type of broadcast that would bypass them and possibly terminate the reason for their existence.

NEW LASER "RADAR" HAS ELECTRIC SCANNING

An electrically scanned laser is the first that can relocate a rocket momentarily lost in the clouds; mechanically scanned lasers cannot move fast enough to rediscover a moving target once it is lost. The new laser, by General Telephone & Electronics Corp., can pinpoint a rapidly moving target to within 12 inches at a height of 8 miles.

The optical-beam deflector consists of 20 movable and 8 stationary mirrors. The 20 movable mirrors are attached to piezoelectric prisms activated by alternating current and direct the beam to 2,000 locations within a half-second after contact with the target is lost. As soon as the beam strikes the target and is again reflected, the ground receiver shuts off the deflector and locks the system onto the moving target.

CHRONIC PAIN RELIEVED BY DC OR RF NEEDLE

Direct current or high-frequency ac, from a needle inserted into the upper spinal column, is now being used to relieve persistent pain. Relief is immediate and continues for a period measurable in months. Dr. Sean Mulla of the University of Chicago School of Medicine, who described the technique to the American Medical Association's 115th annual convention, said that the method had been used chiefly on advanced cases of cancer, but has value in treating persistent pain from other causes. The problem of drug addiction does not arise, and treatments can be given under a local anesthetic. The dc method is used where the doctor does not wish the effects to persist, since treatment with rf produces longer-lasting effects.

STANDARDIZED TAPE CARTRIDGES WITH "MUSICASSETTE" SYSTEM?

North American Philips says 39 major manufacturers of tape recording equipment have adopted the Philips compact cassette (cartridge) system. This may foreshadow a standardized cartridge tape system.

The new tape is less than ¼ inch

Sylvania engineer Robert Johnson inspects beam reflector (left tube), tracking telescope (center tube) and receiving unit (right tube) of the electrically scanned laser system.

The new Norelco compact cassette stereo recorder with its speakers and a set of the "musicassettes." Cartridges aren't interchangeable with all the other systems.

wide and moves at 1⅞ inches per second. Unlike some earlier cartridges, this one can be used to record as well as play back. It is fully compatible and interchangeable for playback on all machines using the Philips compact cassette system.

The musicassettes play for 60 minutes. There is also a version using a thinner tape for 90 minutes of play.

PHONE CALL DIRECT-DIALED FROM US TO SWITZERLAND

Just 90 years after Alexander Graham Bell demonstrated the telephone at the Philadelphia Centennial Exposition, a direct-dial telephone call was made between Philadelphia and the continent of Europe. Lowell Wingert, vice president of the Long Lines Department of AT&T, made the call at a session of the International Communications Conference. He dialed 200-2-33-10-11. The 200 is the international "area code." The 2 routed the call to Switzerland, and the other six digits are the telephone number of Jean Rouviere of the International Telegraph and Telephone Consultative Committee, Geneva. Mr. Wingert told the meeting that direct customer dialing between selected central offices in New York City and several European cities would be introduced on an experimental basis next year.

NEA PROPOSES NATIONAL TECHNICIAN CERTIFICATION

As part of its training and upgrading program, the National Electronic Associations has for some time proposed certification of electronic service technicians on a national basis. It has developed and tested written and practical examinations designed to lead to such certification.

The first NEA test was an essay type, with 115 questions, covering test equipment, antennas, color and black-and-white TV theory, audio and general questions. After trying the test in Indianapolis, Kansas City, Des Moines and Wichita, NEA analyzed the test and defective or ambiguous questions were deleted. The revised test was then brought out in multiple-choice form.

Most capable technicians, says NEA '65–'66 president Dick Glass of Indianapolis, appear to be in favor of certification, and consider the certificates valuable in their customer relations. A certificate also is useful to a prospective employer, as at least a minimum gauge with which to judge a potential employee. Some objections to the program have been voiced, generally by persons with little or no technical training. Approximately 65% of those who have taken the test have passed. An opportunity was provided for a later test for those who failed the first time, and most of them passed on the second try.

The tests are being discussed at the association's national convention (Aug. 18–21) together with plans for putting the certification plan into effect nationally.

ITT SCIENTIST FORECASTS NEW MICROWAVE GENERATORS

Traveling-wave tubes, klystrons, and even varactors may soon be outmoded as microwave generators, Robert Caruthers of International Telephone & Telegraph Corp. (ITT) told the 1966 IEEE International Communications conference.

"Where 2 years ago suppliers were pessimistic about the chances of power transistors ever exceeding 600 MHz, now even greater power output devices are being developed at 1 GHz. Fifteen watts at 1 GHz will soon be a reality and several watts are forecast at 2 GHz by the end of this year.

"The literature is now stressing Gunn-effect, silicon-controlled avalanche (SCAT) and metal-base transistors. With the Gunn device, watts and even kilowatts are forecast at microwave. We can anticipate their use in pulse-type operation, replacing klystron radar transmitters. There is less publicized information on the progress in SCAT, metal-base, and other exotic transistors, but all researchers seem to believe that powers of 5 watts or more are possible through 6 GHz using these devices as transmitting amplifiers," Caruthers concluded.

GENERAL SARNOFF PROPOSES AN INTERNATIONAL PATENT SYSTEM

A global patent system, using satellite communications and electronic data processing, would be an important step in spreading technology more

continued on page 12

Radio-Electronics

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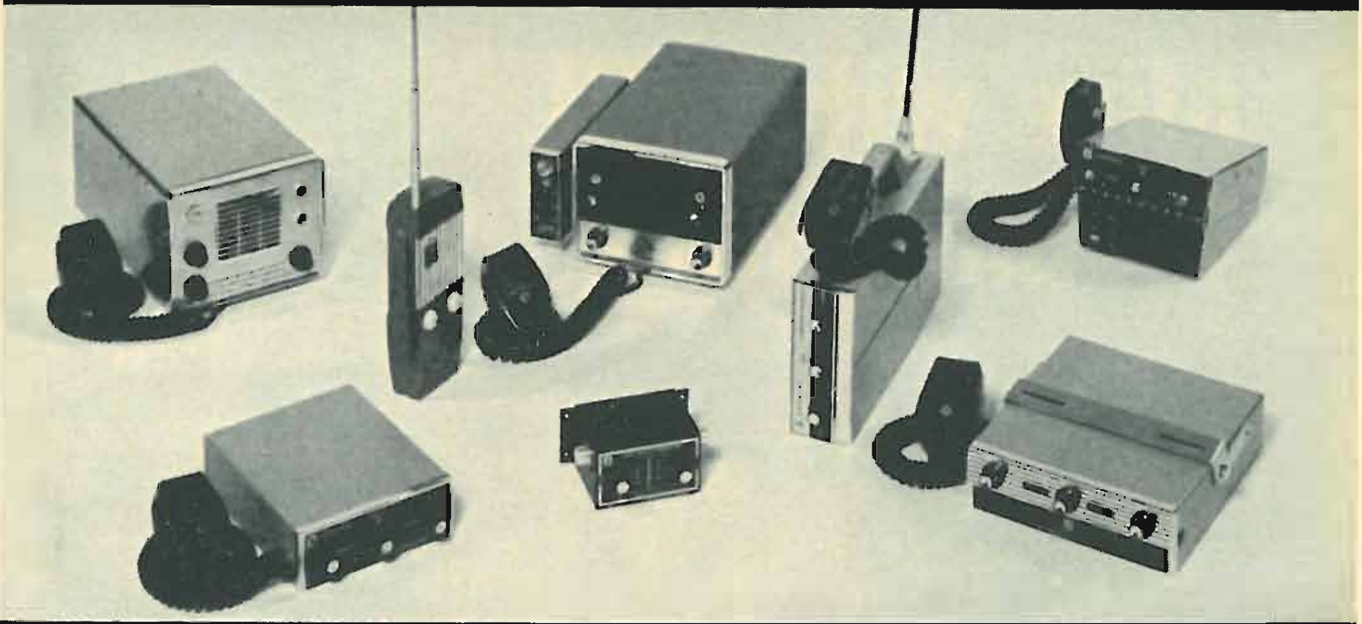

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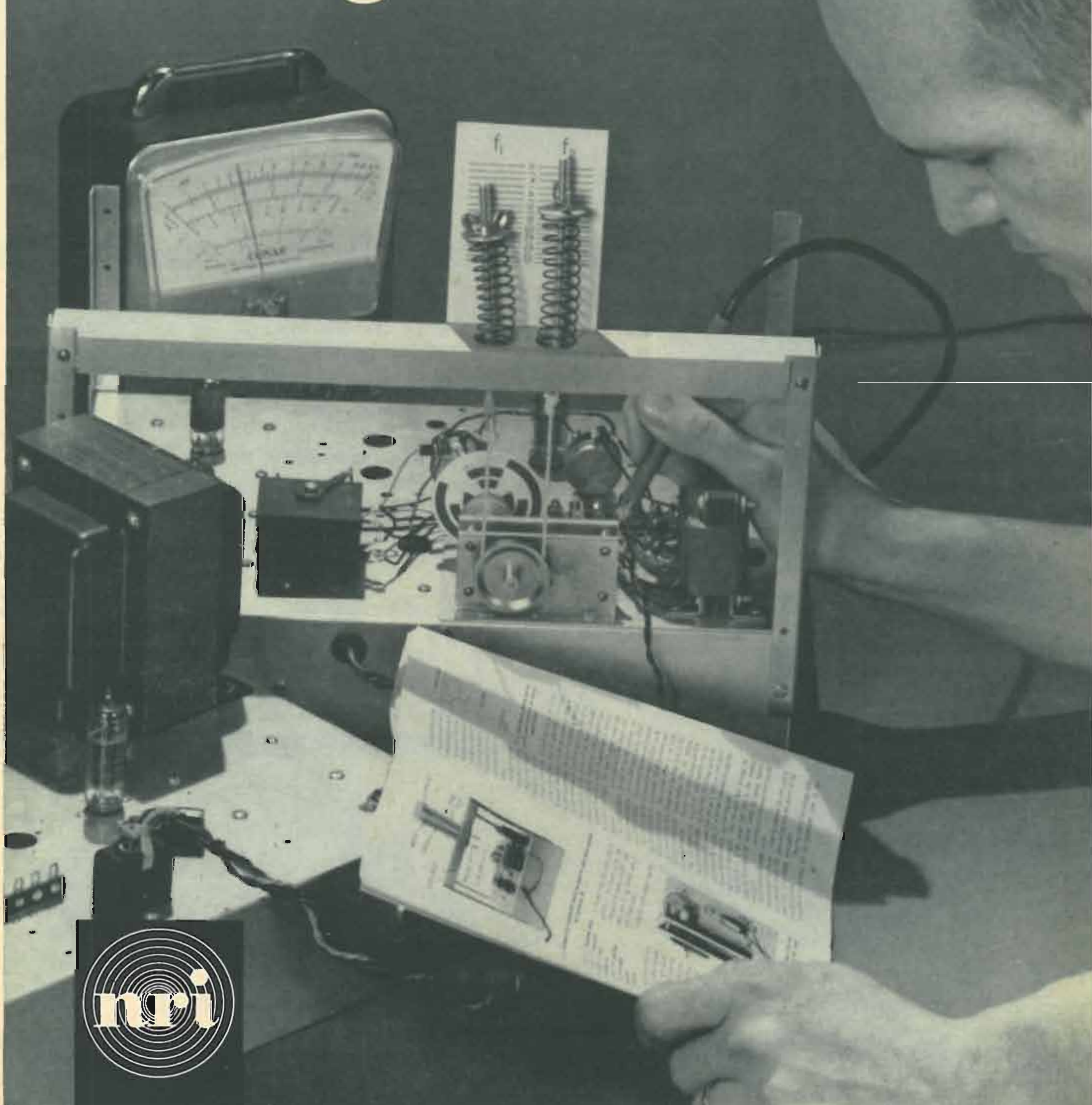

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equitably around the world, General Sarnoff stated to the Patent, Trademark & Copyright Research Institute of George Washington University.

"The fragmented array of national patent systems," said the RCA chairman, "inhibits the swift and equitable worldwide distribution of patent benefits. When we can transmit an idea around the world in less than 1/7 second, why must years elapse before that idea can be validated within or outside the country of origin?

"The instruments for such a system include the coming worldwide array of high-capacity satellites and the emerging generation of high-speed electronic data processing and information storage systems."

NEW UNDERSEA CABLE SYSTEM FIRST TO USE TRANSISTORS

Bell Telephone Laboratories' new undersea telephone cable system can carry nearly six times as many two-way conversations as any present US undersea cable. The new SF system, as it is called, provides for 720 two-way channels, compared to 128 two-way circuits in the previous SD system.

Transistor amplifiers, used for the first time, help broaden the bandwidth and therefore increase the number of voice channels. The transistors are expected to have an even longer life than the estimated 25 years of tubes previously used in such amplifiers. The amplifiers will be spaced 10 nautical miles apart, and each will provide a gain of about 40 dB.

The first cable used in the new system is expected to be a 1,250-mile stretch between Jacksonville, Fla., and St. Thomas, Virgin Islands.

CALENDAR OF EVENTS

NEA (National Electronic Associations, Inc.), August 18-21; Sheraton Motor Inn, Winston-Salem, N. C.

WESCON (Western Electronic Show and Convention), August 23-26; Sports Arena, Los Angeles, Calif.

NATESA (National Alliance of Television and Electronic Service Associations) Convention, August 25-28; Sherman House, Chicago, Ill.

IEEE 16th Broadcast Symposium, September 22-24; Mayflower Hotel, Washington, D. C.

New York Hi-Fi Music Show, September 22-October 2; New York Trade Show Building, New York, N. Y.

Radio-Electronics Adopts Hertz

RADIO-ELECTRONICS is now using the term *hertz* in place of cycles in all references to frequency. Hz, kHz and MHz, abbreviations for hertz, kilohertz and megahertz, are replacing cycles, kc and mc in all recently edited material.

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Correspondence

METAL LOCATOR QUERIES

Dear Editor:

I am building the underwater metal locator described in your June issue. Please explain how I can make the set's i.f. amplifier oscillate or publish the circuit of a separate bfo.

E. WILHELM

Islip, N. Y.

Many transistor i.f. amplifiers are relatively unstable and it doesn't take much to make them oscillate. Connect a short piece of insulated hookup wire to the base of the i.f. input transistor and a second piece to the collector of the i.f. output stage. Twist the two leads together (a "gimmick") and the circuit should oscillate so that you hear a whistle when you tune a station. Twist the leads just enough to get a faint whistle. Don't overdo it, or you'll decrease the set's sensitivity.

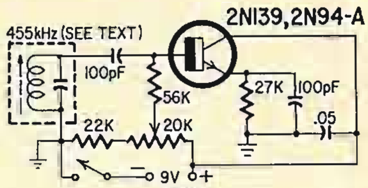

Fig.1

A separate bfo as in Fig. 1 allows more control over the strength of the beat note. The 455-kHz circuit may be the primary of a replacement-type transistor i.f. transformer. The 20,000-ohm pot adjusts the strength of oscillation. You may have to connect a small capacitor—about 10 pF or so—between the transistor base and emitter for reliable oscillation within the range of the pot. Use the tiniest available parts and you'll probably be able to build the bfo in the case with the receiver. Otherwise, build it in a small box you can fasten to the outside of the set. You may have to use a "gimmick" or tiny capacitor to couple the top end of the bfo coil to the set's detector circuit.

Some readers haven't been able to purchase the 75-ohm ribbon-type transmission line specified for the search coil. This cable is made by several firms but is not readily available. In most cases, it only comes in 100-foot and longer rolls. This type wire was recommended simply because it is easer to thread two turns through ½-inch tubing and con-

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Ten chapters, including a basic description on semiconductor fundamentals. Projects include a regulated power supply, intercom, motor speed control, 6-meter converter, minifi amplifier, signal generator and other circuits. Price **$.50**

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nect the leads in series to make a 4-turn coil than it is to thread 4 turns of single-conductor wire. You can use any ribbon-type wire. A convenient and readily available substitute is ordinary POSJ lamp cord.

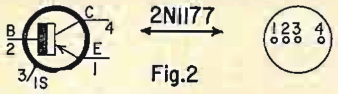


Fig.2

One reader was puzzled by the "extra" lead on the base of the 2N1177 transistor. This transistor has an internal shield connected to a separate lead—see Fig. 2.

CORRECT ADDRESS

Dear Editor:

My thanks to John F. Cleary for his mention of my book "Electronic Musical Instruments" on page 45 of the June issue. Readers and book stores will have better luck obtaining it, however, with the publisher's correct address:

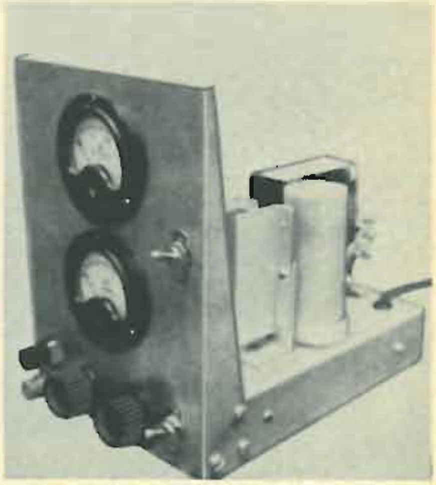
Radiofile
43 West 61 St.
New York, N. Y. 10023
Price, by the way, is $7.50.

RICHARD H. DORF
New York, N. Y.

READER'S RESULT

Dear Editor:

Enclosed is a photo of the supply we built from Mr. Rogers' article "All Silicon Regulated Power Supply" in the June 1966 issue. We service several dozen transistor amplifiers in the language lab of a local college, and the power supply we had just wasn't large



enough to handle them. We made the chassis, the front panel, punched and drilled them, calibrated some 1-mA (0-3V scale) meters we acquired, and put the unit together. You can see the result. We believe this one will fill our requirements. Thanks for this timely article.

E. PAUL HUNT
Liberty, Mo.

SE . . . WHAT?

Dear Editor:

Leslie's article on the European squabble (July 1966 RADIO-ELECTRONICS, page 68) is OK. However, SECAM comes from *SE*quentiel *C*ouleur *A M*emoire, no matter how the French *qu* is pronounced.

Incidentally, direct reports from some English friends who have seen SECAM in operation say (not a direct quote): "Bloody Awful!"

J. WALLINGFORD
Little Rock, Ark. END

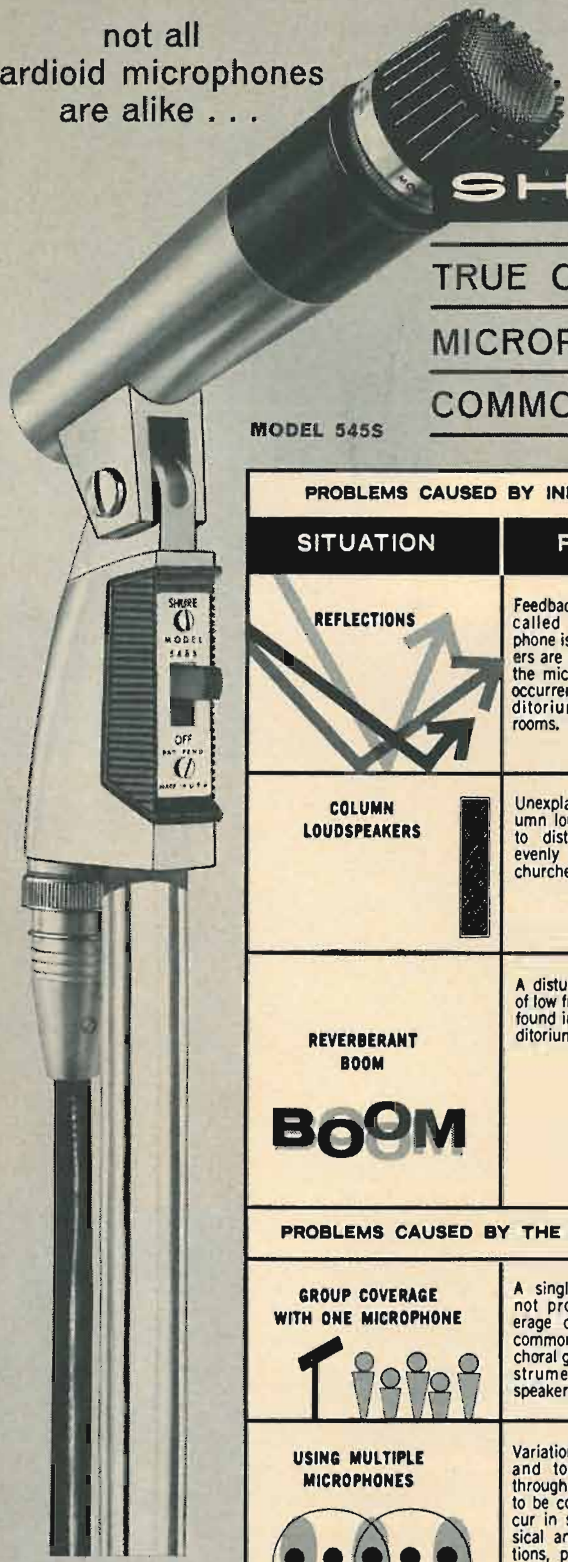
TESTING CAMERA SHUTTERS WITH YOUR OSCILLOSCOPE

Did you know that you can turn an ordinary service scope into a device that will measure how long the shutter remains open? Edward F. Rice explains how you can do this in the October issue.

RADIO-ELECTRONICS

Also see the special section on Industrial Electronics

not all
cardioid microphones
are alike . . .



only the

SHURE UNIDYNE III

TRUE CARDIOID UNIDIRECTIONAL DYNAMIC MICROPHONE SOLVES ALL THESE COMMON MICROPHONE PROBLEMS!

MODEL 545S

PROBLEMS CAUSED BY INEFFICIENT REJECTION OF UNWANTED SOUNDS BY THE MICROPHONE

SITUATION	PROBLEM	CAUSES	SOLUTION
REFLECTIONS	Feedback occurs where a so-called "cardioid" microphone is used and the speakers are placed to the rear of the microphone. A common occurrence in churches, auditoriums, and meeting rooms.	Sound bounces off hard surfaces on the walls, floor and ceiling, in and around the audience area and the microphone used is not effective in rejecting these sounds at all frequencies, and in all planes about its axis.	The Unidyne III eliminates this problem because of effective rejection of sound at the rear of the microphone with uniformity at all frequencies. Sounds bouncing off the floor or other reflective surfaces that reach the rear of the Unidyne III are rejected.
COLUMN LOUDSPEAKERS	Unexplained feedback. Column loudspeakers are used to distribute sound more evenly to the audience in churches and auditoriums.	While column speakers direct the sound toward the audience, they also have side and rear sound lobes which may reach the microphone. Feedback occurs when the rear and side sound lobes of the speakers coincide with the rear and side lobes of a so-called "cardioid" microphone.	The Unidyne III solves this problem because it has no rear or side lobes. Thus it rejects the side and rear lobes of the sound column speakers.
REVERBERANT BOOM BOOM	A disturbing, echoing effect of low frequency sound often found in churches, large auditoriums, and arenas.	The particular "cardioid" microphone used fails to retain its unidirectional characteristics with low frequencies. In addition, its front response tends to accent low frequencies of the desired sounds. These factors result in pickup and reinforcement of the low frequency reverberation and boominess characteristic of many halls.	Using the Unidyne III Microphone will solve the problem because it maintains a uniform pattern of sound rejection in all frequencies, even as low as 70 cps. The frequency response also has a controlled roll-off of the low end. This prevents reinforcement of the low frequency reverberation and diminishes the effect of a boomy hall.
PROBLEMS CAUSED BY THE MICROPHONE'S INEFFECTIVENESS IN PICKING UP THE DESIRED SOUND			
GROUP COVERAGE WITH ONE MICROPHONE	A single microphone does not provide uniform coverage of a group. This is commonly experienced with choral groups, quartettes, instrumental combos, and speaker panels.	The particular "cardioid" microphone used lacks a uniform pickup pattern, so that persons in different positions within the general pickup area of the microphone are heard with varying tonal quality and volume.	The Unidyne III affords uniform pickup of the group with a resulting consistency in volume and sound quality among the members of the group.
USING MULTIPLE MICROPHONES	Variation in the pickup level and tonal quality exists throughout the broad area to be covered. This may occur in stage pickup of musical and dramatic productions, panels and audience participation events.	The pickup pattern of the microphones used is too narrow, causing "holes" and "hot spots". The off-axis frequency response of the microphones also varies.	The Unidyne III permits a smoothness in pickup as the true cardioid pattern gives broad coverage with uniformity throughout the coverage area. This eliminates "holes", "hot spots", and the variations in sound quality and permits blending many microphones with ease.
DISTANT PICKUP	Too much background noise or feedback results when working with microphone at desired distance from sound source.	So-called "cardioid" and particularly long range microphones being used are less directional with lower frequencies. In addition, they have lobes or hot spots that pick up sound at the rear, resulting in the background noise or feedback problem.	Use the Unidyne III to gain relatively long range with effective rejection of sound at all frequencies at the rear of the microphone.

SHURE BROTHERS, INC.
222 Hartrey Ave.
Evanston, Illinois

Circle 17 on reader's service card

TINY ELECTRONIC "CHIPS," each no bigger than the head of a pin, are bringing about a fantastic new Industrial Revolution. The time is near at hand when "chips" may save your life, balance your checkbook, and land a man on the moon.

Chips may also put you out of a job ...or into a better one.

"One thing is certain," said *The New York Times* recently. Chips "will unalterably change our lives and the lives of our children probably far beyond recognition."

A single chip or miniature integrated circuit can perform the function of 20 transistors, 18 resistors, and 2 capacitors. Yet it is so small that a thimbleful can hold enough circuitry for a dozen computers or a thousand radios.

Miniature Miracles of Today and Tomorrow

Already, as a result, a two-way radio can now be fitted inside a signet ring. A complete hearing aid can be worn entirely inside the ear. There is a new desk-top computer, no bigger than a typewriter yet capable of 166,000 operations per second. And it is almost possible to put the entire circuitry of a color television set inside a man's wristwatch case.

And this is only the beginning!

Soon kitchen computers may keep the housewife's refrigerator stocked, her menus planned, and her calories counted. Her vacuum cleaner may creep out at night and vacuum the floor all by itself.

Money may become obsolete. Instead you will simply carry an electronic charge account card. Your employer will credit your account after each week's work and merchants will charge each of your purchases against it.

When your telephone rings and nobody's home, your call will automatically be switched to the phone where you can be reached.

Doctors will be able to examine you internally by watching a TV screen while a pill-size camera passes through your digestive tract.

New Opportunities for Trained Men

What does all this mean to someone working in electronics who never went beyond high school? It means the opportunity of a lifetime—if you take advantage of it.

It's true that the "chip" may make a lot of manual skills no longer necessary.

But at the same time the booming sales of articles and equipment using integrated circuitry has created a tremendous demand for trained electronics personnel to help design, manufacture, test, operate, and service all these marvels.

There simply aren't enough college-trained engineers to go around. So men with a high school education who have mastered the fundamentals of electronics theory are being begged to accept really interesting, high-pay jobs as engineering aides, junior engineers, and field engineers.

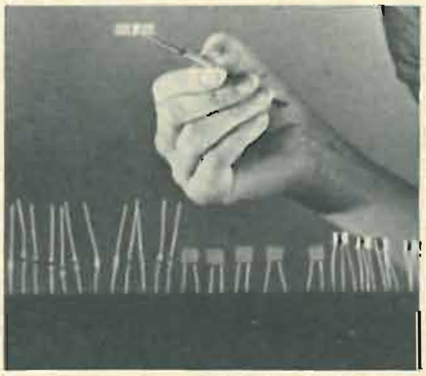
How To Get The Training You Need

You can get the up-to-date training in electronics fundamentals that you need through a carefully chosen home study course. In fact, some authorities feel that a home study course is the best way. "By its very nature," stated one electronics publication recently, "home study develops your ability to analyze and extract information as well as to strengthen your sense of responsibility and initiative." These are qualities every employer is always looking for.

If you do decide to advance your career through spare-time study at home, it makes sense to pick an electronics school that specializes in the home study method. Electronics is complicated enough without trying to learn it from texts and lessons that were designed for the classroom instead of correspondence training.

The Cleveland Institute of Electronics has everything you're looking for. We teach only Electronics—no other subjects. And our courses are designed especially for home study. We have spent over 30 years perfecting techniques that make learning Electronics at home easy, even for those who previously had trouble studying.

Your instructor gives your assignments his undivided personal attention —it's like being the only student in his "class." He not only grades your work, he analyzes it. And he mails back his corrections and comments the same day he gets your lessons, so you read his notations while everything is still fresh in your mind.



50 FUNCTIONS IN A SINGLE CHIP. *The functions of these 50 separate transistors, diodes, resistors and capacitors can now be formed by the tiny dot in the center of the integrated circuit held by the tweezers.*

Always Up-To-Date

Because of rapid developments in electronics, CIE courses are constantly being revised. Students receive the most recent revised material as they progress through their course. This year, for example, CIE students are receiving exclusive up-to-the-minute lessons in Microminiaturization, Logical Troubleshooting, Laser Theory and Application, Single Sideband Techniques, Pulse Theory and Application, and Boolean Algebra. For this reason CIE courses are invaluable not only to newcomers in Electronics but also for "old timers" who need a refresher course in current developments.

Praised by Students Who've Compared

Students who have taken other courses often comment on how much more they learn from CIE. Mark E. Newland of Santa Maria, California, recently wrote: "Of 11 different correspondence courses I've taken, CIE's was the best prepared, most interesting, and easiest to understand. I passed my 1st Class FCC exam after completing my course, and have increased my earnings $120 a month."

TINY TV CAMERA *for space and military use is one of the miracles of integrated circuitry. This one weighs 27 ounces, uses a one-inch vidicon camera tube, and requires only four watts of power.*

Get FCC License or Money Back

No matter what kind of job you want in Electronics, you ought to have your FCC Commercial License. It's accepted everywhere as proof of your education in Electronics. And no wonder—the Government licensing exam is tough. So tough, in fact, that without CIE training, two out of every three men who take the exam fail.

But better than 9 out of every 10 CIE-trained men who take the exam pass...on their very first try!

This has made it possible to back our FCC License courses with this famous Warranty: you *must* pass your FCC exam upon completion of the course or your tuition is refunded in full.

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VETERANS

If you had active duty in any branch of the Armed Forces after January 31, 1955, you may be entitled to Government-paid tuition for any CIE course.

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SERVICE CLINIC

By JACK DARR Service Editor

TRANSMITTING ANTENNAS

WHAT IS THE MOST IMPORTANT THING in a mobile radio installation? The rf power of the transmitter? FM or AM? CB or commercial band? No. It's the antenna. No matter how much power output you get, unless you have the proper antenna, properly *tuned,* you aren't going to reach very far! The antenna is the *load* on a transmitter. Unless you can deliver the rf power to the load, you have no output to speak of.

A proper antenna is a resonant circuit and obeys all the laws and formulas for resonance. A piece of straight wire can form a resonant circuit, and does in this case—the only single-ended tank circuit in electronics! Power flows up the wire and disappears. Or does it? Certainly not. What happens is simple once you understand it.

One wave of current leaves the transmitter, travels to the far end of the wire, and finds there an infinite impedance—an open circuit. So, it bounces. It comes back to the transmitter, where it finds another high impedance. If the length of the antenna is exactly right, it also finds another wave of rf current just leaving. The two have the same polarity, so they join and form a bigger wave, which again goes off toward the other end.

If the antenna isn't the right length, the first wave will not get back to the transmitter at the right time. Then the second wave won't be of quite the same polarity, and will *cancel* part of the first. You get *less* energy than the transmitter is putting out.

With the right antenna, the resonant process builds up the waves each time, until they get so strong they leave the antenna and fly into space. Well . . . almost, anyway.

An antenna is an inductance. Energy in an inductor is stored in the form of magnetic fields in the surrounding space. When the circulating (bouncing) rf currents in a resonant antenna grow big enough, some of the magnetic fields can't get back into the wire, so they leave the antenna. This is antenna *radiation.*

What you have to do to get the most out of any transmitting antenna—from CB to commercial-communication types—is to make sure the wire (or *radiator*) is resonant—that it is properly *tuned.* Transmitters have coils or capacitors for tuning the output stage to make the whole antenna circuit resonant at the carrier frequency.

To check for peak resonance, you need a detector of some sort. The simplest type is a short pickup wire with a diodes in series. If you hook a vom across the diode, you can read the rf strength as a small dc voltage or current. An 18-inch rod with a diode, set up about 10 feet from a CB antenna, will read up to 1 or 2 mA, which will give you a good-sized peak on a 0-3-mA meter.

You can tune a mobile antenna circuit with the pickup on the ground nearby or on top of the car, and a pair of leads running to the vom in the front seat or wherever the transmitter is mounted. You can even tune up base-station antennas with the dc meter leads run as far as 100 feet! All you need to watch for is a peak reading while you make the antenna-tuning adjustments. How much the reading is counts for very little; the actual meter current can be down into the microampere range. What you want is that *peak.*

This procedure applies only to the *antenna* tuning and loading adjustments, not to oscillator or plate-tank tuning. Unless you have an FCC license, you're not supposed to touch those. However, you can legally adjust the antenna tuning on CB radios, for that adjustment can't cause the transmitter to exceed FCC power-output limits in a properly designed CB transmitter.

Maximum meter reading from your simple field-strength meter means maximum energy is being radiated from the antenna. This means that for this antenna and transmitter combination you have made the antenna circuit resonant and are getting maximum efficiency.

If you have some standard to measure against, you can even check transmitters to see if they've lost any rf output strength. Set the pickup at a certain distance from the antenna when the set is first installed and tuned up, and

This column is for your service problems—TV, radio, audio or general and industrial electronics. We answer all questions individually by mail, free of charge, and the more interesting ones will be printed here.

If you're really stuck, write us. We'll do our best to help you. Don't forget to enclose a stamped, self-addressed envelope. Write: Service Editor, Radio-Electronics, 154 West 14th Street, New York 10011.

← *Circle 19 on reader's service card*

note the reading. You can use this as a standard later on to check power output. On commercial FM two-way radios, you can set the pickup at a certain place on the truck or car body, note the reading, and then later check for any rf loss very quickly.

A piece of insulating board of some kind, with a small magnet glued to it, makes a handy mount for the rf pickup. The diode and pickup wire or rod can be mounted on the same board, with a pair of binding posts for the meter leads. You can stick the magnet any place on the car and it'll stay there.

What's a chiff?

I've been listening to a very expensive electronic organ that belongs to one of my friends. There's a stop on it marked CHIFF. *It gives an interesting effect to the note, something like a click, or like the mallet of a marimba striking the note.*

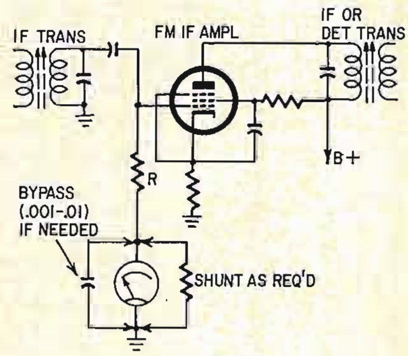
Investigating inside the organ, I found that this consists of a relay circuit with a diode, a capacitor and a resistor for each note "chiffed". Too many wires; so I can't follow the circuit, but I'd like to know what it does.—M. J. R., Los Angeles, Calif.

This is a percussion circuit. What it does, by means of a wave-envelope shaping network (the diode, resistor and capacitor), is give each note a very fast rise time, with perhaps just a wee bit of overshoot. This gives it a very fast "attack", and the percussion effect.

The word "chiff" is used by organists to describe the sharp, short noise caused by the inrush of air into an organ pipe when its key is pressed. For many kinds of music, it's very desirable.

Adding tuning meter to FM tuner

I want to add a tuning meter to my FM tuner. What kind of meter, and where do you connect it?—J. F. S., Islington, Ont.



Basic tuning-meter arrangement that can be found in many FM tuners and receivers.

Almost any kind of meter, depending on where you put it. In AM radios, the tuning meter is a milliammeter in the plate circuit of avc-controlled rf or i.f. amplifier stages. The increase in avc voltage with a strong signal reduces the plate current: so, you tune for a minimum meter reading (a dip).

A good tuning meter in an FM receiver would be a microammeter in series with the ground end of one of the late (third or fourth) i.f. grid resistors. This will read the grid current developed by the stage, which increases as the signal strength increases. The diagram shows how to connect a meter.

When you add a tuning meter to some old or not-so-good FM tuners, you may find that maximum signal strength (as indicated on the i.f. or limiter grid meter) doesn't correspond with best sound. This generally means that the discriminator or ratio detector is not aligned with the i.f. stages, or that the i.f.'s are badly out of line—or both.

RF Pickup Between Recorders

I have an old wire-recorder and a tape recorder. I was transferring some recordings from wire to tape, monitoring with earphones. Sounded good while recording, but when I played the tape back, I had two recordings—one from

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FORM

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Enroll me for a 3-month membership in the Photofact-of-the-Month Club. I agree to pay $10 per month, and understand I will receive 6 current Photofact Sets monthly for 3 months to be delivered by my Sams Distributor (named below).

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Shop Name____________________

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City__________ State______ Zip______

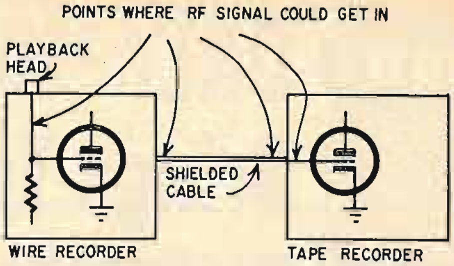
My Sams Distributor is:____________________

Signed:____________________

Circle 22 on reader's service card

the wire, the other from WABC! How did this get in there, and, more important, how can I get rid of it?—F.J.C., Wood-Ridge, N. J.

I can tell you *what* the trouble is, but not exactly *where*. It is undoubtedly rf pickup in the input of the tape recorder, or even in the input circuits of the wire recorder. The rf is being detected and mixed with your recording, so, you hear two different programs at the same time.



The only way to pin this down is by isolation. Hook up both recorders exactly as they were. Turn on the tape recorder, but leave the wire recorder amplifier off. Record a few feet of tape and play it back to see if the WABC signal is there. If it is, then the pickup is in the input of the tape recorder, or in a poor ground in your shielded cables somewhere.

If the interference doesn't show up on this test, turn the wire recorder amplifier on, set it to playback (no wire on the machine) and repeat the test. By this process of elimination you can find out where the unwanted rf signals are getting in.

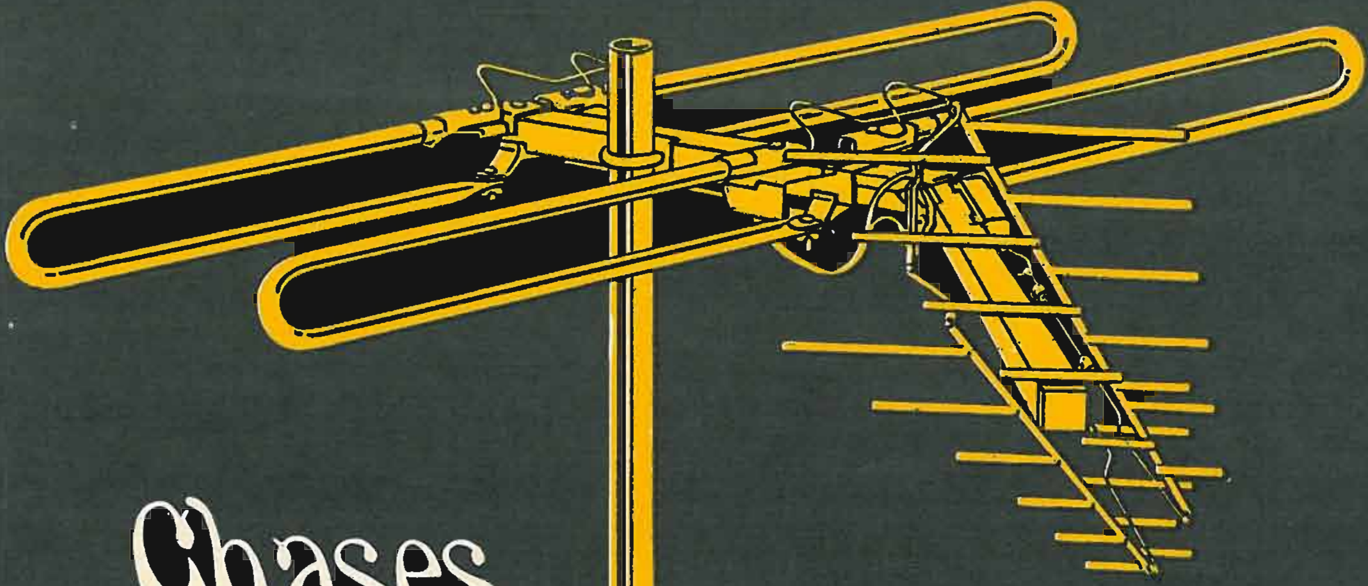
If the trouble does turn out to be in the input of one of the amplifiers, you can check shielding, or, as a last resort, add very small rf bypass capacitors from grid to ground, or even small rf chokes in series with the grid leads.

Intermittent 5U4, Philco 9L41

The filament of the 5U4 goes dark intermittently. I think it's in the power transformer. Can I replace it with a filament transformer?—E. L. Baltimore, Md.

Check carefully before you do any thing that drastic. First, make sure the tube itself hasn't been so hot that it's melted the solder on the ends of its base-pins. This has happened, in this very model. Next, be sure the socket contacts are tight and clean. While it *is* possible that there is a broken wire inside the power transformer, it's fairly unlikely; the filament wire is heavy, and is usually brought out of the transformer as is, without splicing a separate lead onto it. For a check, try pulling and moving the filament wires, watching the tube; if you can make it go on and off, then it may actually have an internal intermittent.

As a last resort, you could always add a small 5-volt filament transformer on the chassis, or a 6-volt one with a small dropping resistor; there should be room on the chassis. Suggestion: how about replacing the 5U4 with a silicon rectifier plug-in replacement?—No filament at all! END



Chases ghosts out of town

In the city you don't need a very powerful antenna. Generally, your problem is too many signals rather than not enough. But strong signals bouncing off tall buildings cause multiple images, commonly known as ghosts. Faint ghosts may not bother black-and-white pictures much, but they're intolerable in color.

Jerrold Metrocolor antennas are especially engineered to solve the problem of metropolitan reception. They reject reflected signals and minimize standing waves. Metrocolor antennas are as effective in preventing ghosts and color smears as many of the bulkiest, most expensive fringe-type antennas. Also, they're made to match Coloraxial cable, a must for color TV.

There are two Metrocolor models: Model MCX-82, covering all UHF-VHF and FM channels, lists for $29.95; Model MCX-13, for VHF and FM only, lists for $16.95. Cash in on the BIG city antenna market with Metrocolor antennas. They chase the ghosts right out of town, and leave the profits for you. Talk to your Jerrold distributor today, or write Distributor Sales Division.

NEW JERROLD

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82-CHANNEL ANTENNAS

FROM JERROLD ELECTRONICS CORPORATION, 401 WALNUT ST., PHILADELPHIA, PA. 19105

Communi-Pac For the Free Lance

CB COMMUNICATIONS

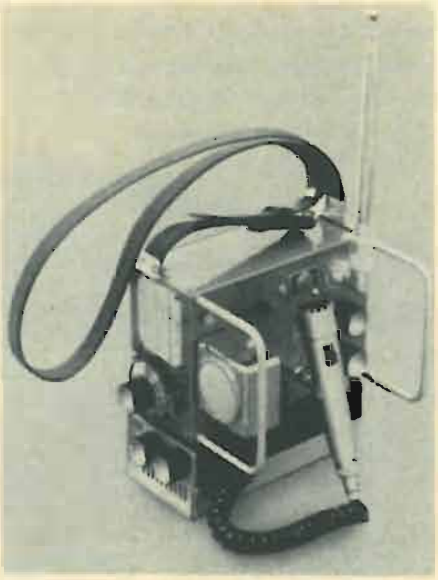
A universal communications system for the free-lance reporter, photographer or writer. Start with recorder and CB radio and add other radios if you need them

By JOHN J. BORZNER

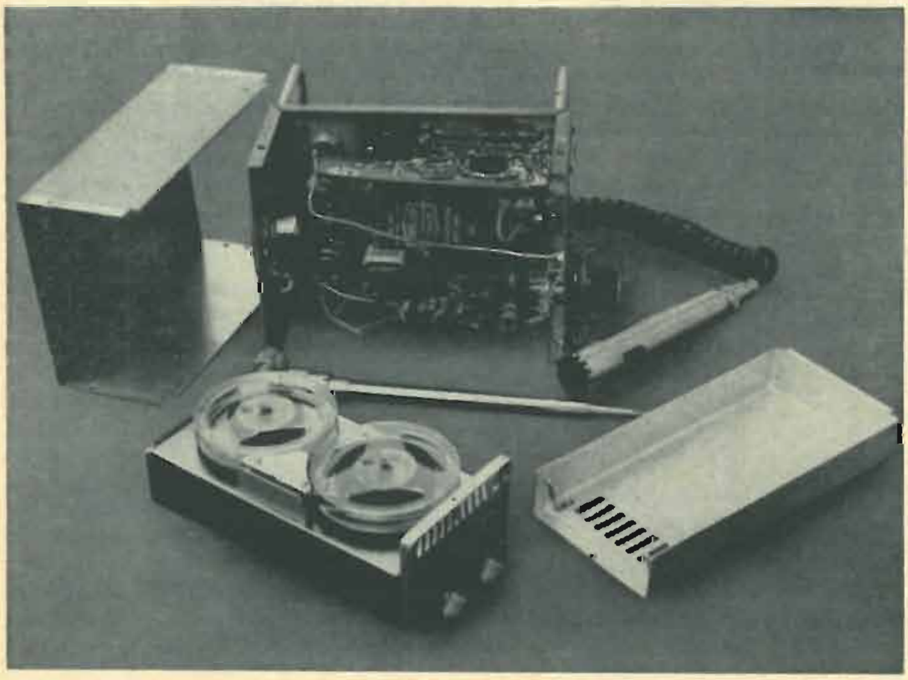
THE FREE-LANCER'S COMMUNI-PAC IS A communications center. Mine was built to suit my own needs whenever I go out chasing a story—to the track, to the stadium, to the docks. You can assemble one to suit your individual needs. Rather than lug several separate pieces of equipment, I devised the Communication-Pac as a single package that contains the specific instruments.

My unit, shown in the photos, contains a Citizens-band transceiver, a tape recorder and an AM–FM radio: A later version includes a marine-band receiver. You may want to use an AM–FM–marine model. An aircraft-tower receiver is to be added to a modification I have planned. Each subunit is transistorized. I picked them so that all have the same voltage requirements, thus the completed unit can use a single battery.

Assembling a Communi-Pac like this one is not at all difficult if the components are carefully chosen for size and weight. Decide on a complete packaging plan before you start construction. The CB transceiver I chose is a Lafayette HA-70A. It has a continuous-tuning superregenerative type receiver. It was selected because its broad tuning covers several channels simultaneously. This is useful for listening at football games or racetracks where several channels are being used. You know where the action is all the time without constantly flipping a channel switch. This feature is also helpful for listening in a moving car where constant tuning is not practical. (The Communi-Pac once picked up two billboard poster men, each analyzing the other's work from opposite sides of a busy four-lane highway.)



Three-quarter view of the Communi-Pac. Custom-built, the basic set consists of tape recorder, Citizens-band transceiver and an AM-FM radio for monitoring. Inexpensive sets and accessories make professional unit.



Interior view of the Communi-Pac. Note that the Citizens-band transceiver and the AM-FM receiver are removed from cabinets. New controls and speakers were added.

The marine-band radio was selected because of my proximity to the fishing fleets. I frequently get my first inkling of a good story listening to the boats pass "the news" to one another.

The AM radio is a natural addition. Considering the small size and low power needs of transistor AM–FM receivers, it seemed logical to pick a combination unit.

Aircraft, fire, public works or other bands of specific interest to you can be substituted. Caution should be used if you plan to add a police-band receiver. Local laws vary on restrictions, but mobile reception of police bands is prohibited in most localities.

The tape recorder is probably the handiest addition. You can record any event you happen to be receiving on the other components, for an audible record. Or, it can be extremely useful for interviews, or simply for taking notes on the scene of a story. Many recorders are suitable. Mine is a Lloyd.

After you have selected the parts, construction of the Communi-Pac is mainly a matter of bolting them together. You can see from the photos and assembly diagram how the unit is built. You can vary the location of the controls, but they should all be kept where they can be adjusted "blind." Also, they should be placed so that they don't interfere with body movements.

I recommend using two speakers. I used the rear-seat auto speaker because the CB transceiver has no squelch control on the receiver and the constant "rush" sound is annoying; with a separate speaker, I can turn it down and still hear the other receivers. A small speaker for listening to both the AM–FM receiver and the marine-band radio is mounted in the rear of the main cabinet. You can see it in the photo showing the unit disassembled.

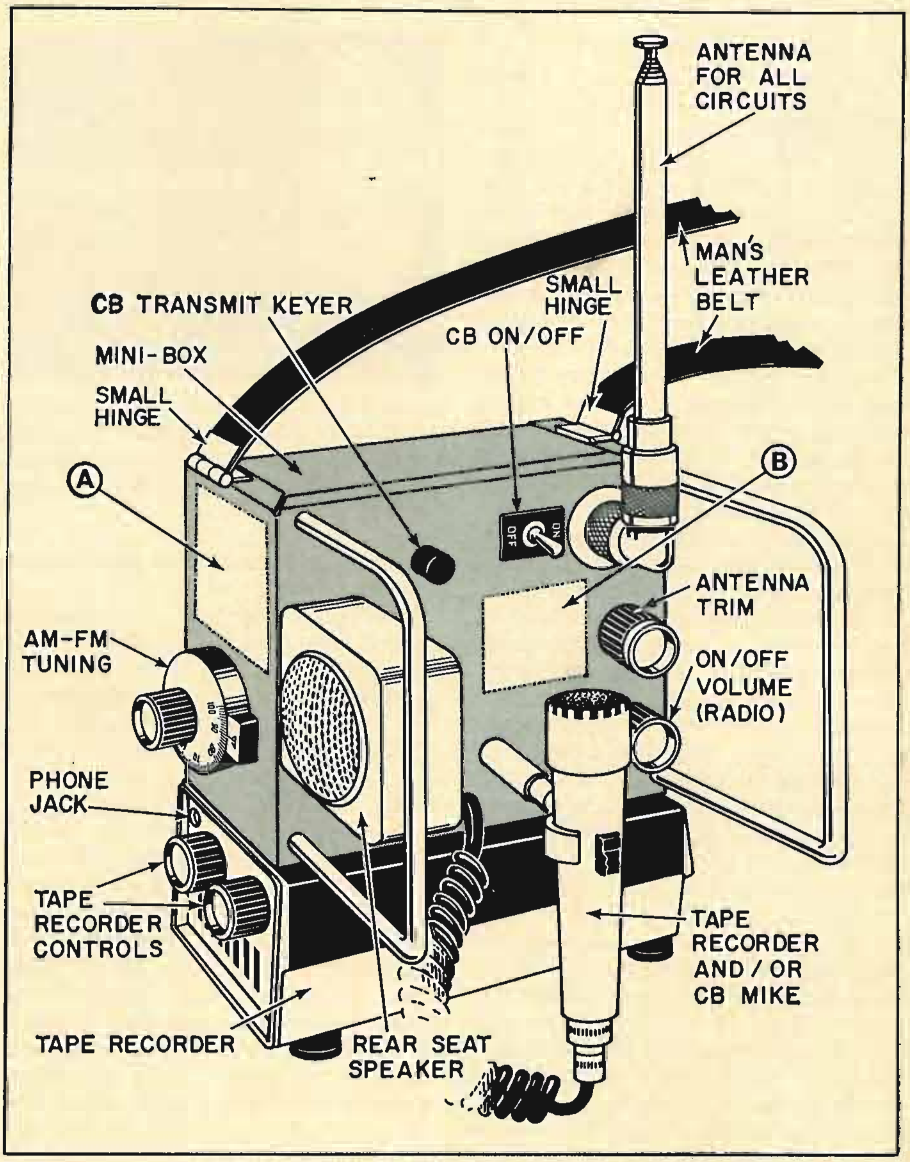
The U-shaped "crash" bars make convenient pickup handles. They were handy in the construction phase and make good supports during trouble-shooting. They also offer protection to the unit during field trips.

The collapsible antenna is the one that is supplied with the transceiver. It was force-fitted into a standard PL-259 coaxial connector, then attached to a right-angle Amphenol rf connector or equivalent. The AM–FM receiver is also coupled to this antenna. A small trimming capacitor is connected between the antenna and all the radios for best matching, and the transmitter is peaked for use with the same antenna, extended halfway. A Hammarlund type-HFA (or equivalent) 4.3–50-pF capacitor is used.

The transceiver speaker can be switched to use as a microphone, of course, and the tape recorder comes with its own mike. However, for convenience, an inexpensive microphone was bought and connected into the Communi-Pac. The one I'm using (you can see it in the photo) is a crystal type that cost $3.95. A clip holds it conveniently on the front of the set, out of the way but easy to reach. How the mike is hooked up depends on what tape recorder and CB set you select.

One dress-up detail is the nameplate, which can be glued on using contact cement, or screwed on. I made mine up very inexpensively, and you can do the same. Cut out magazine type in any style you like and spell out the unit's name or your name and address, reward, etc. Glue the letters and words on card stock. Then shoot a Polaroid picture of the label you have put together, making sure it comes out the final size you desire. RADIO-ELECTRONICS has made up a couple of nameplates that you can use. Cut them out and type in your name and address. Take them to a plastics laminator and have them encased in plastic. The ones on my Communi-Pac cost 50¢ for laminating.

That's about all there is to the Communi-Pac. The units included in mine will be handy no matter what you use the Communi-Pac for. With the "guy on the roof" and the "guy at the set" trying to adjust the antenna in a tough-ghost spot, communication via Citizens band is a distinct advantage. After a climb down a rickety ladder, two and a half stories over the rose bed, your partner's assurance that the picture is perfect had better be good. You can have the evidence on tape. END



A detailed exterior of the Communi-Pac. Note the construction and convenience features that go a long way toward providing good professional performance and reliability.

Nameplates for your Communi-Pac. Cut out and laminate in plastic. The large one goes at A and the smaller at B in drawing above.

LET THE LASERS DO THE TALKING

Coherent light beams are the communications carrier of the future

By H. DALE BELT

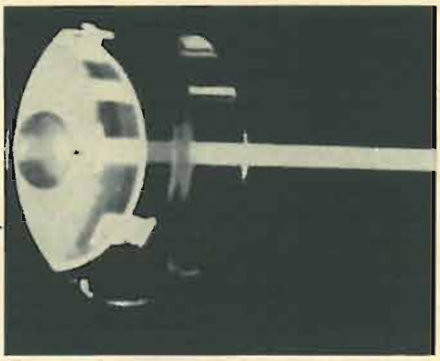
CB COMMUNICATIONS

AS GEMINI 7 PASSED high over Kauai, Hawaii, in its record-setting flight last December, a tiny beam of blue-green light shot up from the island. Astronauts Frank Borman and James Lovell saw the blinking light as it intercepted their spacecraft, and moved into action. With a hand-held unit they sent their own tiny ray toward the earth. Unfortunately, during the few minutes the island was within range for the experiment, the return signal was not detected on the ground. If his signal had been received, Lovell would have switched his unit to a special mode of transmission and sent his voice down the beam to establish the first laser communication between men on earth and men in space.

While our astronauts were looping their way around and around the earth, scientists in Russia were busy testing another laser communication system. They were using a laser beam to connect a telephone exchange office with a tall building at Moscow University. It worked. The system they developed is to be used to transmit large numbers of voice and television channels between two telephone exchanges in Moscow.

In this country, the laser is being put to similar communications uses. In 1963 a laser beam carried a CBS television network program across a table to a receiver where it was detected and sent out to viewers all over the country. Garry Moore cut his program off the air by placing his hand in the beam.

Voices have now been transmitted by lasers thousands of times. Laser light recently carried signals to an Explorer satellite in orbit; the satellite returned them to earth by specially constructed reflecting devices. Today, hundreds of laboratories throughout the United States are experimenting with ways to generate, amplify, modulate and detect laser light, with an eye to its future in communications.



Extreme intensity of laser beam, combined with lack of spreading, makes it especially suitable for line-of-sight communications. One such beam has even reached the moon.

What is the laser (pronounced layzer)? How does it produce its revolutionary new light, and why does it hold so much potential for communications?

The term *laser* is an acronym for *L*ight *A*mplification by *S*timulated *E*mission of *R*adiation. The laser draws energy from the excited molecules of certain materials and emits that energy as a *coherent* beam of light. (Webster: *cohere*—to hold together firmly as parts of the same mass.) The laser beam is coherent in three ways: in direction, in frequency and in phase. This is illustrated in Fig. 1, where a highly directional light beam is represented as many waves, all exactly the same frequency and in perfect phase. This is in contrast to noncoherent light from conventional sources (fluorescent, incandescent and arc lamps, the sun, etc.) which is emitted as a jumble of many wavelengths in every direction and with all possible phase relations. It is the coherency of laser light that makes it so useful and its future so bright.

The laser was proposed by A. L. Shawlow and C. H. Townes in 1958, and a working model was built by Theodore Maiman only 2 years later. (Townes shared the Nobel prize in 1964 for maser and laser work, and early this year Maiman received the Buckley prize.)

Both the maser and laser—as their names imply—operate on the principle of *stimulated emission.* This process is in contrast to the way ordinary light is produced, which is by *spontaneous emission.* In a lamp filament, for example, atoms absorb electrical energy in the form of heat. This causes each atom to undergo internal structural changes that leave it in an excited state. Almost immediately the atom changes back to an unexcited state by spontaneously emitting the absorbed energy as a pulse of energy. This pulse-release process is being repeated billions of times a second by the huge number of atoms the lamp filament contains. The frequency of occurrence of these energy pulses is the frequency of light. Because they are spontaneously emitted, the pulses (called quanta) are random in phase and direction and consist of a wide range of frequencies—from infrared all the way through the visible-light spectrum.

Stimulated emission, on the other hand, is a much more orderly process. Atoms in a carefully prepared environment are raised to an excited state (a process called pumping) but do not spontaneously emit light. Instead, they remain in this condition long enough for a light beam of preselected frequency to be introduced. In response to this light, all the excited atoms are stimulated to release their quanta simultaneously and in the same direction as the original beam.

Fig. 2 shows how the light stimulation is introduced, by flash tubes around the laser rod. The ends of the rod are mirror-finished for reflectivity, but one end is left slightly translucent. The coherent light generated in the rod is bounced back and forth between the ends many times until it grows to an intensity great enough to penetrate one of the reflectors. The result is an intense ray of light with very precise frequency. This is laser light.

The laser has found many applications in the few years since its discovery. It can be focused to provide extremely narrow beams more intense than light from the surface of the sun. Such narrow beams have been used for precise welding, drilling, and machining operations.

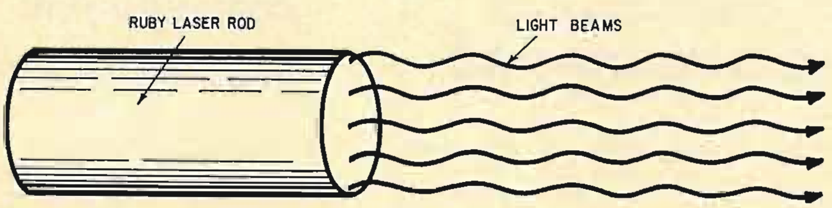


Fig. 1—Light beam from laser rod keeps same frequency and phase throughout. The coherency of the ray makes it as easy to modulate as an ordinary radio wave.

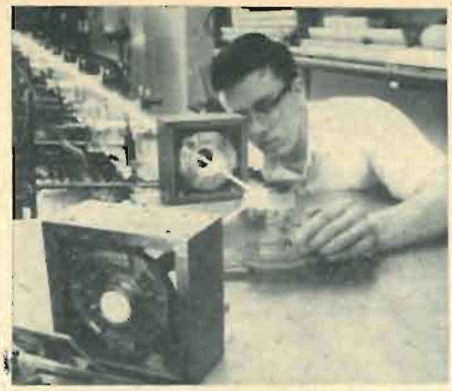
In medicine a laser beam has been used to destroy a tumor in a human eye and shows potential in cancer treatment, dermatology and other procedures where its tiny, powerful beam can pinpoint and affect individual cells. The monochromatic feature of the laser's light has contributed to the design of a gyroscopic leveling device with no moving parts. Lasers have also been put to work in various ranging and tracking devices of hitherto unbelievable precision and accuracy.

A listing of laser applications would take many pages. And new uses are found regularly. All take advantage of the unique property of laser light—its coherency. This is also the basis for its value in communications, which may hold the greatest potential for laser application.

In communications the very frequency of the laser emission is of primary importance. The bandwidth needs of a signal increase as the modulating frequency increases. This has been one of the forces directing engineers to higher and higher frequencies over the history of electromagnetic communications. Also, the trend toward more complex groups of information to be transmitted requires wider bands. Voices can be transmitted with bandwidths of only a few thousand hertz. But television channels need a band several million hertz wide.

In modern communication systems, multiplexing makes possible several television channels or thousands of voice channels on one carrier, for economy in long-distance transmission. Such a carrier must have a very wide bandwidth and high frequency if it is to keep these multiple signals independent of each other. To achieve this, transmitting devices were pushed into the microwave region during World War II. Now, microwave radio-relay systems carry most of our communications traffic between cities.

Communication needs grow at a faster rate than the population. In the decades ahead, these needs will put an increasing strain on present systems of communication. However, attempts to extend electronically generated frequency bands above microwave values met with many difficulties. New waveguide technology has produced useful rf systems in the millimeter range; but, until the appearance of the laser, scientists looked helplessly at the infrared and visible portions of the electromagnetic spectrum—which they knew to contain tremendous bandwidths. Now, thanks to the laser, it is becoming possible to utilize this rich region. In the visible portion of the spectrum alone, a single laser beam could carry all the communications of the world at one time. Properly utilized, it could simultaneously carry several million television programs with room to spare. When the much broader infrared region—where the laser also functions—is included, the almost limitless capacity of the laser becomes evident.



Laser beams for communications are able to be bent around corners by periscope devices. Here, a small prism is used as a passive relay device that changes the direction of the highly concentrated laser beam.

Conventional light sources also emit light at these high frequencies, so why have they not been used for communication? Conventional light is incoherent, which renders it difficult to be systematically modulated and demodulated. The laser, because of its controlled emission, is like electronically produced radio waves and microwaves, carefully monochromatic and in phase. Laser waves, then, like radio waves, can be modulated with information signals.

Much experimental work is under way to find new and more effective ways to modulate and detect these laser light beams. Because there are many different types of lasers (crystal, gas, solid-state), this study is developing on many fronts and with considerable success. It seems evident that when the other elements of a laser communications system are ready, the modulation problem will have been solved.

There is another drawback to ordinary light; it travels in every direction from its source. This property causes its intensity to decrease rapidly with distance. Searchlights overcome this difficulty by using focusing reflectors, and telescopes use lenses. The beam from a laser has the advantage that it does not diverge in this manner. It maintains its direction and strength for great distances, spreading only a few inches in a mile. Such a narrow beam was sent half a million miles on a round trip to the moon and back in 1962. The reflection from the moon's surface was strong enough to be recorded in the laboratory, and was only 2 miles in diameter on the moon's surface—239,000 miles away.

For communication purposes this narrow spread of the laser's light is of prime importance, because it delivers such a large proportion of the original signal compared to other transmitters. Microwave-radio relay systems derive much of their utility from the directionality and minimal spreading of their beams. Even so, spreading and other attenuations usually reduce the microwave signal to a hundred-thousandth of its transmitted strength in the 20 or 30 miles between relay stations. The narrow laser beam could traverse the same distance with only a tiny fraction of these losses, because it spreads so little.

While spreading losses are almost negligible, losses due to atmospheric attenuation are not. This is one of the major problems confronting laser-communications engineers. Air itself is not the chief difficulty here, but what the air may contain. Rain, snow, fog or haze would cut off a laser beam over even a relatively short distance. Light cannot penetrate these obstructions in the manner that radio and radar can. Since most communications require continuous operation without gaps or interference, this imposes a severe limitation on laser systems.

Of course, outside the atmosphere, in space, this problem does not exist. For that reason, laser communication will play an important role in our future

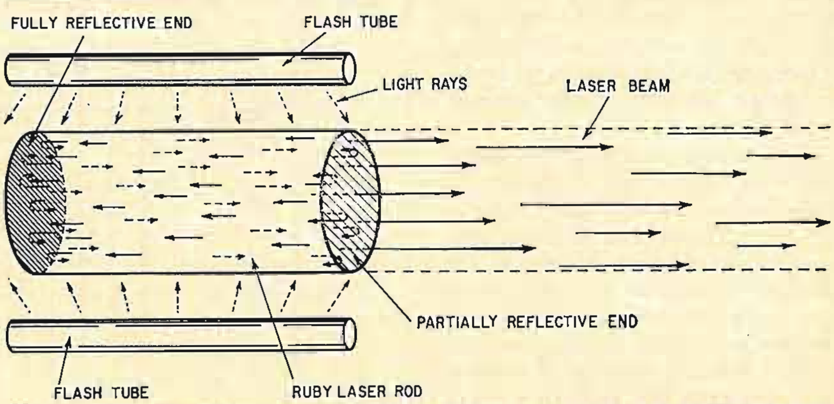


Fig. 2—Mirrored ends of ruby rod reflect light energy back and forth until it is strong enough to break through the end that is least reflective, forming a ray.

space programs. Their huge data-carrying capacity and miniscule beam spreading are compulsory qualities for interplanetary communication where distances are vast and data rates from manned and unmanned exploration craft will be very high.

Atmosphere problems are unimportant in another area where laser communications will play a significant role. Great volumes of information are transferred through the various sections of computers, especially to and from memory storage units. In large computers the hugeness of this exchange is beginning to strain the wires that must handle it. Here the laser may be able to handle the job, again using its ability to carry almost infinite data loads. It could also be used for information transfer between computers—a practice that is becoming increasingly attractive as computers grow in size and cost.

Scientists are presently studying ways to avoid atmospheric interference in earth-bound laser-communication systems. One workable solution may involve some method of enclosing the laser beam in a pipe or tube from which the air can be excluded. Lenses spaced at intervals in the tubes could re-focus the laser light and prevent its spreading. Experiments have shown that power losses are slight in the lenses that could accomplish this, especially with the new gas lenses that have been developed.

As in microwave-radio links, these systems must pass around the curvature of the earth for long-distance usefulness. This means that additional lenses or repeater units will be needed. If the tubes are underground or attached to the surface, they will have to be able to withstand earthquake and other geological stresses without altering transmission. The close tolerances necessary in the lens systems envisioned will provide a considerable challenge to engineers.

A tube laser-communications network will involve high installation costs in addition to its other difficulties. However, the huge quantities of information that a single system could carry should offset these shortcomings. Properly modulated, one laser beam could conceivably handle all communications between two large metropolises for decades to come, even though channel needs increase many times.

Major communications companies are investing money and manpower to develop this young genie. Laser systems are not needed today because our microwave and coaxial-cable systems so far can handle the volume of traffic. However, in the next decade, in our burgeoning space-age society, existing systems may not be sufficient to handle the information explosion. By that time, laser communication systems should be ready to carry the load. END

Zeners as Hi-Cap Variable Capacitors

Reasonably priced diodes exhibit high reverse-bias capacitance

By RUFUS P. TURNER

SOME ZENER DIODES HAVE HIGH JUNCTION capacitance, which can be varied by a negative dc voltage applied to the anode—the higher the voltage, the lower the capacitance will be. You can use this phenomenon to provide a solid-state voltage-variable capacitor with a value higher than is obtainable with regular capacitive diodes. Such high capacitance is useful in audio-frequency tuned circuits and filters, for which a plate-type variable capacitor is not practical. Only a few microamperes of current are required to vary the capacitance, so the value is essentially voltage-controlled.

I tested a number of Zener diodes rated at various wattages and breakdown voltages, and found their zero-dc capacitance to range from 200 pF to .0086 μF. Capacitance, however, is a secondary property in a Zener diode; it is not deliberately engineered into the device. Consequently, its value may vary widely in different diodes of identical type and voltage rating. For this reason, you may have to check several Zeners to find one yielding a capacitance near a desired particular value. Be sure the bridge or capacitance meter you use to test them places no more than 0.1 volt rms across the diode. A good sampling may be bought without spending much money; one mail-order house recently offered a dozen Zeners for less than $2.

Fig. 1-a shows a circuit in which you can use the dc-variable Zener-diode capacitor. The dc control voltage, which may be supplied by a simple battery-and-potentiometer combination (Fig. 1-b), is applied to the dc input terminals. External connections are made to terminals X and Y in the same way as to any conventional capacitor. In Fig. 1-a, 1-meg ½-watt resistor R serves as a current limiter for diode D and also acts somewhat like a choke, isolating the dc supply from any ac that exists in the external circuit connected to the capacitance terminals. C is a 1-μF blocking capacitor (a 200-volt metallized paper tubular is fine) that keeps an external circuit from shorting the dc control voltage and protects the diode from any high dc voltage in the external circuit. The capacitance of C is so high with respect to the diode capacitance that the capacitance "seen" at terminals X and Y is essentially that of reverse-biased Zener diode D.

Fig. 2 charts how capacitance varies with dc input voltage, from .004 to .0086 μF, in a particular 1N1604 10-volt 10-watt Zener diode. The test was made with the combined circuits of Fig. 1. Larger changes seem to be afforded by diodes having lower maximum capacitance. For example, in one 27-volt 500-mW diode, the capacitance varied from 65 to 240 pF as the control voltage was reduced from 22½ volts to zero. END

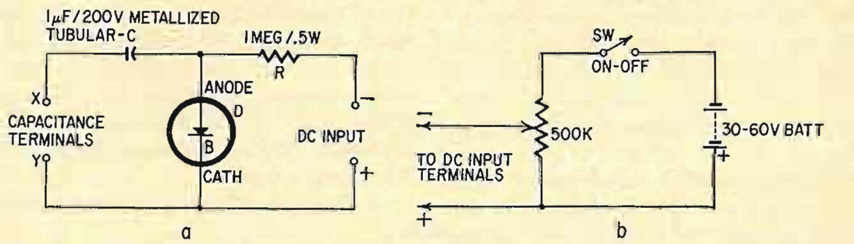


Fig. 1—With reverse bias applied through resistor, Zener diode is capacitor.

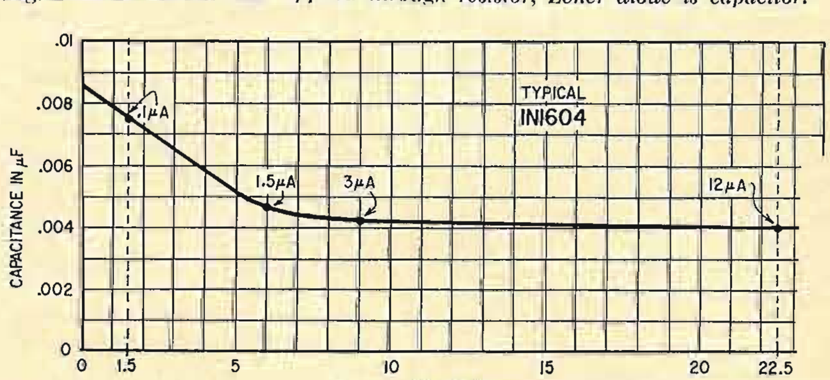


Fig. 2—Capacitance values exhibited by diode picked from low-cost group.

ANALYZING CB FAILURES

If new CB circuits find you in a fog, here's your way out on a course that will guide you to top-notch CB efficiency

By E. F. RICE and ANDREW J. MUELLER

CB COMMUNICATIONS

THE CITIZEN'S-BAND transceiver is no longer a toy. It's a compact, 23-channel, solid-state unit with very sophisticated transmitter circuitry that may include electronic switching of the antenna from the transmitter to the receiver. Many units have crystal-controlled dual-conversion receivers using a frequency synthesizer. Since a typical transceiver may carry a price tag over $200, the CB user wants his unit to be repaired by an expert technician, and there is a growing need for such experts in the service industry. This article describes some of the newer and possibly unfamiliar circuits and offers servicing tips in the form of brief case histories.

An example of up-to-date solid-state design is the Pearce-Simpson Director, a block diagram of which is shown in Fig. 1. The receiver section audio-output stage doubles as the modulator for the transmitter, but the low-level speech amplifiers are separate from the receiver audio amplifiers. Tracing the modulated B+ line from the audio output, you'll see that both the driver and the final rf amplifier are modulated. At the upper left of the diagram is the receiver front end which has two agc systems and employs dual conversion. As we noted before, the modern CB mobile unit is mighty refined.

How frequency synthesizers work

The stages that make up the frequency synthesizer in Fig. 1 are shown within the broken lines. The beauty of a synthesizer is that, by using a master oscillator to feed both transmitter and receiver, the total number of crystals required to transmit and receive on all 23 channels is much less than the 46 required when separate transmitter and receiver crystals are used for each channel. The Director uses 14; others use only 11. The transmitter and receiver sections have their own separate oscillators which heterodyne the signal supplied by the master oscillator. A little arithmetic will illustrate the basic principle: To *transmit* on channel 1 (26.965 MHz), the master-oscillator frequency is 33.000 MHz. Subtact the transmitter oscillator frequency (6.035 MHz), and the difference is 26.965 MHz, which is fed through the rf section to the antenna.

To *receive* on channel 1, the master oscillator frequency remains 33.000 MHz. Subtract the incoming signal frequency (26.965 MHz), and the difference is 6.035 MHz, which is fed to the 2nd mixer to be heterodyned by the receiver oscillator. Receiver oscillator frequency is 6.490 MHz; subtract the first i.f.—6.035 MHz—and you have 0.455 MHz, or 455 kHz, the second i.f.

Fig. 2 shows how the same master-oscillator crystal is used to obtain the first four channels. The transmitter and receiver crystals are chosen so that the correct beat frequencies are produced at the buffer and i.f. stages. For channels 5 through 8, a different master-oscillator

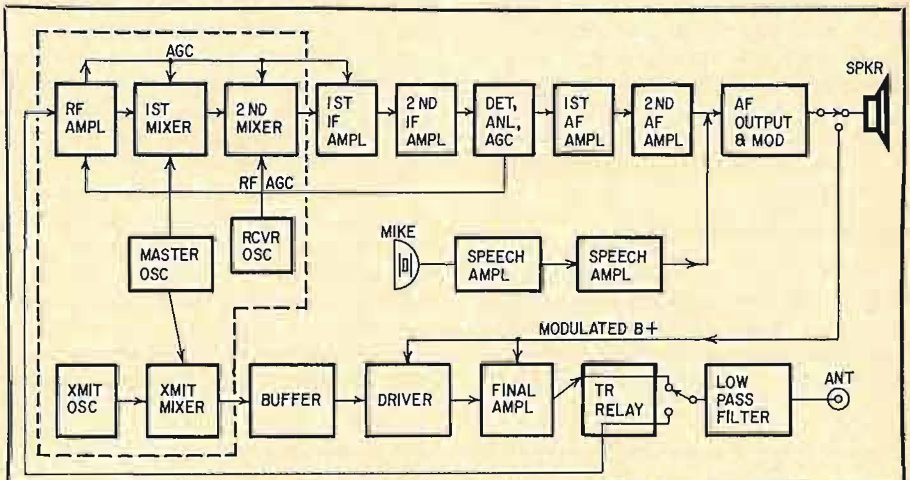


Fig. 1—As in the case of most service-bench problems, CB transceiver problems can best be sorted out by examining overall functions on a block diagram, then pinpointing the trouble to a specific stage that can be serviced using old familiar techniques.

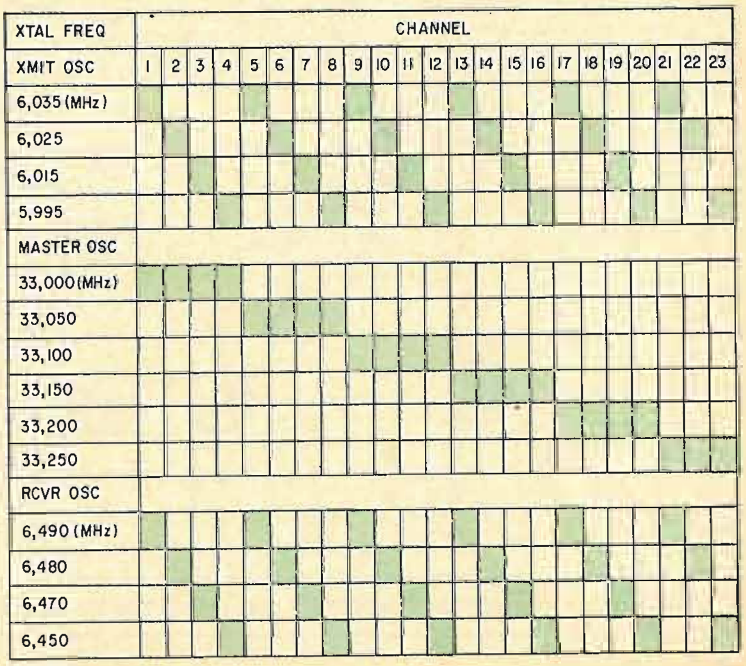
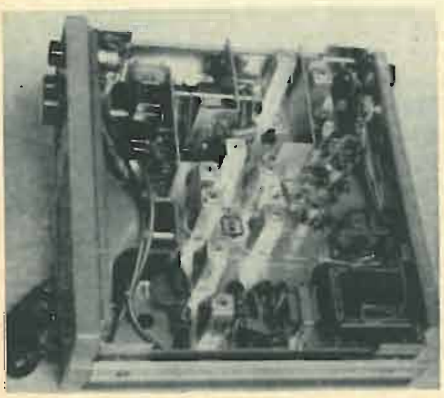


Fig. 2—This chart and a basic understanding of heterodyne frequency mixing will go a long way toward removing the glazed look from the service technician's eyes.



The modern CB transceiver is a precision-crafted instrument demanding highly developed troubleshooting and technical skills.

frequency is employed, and the same transmitter and receiver crystals are used over again. In this manner, all 23 channels are covered by combinations of the 14 crystals listed in the chart.

This ingenious method of obtaining the needed frequencies can lead to some peculiar symptoms when something goes wrong. If one of the receiver crystals fails, for example, or if the channel switch makes a poor contact on one position, reception will be lost on every fourth channel. The same thing happens in the case of a defective transmitter crystal. But if a master-oscillator crystal fails, four adjacent channels will be dead on both *transmit* and *receive*. These situations become even more confusing when some would-be repairman has swapped the crystals around.

Component failures in the oscillator stages produce a different effect and are easier to localize. A failure of 680-ohm emitter-resistor R10 in the master-oscillator circuit of Fig. 3, for example, disables both transmitter and receiver on all channels. A defective R15 in the transmitter oscillator, however, disables only the transmitter on all channels, while an open R13 in the receiver oscillator renders the receiver inoperative on all channels.

Output-transistor failures

Rf output transistors are easily damaged by wrong voltages or improperly loaded antennas. One stubborn case was finally cured by sending the owner to an auto mechanic. The unit was a Hallicrafters CB-12, mounted in a 1965 Ford. The first time the set came in for repairs, the output transistor was shorted. It was replaced, and the rig seemed OK when operated on the service bench, so it was installed in the car.

A few hours later the car was returned, and the owner complained that the transmitter was out again. Examination showed the output transistor was shorted once again. After replacing the second transistor, the unit was installed in the car, and collector voltage was measured with the transmitter operating and the engine running at a fast idle—the meter read 18 volts. This could mean only one thing: The output transistors had failed because a defective voltage regulator in the car allowed the alternator to supply 18 volts.

When replacing output transistors, it's important to use the exact transistor recommended by the manufacturer. This is one place where the so-called "universal" replacements don't work. Be sure to check whether a later modification of the unit might use a different transistor from the original; the new one may have higher ratings. Remember to replace the silicone grease and the radiating fins when they are used.

Another case involving an output transistor is illustrated in Fig. 4 and shows a common-collector output stage used in the Lafayette HB-500. The unit had no rf output and the following steps were taken: A milliammeter inserted at point X revealed that there was no collector current. A milliammeter at point Y indicated normal 50-mA collector current in the driver. With the trouble isolated to the output circuit, the voltages in this stage were checked—11.5 volts on both the base and collector indicated the output transistor was shorted.

The reason for the original transistor failure was not discovered until the technician installed a new one and attempted to load the unit into a dummy antenna; there still was no output. It is standard practice to begin the tuneup procedure with about 8 volts on the output collector, and in this case the technician had inserted a 10-ohm 2-watt resistor in series with the collector. The precaution paid off, because the input capacitor (C2) in the pi-section antenna-coupling circuit was shorted. This removed the output-load impedance and caused excessive collector current, enough to have destroyed the new transistor if full voltage had been applied during the final check.

Another interesting aspect of the output circuit shown is the use of *negative* bias on the base of an npn transistor. We usually expect to find *positive* or forward bias on the base of an npn, but in this case reverse bias on the base is used to keep the stage well beyond cutoff so the amplifier operates in class C.

The reverse-bias voltage is developed like grid-leak bias in vacuum-tube amplifiers. The base of Q1 is driven positive enough at the peak of the input-drive signal to cause a flow of electrons through the emitter–base junction to the right side of C1. Following the positive peak of the input cycle, these electrons leak from the right side of C1 through R1 to the left side, producing a 1-volt bias across R1 and also across the base–emitter junction. This results in a net voltage of −0.62 from base to ground, as indicated on the schematic.

TR-switch failures

Fig. 5 illustrates a typical TR-switch circuit used in many CB units. The receiver-section rf amplifier is coupled to the antenna through C1. During receiver operation, D and C2 have very little effect on the signal. During transmission, the mike switch places a positive voltage on the anode of D, thereby lowering its resistance and effectively shorting the base of the receiver-section rf stage to ground through C2. C1 has enough reactance at the transmitter frequency that it causes only slight attenuation.

The diode is likely to fail in these circuits, and if it shorts, the receiver is disabled permanently. An open diode might not be noticed until the rf-amplifier transistor is destroyed.

The transmitter would not be affected by TR-circuit failures unless C1 were shorted. This condition would probably lead to replacement of the di-

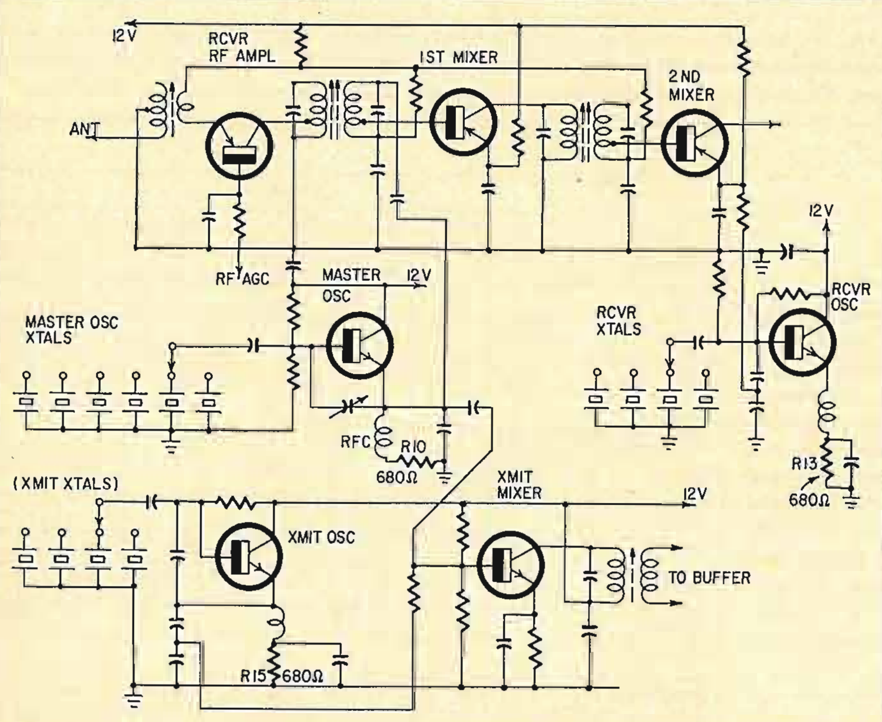


Fig. 3—The frequency synthesizer has enabled CB manufacturers to provide a very complex and serviceable transceiver which uses circuits familiar to most technicians.

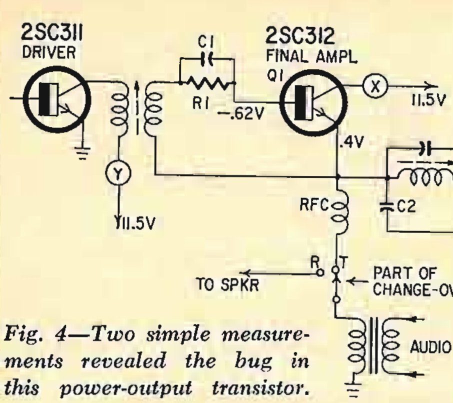


Fig. 4—Two simple measurements revealed the bug in this power-output transistor.

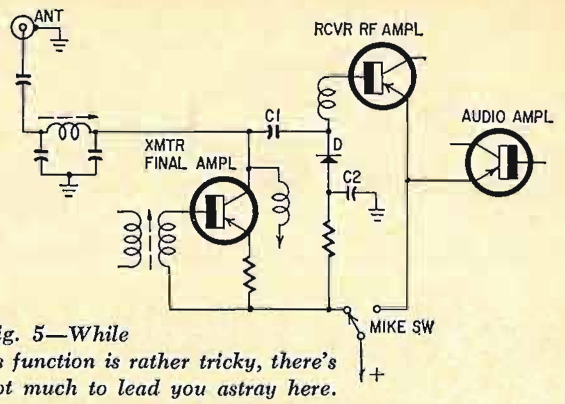


Fig. 5—While its function is rather tricky, there's not much to lead you astray here.

ode and the rf-amplifier transistor in the receiver section.

Relay-type TR switches also develop defects, but the result is usually intermittent operation in transmit or receiver modes, or in both. A typical case is the Johnson Messenger II, which has a plastic cover over the relay that frequently causes the contacts to jam. This failure causes considerable consternation because the unit usually begins to work again after it has been removed from the cabinet, and the unsuspecting technician doesn't know where to begin.

Some tuneup tips

Receiver alignment is pretty straightforward, and you'll find that most manufacturers' instructions are essentially the same. The first step is to feed 455 kHz to the input of the mixer stage (the second mixer in the case of dual-conversion receivers) and tune the i.f. transformers for maximum agc voltage. Then connect an antenna and tune up the rf stage (and the first mixer if there is one) on a signal from another transmitter or from a signal generator loosely coupled to the receiver. Try to make an adjustment which gives the best overall sensitivity on all channels.

The FCC requires that persons adjusting the frequency-determining circuits of CB transmitters must hold at least a Seocnd-Class Radiotelephone Operator License. When making adjustments of the transmitter which might affect the frequency, keep this FCC requirement in mind.

To tune the transmitter, some kind of output meter is needed. Fig. 6 shows one you can make in an emergency, but a calibrated power-output meter such as the Electronic Communications, Inc. Portalab or EICO model 715 CB Tester will do a much better job. The best result will be obtained when following the manufacturer's instructions exactly. If this is not possible, you can do a good job by following the general procedure outlined here.

Start with reduced voltage on the collector of the rf output stage, unless you're sure the transmitter circuits are already close to resonance, then connect a dummy antenna or rf power meter. Measure the dc bias voltage developed at the base of the final rf amplifier and tune the buffer stages and the input tank of the final amplifier for the highest reading on a channel in the middle of the band. Retouch the alignment of these circuits at the high and low ends to be sure the drive voltage does not fall off considerably. Remember that drive voltage will be reverse bias—that is, *negative* voltage when the output transistor is an npn.

Next come adjustments to the final tank and antenna-coupling circuit. Some manufacturers recommend using a scope connected to the final tank to facilitate tuning for maximum rf voltage. A vtvm with an rf probe is simpler to use, and in many cases the point of maximum power output is easier to determine. The scope and vtvm do not actually measure output power; they provide only relative indications, permitting you to adjust for maximum. To determine exactly how much power output this maximum is, you need a commercial dummy load and a calibrated rf power meter.

Final touchup of antenna tuning must be done "on the air," using the regular station antenna. If your earlier adjustments have been made carefully, it will not be necessary to make long test transmissions. The FCC requires that tests on the air be as brief as possible, during a time when the channel is not being used. You also must give the station call sign and identify the transmission as a test.

There are two ways to check the final adjustments: Monitor the signal on the S-meter of a receiver located a few blocks away and have another operator at that position report on the results of each adjustment. Or, use an swr bridge between the transmitter and the antenna and simply tune the antenna-coupling circuit for maximum forward power with the least possible reflected power. The latter is the easiest and more accurate method. Remember to check the signal on several channels and obtain the best compromise.

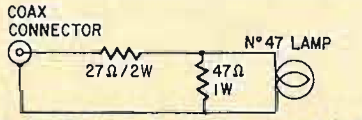


Fig. 6—You can build this output indicator and dummy load for quick or emergency checks, but a power meter and well-matched dummy load are preferred.

Shaping up the whip

Here are some suggestions for getting the best results from mobile-style whip antennas: Some whips, when obtained from the manufacturer, are longer than an electrical ¼-wave and must be trimmed to the correct length as determined by the specific characteristics of the installation. In some cases, the swr of a mobile whip can be as high as 4:1 before it is trimmed, and this represents more than 60% reflected power. With base-loaded whips, cut ¼-inch sections from the base end until an swr of less than 2:1 is obtained. With center- and top-loaded whips, cut off about 1/16 inch at a time.

In areas where salt is used on the streets in the winter, it's a good idea to clean the antenna coil and the spring mounting regularly to improve the swr as well as to prevent corrosion.

Check the button at the tip of the whip when the receiver seems to have excessive noise. If the button is missing, a static charge builds up on the antenna and can cause severe interference.

Repairing CB units is really no different from repairing any other electronic equipment; it takes a combination of theoretical knowledge and practical skill. But, most of all, it takes a lot of common sense. If your CB customers feel you are technically competent and interested in helping them get the best out of their rigs, they will tell their friends, both in person and on the air, and you will be assured of plenty of service business on CB equipment. END

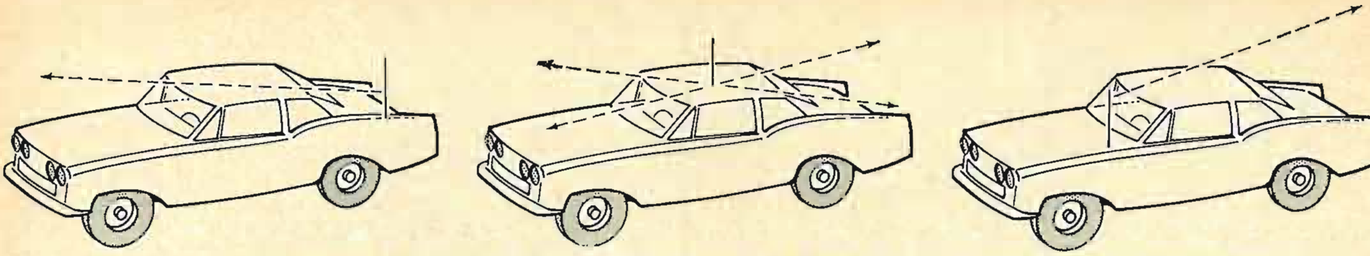


Fig. 1—Arrows show antenna directivity. Top-mounted antenna has greatest range as well as most uniform coverage.

Two-Way Radio Has Its Tough Dogs, Too!

A practical technician gives a few hints direct from his mobile service experience

By DON DUDLEY

CB COMMUNICATIONS

I BEGAN TO HEAR THE term "tough dog" first in TV service; but, believe you me, we've had 'em in mobile FM two-way communications for years—those unique problems that make any kind of servicing challenging to technicians.

Many obscure troubles can be traced to an ineffective antenna. No matter how powerful the transmitter is or how sensitive the receivers, a defective or poorly installed antenna can block both completely. To be an effective radiator, the antenna must use the car for its ground plane. So the best place to mount the antenna is in the middle of the largest expanse of horizontal metal—the roof of the car (Fig. 1). Any other position will give you a weaker signal. With the antenna mounted on the left rear fender, the lobe will be aimed across the car as shown. In fringe areas, take advantage of this and instruct the user to aim the car if he is having trouble getting through to the base station.

Three types of antennas are generally used in the low band: the full-size quarter-wave whip, the disguised antenna, and the glass-fiber helical-wound type.

The braid inside the spring used on the full-sized whip often breaks after long use. Any resistance then between the coils on the spring will allow the spring to act as a base load. The resulting load and increased standing-wave ratio (SWR) reduce the working range. This shows up more with the vehicle in motion.

The disguised antenna has a shorted stub on the antenna feed line to make up for the reduced antenna height. If the stub is not properly placed, it can cause some head scratching. A unit came into the shop with "poor reception." The receiver was gone over and found normal. The antenna was then suspected, but an SWR check read normal for that type of antenna, thank goodness. The officer casually mentioned that the technician who installed his radio did not know if the stub should be shorted or left open. Not wishing to place a short across the feed line, he left it open and then pruned it till he had good loading. A proper length of shorted stub licked the poor-reception problem. Apparently the open stub allowed the transmitter to tune up OK, but soaked up the receiving frequency.

It is sometimes hard to get a good ground with the disguised antenna. As with the open braid, trouble will show up mainly when the car is moving. A squad car came into the shop with the complaint that the operator heard arcing in his transmitted signal. It turned out that the convex half-moon washer was touching the rubber gasket. The rf had completed a carbon path and was arcing to ground across it when transmitting.

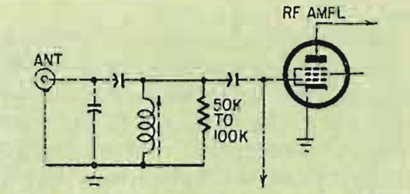


Fig. 2—The resistor improves matching.

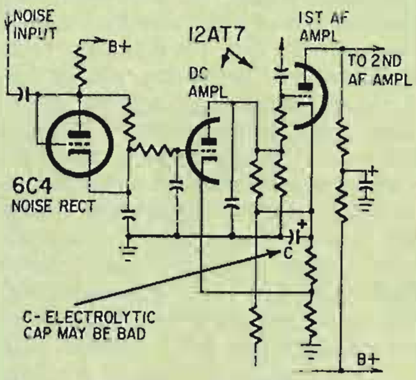


Fig. 3—Bad capacitor kills squelch.

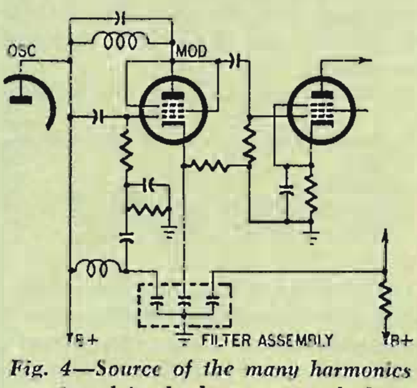


Fig. 4—Source of the many harmonics was found in the least expected place.

The helical-wound antenna is pretty sturdy, but trouble can occur with it, also. A squad car with a helical-wound antenna reported he could not transmit. The unit would not load the antenna. An SWR meter showed as much power coming back as was going out. No breaks could be seen in the plastic sheath. At the shop, a little of the plastic was cut back at the top to expose some wire. A resistance check then indicated the antenna was open. The officer said his children had bent the antenna and let it spring back a few times. Most likely the constant vibration broke the wire lead.

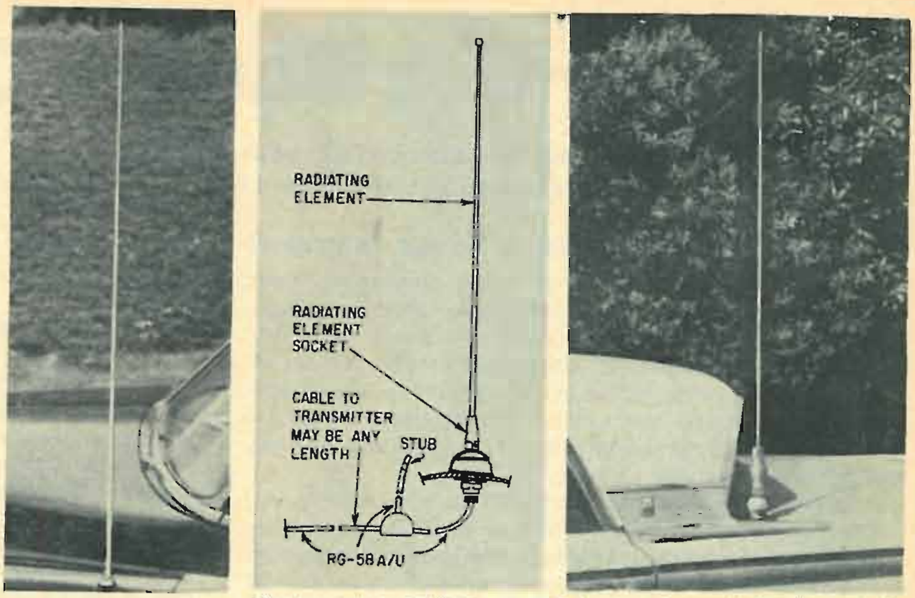
Oscillations and oscillators

Oscillation in the receiver—as indicated by squealing and an abnormally high limiter reading—can be caused by a too high impedance stepup between the antenna and the grid circuit of the tube. This can happen if the antenna impedance becomes lower—which is highly possible with the vertical whip—or if the grid circuit impedance increases. If you don't care to detune the front end of the receiver, place a 50,000 to 100,000-ohm resistor across the grid circuit of the rf tube (Fig. 2). It will improve the impedance match.

Sometimes the oscillations are in the second i f. circuit. In that case tubes are generally at fault. Pulling the antenna and even the rf tube won't stop oscillations in the second i.f. The squelch will be dead, the same as with rf oscillation, and the discriminator will be off zero. A unit with these symptoms came in for repairs. The tubes were carefully checked and even the border-line ones were replaced, but the oscillations continued. The second i.f. tubes were replaced one by one and left in the circuit, with no results. Finally, second i.f tubes of a different make were used. That did it! Apparently the internal capacitance of that particular run of tubes was too high for that circuit.

In some makes of two-way equipment, the front-end crystals are oven-heated to maintain their frequency. Off-frequency operation reduces sensitivity and increases motor noise in the receiver. However, in a few cases frequency shift has been traced to the oven itself. If you have a unit under contract and must supply the parts, a little money may be saved by checking on this item. The thermostat contacts on the oven heater may short together, applying continuous heat and ruining both crystal and oven. In suspected cases, place a voltmeter across the oven heater. The voltage abruptly increases and decreases slightly as the heater kicks on and off. If there is more than one heater, remove them, as they mask the suspected one. You can save the cost of a new crystal if you catch it in time.

In newer Motorola units, the first audio–squelch grid has a high resistance, and a high-resistance short in the squelch tube will cause loss of squelch control. A short tester will have to be very good to be able to pick it out. If you find you are replacing this tube more often than seems necessary, try replacing the electrolytic connected to the cathode of the audio-squelch tube (Fig. 3). If the capacitor shorts, squelch control is lost. If it opens, the audio level drops. Pulling out and replacing the audio-squelch tube (12AT7) often heals the capacitor, giving the illusion the tube repaired the fault.



Photos courtesy C/P Corp. Drawing courtesy Communication Products Co.

Two-way mobile antennas. Disguised antennas are at left and center. The one on the right may be quarter-wavelength long. This type is usually on bumper to reduce height.

Harmonic radiations

We had a complaint from another source that the base transmitter was not only on its own frequency but on several others as well. The tubes and the crystals were replaced and the unit retuned, but to no avail. Further checking and some head scratching revealed a bad filter capacitor assembly in the cathode circuit of the modulator (Fig. 4). Replacing it kept the transmitter on its own frequency only.

The same trouble showed up in a fairly new walkie-talkie. A bench check indicated no defective part, tube or crystal. After a lot of work, we started to go over it with the idea that the fault had come from the factory. The unit was checked part by part against the parts lists. Sure enough, we came up with the wrong tripler coil. The identification mark on the coil did not match the one in the parts list for that frequency.

Some people around the base station complained they were picking up our police calls on the FM tuners. A borrowed FM tuner revealed that the second harmonic of the assigned frequency was causing the trouble. After the usual checks, replacing tubes, tuning, and replacing the crystal, the trouble turned out to be in the second-harmonic filter in the output circuit of the transmitter. Replacement of this one-in-a-hundred fault took the police out of the entertainment field.

Some manufacturers have both primary and secondary tuning slugs on the transmitter accessible from the top of the chassis. Others have one on top and the other on the bottom. I wonder how many technicians made the same mistake I did in the beginning, trying to decide why some of the meter readings were getting low, while forgetting to tune the slug from underneath?

Resistable fuses

Some fuses are good, some are bad, and a few others oddly enough, develop into resistors. While troubleshooting in a two-way unit, I accidentally touched the fuse and discovered it was quite warm. It had turned into a resistor and current through it made it hot. We now measure for a voltage drop across all fuses. A few wrong-gos have been found before they could cause any trouble. The main A-plus fuse, usually located under the hood, may also develop a voltage drop due to rust and dirt which becomes wedged between the fuse and the fuse holder. Many cases of intermittent operation and low sensitivity and power output have been traced to this fault. The battery voltage drops too low for proper operation.

Transistor trials and troubles

A unit came into the shop with a shorted power transistor in the power supply. It was checked out and the transistor replaced, only to have the unit come back a few days later. As nothing could be found wrong, and as only one of the pair was replaced the first time, both were now replaced. A few days later the unit came back. We then checked the generator output with the motor running fast, as we should have done in the first place. The 18 to 22 volts and maybe more the generator was putting out on a high-speed chase was burning out the transistors. A repair on the car's electrical system stemmed the run on my transistor supply.

Low B-plus or no B-plus may often be traced to the silicon rectifiers. In one case, the front-to-back ratio in all rectifiers was checked and found to be normal. The transmitter was held on for a few seconds. Then the old reliable finger meter was used to see if a hot one could be found. Sure enough, there it was! The rectifier would turn bad only under a current drain.

A transistor checker did not pick out the bad power transistor in the case of low-B-plus in a transistorized power supply. The mystery was that, with the transmitter energized, the B-plus to the final was half its normal value but was higher than the receiver B-plus, which is added to the high-voltage supply for the transmitter. The high-voltage circuit and the current drain of the final were checked and nothing found wrong. As the same two power transistors supplied the ac for both the receiver and the high-voltage power supplies, they were not checked till last. Despite what the transistor checker indicated, we replaced them and the high voltage went back to normal. The transistor checker could not tell that the transistors could no longer carry high current. So the old rule "Don't always believe what your tube checker tells you" applies to semiconductors too! END

Xtal + Oscillator = Citation?

The number stamped on your crystal can may not always be the frequency at which your CB equipment is actually operating

By WILL CONNELLY, W6QID, N0TLJ, KKX0973

CB COMMUNICATIONS

MANY CB'ERS HAVE HAD PROBLEMS WITH crystals. Sometimes they won't oscillate. Sometimes they oscillate so far off frequency that the fact is brought to their attention by other CB'ers (or worse, by the FCC!). There is a strong tendency in these cases to think unkind thoughts about the crystal maker or the set manufacturer; but the truth is that both the set and the crystal are probably all right.

Before the manufacturer installs it in its mounting, encloses it in a can, fils the can with an inert gas and solders the case shut, every crystal is tested extensively for frequency, activity and stability. The frequency stamped on the crystal can is (with rare exceptions) a precise and accurate statement of the crystal's frequency *in the oscillator circuit for which it was designed.*

The overtone crystal

Crystals are classed as *fundamental* or *overtone*. These terms define the type of mechanical vibration within the crystal structure. Put two hands together with palms facing each other and rub: the flattened hands represent the crystal blank and the rubbing shows the *single thickness shear vibration* of a *fundamental* crystal. Add a third hand (your own or someone else's) between the others. Keep all three flat and in contact, then move the outer hands in one direction while the inner hand moves in the opposite direction. Reverse directions. This demonstrates the *multiple thickness shear vibration* of a third-overtone crystal. Other modes of vibration can be set up in crystals, but these are the ones used in crystals ground for CB.

A fundamental crystal can often be made to oscillate at the third overtone. A third-overtone crystal can *always* be made to oscillate at the fundamental. For example, a crystal marked 27.105 *MHz* will operate at either 27.105 MHz, in the third overtone mode, or at *approximately* 9035 kHz as a fundamental crystal. (The actual fundamental of a crystal calibrated at the overtone frequency will be slightly lower than one-third of the calibrated frequency—closer to 9031 kHz than 9035 kHz.)

The same crystal can also be operated in either a *parallel-resonant* (high-impedance) or *series-resonant* (low-impedance) condition. The parallel-resonant frequency of a crystal is 1 to 2 kHz higher than its series-resonant frequency. For any given crystal, then, *four frequencies* may be possible (two each at the fundamental and at the third overtone), depending on variables in the operating mode. In the proper oscillator circuits, that third-overtone channel-12 crystal can probably be made to oscillate at 9029, 9031, 27099 and 27105 kHz.

It should now be clear that the numbers stamped on a crystal case refer to the frequency when the crystal is operated in the specific mode for which it was calibrated. But even this is not the whole story. The oscillator circuit must be identical to the oscillator in which it was calibrated. For crystals operated parallel-resonant, good frequency correlation depends on making the load capacitance into which the crystal works identical with the load capacitance for which it was calibrated.

Fundamental crystals are seldom ground for frequencies above 20 MHz, and even here they are but a few thousandths of an inch thick. For operation at 27 MHz, then, it is necessary to use either a third-overtone crystal with output at 27 MHz, or to use a fundamental crystal with output at 27 MHz, or to use a fundamental crystal at 13.5 MHz and double the frequency.

Another characteristic of crystals is temperature sensitivity. Crystals *do* vibrate at different frequencies at different temperatures. And, by the very act of vibrating, crystals heat themselves. So, keep the drive level to a crystal as low as possible. Moderate overdrive causes frequency drift—greatly excessive overdrive will fracture the crystal.

Crystal oscillator circuits

Five circuits predominate in CB equipment: the Miller, the Pierce, the electron-coupled Pierce, the Colpitts and the series-resonant Colpitts. Each is good when used as intended by its inventor, but the first three have serious disadvantages, though they were popular with early CB set designers.

The Miller (Fig. 1) presents a high-impedance load to the crystal, which accordingly oscillates at one of its parallel-resonant frequencies. It can be used at the fundamental or at overtone frequencies if the plate tank is adjusted to the desired frequency. The "plate tank" circuit may be a parallel coil and capacitor or a slug-tuned coil alone (the distributed capacitance of the coil plus the output capacitance of the tube serve as the required capacitor). For CB use, the Miller circuit almost always uses a third-overtone crystal.

Bear in mind that parallel-resonant crystals are calibrated into a specific load capacitance. The capacitance the crystal "sees" in this circuit is the stray wiring capacitance which may consist of socket capacitance plus the interelectrode capacitance of the tube and the capacitance of the crystal

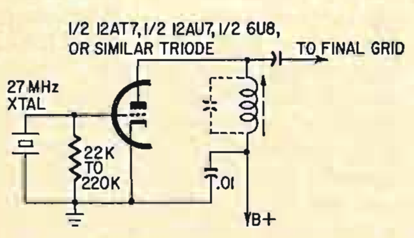


Fig. 1—The Miller circuit, common in the earlier Citizens-band equipment.

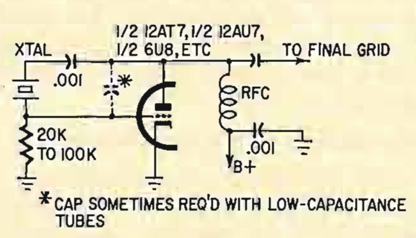


Fig. 2—The Pierce oscillator works well when lightly loaded by circuit after.

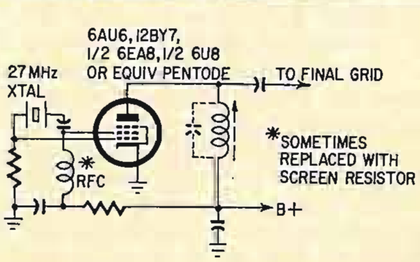


Fig. 3—Electron-coupled Pierce, an improvement over Fig. 2, is more stable.

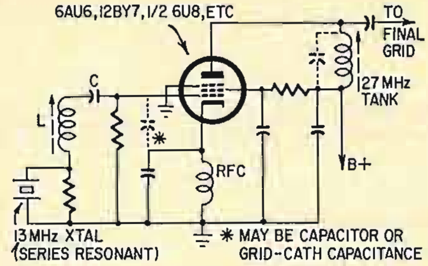


Fig. 4—Series-resonant Colpitts, used as oscillator in some modern transmitters.

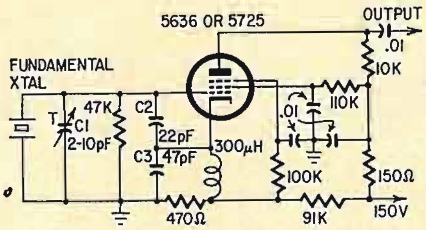


Fig. 5—Navy/NBS version of the standard Colpitts circuit used in military sets.

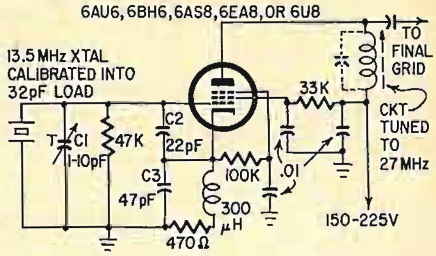


Fig. 6—This commercial Colpitts uses an easier-to-get tube working as doubler.

switch (if used). Any change in plate-circuit tuning affects the capacitances the crystal "sees" as well as the drive to the crystal. The crystal frequency can be "bent" over 5 or 6 kHz—several times the allowable tolerance—by shifting the plate tank.

In fairness, when the Miller circuit is lightly loaded and operated at a point well below maximum output, it is as stable as any other oscillator.

The "lightly loaded" consideration is all-important. The Miller oscillator is not meant to provide *power* to the next stage. It is intended to *establish an accurate frequency,* not to act as a driver. It is very satisfactory as a local oscillator for receivers. For transmitter applications, it should be followed by a buffer (driver) stage.

Another popular third-overtone oscillator using parallel resonance is the Pierce, shown in Fig. 2. (The rf choke is often replaced by a tuned circuit in CB equipment.) It is an improvement over the Miller from the standpoint of frequency stability (there is no adjustment) but has the same faults: inadequate drive to the final unless overdriven, and susceptibility to oscillation with *any* crystal plugged into its socket. The drive problem can be solved by using the electron-coupled Pierce (of Fig. 3). But, unless the tube has an independent suppressor operated at rf ground, the infamous plate tank can once again affect the output frequency. Either Pierce circuit is fine for receiver crystal control.

Note that several new CB transceivers use crystal synthesizers. Miller and Pierce oscillators are entirely proper and satisfactory in these sets, because: first, the oscillators are very lightly loaded, as they were intended to be; and, second, there is no crystal-frequency correlation problem since all crystals are installed by the manufacturer.

A fourth oscillator, this time operating at fundamental series resonance, is the series-resonant Colpitts, shown in Fig. 4. It is apparently used only in Johnson equipment. Coil L is adjusted at the factory, and with C transforms from the very low impedance of the crystal to the high impedance the tube wants to "see." The circuit uses electron coupling. While the crystals actually oscillate at around 13 MHz, the frequency is doubled in the plate tank circuit (which has no effect on the crystal operating frequency). Ample drive is provided to the final amplifier. Crystals may be ordered from any crystal manufacturer by specifying "series-resonant fundamental" and the desired frequency (which is one-half the actual output frequency). This is an excellent, stable oscillator.

The parallel-resonant Colpitts

The Colpitts oscillator is supplanting the Miller in newly designed CB sets. The crystal operates at the fundamental, and the frequency is doubled in the plate tank. Although the crystal is operated parallel-resonant, the Miller oscillator's extreme sensitivity to external circuit changes is eliminated by the heavy capacitance loading across the crystal itself. A circuit change of a picofarad or two—disastrous in a Miller circuit—will seldom move the Colpitts out of tolerance. The very fact that the crystal is capacitively loaded permits a major standardization for the crystals.

The Colpitts oscillator is widely used in military equipment. Preferred circuit PC 102 (from Supplement No. 2 to the Navy's *Handbook of Preferred Circuits,* NAVAER 16-1-519, available from the Superintendent of Documents, Washington, D.C. 20025) is an electron-coupled Colpitts for use from 800 kHz to 20 MHz. It was designed for the Navy by the National Bureau of Standards. The design recognizes a long-existing commercial and military standard for crystals: *frequency calibration with the crystal operated into a 32-pF load capacitance.* The Navy circuit in Fig. 5 is untuned and delivers its output at the fundamental frequency. The circuit values are for operation from 5-20 MHz. A modified version (Fig. 6) uses a commercial tube and includes a plate tank tuned to the second harmonic of the 13-MHz crystals with which it is used.

Once the load capacitance (C1, C2, C3), the stray wiring capacitances and the capacitance of the crystal holder are established, any crystal specified for a 32-pF load may be plugged into the crystal socket with every confidence that the crystal manufacturer will have done an excellent job of frequency calibration. Crystals may be specified as MIL type CR-18. This specification defines a crystal in an HC-6/U holder (the usual CB type) with a frequency tolerance of .005% (as required by the FCC) and calibrated into 32 pF. With the usual stray wiring capacitances, the load capacitance can be adjusted with C1. Plug in one crystal, adjust C1 to zero-beat with a commercial frequency standard (or have the frequency measured with a freqmeter while adjusting C1 to precisely the desired frequency) and all additional crystals ordered to spec will be on frequency.

The closest commercial equivalent to the 5636 subminiature tube used in the Navy is the 6AS6. Excellent results will be obtained with 6AU6 seven-pin or 6AS8 nine-pin tubes in the circuit of Fig. 6. In each case, the independent suppressor grid permits the suppressor to operate at rf ground but at the same dc potential as the cathode. This helps reduce or eliminate frequency variation resulting from plate-circuit loading or tuning variations.

Many new CB sets are adopting the parallel-resonant Colpitts design. One manufacturer (International) of both crystals and CB gear has been using Colpitts oscillators in its transmitters since its earliest design and has ground all its crystals for a 32-pF load. When set builders do adopt the standard suggested by the best engineering minds in the country, the frequency and "pink QSL" problem should be solved permanently for all future CB set production, and users will benefit from universally interchangeable crystals.

For the solid-state fraternity, the Navy and the National Bureau of Standards have created a new line of transistorized preferred circuits. The Colpitts oscillators appear in Supplement No. 1, Vol. II of the *Preferred Circuits Handbook.* END

Quick-Change PA System Saves $$

A multipurpose system that didn't strain a small-town budget

By WILLIAM DARRAGH

EVERYBODY WAS TALKING AT ONCE. "I need a PA system for meetings and banquets," said the Chamber of Commerce.

"I've gotta have sound at the rodeo arena and out on the fair midway for paging," said the Fair Committee.

"We've got to have a sound system in the sale barn," said the Cattlemen's Association.

"We could use better sound at the football stadium," said the Athletic Association.

"How about the beauty contests and talent shows?" asked the Jaycees.

At that point, they all bent over, dragged me out from under the conference table, and demanded, "Well, how about it?"

Badly outnumbered, I got out my little pad and pencil. "OK, OK," I said resignedly. "Just tell me what you want at each place." The co-channel interference started again—all yakking at once. I got them calmed down, and then made a list of requirements and a hasty exit, swearing I'd never make *that* mistake again—attending meetings, that is.

Back at the ranch, I sorted out all the demands and began figuring. This was, of course, one of those "just get us what we want but don't spend any money" jobs, standard in municipal and civic-society work. So, I had to figure out maximum usage with minimum equipment.

Well, Bill, start with a medium-powered amplifier; got to have that. Say about 30 watts—ample power for these jobs. Now, how to spread this out as thin as possible. Fortunately, none of the activities take place at the same time. Rodeo at nights, cattle sales in the afternoons, no football games during rodeo time, and so on. So, here's an idea: maybe use the same amplifier for all of 'em!

Maybe. But what about that most important part—speakers? The first thing that comes to mind is a pair of portable speakers. No. You simply can't cover big crowds like at rodeo arenas and football games, where three or four thousand people are on both sides of a big arena, with portable speakers.

Hey! How about putting up the *right* speakers at each place, and then just lug the amplifier back and forth. Now, that idea looks promising.

Let's see. Four small paging-horn speakers at the rodeo arena, mounted on the light poles so they spread the sound out over the crowd (like in Fig. 1). Already have two horns at the football field, but the amplifier there is old enough to draw Social Security, and not big enough, anyway. Could work out a fixed-speaker system for the bull barn. Finally, a pair of small cone speakers in cabinets for the banquets where we won't need much power output. That ought to do it.

So what'd I do? Well, I started with the rodeo arena. We have rodeos in the fall and spring and, at fair-time, high-school beauty contests, talent shows and so on. For these, they put a portable

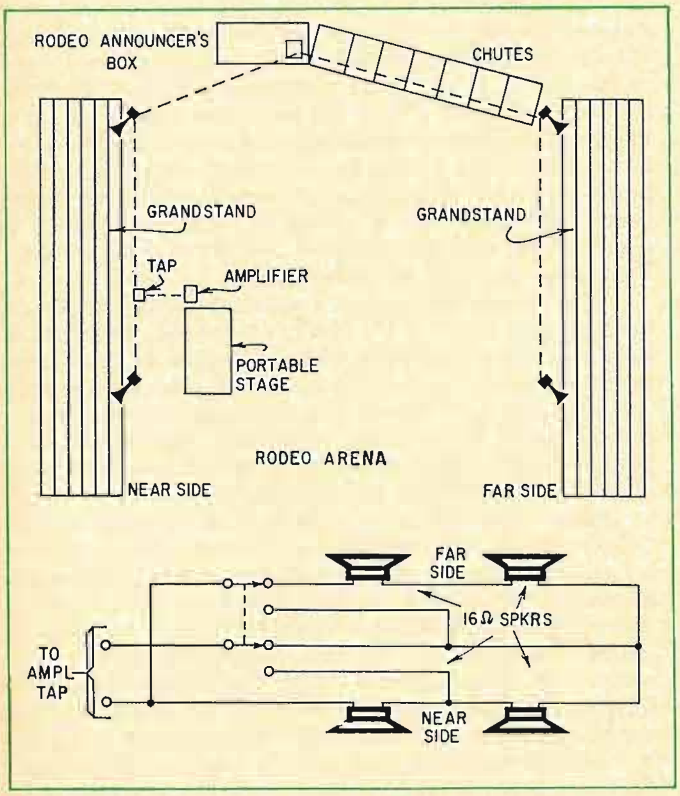


Fig. 1—Dpdt switch in announcer's box opens line to far-side speakers to silence them during such events as beauty contests.

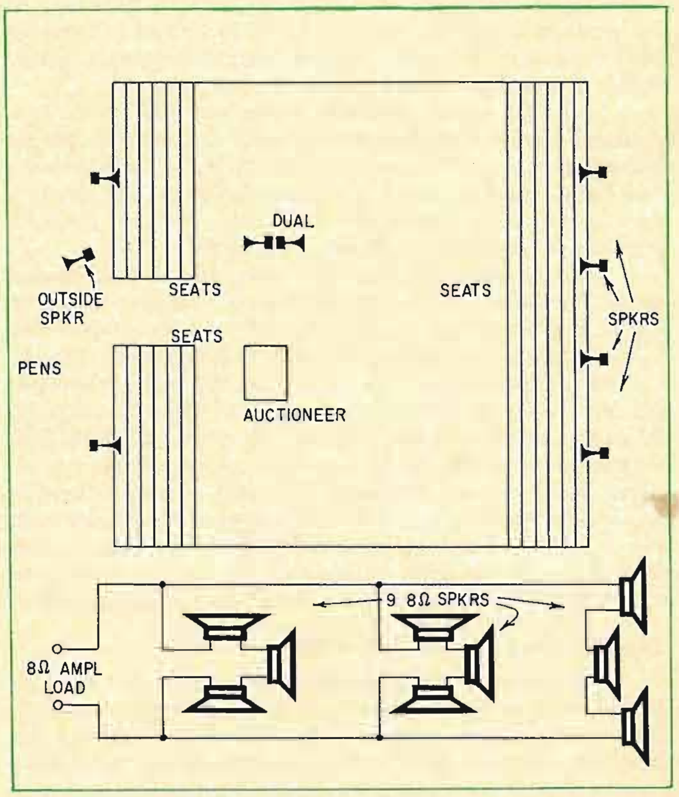
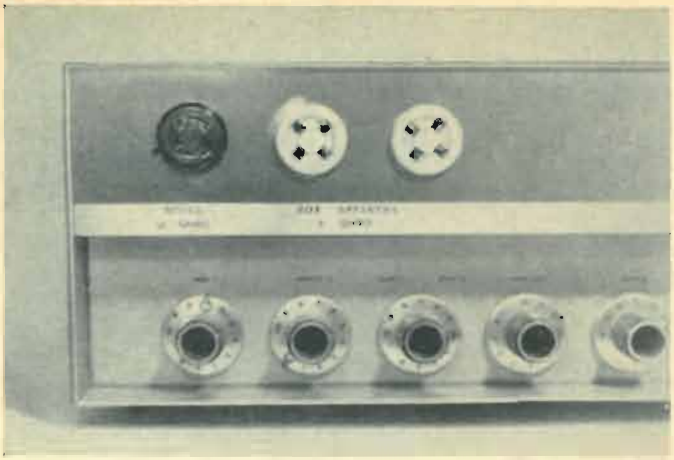
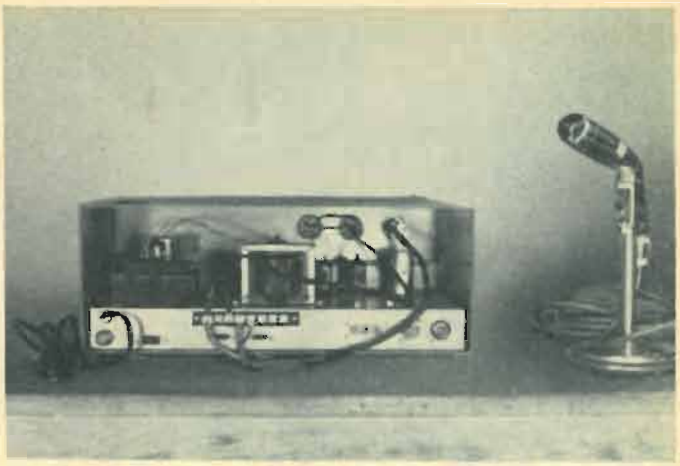


Fig. 2—Speaker system in the bull barn uses nine speakers wired in series-parallel to provide a proper impedance match.





Mounting speaker sockets on the front and color-coding them makes the system easier to use. Sockets are wired to terminal strip on back apron. Mike connector was moved to front panel after this photo was taken.

stage at one side of the arena, and use one side of the rodeo grandstands. To cover the whole crowd, I used four 16-ohm 15-watt paging-horn speakers. Connected the speakers on each side in series, then connected the two in parallel, and I had a neat 16-ohm impedance. The lines were terminated in a terminal block, with wing nuts, at the rodeo announcer's box. A switch was added here, to disconnect (short out) the "farside" circuit. Tell you why in a minute.

To save trouble, I ran a drop down the center light pole, as you can see in Fig. 1. Another terminal block there, for the speaker lines. Also, an ac outlet, wired into the arena light circuit.

When they set up the stage for the beauty contest, we put the amplifier on the ground and connected it to the speakers on one side of the arena, then threw the switch in the announcer's box since we didn't need the farside speakers. This gave us a nice 8-ohm pair on this side.

The speakers were about 100 feet apart, and I wanted to run low-impedance for simplicity. So I used solid No. 12 wire for the speaker lines so that it would be self-supporting over those long spans. Also, saved quite a bit on transformers. The heavy wire avoids line drop on long runs.

Football field: no problem. Already had two nice big horns here that I'd put up some time ago. Both were 16-ohm, in parallel, so I had another 8-ohm set.

Banquet speakers: Got a pair of new 8-inch 16-ohm speakers and had boxes made for them. I fixed them so they buckled together; that made a handy carrier for the amplifier and mike.

Now the worst of all: the bull barn. This is a sheet-metal building about 50 x 50 feet, with seats on both sides and the auctioneer's rostrum down on the sale floor. The acoustics are about as poor as you'd expect, and I was going to have some background noise (an understatement, with the bulls and auctioneer bawling at the same time!). If I tried to brute-force it, all I'd get would be the grandfather of feedback howls from those tin walls. So, I decided to use the "sprinkle" method, which had worked before in similar situations.

I got nine small speakers, 8-inch medium-power jobs (5 watts) and built them into little boxes. Then, we scattered them around all over the place, as in Fig. 2. Just for luck, I put two boxes back-to-back, and hung them well up toward the ceiling over the sale floor. One more was weatherproofed and hung on the outside of the building so the auctioneer could call people out in the holding pens and so on.

Here again I got an 8-ohm impedance. These were 8-ohm speakers, so I hooked three in series, and then paralleled three series groups to get my 8 ohms back again.

With comparatively low sound level in each speaker, I got a good average sound level over the whole area without having to use so high a level that I got bounces and feedback from the metal walls. Works very well, too.

Since the bull barn is at one end of the fair midway, I mounted another outdoor horn—a 16-ohm 20-watt job—on the roof, aimed down the midway. That was the paging horn. The main use is finding out where the county agent is, so somebody can chew him out about something.

A shelf was mounted on the wall behind the auctioneer's stand, and another near the front door. The first holds the amplifier during sales; the other is for paging while the fair is going on.

That took care of the coverage. To finish the job, I had to set this thing up so it would not only be foolproof but "dang-fool proof," too. So, I modified.

The amplifier originally had small, delicate-looking speaker plugs on the back apron. Usable, but they didn't look strong enough to stand up under the abuse they'd get from the amateur soundmen around here! I could have used the multiple-impedance terminal strip on the back, but that would require tools and the ability to figure the right impedance; so that was out. This system had to be automatic!

The front panel was nice and blank above the controls, so I punched three holes and put in heavy 4-hole sockets. I ran heavy wires to the terminal strip on the back of the amplifier. To make it easy for anyone using the system, I used a black socket for 16 ohms and two white sockets for 8 ohms.

At each "speaker system" location, of course, I ran a heavy pair of flexible wires and put on a heavy-duty shell-type 4-pin plug. The 16-ohm system plugs were left black, and the shells of the 8-ohm plugs were painted white. Now, all they have to do is match the colors.

A rugged semicardioid dynamic mike is used with this system. It gives excellent speech reproduction and is good for music as well. With a desk stand for the bull barn, banquets and rodeo announcer—plus a floor stand for the beauty contests and talent shows—we were in business. A short mike cable, about 15 feet, is used for most applications, and a 50-foot extension mike cable takes care of anything else that is needed.

By "designing for use," we came out with a multiple-application sound system that works like a horse. Of course, extra amplifiers permanently installed at each location can be added whenever the boys get up the money. However, this flexible system of mine is one way to get full sound coverage of all kinds of events.

There was only one small hitch in the way it worked. When someone wanted to use the amplifier, it took 2 or 3 hours to find out who had it. We finally solved that by making the county agent responsible for it all the time. Whenever anyone takes it, they sign a log. At least we know where to start looking! END

"And/Or...Nand/Nor"...Computer Talk

Logic circuits aren't confined to computers. Here they are in everyday guise

By IRWIN MATH, WA2NDM

AUTOMATIC INDUSTRIAL CONTROL SYSTEMS, complex computers, and a host of other "thinking" machines use preplanned programs to dictate their operations. These programs tell the machine exactly what to do at each stage of an operation. Such a program, besides commanding each step of a process, entails logical step-by-step evaluation of exactly what effect each event has on following events.

Special circuits, called *logic circuits,* perform comparisons and make decisions. Four of the elementary logic circuits are the *and* circuit, the *or* circuit, the *nand* circuit, and the *nor* circuit. These circuits are the building blocks of complex computers. If you know how they work, you are on your way to understanding computers. In discussing applications, however, you'll see that these logic devices are used in more everyday ways than you might think.

Fig. 1-a is a simple *and* circuit or *and gate* as it is usually called. Switches and a relay are shown, to make the principle easy to understand. Switch A energizes the lamp circuit, and switch B the relay coil. You can see that only when switches A and B are closed can the relay close and light the lamp. Neither switch can light the lamp alone. If you consider the *act* of closing a switch to be an energy input, and the lighted lamp to be a result of output, you can visualize the underlying operating principle of the *and* circuit: both input A and input B must be present for an output.

Fig. 1-b is a semiconductor version of the *and* gate. Again, switch A must be closed to supply collector voltage to the transistor, and switch B must be closed to bias the transistor into conduction, before current can flow through the lamp.

This idea can be expanded to produce an *and* gate with any number of inputs. Fig. 1-c shows a four-input *and* gate. For the lamp to light (an output) all four of the series-connected transistors must conduct. This requires that all switches be closed (all inputs be present) —1 *and* 2 *and* 3 *and* 4. If any one (input) is missing, there is no output. You can make the output (lamp lighting) depend on as many inputs as you like.

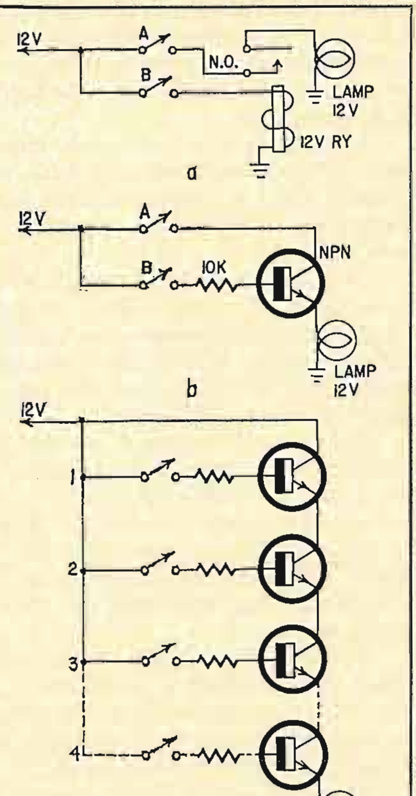


Fig. 1—The AND gate can be set up to operate from as many inputs as you would like; but every input must be active (on) before this gate will generate an output of any kind.

Fig. 2-a is a simple *or gate.* In this circuit input A or B must be present before you get an output. Since the two switches are in parallel, either one will energize the relay and light the lamp. When you examine the solid-state version in Fig. 2-b, you'll see that B+ is always supplied to the transistor so it is ready to conduct all the time. All that is required for an output (make the lamp light) is that any switch be closed, biasing the transistor into conduction. Expanding the number of *or*-gate inputs is simply a matter of adding more switches in parallel with the ones already present.

Up to this point, closing a switch has represented an input. In the next example, you'll see situations where it is desirable to produce an output by opening a switch (removing an input). These characteristics, basically the opposite of the circuits just described, are called *not-and* (or *nand*) and *not-or* (*nor*) logic.

The *not-and* or *nand* circuit will produce an output only when inputs A and B *are not* present. For instance, consider Fig. 3-a. Assume that *opening* a switch constitutes an input. It is obvious that only when *both* switches are open will the relay contacts close and the lamp light. The same function with semiconductors (Fig. 3-b) takes a pnp transistor. When both switches are closed, the transistor base is essentially tied to the emitter. With no base-to-emitter bias the transistor is cut off. Opening both switches (*not* input A and *not* input B) removes this short and the transistor conducts, lighting the lamp.

The *nor gate* (Fig. 4-a) produces an output when either switch A *or* switch B is opened. When either is opened, the corresponding relay drops out, its con-

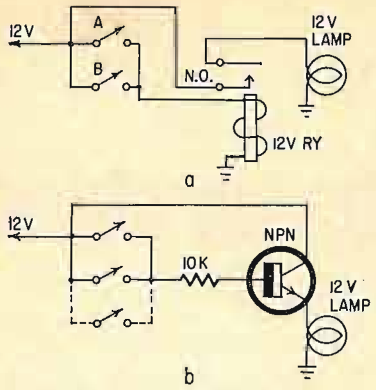


Fig. 2—In the OR gate, you can have any number of inputs; in this logic circuit, however, an output will be produced if any one of the inputs becomes active (or turns on).

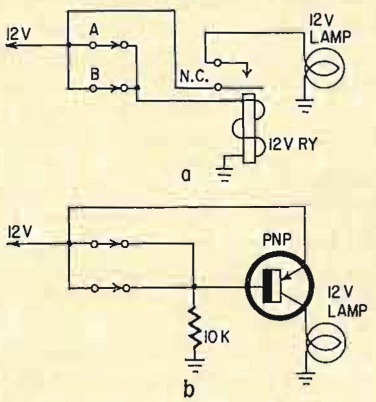


Fig. 3—NAND gate circuit depends on inputs becoming inactive (turning off or being removed). However, every input must be inactivated before an output will be produced.

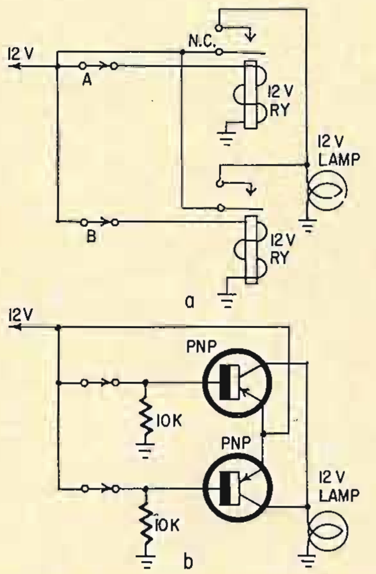


Fig. 4—The NOR gate depends on removal of a single input. Can have as many as is necessary, but losing just one of them is enough to cause the gate to produce output "pulse."

tacts close, and current flows to the lamp. The semiconductor version does the same thing. With neither switch open, the bases of the pnp transistors are at emitter potential and the transistors are cut off. When a switch is opened, however, its transistor is biased on, current flows and the lamp lights.

While the operation of these circuits has been explained using the action of closing and opening switches as inputs and the action of lighting lamps as outputs, most computer circuits are more sophisticated. The usual logic circuit responds to either voltage-level changes or to pulses of some sort.

A typical example of such a logic circuit is given in Fig. 5. This *and* gate is part of one type of punchcard reader. The transistors are biased into cutoff by the base resistors: the resistance of the photocells is very high. When a card moves into place and the two holes on the card reach the right position, light shines through them, illuminating the photoconductive cells. Their resistance drops to a point where the two transistors are switched on. Current flows through the transistors and the 1K load resistor, producing a voltage across it. This voltage pulse is fed to the next logic circuit where it produces another action, and so on. Whenever the specific two holes on a card are in that particular position, there is an output from the *and* gate. By selecting positions for lamps and photocells, you make the many holes on a card represent specific data. The computer "reads" this data as each card moves into position.

Now think about a simple but useful logic-type warning device. Consider this situation: If you leave your automobile with the motor off and the headlights on, the battery will discharge. How about an alarm to warn you before you leave the car? Plan it so the passengers can leave the car without sounding the alarm. The sources of information (inputs) can be: the ignition switch, which we will call A; the headlight switch, B, and the door switches, C. The alarm should sound only if A is open and B and C are closed. Any other condition should not trigger the alarm.

Fig. 6 shows the relay approach. RY1 forms a *nor* gate with switch A as the input, while RY2 forms an *and* gate with B and C as the input. The buzzer sounds only when the headlights are on *and* one of the doors is open, B and C are closed and A is open. The solid-state version (Fig. 7) operates in exactly the same manner. B applies base bias for Q2, but Q2 can conduct only if Q1 does. C applies emitter voltage to Q1, but it can conduct only if a door is open. So, with the headlights on *and* a door open, Q1 and Q2 are both ready to conduct—except that a closed A holds the base of Q1 at the same potential as

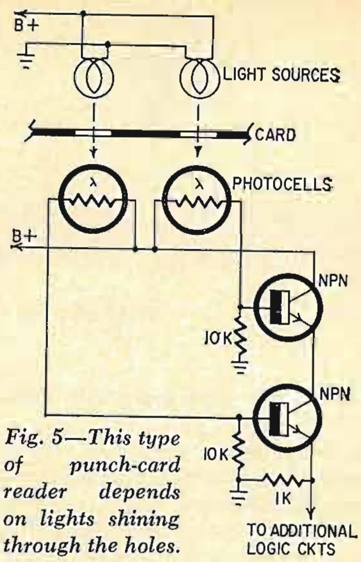


Fig. 5—This type of punch-card reader depends on lights shining through the holes.

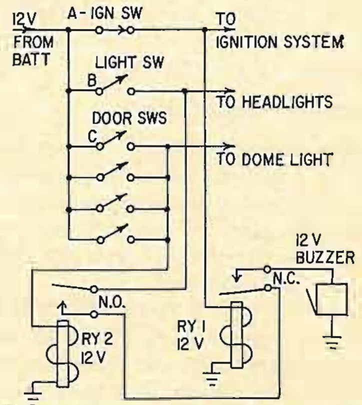


Fig. 6—Headlight alarm shows how logic circuits can be turned to everyday use. This setup takes one AND gate and one OR gate to turn on.

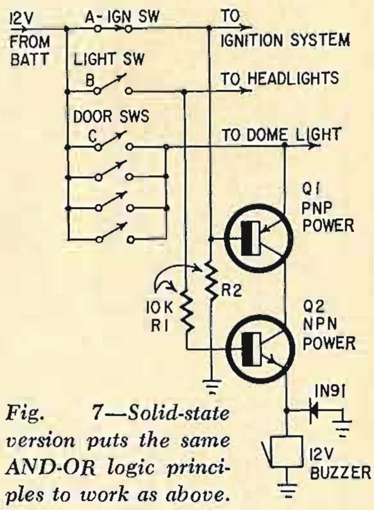


Fig. 7—Solid-state version puts the same AND-OR logic principles to work as above.

the emitter and keeps it cut off. Turn off the ignition switch and you add the final input that sets off alarm. The diodes across the buzzer coil prevent voltage spikes generated by the buzzer coils from damaging Q1 or Q2.

By thinking along these lines, you can construct similar and even more complex control circuits for whatever special application you may have. END

Making Modulation Easy to Understand

This sequel to "Vectors Show How Circuits Work" proves the point

By NORMAN H. CROWHURST

IN THE JULY ISSUE, I SHOWED YOU HOW VECTORS CAN HELP you understand circuit operation. In this followup article, I'm going to show you how to uncover some of the mysteries of modulation through the use of vectors. Take a quick look through the first article (page 58 July RADIO-ELECTRONICS) if you've forgotten any of the fundamentals I brought out there. Then proceed, and see how vectors truly do help you understand circuit operation.

Amplitude modulation

You may recall that amplitude modulation can be represented by a carrier and two sidebands. You can graph this by laboriously adding the sine waves that represent these three frequencies, point by point. *Once you realize that vectors "work", you can do the same thing much more easily from a simple vector diagram.*

You're probably familiar with the convention that a vector rotates *counterclockwise* at the frequency it represents. If we have three *different* frequencies, such as a carrier and two sidebands, then we shall have three vectors, each rotating counterclockwise at a rate determined by its frequency.

With vectors that represent a circuit working at only one frequency, we examine relationships in only one position of the vectors, to make the drawing easier. We imagine, in effect, that we're going around with the vectors, so they appear stationary to us. Or, if you imagine the vectors being driven around by some sort of motor, they could be viewed as stationary by using a strobe light operated at the same frequency. We "stop" them all at a particular point in their travel.

Now, when we imagine the amplitude-modulation vector diagram, we work the strobe light at the carrier frequency. The carrier vector will now appear stationary. The lower sideband will appear to rotate clockwise, and the upper sideband vector will appear to rotate counterclockwise, each at the frequency by which it differs from the carrier frequency.

Completing the analysis, we can show the vector diagrams at different points through the modulation cycle, and show that the resultant vector, made up by adding the carrier and its two sidebands, is always in phase with the carrier (never at an angle to it) and is of varying amplitude, to represent true amplitude modulation (Fig. 1).

In this diagram, C is for carrier, L for lower sideband and U for upper sideband, with R for resultant. We also see a half cycle of all three frequencies at points marked 1, 2 and 3 on the modulation envelope, to demonstrate how the waves themselves add up at the corresponding points on the modulation wave.

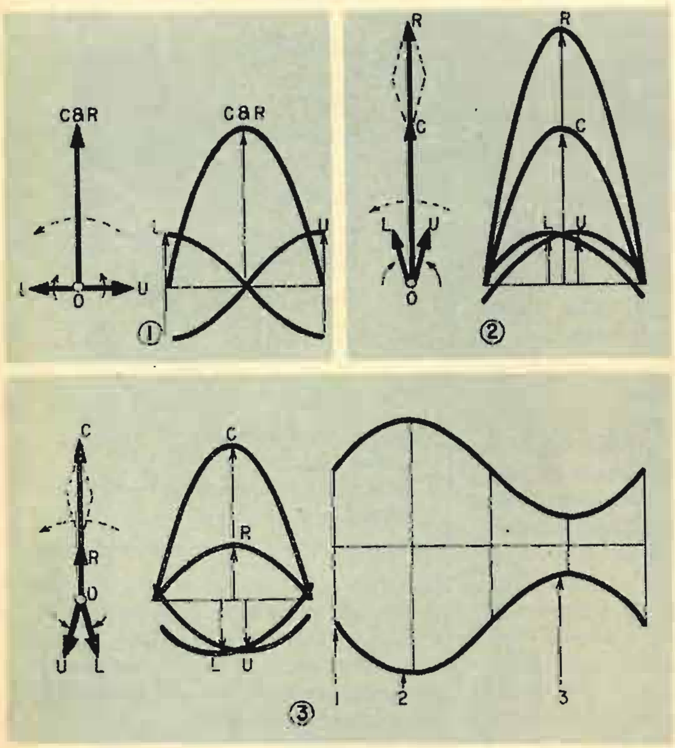


Fig. 1—Vector representation of amplitude modulation. Comparing with sine-wave equivalents shows how the vectors are developed. Sine waves show instantaneous phase relationships.

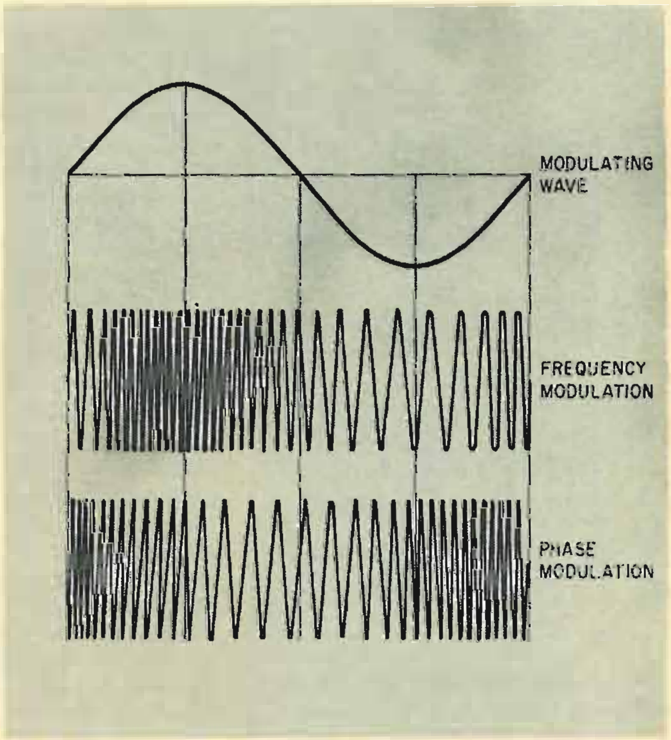


Fig. 2—FM alters frequency of the carrier with modulation; PM (phase modulation) affects the phase of each cycle of carrier. Compare the modulation envelopes of the PM and FM signals.

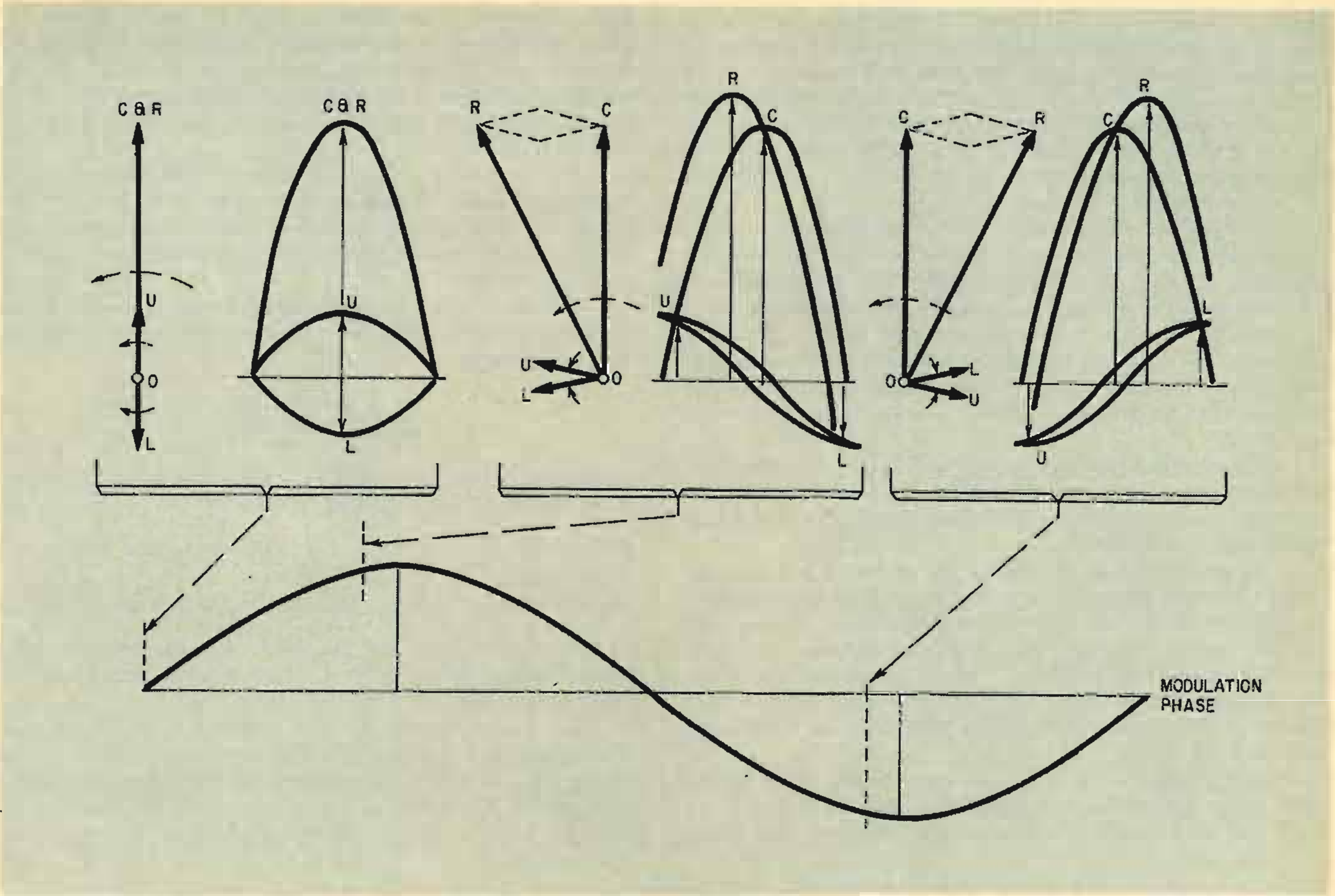


Fig. 3—At center frequency, resultant coincides with carrier. During modulation, the resultant lags, then leads the carrier vector.

Frequency or phase modulation

So far, so good. Now we turn to frequency or phase modulation. For any one modulating frequency, these two types of modulation come out to the same thing. The distinction between them shows up when we consider impressing a complex wave, or a complete program on the carrier, and then determine the relationship between the modulating waveform and the carrier deviation it produces. Frequency modulation changes the *frequency* to match the instantaneous amplitude of the modulating waveform; phase modulation changes the carrier *phase* (Fig. 2).

For our analysis, at one modulating frequency the methods are identical: linear frequency modulation is also linear phase modulation, and vice versa.

Linear amplitude modulation makes the amplitude of the carrier fluctuate in faithful replica of the modulating waveform. It also keeps the carrier frequency or phase constant, as shown by the fact that the resultant wave is always in phase with the carrier. The object of frequency (or phase) modulation is to have the frequency or phase of the resultant vary in faithful replica of the modulating wave, while keeping its amplitude constant.

Frequency or phase modulation is developed by using circuits that modulate the carrier in one of these ways. This modulation must add sidebands to achieve the desired effect. For other reasons (connected with bandwidth and interference), the number and magnitude of the sidebands must be restricted.

What limitation on performance do these restrictions impose? Some discussions imply that nothing is really lost by clipping off some of the sidebands. Even the best explanations have left the matter somewhat hazy. To examine why sidebands are necessary and what they contribute to overall performance quality, we will examine them as if they are added consecutively, in pairs, as required. Then we will analyze just what can be done with successive limited numbers of sideband pairs.

The first step is to add the first pair of sidebands in a different phase relationship from that used for amplitude modulation (Fig. 3). These sidebands have equal amplitude, and start 180° out of phase with each other. Now the resultant swings forward and backward in phase, as well as changing amplitude much less than in Fig. 1 (and at twice the frequency, being minimum at zero and increased at both extremes of the modualting wave). As long as the phase deviation is small, this looks good: the resultant swings on alternate sides of the carrier, and its magnitude doesn't change too much.

But as soon as we step up the amount of modulation a little more, the amplitude starts to change more rapidly than the phase. Before the phase swing can reach 90° in each direction from center, amplitude goes up to infinity. This is why frequency or phase modulation must add further sidebands. First we add another pair, called second-order sidebands. Their frequency of contrarotation, relative to the carrier, is double that of the first pair (Fig. 4). These new sidebands "b" start out in phase with each other. Their amplitudes are equal.

If the second-order sidebands augment the carrier at the zero-modulation (center) point, they will neutralize one another at the half-phase (45°) points, where the first-order sidebands produce a resultant 0.707 of the maximum deviation. At maximum deviation (90°) of the modulating wave), the second-order sidebands will oppose the carrier by as much as they augmented it at the zero point.

Now we can examine how the resultant changes at these three positions (five positions, if we consider positive *and* negative phase excursions, which are identical). Each deviation point considered is analyzed into in-phase (zero-angle) and quadrature (right-angle) components. For the zero-phase point, the resultant is the carrier plus twice the individual second-order magnitude. For the maximum deviation point (90° and 270°), the in-phase component is carrier *minus* twice the second-order magnitude, while the quadrature component is twice the first-order magnitude.

Using C for carrier, a for first-order magnitude and b for second-order magnitude, we can write expressions for the resultant, R, using the Pythagorean theorem. We equate those expressions, to represent the condition that the magnitude is the same at zero and maximum deviation points. (Actually, we equate R^2, to make the algebra simpler: if R^2 is equal at both points, R will be also). Then we derive an expression for second-order magnitude, in terms of carrier and first-order magnitude.

We want to know two more things: Does the amplitude *stay* constant, because we've made it the same at the middle and extremes. Is the phase movement linear with the modulating signal it represents?

To answer the first: making the extremes equal to the middle position magnitude required the value of the resultant at each to satisfy $R = C + 2b$, or $R^2 = C^2 + 4Cb + 4b^2$. Substituting the condition that yields this equality, the intermediate value of R^2 (at the 45° point) becomes $R^2 = C^2 + 2a^2$ (which it is regardless, but by substitution) $= C^2 + 4Cb$. In this last form, it is obviously less than R^2 at the middle and extremes, by $4b^2$.

So the bigger b becomes, the more the amplitude fluctuates at the intermediate modulation point.

The phase-linearity test involves a little trig, but this is fairly simple if we use different reference angles. At the 30° phase-modulation points, deviation (measured as an angle) should be half the maximum, because sin 30° = 0.5. So now we have different relationships at the intermediate phase point, although the middle and extremes are the same as before (Fig. 5).

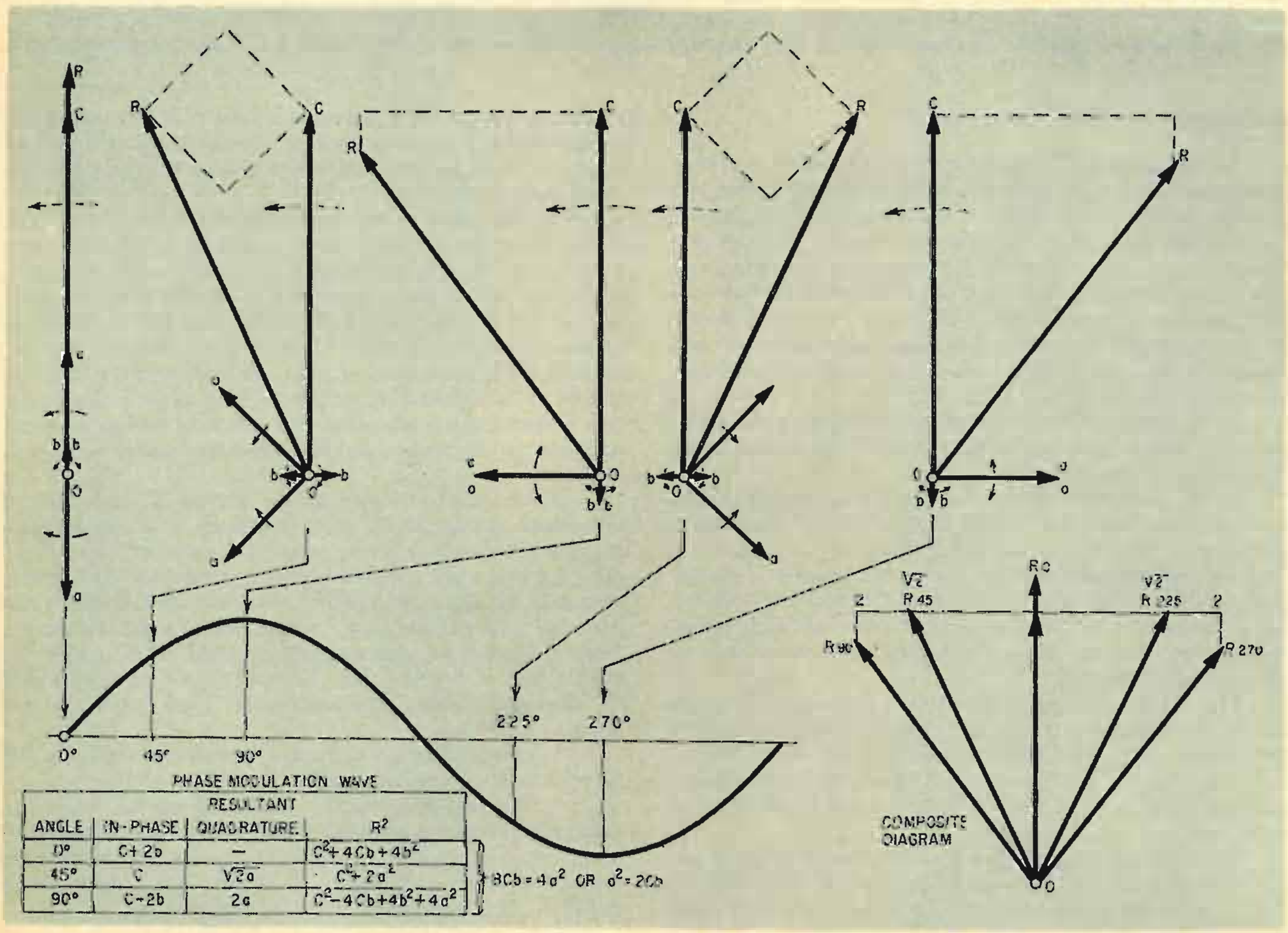
The first-order sidebands will have half their maximum quadrature value in the resultant. The second-order sidebands will be half their maximum value, in-phase-augmenting the carrier (they augmented it by twice this in the zero or middle position).

To check what happens now, we make the half-phase deviation precisely half the maximum deviation, using the tangent formula

$$\tan 2\phi = \frac{2\tan\phi}{1 - \tan^2\phi}.$$

Making the proper substitutions, tan ϕ (the half-angle vector) is its quadrature component divided by its in-phase component, or $\frac{a}{C + b}$, while tan 2ϕ is the same ratio for the full-angle vector, or $\frac{2a}{C - 2b}$. Equating the two values for tan 2ϕ (one from its vector and the other from the formula using tan ϕ) and simplifying by ordinary algebra (not shown in detail) yields the condition $a^2 = 3(Cb + b^2)$.

As the expression for the zero-phase amplitude does not include any quadrature component (component with a in it) and those for half-phase and full-phase amplitudes both do, we can substitute for a^2 in each of the latter, to get the same form, so amplitude variation is more apparent. Now



ANGLE	RESULTANT IN-PHASE	RESULTANT QUADRATURE	R^2
0°	C + 2b	—	$C^2 + 4Cb + 4b^2$
45°	C	$\sqrt{2}a$	$C^2 + 2a^2$
90°	C − 2b	2a	$C^2 - 4Cb + 4b^2 + 4a^2$

$8Cb = 4a^2$ OR $a^2 = 2Cb$

Fig. 4—Modulation increased. Vectors associated with different points on the modulating wave show why more sidebands exist.

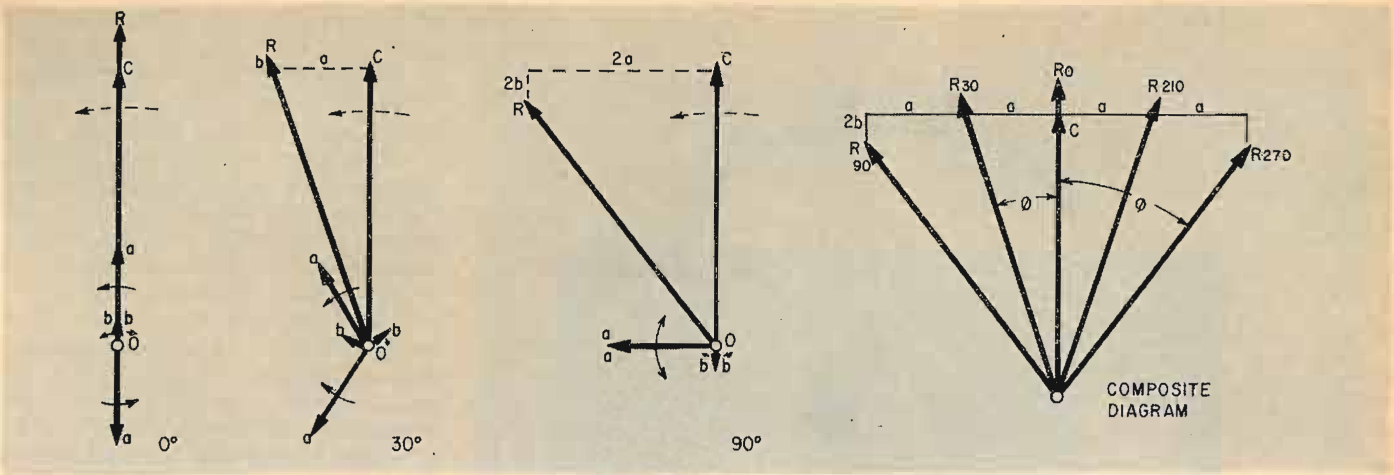


Fig. 5—Vectors here resemble those in Fig. 4 to some extent. The 90° vectors are exactly the same, intermediate points differ.

the expressions are

For zero phase, $R^2 = C^2 + 4Cb + 4b^2$

For half phase, $R^2 = C^2 + 5Cb + 4b^2$

For full phase, $R^2 = C^2 + 8Cb + 16b^2$

The value substituted for a^2, in terms of C and b, makes the half-phase point true. Maintaining linearity of phase modulation makes the amplitude vary even more than it does when zero and maximum-phase amplitudes were made equal, because half-phase and full-phase values of R^2 are both greater than the zero-phase value.

From this point, we can add the third-order sidebands and see what *they* yield. This has been done, qualitatively, in Fig. 6. The math to go with it gets a little more involved.

The point to emphasize is that, as each sideband is added, vector analysis provides a complete picture of what happens, which cannot readily be gained from the analysis using pure math involving Bessel functions. Adding this third sideband pair enables both the constant-amplitude and the phase-linearity conditions to be preserved more closely.

As deviation is increased, fourth-order sidebands are needed to keep phase linearity.

What FM sidebands do

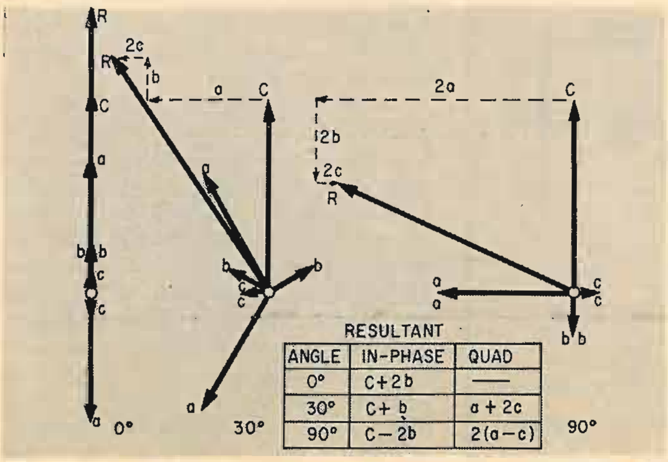
In summary, the first-order sidebands change their amplitude before they show appreciable nonlinearity of phase modulation. The second-order sidebands primarily correct the variation in amplitude, but in doing so fail to maintain phase linearity. The third-order sidebands enable phase linearity to be preserved further, but again leave amplitude deviating a little more. The fourth-order sidebands correct this, and so on, back and forth, as wider overall deviations become possible.

We can see that the first difference between amplitude and phase modulation is in the phasing of the same first-order sidebands. From this it can be shown that a phase shift here will transfer some modulation energy from amplitude to phase, or vice versa (Fig. 7).

The successive magnitudes of the carrier and the different sidebands can be shown for different magnitudes of maximum deviation.

The carrier gets smaller and smaller and eventually passes through zero and reverses its phase, relative to the rest of the family. Further study would show that all the sideband amplitudes go through cyclic variation of magnitude and phase, as deviation is increased, to preserve the same constant resultant magnitude.

This is an interesting and enlightening way to study frequency modulation. It shows "what has to give," from a performance viewpoint, to maintain linear modulation and constant amplitude. We can use vectors, as we said, to show how various other electronic circuits work. In later articles, if we find you're interested, we can take up some of them. END



RESULTANT

ANGLE	IN-PHASE	QUAD
0°	C+2b	——
30°	C+ b	a + 2c
90°	C−2b	2(a−c)

Fig. 6—More sideband pairs added, third-order this time. By vectors, we see proof that adding sidebands preserves linearity. Math required for the analysis is involved but is not difficult.

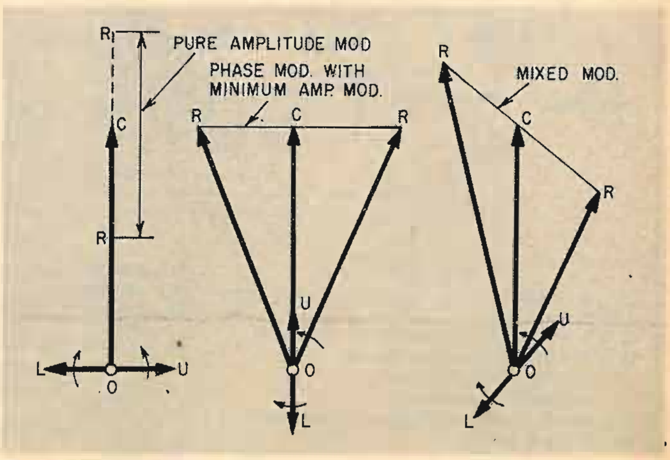
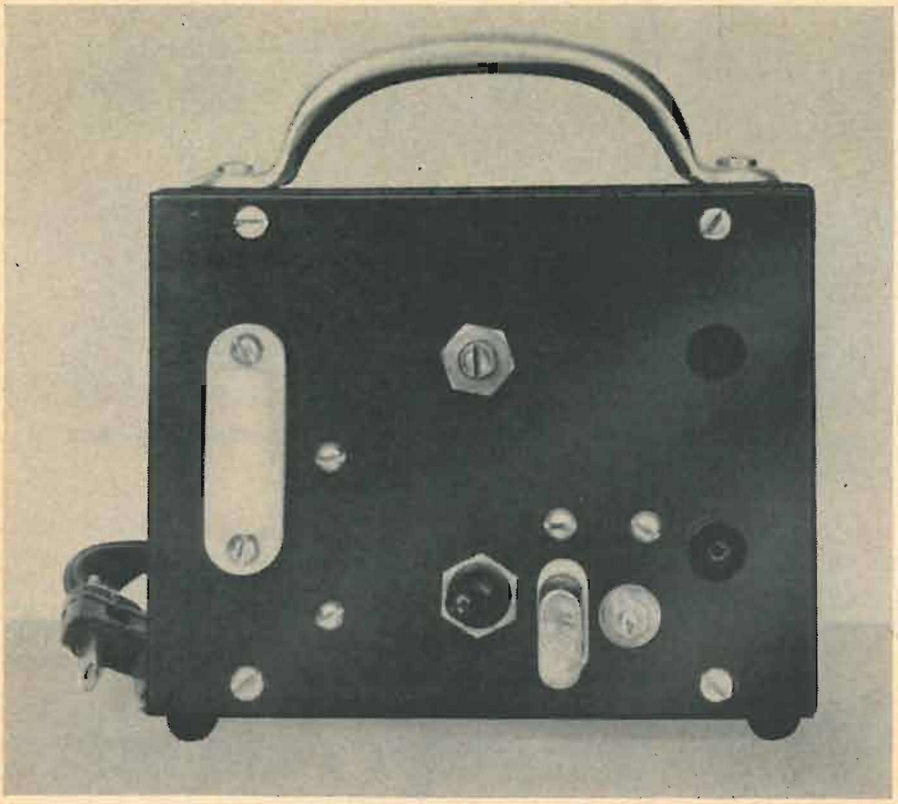


Fig. 7—Showing the effects of mixed modulation on transmitter output. Resultants at equidistant points vary radically in amplitude, thus indicating presence of undesired modulation products.

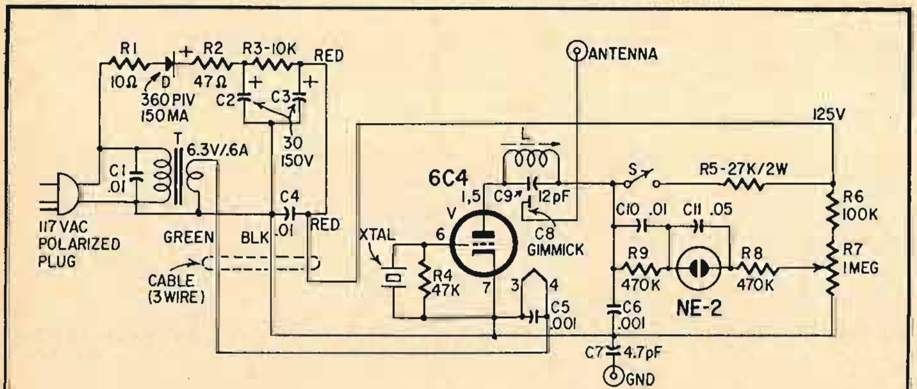


Although a specialized kind of signal generator, this CB calibrator is useful for a variety of other purposes around the CB owner's workbench and for repair technicians as well.

CB'ers Crystal Calibrator

CB COMMUNICATIONS

This 23-channel calibrator makes channel identification as simple as plugging in an overtone crystal



Parts List

- C1, C4, C10—.01 µF, tubular ceramic, 600 volts
- C2, C3—30 x 30 µF, electrolytic, 150 volts
- C5, C6—.001 µF, ceramic wafer
- C7—4.7 pF, tubular ceramic
- C8—"gimmick," see text
- C9—12 pF, Centralab TCZ-12 or equivalent
- C11—.05 µF, mica
- R1—10 ohms, 1 watt
- R2—47 ohms, 1 watt
- R3—10,000 ohms, ½ watt
- R4—47,000 ohms, ½ watt
- R5—27,000 ohms, 2 watt
- R6—100,000 ohms, ½ watt
- R7—1-megohm potentiometer, screwdriver-adjust
- R8, R9—470,000 ohms, ½ watt
- D—silicon rect, 360 piv, 150 mA
- L—11 turns No. 28 wire on CTS PLS5/B form
- S—spst toggle
- T—6.3-volt filament transformer, 0.6 amp
- V—6C4
- Xtal—Third-overtone-cut for each CB channel
- Miscellaneous hardware, NE-2 neon bulb, sockets, coil form pin jacks, handle, 5 x 4 x 3-inch box, Bakelite

By LYMAN E. GREENLEE

ALTHOUGH THE SIGNAL GENERATOR found on the average workbench may be adequate for servicing AM radios, it's of very little use in locating Citizens-band channels. About all you can depend on is that it will locate the 27-MHz band. To locate individual channels, a crystal calibrator is almost essential.

The calibrator shown in the photo will pinpoint all CB channels, using a separate plug-in overtone crystal for each frequency. Cost of the unit is moderate, and construction is simple. Power-supply components are mounted to the rear metal panel of a 5 x 4 x 3-inch metal utility cabinet, and the 6C4 oscillator and its associated rf components are assembled on a Bakelite front panel. There is no chassis.

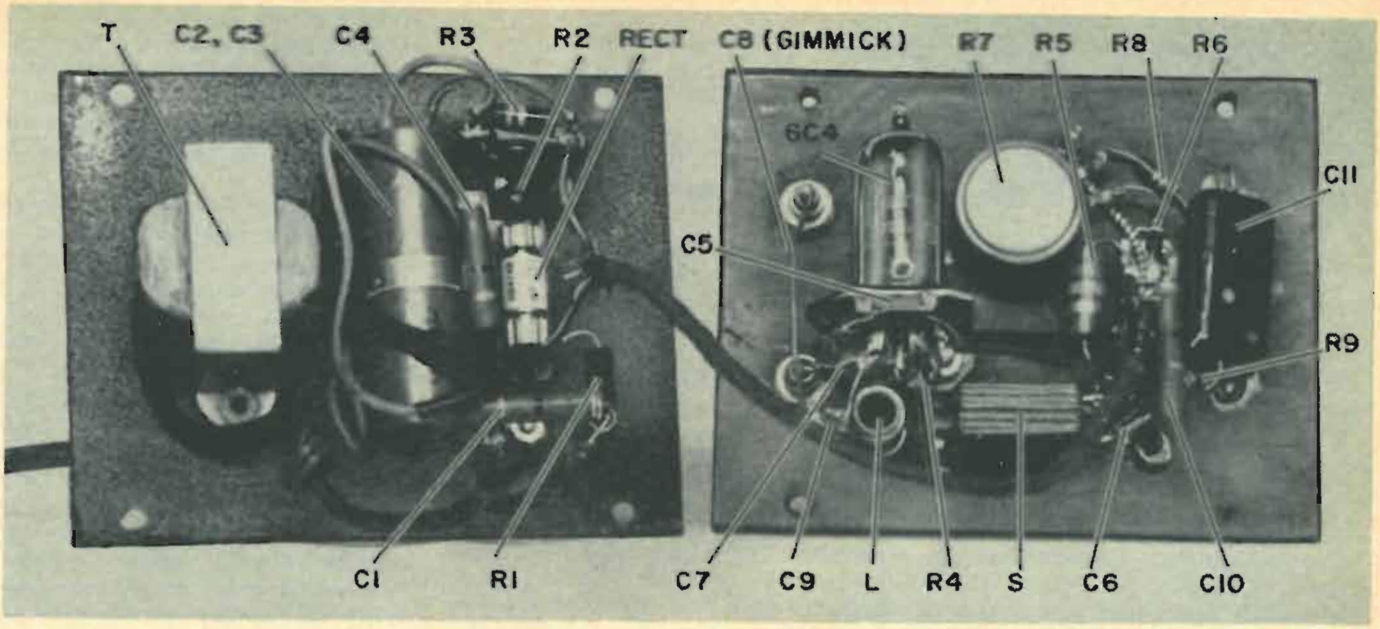
Construction tips

Resistors R1 and R2 limit the initial charge to C2 and also serve as slow-acting fuses to protect the instrument in case of a shorted rectifier or filter capacitor. The power supply is connected to the rf section on the front panel through a 3-wire cable, so that both front and rear panels are easily removable for adjustment or service.

The rf section is quite straightforward and uses a neon lamp to indicate the intensity of oscillation (crystal activity). The tank coil is wound on a CTC PLS5/B coil form with a 12-pF capacitor in parallel. Any small slug-tuned coil resonant at 27 MHz should work equally well.

Parts should be mounted on the front and back panels as shown in the photographs. The front panel is 4 x 5 x ⅛-inch Bakelite or similar material drilled to accept the various oscillator components. The 6C4 socket is mounted on a small bracket made from a scrap of sheet aluminum. The crystal socket and oscillator coil are mounted close to the 6C4 socket to keep leads as short as possible. Arrangement of the other components is not critical.

When winding the tank coil, it's a good idea to add a couple extra turns of wire that may be removed later if necessary, to center the slug's tuning range in the center of the 27-MHz band. A grid-dip meter, if available, will be most useful for tuning the coil. Otherwise, use a mid-band crystal and set the slug halfway into the coil form. Tune by removing a turn at a time from the coil, or by substituting different values of fixed capacitance. A ceramic trimmer (4–30 µF) may be used in place of fixed capacitor C9 to simplify tuning the coil to cover the band. However, the trimmer will not be as stable as the drift-corrected fixed capacitor.



Current-limiting resistors R1 and R2 reduce the current surge as C2 charges and act as fuses to protect against short circuits.

Leads of oscillator-section components are kept as short as possible for best results. Inductor L is tuned from the front panel.

Insert a 27-MHz crystal in the socket, allow the 6C4 to warm up, then adjust the tuning slug for maximum rf signal as indicated by the neon lamp. Adjust R7 so the neon indicator is fired by the rf signal (not by the dc power supply). Once the potentiometer has been set to respond to an active crystal, it will not need to be readjusted.

When L is correctly tuned, crystals for all channels will function with only minor adjustment of the tuning slug.

A short piece of wire may be inserted into the "antenna" pin jack if the signal level at the receiver is too low. The oscillator tank coil is coupled to the antenna jack through a "gimmick," a short piece of insulated hookup wire running from the pin jack through the center of tubular ceramic capacitor C9. This short piece of wire may be fastened in place with coil dope.

Note that the "ground" connection is made through capacitor C7. A POLARIZED AC-LINE PLUG AND SOCKET ARE REQUIRED to maintain the common (white) lead and the cabinet at ground potential at all times.

To check crystal activity, use a field-strength meter, adjusted to read half-scale, as an indicator. By substituting various crystals cut to the same channel, it is easy to make a relative evaluation of their activity. Weak, erratic signals indicate crystals of low activity. Mechanical instability can be checked by lightly tapping the crystal case with a pencil. Defective or weak crystals should be replaced.

The most useful application of the Crystal Calibrator is to pinpoint the various CB channels on a tunable receiver dial. The calibrator may be left plugged in at all times so that the 6C4 is heated, and it will be ready for instant use simply by applying the plate voltage. Any channel can be instantly and exactly spotted on the receiver by plugging in the correct crystal. No direct connection between calibrator and receiver is needed, and you can be sure of being tuned exactly to the channel without having to wait for a transmission to check the tuning. END

WHAT'S YOUR EQ?

Conducted by E. D. CLARK

Remote-Control Circuit

Using 60-Hz current and single-pole switching, how many *independent* relay-controlled circuits can you operate from a two-conductor line? Only one load circuit is energized at a time. —*E. A. Johnson*

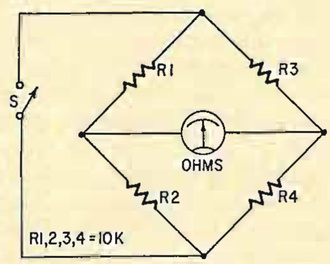
Three puzzlers for the student, theoretician and practical man. Simple? Double-check your answers before you say you've solved them. If you have an interesting or unusual puzzle (with an answer) send it to us. We will pay $10 for each one accepted. We're especially interested in service stinkers or engineering stumpers on actual electronic equipment. We get so many letters we can't answer individual ones, but we'll print the more interesting solutions—ones the original authors never thought of.

Write EQ Editor, Radio-Electronics, 154 West 14th Street, New York, N. Y. 10011.

Answers to this month's puzzles are on page 101.

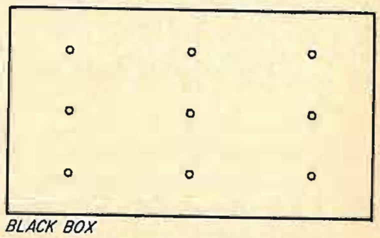
Bridge Resistance

The diagram shows the familiar bridge circuit. What value will the ohmmeter read with S1 open? With S1 closed?—*Joseph Kish Jr.*



All 1-Ohm

The black box in the diagram has 9 terminals. Using only 9 resistors (same value), how can one connect them in such a way as to have a value of 1 ohm appear between any two terminals?—*Robert G. Donnell*



BLACK BOX

50 Years Ago

In Gernsback Publications

In September 1916

Electrical Experimenter

Why not Have the President Talk Simultaneously to All the People?

Engineering as a Vocation

Tikkers for Undamped Signals

Making Selenium Cells

SEISMIC AMPLIFIER TOPS OUT AT 1 Hz!

With an upper limit well below the bottom of many "low-frequency" amplifiers, this instrument has uses impossible to other equipment

By EARL T. HANSEN

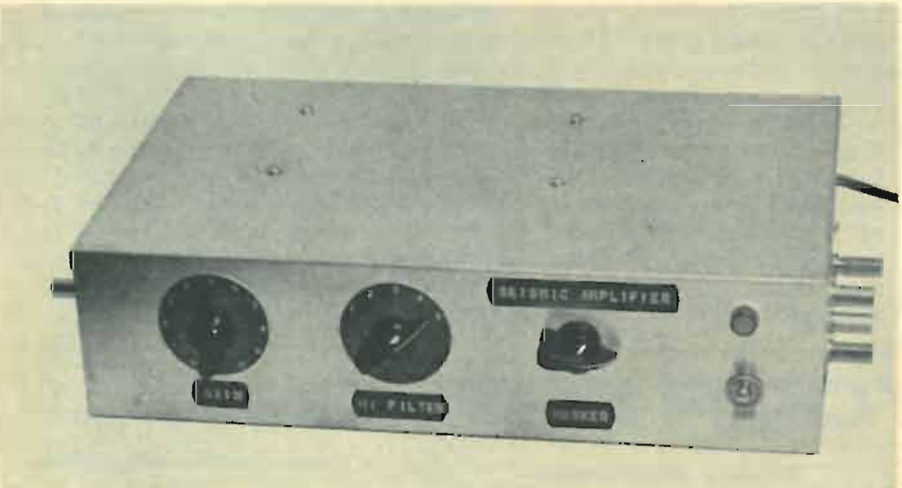
THIS AMPLIFIER WITH HIGH GAIN AND ultra-low-frequency response was designed to amplify the output from a moving-coil seismometer and apply it to a pen recorder. The purpose is to record distant earth disturbances. The amplifier can also be used for other geophysical or biomedical applications. Total cost of components is about $50.

Other features include a balanced differential input with good common-mode rejection, a variable high-frequency filter, a step attenuator, provision for external marker, very low power consumption, and a long reliable life.

The frequency range (Fig. 1) of the amplifier extends from below .01 to about 1 Hz (cycle per second). For seismic use, upper-frequency rolloff must begin between 1 and 10 Hz. This aids in rejecting manmade earth disturbances. The amplifier has a variable two-section, five-position R-C filter (selected by S1 in Fig. 2) to adjust the upper cutoff frequency, from 1 to 5 Hz. Attenuation is 12 dB per octave above the selected cutoff point. For frequencies below 0.3 Hz there is a gradual increase in gain at 6 dB per octave to .02 Hz.

The need for the rising low-frequency response may be compared to a similar need in a magnetic phono preamplifier. The velocity of the needle (or seismo coil) decreases with frequency, and therefore the amplifier requires low-frequency boost to maintain a flat overall response.

If you have a use for an amplifier of this kind with flat response, replace C15 and C16 with jumper wires. Switching them in and out is not practical, since R43 must be readjusted each time for correct transistor bias.



The amplifier looks conventional, but don't try it on your phonograph!

With the output unloaded, the attenuator on position 5, and R35 omitted, the voltage gain is approximately 5,000 at 0.5 Hz. With R35 reduced to zero, and the attenuator on position 1, the voltage gain is over 150,000. (Since the amplifier is to be used with a pen recorder which responds to *current*, the voltage gain is not really significant.) The internal impedance is approximately 1,500 ohms, and voltage may be converted to current on this basis. An open-circuit voltage of 5, when short-circuited, would produce an output current of 3.3 mA ($5 \div 1500 = .0033$). The value of R35 can be selected between zero and infinity to obtain the desired gain. For the present application, more than adequate gain is available without R35 (infinite resistance). For very-high-gain applications it may be necessary to short out C15 and C16 to prevent objectionable noise in the ultra-low-frequency region.

The preamplifier uses four transistors in a direct-coupled push-pull circuit. R12 is a dc balance adjustment to equalize the collector voltages on Q7 and Q8. C2, C3, C4 and C5 attenuate high frequencies. This reduces the possibility of saturating the preamp with rf or other high-amplitude unwanted signals before they can be rejected by the variable low-pass filters.

The preamp, designed for maximum gain and signal-to-noise ratio, does not have a high input impedance. The input impedance is further lowered by R9 and R10, which are a damping load for the seismometer coil. The transistor dc operating levels are stabilized by dc feedback from common-emitter load R19 to the common input return of Q5 and Q6.

The preamp is ac-coupled through two low-leakage tantalum electrolytic capacitors, C7 and C8, to the first section of the R-C low-pass filter and the attenuator. The R-C filter attenuates the signals 6 dB per octave for frequencies above the cutoff point selected by S1. The attenuator switch, S2, was used instead of a dual control, to reduce noise and to make settings repeatable. There are 10 steps, approximately 2.5 dB (25% change) each, and an off position.

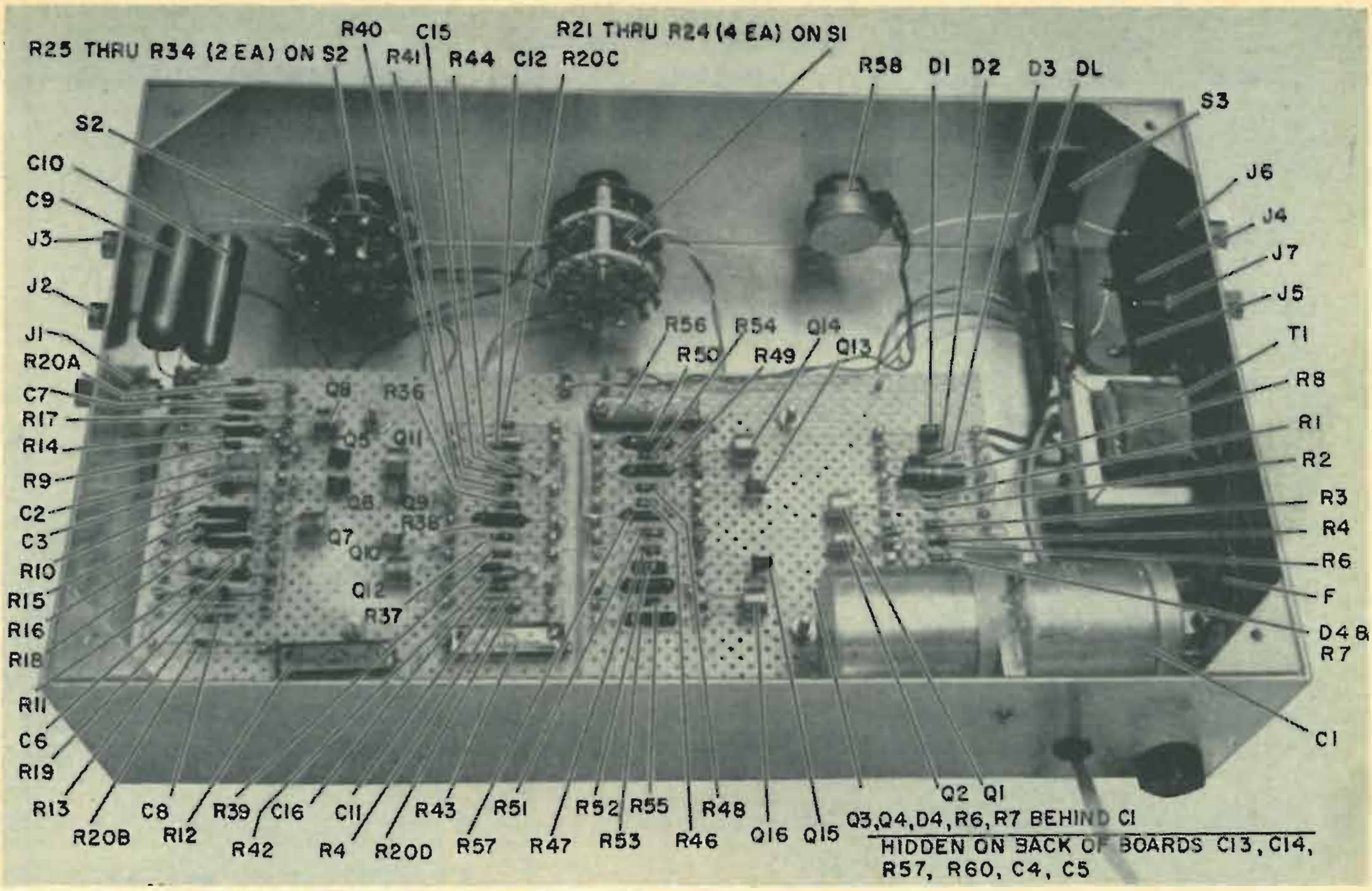
The high-impedance equalizing amplifier is designed to sacrifice gain in favor of very high input impedance, and stability of gain. It boosts the low frequencies with the help of feedback via R41 and R42. The dc operating point is stabilized by obtaining the bias to Q9 and Q10 from common-emitter load R43.

This amplifier is ac-coupled through the second variable R-C filter section to the output amplifier. The 6-dB-per-octave attenuation of the second filter, combined with that of the first filter section, provides 12-dB-per-octave attenuation above the frequency selected by S1.

The output amplifier section sacrifices voltage gain in favor of high input impedance and current gain. Q13 and Q15 are emitter followers, direct-coupled to the push-pull output stage. R54 and R55 allow degeneration in the emitter for stability. R56 is an adjustment for zeroing the output to the recorder.

Regulator power supply

The power supply is regulated. At the normal operating current of 18 mA, line voltage changes of 20% cause less than 1-mV change in the supply voltage,



Underchassis view of the seismic amplifier shows perforated boards used to mount components in "military" order.

and have no effect on the amplifier output. Short-circuit current is limited by R8, so the power supply will not be damaged by a short. Q1, D3 and R2 form a constant-current source for series regulator Q2 and the difference amplifier Q3 and Q4. D4 is a Zener reference element. R3 compensates for any line-voltage change which might otherwise be passed by the regulator.

Construction hints

In building the amplifier, mount small components on perforated boards with push-through terminals. All circuitry should be in a metal enclosure, preferably with a *minimum* of vents, for best thermal stability. I used a standard chassis and cover.

If the 2N3391-A transistors are not already painted black, paint them. At low currents they are quite sensitive to light. Light variations could cause unwanted outputs from the amplifier. Input resistors in the preamp must be metallized-film or deposited-carbon type for minimum noise. The coupling capacitors (C7, 8, 11, 12, 15, 16) must be tantalum. Normal electrolytics have far too much leakage.

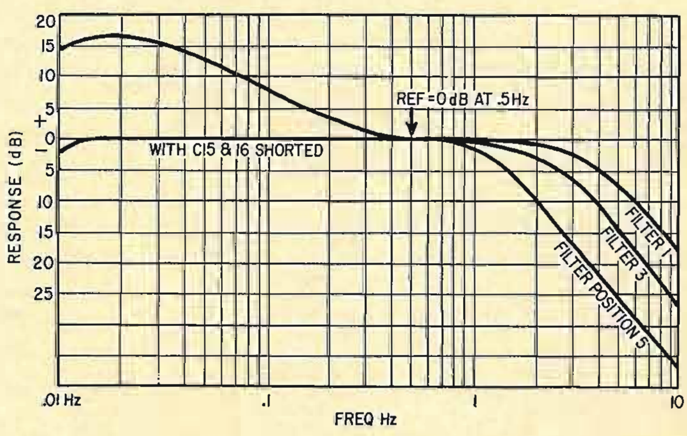
Complete the power supply first and check it for proper operation before connecting it to the other circuitry. The output voltage should be 12 ±0.5. Since Zener diodes vary considerably between units, some adjustment will probably be necessary. If the voltage is too high, shunt R4 with some additional resistance (47,000 ohms will change it about 10%). If it is too low, shunt R5.

Complete the amplifier except for the coupling capacitors, C7, 8, 11, 12. Apply power and adjust R12 for equal collector voltages within 0.5 volt on Q7 and Q8, measured to ground. These should be between 8 and 10 volts. Decrease R13 if the voltage is too low. Set the attenuator (S2) about midway. Adjust R43 so collector voltages of Q11 and Q12 are between 7.5 and 9.5.

If there is excessive spread in the collector voltages of Q11 and Q12, it may be necessary to match Q9 and Q10 more closely. Allow several minutes for the voltages to stabilize after adjusting R43. If C15 and C16 are shorted out to flatten out the low-frequency response, R43 will require readjustment.

In balancing and adjusting the stages, be careful not to cause a momentary thermal unbalance by touching or blowing on transistors. Adjust R56 for zero voltage across output terminals J4 and J5. (If you can't zero the output, you may have to match Q13 and Q15

Fig. 1—Frequency response of the seismic amp.



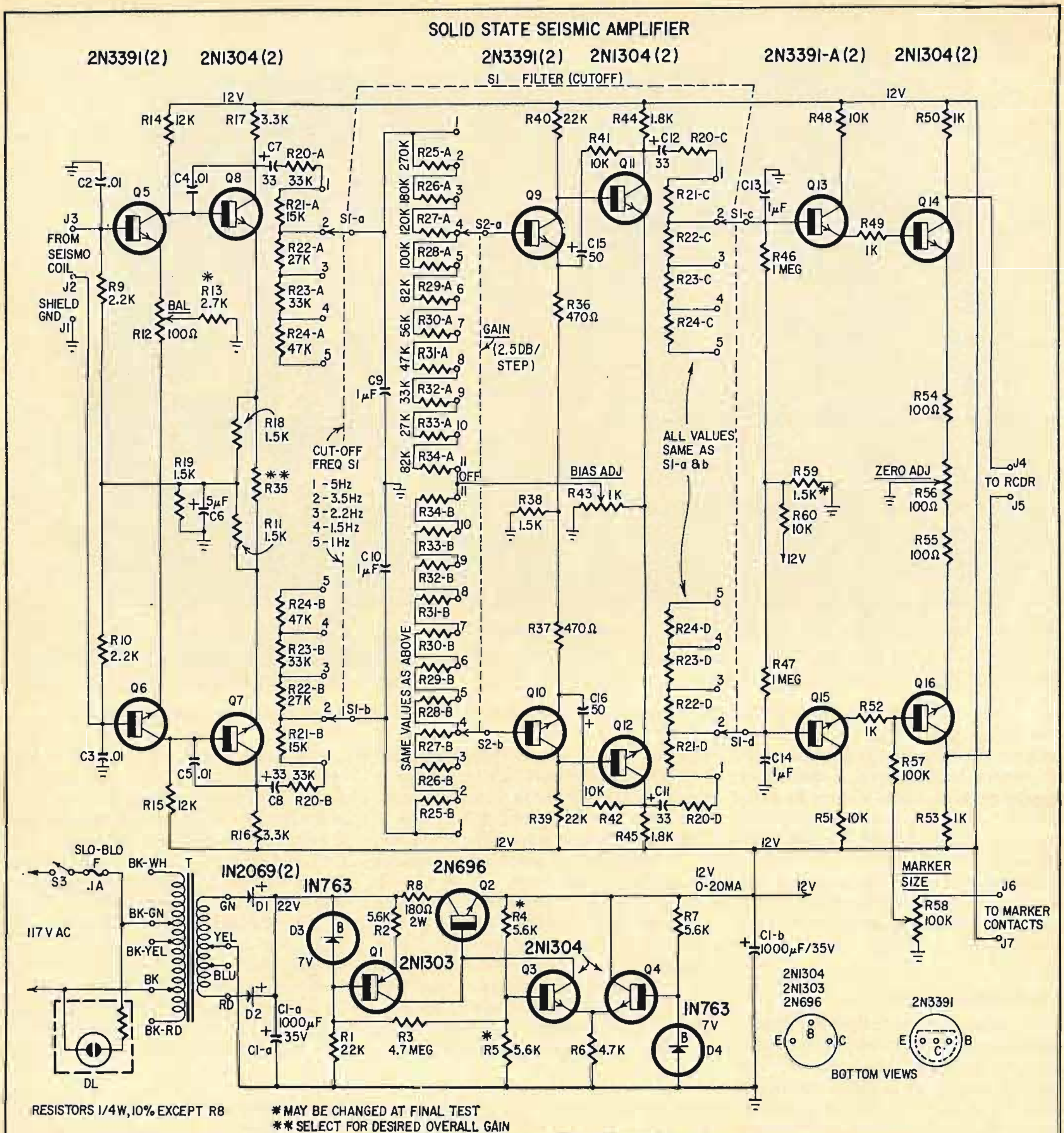


Fig. 2—The seismic amplifier has an all push-pull circuit, with differential input and a 4-transistor power supply.

All resistors ¼ or ½ watt except R8. All ± 10%, except where noted. Total needed shown parenthesis.

R1, R39, R40—22,000 ohms
R2, R4, R5, R7—5,600 ohms
R3—4.7 megohms
R6—4,700 ohms
R8—180 ohms, 2 watts
R9, R10—2,000 ohms, 5% carbon film
R12, R56—100 ohms (Bourns E-Z-Trim pot, or equivalent)
R13—2,700 ohms
R14, R15—12,000 ohms, 5% carbon film
R16, R17—3,300 ohms
R11, R18, R19, R38, R59—1,500 ohms
R20, R23, R43 (10)—33,000 ohms
R21 (4)—15,000 ohms
R22, R33 (6)—27,000 ohms
R24 (4)—47,000 ohms
R25 (2)—270,000 ohms
R26 (2)—180,000 ohms
R27 (2)—120,000 ohms
R28, R57 (3)—100,000 ohms
R29, R34 (4)—82,000 ohms
R30 (2)—56,000 ohms
R31 (2)—47,000 ohms
R35—see text
R36, R37—470 ohms
R43—E-Z trim pot, 1,000 ohms
R44, R45—1,800 ohms
R46, R47—1 megohm
R41, R42, R48, R51, R60—10,000 ohms
R49, R50, R52, R53,—1,000 ohms
R54, R55—100 ohms
R58—pot, 100,000 ohms
C1—1,000-1,000 μF, 35V, dual electrolytic
C2, C3, C4, C5—.01 μF, paper or ceramic, 100 volts or more
C6—5 μF, 6 volts or more, electrolytic
C7, C8, C11, C12—33 μF, 10 volts, tantalum electrolytic
C9, C10, C13, C14—1 μF, paper or ceramic, 10 volts or more
C15, C16—50 μF, 10 volts, tantalum electrolytic
T—Pri, 117 volts, sec. 34V, center tapped, .035 amp (Knight 64G 731, Triad F94-X, or equivalent)
J1, J2, J3, J4, J5, J6, J7—5-way binding posts
F—0.1-amp fuse and holder
DL—dial lamp, neon with resistor (optional)
D1, D2—1N2069 or equivalent, silicon rectifiers
D3, D4—1N763 or equivalent 7-volt ±20% Zener diode, 250 mW
Q1—2N1303 p-n-p germanium transistor
Q2—2N696 n-p-n silicon transistor
Q3, Q4, Q7, Q8, Q11, Q12, Q14, Q16—2N1304 n-p-n germanium transistor
Q5, Q6, Q9, Q10, Q13, Q15—2N3391-A n-p-n silicon planar transistor
S1—4-pole 5-position, shorting, rotary switch (Centralab PA-2010 or equiv.)
S3—spst toggle switch (optional)
Misc: ac power cord, wire knobs, and small hardware
Perforated circuit boards (Vector 85 G 24 or equiv.)
Insertion terminals .062 in. (Vector T-28 or equiv)
7 x 13 x 2 in. chassis, with cover

more closely.) Measure this voltage to ground, J1. It should be between 6 and 8 volts. If necessary, change R59 to meet this requirement, and rezero R56.

Temporarily connect the four coupling capacitors across the 12-volt supply (watch polarity). By re-forming the tantalum capacitors before installing them, the initial stabilizing time can be greatly reduced and we lessen the possibility of circuit damage. After about 5 minutes, remove the capacitors and discharge them by shorting. Install them and apply power to the amplifier.

Because of the long time constants (33 seconds) in the amplifier, several minutes may be necessary for it to stabilize. This is not normally a problem since operation is usually continuous. After stabilization. none of the voltages should be appreciably different from what they were without the capacitors. A slight readjustment of R56 may be needed to rezero the output.

The amplifier was designed for isolated input and output coils. *These external circuits must not be returned to the amplifier ground.*

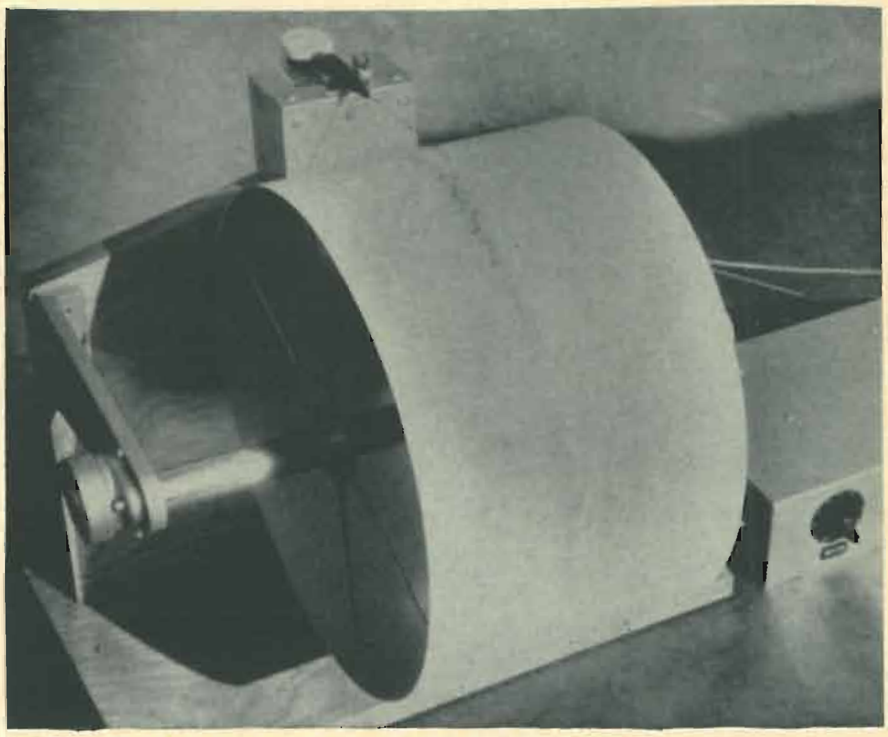
In using the amplifier, let it stabilize each time you change the gain switch. The filter switch can be varied without creating disturbances since there is no dc at the contacts.

The seismometer and the recorder shown in the photographs are both home-constructed. In the seismometer, the mass is mechanically coupled to a 500-ohm coil moving in a dense magnetic gap. The natural resonant period of the mass is approximately 30 seconds. The recorder has a 500-ohm coil and a full-scale sensitivity of 5 mA. A synchronous clock type motor rotates the drum once an hour. A screw on the drum axis moves the drum laterally as it rotates, making the recording in the form of a long spiral. Approximately 48 hours may be recorded with only a single change of paper.

Timing marks are recorded every minute and hour. This is done by an electric clock modified to include contacts on the second and minute hands, at the 12 o'clock position. The contacts are connected to the marker terminals on the amplifier. (A following article will give construction details on these instruments.)

Fig. 3 is a typical recording made with the amplifier, seismometer and recorder combination, at Covina, Calif. It shows an unidentified earth disturbance, recorded twice—once as conducted through the earth, and again as the surface wave. The time difference between the two displays was about 9 hours.

I measured frequency response with a Hewlett-Packard 202A low-frequency function generator, a dc scope, and lots of patience waiting for the cycles to stabilize. **END**



This recorder is the output device that the low-low-frequency amplifier works into.

The home-built seismograph recorder for which this low-Hz amplifier was designed.

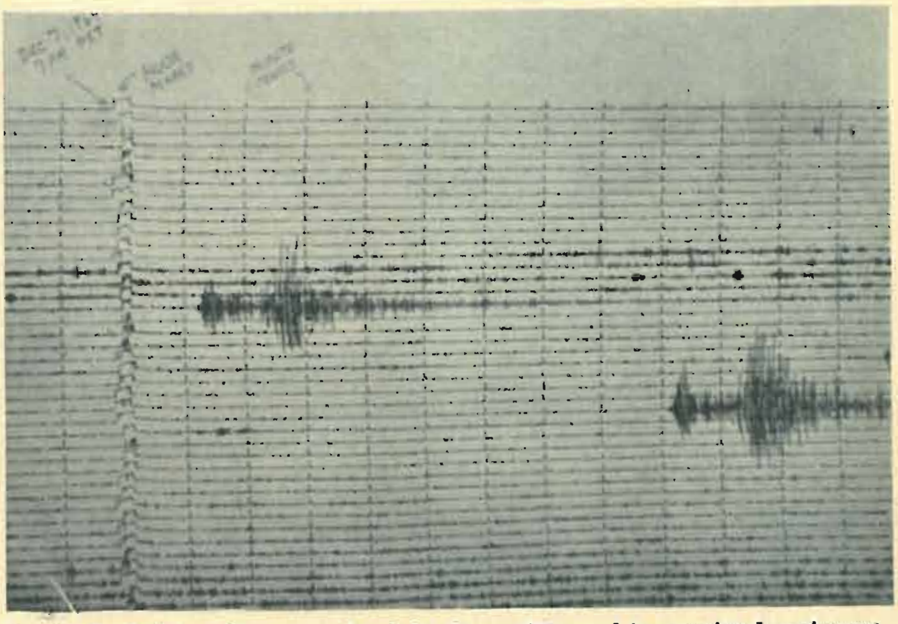


Fig. 3—Typical recording as produced by the amplifier and its associated equipment. Timing pulses recorded each minute and hour show the time and the duration of shocks.

An RF Wattmeter for UHF

By HAROLD BALYOZ

CB COMMUNICATIONS

WITH A RESPONSE ACceptably flat from 2MHz to at least 500 MHz, the instrument described here will indicate full-scale power levels of 30 or 100 mW. Using the separate 10-dB 50-ohm pad between transmitter and wattmeter, the ranges expand to 300 mW and 1 watt. Similar pads of adequate power-handling capability can further extend the two full-scale ranges.

Construction

The heart of the wattmeter is the assembly shown in the schematic (Fig. 1-a) and in Fig. 2. All components should be assembled exactly as pictured to insure a response flat to 500 MHz.

Begin construction by mounting J1 in the case to be certain it will slip in easily after all components are attached to it. Using a hot soldering iron and resin-core solder, tin the connector flange at four points between the mounting holes. Be absolutely certain to use heat-sink clips (Hunter 51G or equivalent on all leads when soldering resistors R1 through R4 and diodes D1 and D2 to the connector flange. Excess heat will destroy the diodes and alter the values of the resistors.

Solder one lead of each resistor to the pretinned spots on J1, then solder

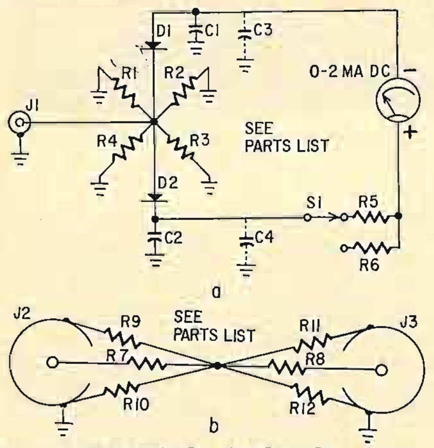
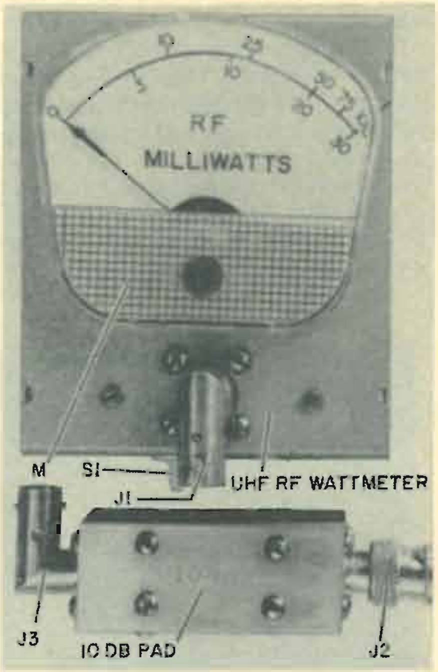


Fig. 1—Deceptively simple schematically, the wattmeter (a) and attenuator (b) require careful attention to minor construction details. Follow layouts in Figs. 2 and 3.

PARTS LIST

J1—UG-290/U or UG-535/U BNC connector
J2—Avien 165-540 or equivalent BNC connector
J3—UG-290/U BNC connector
R1, R2, R3, R4—200 ohm, ¼ watt, 5%
R5—Meter multiplier, see text
R6—Meter multiplier, see text
R7, R8—27 ohm, 1 watt, 5%
R9, R10, R11, R12—150 ohm, ½ watt, 5%
D1, D2—1N82A, flex-lead style
C1, C2—1,000 pF (Erie 662-003 102K or equivalent)
C3, C4—.01 μF disc ceramic (optional, see text)
MA—dc milliameter, 2-mA full-scale movement
S1—spdt toggle switch
Chassis box, 3¾ x 3 x 2⅛ inches (LMB 135 or equivalent)
Heat-sink clips, Hunter 51G or equivalent (6 required)



Use of BNC connectors throughout insures good efficiency in coupling the wattmeter and 10-dB pad to transmitter under test.

Table I

Volts	mW	Volts	mW
0.39	3.0	1.24	30.0
0.71	10.0	1.60	50.0
1.00	20.0	1.94	75.0
1.12	25.0	2.24	100.0

the other end of each resistor and one lead from each diode (watch the polarity) to the center conductor of J1. Finish the assembly by soldering button capacitors C1 and C2 to the diodes (and capacitors C3 and C4 if you want a flat response as low as 2 MHz).

Insert the basic assembly into the predrilled box and mark the holes to be used for mounting the button capacitors. Remove the assembly, drill the holes, then mount the assembly and the remaining components. The placement of the other parts is not critical.

Remove the meter scale and glue a piece of white paper or cardboard to it and reassemble the meter. Later you can mark the appropriate divisions lightly in pencil, then fill them in using India ink.

Calibration

Two calibration methods are feasible. If you can beg or borrow a commercial rf wattmeter or a calorimetric power meter like the Hewlett-Packard Model 434A, you can calibrate directly against it. Otherwise, use an rf voltmeter to measure the input voltage developed at J1 by a signal fed from an rf signal generator, marking the scale according to Table I. For the low end, an audio vtvm like the Ballantine Model 310A is accurate to 2 MHz. If you include capacitors C3 and C4 in your instrument, you will be able to calibrate at that frequency using a 2-MHz audio or rf signal generator as a source.

First select values for R5 and R6 so the full-scale ranges of 30 and 100 are set accurately (30 mW equals 1.24 volts —see Table I.) R5 will be around 620 ohms and R6 around 1,400 ohms. If you'd rather use pots instead of fixed-value units, R5 can be 1,000 ohms and R6, 2,500 ohms. Merely set them for proper full-scale deflections at the correct input voltages. Their adjustments should not be accessible from outside the case to avoid their being turned accidentally during use.

The 10-dB pad

Construct the pad (Figs. 1-b and 3) by connecting R7 and R8 in series, then to the center conductors of connectors J2 and J3. The connector flanges should be 2³⁄₁₆ inches apart. Solder resistors R9 through R12 as shown, two to one flange and two to the other. As before, pretinning the inside surfaces of each connector flange will simplify construction. Finally, drill and tap four round or square pieces of ¼-inch aluminum stock to fit snugly between the two flanges.

When the instrument is finished, it can be used in many helpful ways. A two-turn link around the tank coil of a small crystal oscillator or rf amplifier stage, for example, will enable you to check the activity of various crystals or the performance of tubes, transistors, or various other circuit elements by comparing power outputs. Few instruments can be as varied in test-bench applications as a wattmeter. Top efficiency for rf circuits demands a means for measuring power levels, and this instrument provides that means at reasonable cost.

END

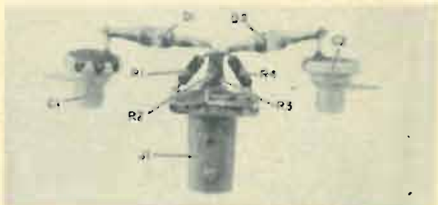


Fig. 2—Basic assembly requires careful construction to assure good uhf response.

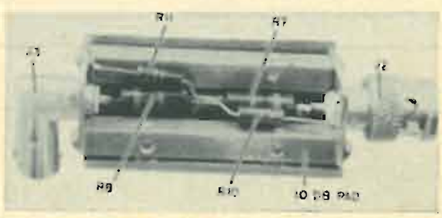


Fig. 3—Simply built attenuator extends wattmeter's power-handling capabilities.

Heavy-Duty 5-Amp Supply—With Regulation

Up to 30 volts that will take care of tests in mobile 2-way radios

By ALLAN W. CROWELL

FOR A GROWING VARIETY OF WORKbench applications, especially for troubleshooting and repairing Citizens-band and business/industrial radiotelephone equipment, a heavy-duty regulated power source is a basic tool. For those who have lots of extra bucks or who can anticipate enough business activity to justify the cost, there are several excellent commercially built supplies. They are expensive—several hundreds of dollars, as a rule. The supply described here will provide 5 amps of dc power continuously variable over a 7-to-30-volt range, and its total cost is far below the commercial equivalents. A quick look at the SPECIFICATIONS box on this page reveals performance capabilities generous enough to satisfy most technicians and home builders.

All operating controls are conveniently arranged on the front panel of the utility-box cabinet, and a direct-reading meter can be switched to monitor load current or output voltage. A chassis-mounted fan provides sufficient air circulation across the heat sinks for the power transistors.

General component arrangement can be seen quite clearly in Figs. 1 and 2. The differential amplifier and driving circuitry for the pass transistors are mounted on the vertical phenolic board at the left of the panel, and 5-volt and 33-volt transformers with their related components are mounted on a second subpanel assembly bolted to the power transformer main frame at the right side of the chassis. The mechanical subassembly, consisting of heat sinks for the pass transistors and the diode-bridge rectifiers with their associated spacers, takes up most of the central chassis.

The mechanical assembly

While the schematic clearly shows the electronic circuitry, the mechanical

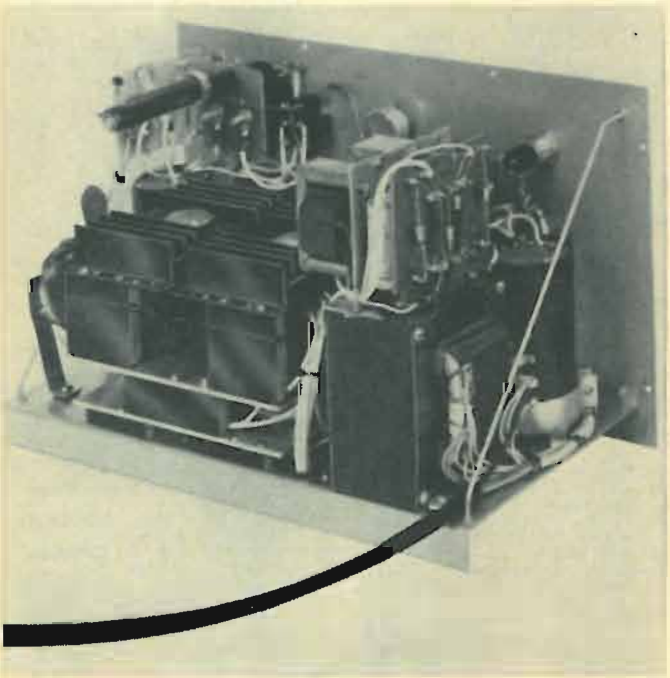


Fig. 1—Right-rear view of power supply. The low-voltage supplies are mounted on subpanels fastened to the power transformer.

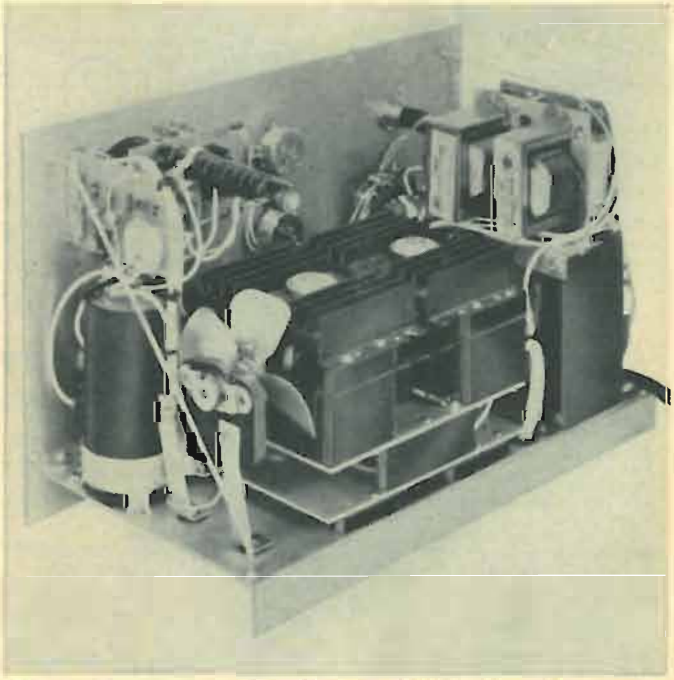


Fig. 2—Power supply as seen from the left-rear. Fan and control transistors are on circuit board fastened to the front panel.

aspects of the heat-sink stack can be understood most easily by reference to Fig. 3, an end view of the assembly. The photographs provide oblique views to aid in duplicating the stack.

Each pass transistor (Q1 through Q4) is mounted directly to its heat sink after two additional $\frac{3}{16}$-inch holes are drilled to accept the transistor leads. All spacers used to construct the heat-sink units are ¼-inch phenolic. Two 2 x ½-inch spacers (A) separate each pair of sinks and are held together with two 2-inch 6-32 screws at each end which pass down through the top sink, the spacer, the bottom sink, and into tapped holes in each of two 2 x 1½-inch spacers (B). Screw spacing is 1-⅛ inches. This method allows the sinks to be separated quickly for checking each transistor at its terminals during debugging or troubleshooting of the unit.

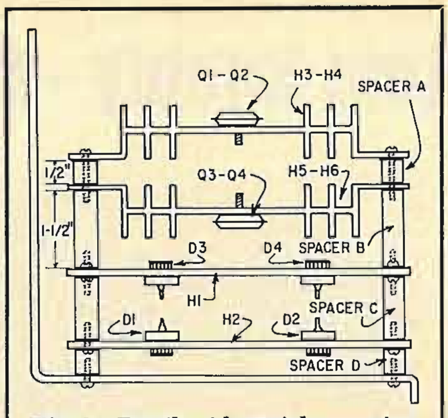
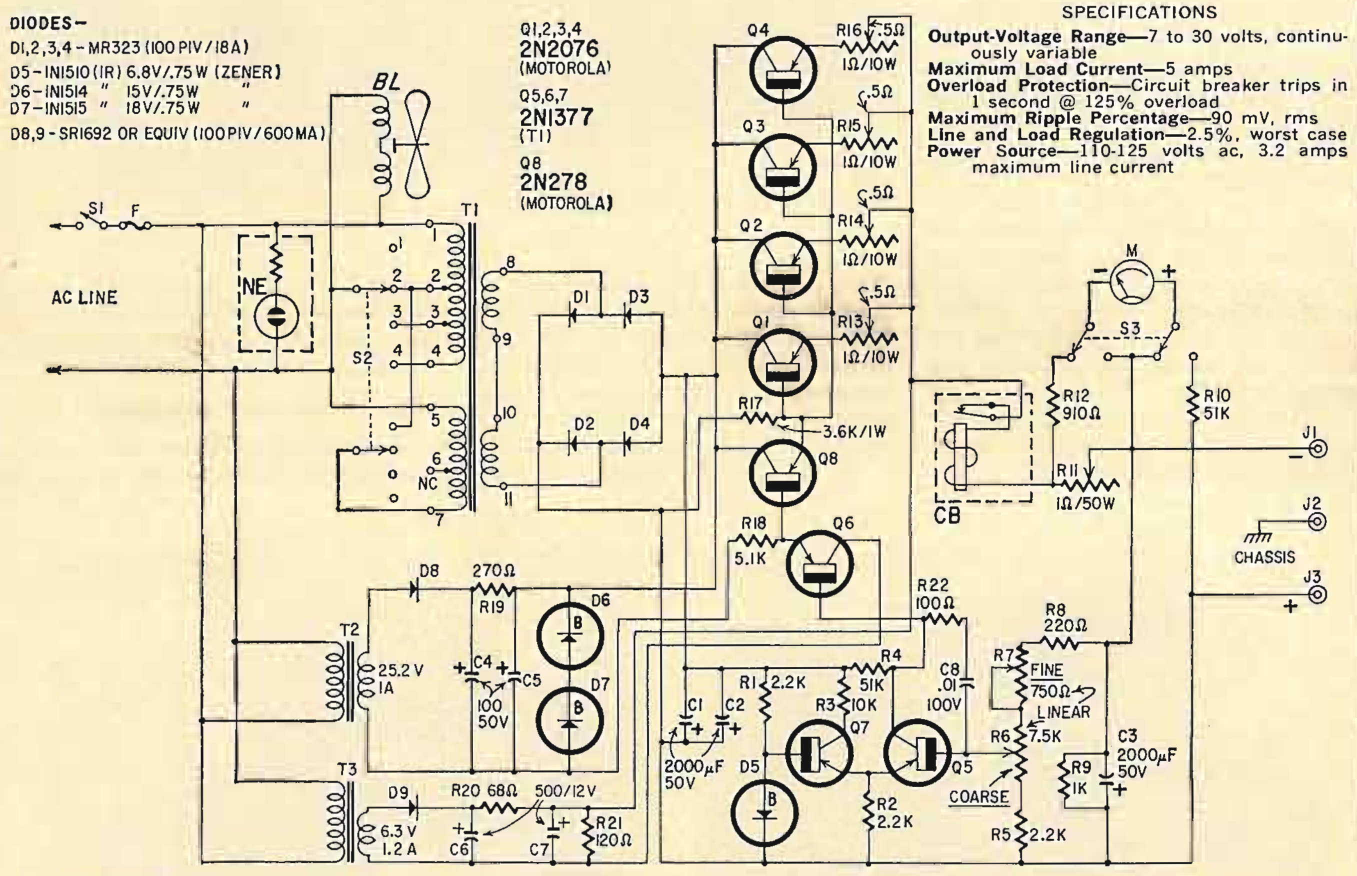


Fig. 3—Details of heat-sink mounting.

Although all sinks are at the same potential, and therefore may be connected together mechanically, they should not be used to carry transistor collector-circuit current. Each collector should be wired into the circuit.

Each 2 x 1½-inch spacer (B) is fastened to the top ⅛-inch aluminum plate (actually one of the two diode sinks of the assembly described in the next paragraph) using two ½-inch 6-32 screws threaded into tapped holes in the spacer. Two 3 x 1-inch tapped spacers (C) separate the two 6 x 6-inch diode sink plates (H1 and H2). Two 2 x ⅜-inch spacers (D) support the bottom sink. This is fastened to the baseplate with four 6-32 screws, two down into the spacer and two up from the baseplate. Be sure these screws are staggered so that they do not touch each other; the entire assembly must be above electrical ground.



SPECIFICATIONS

Output-Voltage Range—7 to 30 volts, continuously variable
Maximum Load Current—5 amps
Overload Protection—Circuit breaker trips in 1 second @ 125% overload
Maximum Ripple Percentage—90 mV, rms
Line and Load Regulation—2.5%, worst case
Power Source—110-125 volts ac, 3.2 amps maximum line current

Fig. 4—A complete schematic diagram of the power supply. Construction is simpler than the circuit tends to indicate.

PARTS LIST

R1, R2—2,200 ohms, ½ watt, 5%
R3—10,000 ohms, ½ watt, 10%
R4—51,000 ohms, ½ watt, 5%
R5—2,200 ohms, ½ watt, 10%
R6—7,500 ohms, linear-taper pot
R7—750 ohms, linear-taper pot
R8—220 ohms, ½ watt, 10%
R9—1,000 ohms, ½ watt, 10%
R10—51,000 ohms, ½ watt, 10%
R11—1 ohm, 50 watts, adjustable
R12—910 ohms, ½ watt, 5%
R13, R14, R15, R16—1 ohm, 10 watts, adjustable, set to .5 ohm
R17—3,600 ohms 1 watt, 5%
R18—5,100 ohms, ½ watt, 10%
R19—270 ohms, ½ watt, 10%
R20—68 ohms, ½ watt, 10%
R21—120 ohms, ½ watt, 10%
R22—100 ohms, ½ watt, 10%
C1, C2, C3—2,000 µF, 50 volts, electrolytic
C4, C5—100 µF, 50 volts, electrolytic
C6, C7—500 µF, 12 volts, electrolytic
C8—.01 µF, 100 volts
D1, D2—silicon diode 100 piV, 18 amps, MR323 (Motorola)
D3, D4—silicon diode 100 piV, 18 amps, MR323R (Motorola)
D5—Zener diode, 6.8 volts, .75 watt, 1N1510 (IR)
D6—Zener diode, 15 volts, .75 watt, 1N1514 (IR)
D7—Zener diode, 18 volts, .75 watt, 1N1515 (IR)
D8, D9—diode, 100 piV, 600 mA (Sylvania SR1692 or equiv)
Q1, Q2, Q3, Q4—2N2076 (Motorola)
Q5, Q6, Q7—2N1377 (TI)
Q8—2N278 (Motorola)
S1—spst toggle, 5 amps
S2—2-pole, 4-position rotary (Centralab PA2003 or equiv)
S3—dpdt toggle
T1—power transformer, 12—30 volts ac, 6 A, (Stancor RT206 or equiv)
T2—filament transformer, 25.2 volts, 1 amp, (Stancor P6469 or equiv)
T3—filament transformer, 6.3 volts, 1.2 amp, (Stancor P6134 or equiv)
F—4-amp fuse
BL—blower motor with 4-in. blade
J1-J2—5-way binding posts, black
J3—5-way binding post, red
H1, H2—heat sinks (see text)
H3, H4, H5, H6—heat sinks, Motorola MS-10
Cabinet—7 x 9 x 15-in. steel, (Bud CU-882HG or equiv)
M—meter, 0-1 mA dc (Simpson 1227 or equiv, see text)
CB—circuit breaker, magnetic; 5 amps dc, 50 volts Heinemann type AM12-5-50-DC-5, (Federated Purchaser Inc., 155 US Route 22, Springfield, N. J. $8.85)
NE—Pilot lamp assembly with built-in resistor for NE-1 neon lamp (Dialco 95408-937 or equiv)

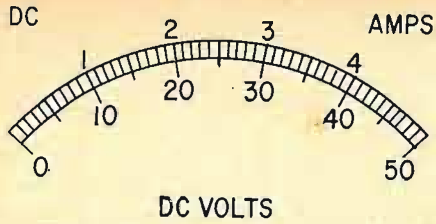


Fig. 5—Drawing of the meter scale.

The diode bridge (D1 through D4) consists of two Motorola type MR-323 and two type MR-323R diodes mounted on the two 1/8-in. heat-sink plates. Each pair can be pressed into 1/2-inch holes in its heat sink, because the 323's have their *cathodes* connected to the case and the 323R's have their *anodes* connected to the case. Two diodes are mounted on each plate, spaced 2 inches from each of two opposite corners along a connecting diagonal. The top sink contains the two MR-323R diodes. The insulated heat sinks permit mounting the diodes directly into the metal, resulting in the greatest possible heat dissipation. Mount the plates so they face on opposite diagonals to avoid shorting the diode leads.

The diodes are designed for a force-fit in 1/2-inch mounting holes. *Press* them into the holes with a drill press (turned off!). *Do not hammer* or otherwise shock them into place. You may change their characteristics or completely ruin them.

If a preinsertion check shows that a diode will not fit snug, place the heat sink on an anvil or other solid surface and tap around the edges of the holes with a ball-peen hammer. This spreads the metal and insures a snug fit when the diodes are forced into place.

Construction is straightforward

All wiring can be No. 20 stranded wire, except for those circuits which carry the 5-amp load. These include T1's secondary, the diode bridge, the collector and emitter circuits of Q1–Q4, the four equalizing resistors (R13–R16), the circuit breaker, resistor R11, and all wiring to the two 5-way output terminals. The wiring in these circuits should be No. 10 or 12. Be sure that wire is used to carry all current. Do not depend on frames, chassis or panels; such practice is extremely unreliable in the long run. A plastic cable clamp secures the line cord against damage.

Adequate ventilation is provided by a 4½ x 6-inch cutout at each end of the cabinet and a 6 x 11½-inch cutout in the back panel, cut using a nibbling tool available at most parts-supply houses. The openings are covered with perforated sheet aluminum, mounted inside the cabinet and secured with aluminum rivets.

Four rubber feet are installed at the corners to prevent scratching. A 10-32 screw passes up through the bottom of the cabinet into a tapped hole at the rear of the baseplate to secure the entire assembly within the cabinet. Be sure this screw does not extend near enough to the bottom diode sink to ground it out.

The original meter scale was removed using a medium-hard eraser. Then the 0-50 scale and the designation DC VOLTS were inked in with a Wrico VCN120 lettering guide as in Fig. 5. The ampere scale was added above the voltage scale as was the designation DC AMPS. The 0 and 5 were omitted to avoid crowding. If 1% or 2% voltmeter accuracy is desired, select R10 (the meter multiplier) for 49,900 ohms, since the meter itself has a 100-ohm movement.

Calibration

After setting up the voltmeter circuitry, calibrate the current scale by connecting a 10-ohm 50-watt load resistor across the supply output and adjusting the resistance of R11 until the meter reads 2 amps when 20 volts ($I = E/R = 20/10 = 2$ amps) is applied across the load. Be sure to remove the load before making any adjustments, because the slider on the resistor invariably will open-circuit during movement, resulting in all current going through the meter itself, with damaging results.

The value of R12 can be altered if required to obtain acceptable meter accuracy in conjunction with R11 when the best slider position falls between two adjacent turns. Power-supply circuitry is isolated from ground (chassis) so that either positive or negative terminals can be connected to ground. The three 5-way output terminals, 2 black and 1 red, are labeled as indicated on the schematic. They are mounted on ¾-inch centers to permit use of dual banana-plug connectors.

Operation

The line switch has an associated 4-position rotary switch for selecting combinations of T1 primary windings for best output power regulation vs input line voltage. In use, set the switch to the lowest number consistent with best output-voltage regulation. Before switching, momentarily rotate the COARSE output-voltage control maximum counterclockwise to reduce line transients, avoiding the possibility of blowing the line fuse. The output-voltage control is adjusted conveniently close to the desired value with the COARSE control, then set to the exact value with the FINE control.

Because most experimenters and technicians who will build this supply will rely on their stock of on-hand spare parts, no two units built will likely be identical. Following the schematic faithfully and not straying too far from the suggested mechanical construction and parts layout, however, should provide good results. END

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You'll miss a lot of opportunities if you try to get along in the electronics industry without an advanced education. Many doors will be closed to you, and no amount of hard work will open them.

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EQUIPMENT REPORT

Knight-Kit KG-625 6-inch VTVM

Circle 26 on reader's service card

One of the newest vtvm kits, this instrument has two outstanding features: a 0.5-volt full-scale dc range, and separate internal calibration pots for the 0.5- and 1.5-volt dc ranges.

If you have done any experimental work with transistors, you know that their base-to-emitter potentials can be fractions of a volt. It takes a 0.5-volt scale to allow them to be read easily and accurately. The KG-625 also has direct peak-to-peak voltage scales, important in TV servicing.

The Knight-Kit vtvm seems to reflect good electrical and functional design. The scales on the 6-inch meter have 100° arcs. Two colors are used, red for peak-to-peak (which matches the red panel markings at the function and range selectors) and black for the rest. All lettering is large and bold.

The front-panel controls are the same as on most vtvm's: range selector, function selector, zero-adjust and ohms-adjust. The pilot light is a neon lamp, shining through a red bull's-eye on the panel. A screw-on microphone-type cable connector is the input for all ranges, and provides complete shielding, a must for high usable sensitivity.

The case is steel, as is the swinging gimbal mount. That gimbal mount is a nice idea. With it you can tilt the instrument to any angle on the workbench, mount it against a wall or under an overhanging shelf. The front panel is aluminum, with an etched finish lithographed in charcoal gray and red. The bottom of the case has a trap door for access to the ohmmeter battery. Four holes on the side of the case are for getting at internal adjustments. They are identified on the case.

The circuit is standard for better vtvm's. A 12AU7-A dual-triode is a balanced bridge, with a 200-μA meter connected from plate to plate. The tube is an aged Mullard Master 10M series, with a 10,000-hour guaranteed life, matched for equal characteristics in each section. A 6AL5 develops peak-to-peak readings on ac. Range resistors are all 1%. Input resistance on dc is 11 megohms, with 1 meg of that in the probe. A single, switchable probe is used for all functions, and a removable alligator clip is supplied with it. The separate ground lead has an alligator clip on its end.

The function switch throws a short across the meter movement when it is in the OFF position. This damps the meter and prevents wild needle bounce when the instrument is carried around.

Assembly and wiring was fairly easy. There is lots of room to work, because of the 7¾ x 5½ x 12-inch size and the use of a large U-bracket, which holds all the parts except those on the front panel. All wiring is point-to-point. Two multiconductor, multicolor cables are supplied, plus a variety of different-colored hookup wires, already cut to size and skinned.

The four internal-adjustment pots and the separate low-range ac scales on the meter make it possible to set up a very accurate instrument, if you have accurate voltage standards to start with. The adjustment instructions recommend using mercury batteries (1.354 volts) for the dc range adjustments. The 1.5-volt dc range is adjusted before the 0.5-volt range. Then a pot is connected across the battery and turned down to read 0.5 on the 1.5-volt range. This becomes the standard for the 0.5-volt range. Ac calibration adjustments are made from the 120-volt line. Greater accuracy is possible if you can determine what the exact line voltage is, of course. I was fortunate to have a lab-type ac meter which told me my line voltage was 123 at the time.

The kit comes with two manuals: one for assembly and wiring, and one for permanent use afterward, as an operator's manual. The operator's manual contains calibration, service and detailed how-to-use information. A circuit description and schematic diagram are in the back. An added feature is a graph for reading dB from voltage across a 600-ohm load, and a chart for straight-edge conversion of the ratio of any two voltages to dB.—*Louis M. Dezettel*

MANUFACTURER'S SPECIFICATIONS

Input resistance: 11 megs on dc
Accuracy: dc: ±3% of full scale
ac: ±5% of full scale
Dc ranges: 0–0.5–1.5–5–15–50–150–500–1500 volts full scale (to 25,000 volts with accessory high voltage probe)
Ac ranges: rms: 0–1.5–5–15–50–150–500–1500 volts full scale
P-P: 0–4.2–14–42–140–420–1400–4000 volts full scale
Frequency response: ±1dB, 30 Hz to 3 MHz. (To 250 MHz with accessory rf probe.)
Ohmmeter ranges: 0–1000–10,000–100,000 ohms; 0–1–10–100–1000 megohms
Center scale: 10, 100, 1000, 10,000, 100,000 ohms, 1 and 10 megohms
Battery: 1½ volt, "C" size
Tubes: 12AU7-A pre-aged, matched; 6AL5.
Price: $39.95 kit, $59.95 wired
Allied Radio Corp., 100 No. Western Ave., Chicago, Ill. 60680

END

Circle 27 on reader's service card

Circle 28 on reader's service card →

Sony has developed the world's finest audio transistors...

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Many manufacturers have made fairly good transistor amplifiers. Until now nobody has made a great one. And everybody knows the reason: distortion. Unfortunately, most transistor amplifiers distort in a very special way. Not so much at top power, but rather more at normal listening levels where it hurts most.

The Sony TA-1120 integrated amplifier and TA-3120 power amplifier are the first high-powered transistor units to really overcome the problem of distortion. At all power levels, at all frequencies distortion is kept below that of the finest tube amplifiers. The TA-1120 and TA-3120 both provide 120 watts IHF at 8 ohms, both channels operating. Distortion, at rated output, is 0.1%. And at normal listening levels it is even less, 0.05% at ½ watt. In addition, they have achieved an extraordinarily high damping factor, better than 70 at 1000 cps to assure clean, low-frequency power response. Frequency response is practically flat from 10 to 100,000 Hz (+0 db/−1 db). For safety's sake, an SCR (silicon controlled rectifier) protects the power transistors against accidental shorts and other overloads.

The integrated amplifier, the TA-1120 features a sensible arrangement of the front-panel controls for the greatest versatility and ease of operation.

We believe that these are the first great transistor power amplifiers. How can Sony do what other manufacturers couldn't? Sony is a pioneer in transistors. With first after first. Such as the tunnel diode. Transistor television. And the all transistor video tape recorder. The point is that Sony knows transistors. To the 'n'th degree. And designed new, advanced types especially for the driver and output stages of these amplifiers. And silicon transistors are used throughout. They are the most stable. The TA-1120 integrated amplifier, $399.50. A handsome oil-finish walnut enclosure is optional. The power amplifier, TA-3120, $249.50.

Visit your Sony high fidelity dealer and make him prove that Sony is worth the money. Make him compare it with the finest tube amplifiers. We think you'll end up with a Sony. For a free brochure write:

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Sencore MX11 Channelizer FM-Stereo Signal Generator

Circle 31 on reader's service card

A TEST INSTRUMENT IS VALUABLE IF IT will do something none of your other test equipment will do and do it faster and easier. The Sencore MX11 Channelizer FM stereo generator does both, at least in *my* shop. FM stereo is growing by leaps and bounds, and it does require a very special type of signal generator.

With isolated meters and rf stereo signal, battery-powered unit can be used to align multiplex receivers fairly close if your sweep generator happens to be unavailable.

The MX11 is in a case only 3 inches high and about 10 inches square, with a carrying handle. All-transistor and powered by self-contained dry batteries, it's ready to go whenver you are. Clips on the back keep the cables wound up out of the way. Soft rubber feet let you set the unit on even the finest cabinet.

The MX11 delivers a 3,000-μV signal. This is set at 100 MHz but can be retuned to any frequency between 90 and 105. The FM multiplex signal has both L and R signals at 1,000 Hz, plus the standard 10%-modulation 19-kHz pilot carrier. The rf output cable, with 300-ohm impedance, can be connected directly to the antenna terminals of an FM tuner. You can also take the composite signal without the rf carrier from a pair of tip jacks on the front panel.

The MX11 is easy to operate. There are only four switches on the front panel: ON–OFF, RIGHT SIGNAL, LEFT SIGNAL and PILOT MODULATION-PERCENTAGE SELECTOR.

A crystal-controlled Pierce oscillator produces a 76-kHz signal which is shaped and used to control a 38-kHz bistable multivibrator. The 38-kHz signal takes the form of two symmetrical square waves, 180° out of phase. These control the L (left) and R (right) switching transistors.

A 1,000-Hz phase-shift oscillator generates a sine-wave audio signal. The output of this is coupled to both L and R panel switches, then through a pair of emitter followers to the switching transistors. They are activated by alternate halves of the 38-kHz square wave. The L signal joins during one excursion, the R signal during the other, producing a multiplex L—R sideband signal. Filters correct any phase shift and take out any 114-kHz (third harmonic of 38 kHz) component of the signal before it reaches the modulator

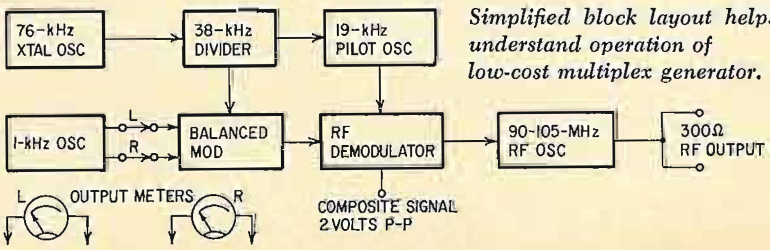
The 19-kHz pilot oscillator is a Colpitts, timed by a pulse from one side of the 38-kHz square wave. The 19-kHz output goes through the PILOT switch to the modulator and its attenuators.

From the modulator another composite multiplex signal goes to the STEREO-SIGNAL jacks on the front panel, and also to the rf oscillator—another Colpitts. The modulator frequency-modulates the composite signal onto this carrier. Rf output is through a coaxial cable terminated in a resistive pad to match the 300-ohm input on FM tuners.

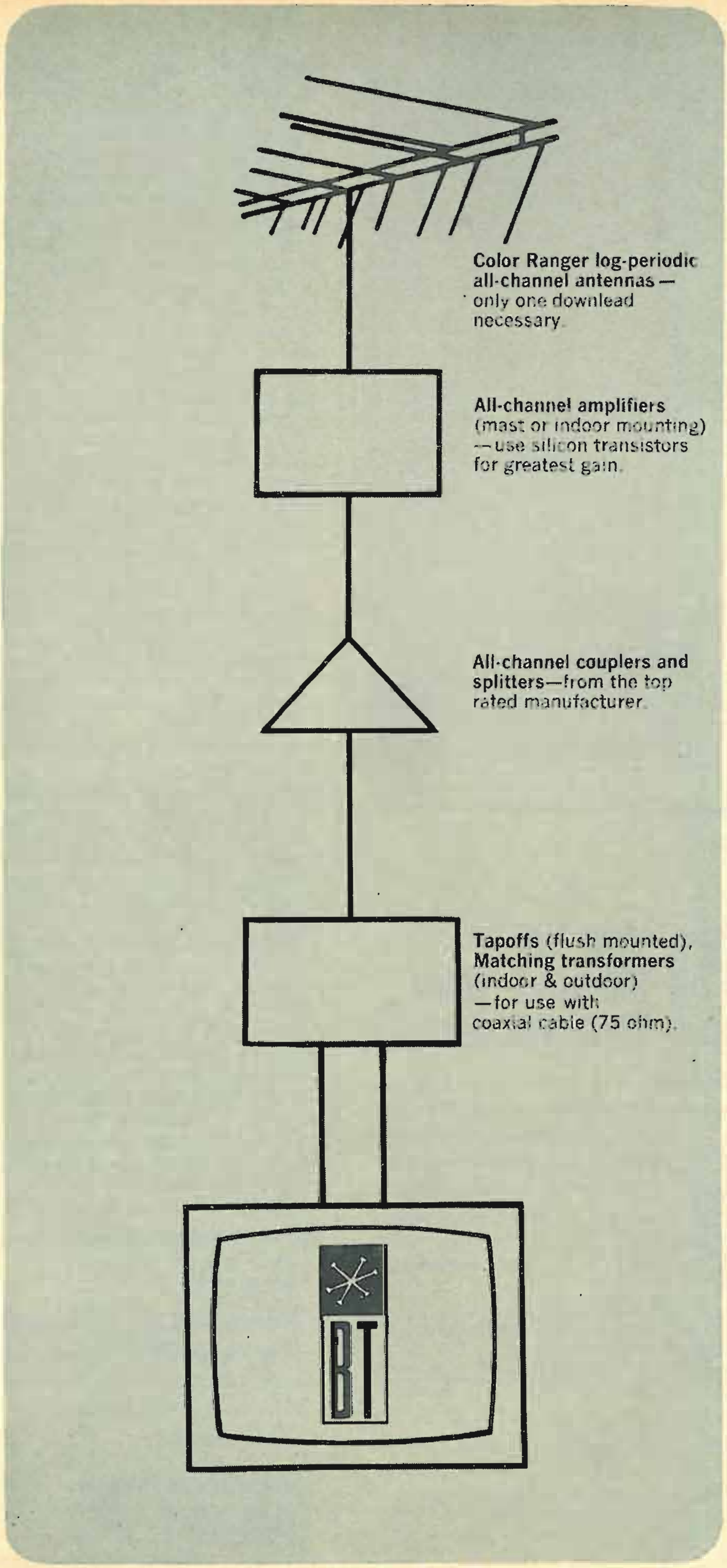
The power supply for the MX11 is eight C-cells, hooked up as two 6-volt sources—one positive and one negative. Normal current drain is 12 mA from each, so battery life should be good. The batteries can run down to a level of about 5 volts before replacement is necessary.

One feature is handy in a lot of ways besides the one for which it's intended: a pair of output meters! They are not connected in any way to the MX11 circuitry; each has its own cable on the back panel, plainly marked. Each meter has an 8-ohm 5-watt load resistor and a diode rectifier. Hooked across the speakers of a stereo system, these meters measure audio output level. If you run into a transistor system with an odd speaker impedance—like 100 ohms—add a blocking capacitor in series with each meter.

Each is a 3-volt rms-reading ac voltmeter. The scales are marked HI–GOOD–LOW and in dB. If one meter is at full scale and the other is at the HI mark, this indicates a 20-dB separation between



Simplified block layout helps understand operation of low-cost multiplex generator.



GO ALL CHANNEL ALL DOWN THE LINE WITH BLONDER TONGUE

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Blonder-Tongue Laboratories, Inc., 9 Alling Street, Newark, N. J.

Circle 30 on reader's service card

channels or signals being compared.

You can make a lot of tests very quickly with the MX11. To check channel separation in FM stereo receivers, connect the rf cable to the input and the meter cables to each speaker terminal. Tune in the signal, set the volume control for full-scale deflection of one meter, turn the balance control for equal readings. If the 1,000-Hz tone annoys you, disconnect the speakers (the built-in load resistors will protect the amplifier.)

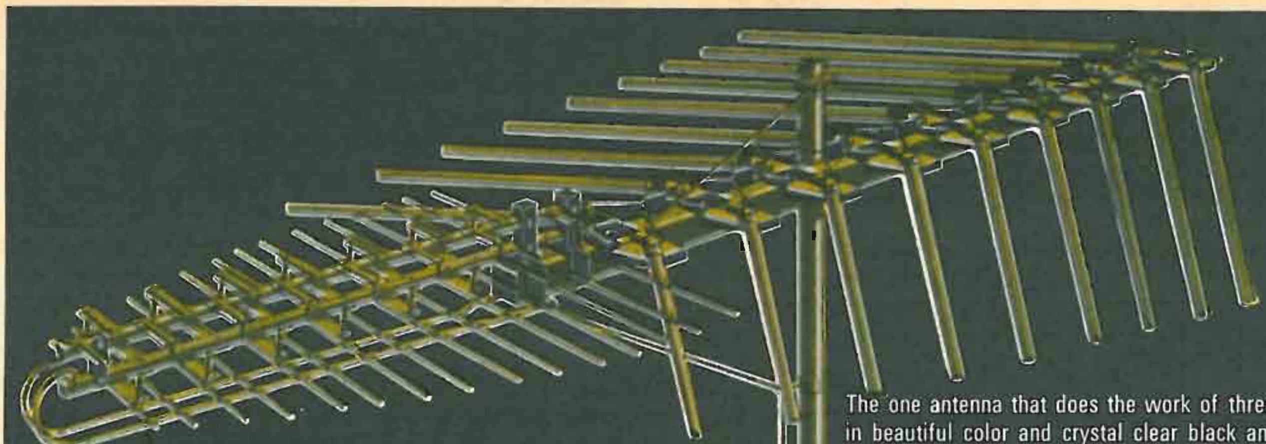
Set the PILOT switch to 10% and turn off either L or R. The corresponding meter reading should drop, while the other stays where it was. Channel separation is read directly in dB from the scale that dropped. Repeat the test for the other channel. This test can catch a lot of troubles. For instance, if you turn off the R signal and the L meter drops, something's wrong! (Be sure you've hooked the meter clips to the correct speaker terminals.) The mpx adapter could be misaligned so that the output is 'way out of phase.

If you find a system with poor separation, the mpx section can be aligned with the MX11. Feed the composite signal directly into the multiplex input or FM detector output point. If this shows good separation, the trouble must lie in the FM tuner circuits. Incorrect alignment or defective parts can cause the tuner bandpass to become too narrow for the full multiplex signal. Tuner rf and i.f. stages can be aligned roughly with the MX11 signal. The meters are used as output meters, a full stereo signal applied at the input, and the receiver circuits tuned for maximum indication on both meters.

In the shop, the MX11 can be used with a scope for checking multiplex detector and pilot carrier. If the trouble seems to be in the pilot carrier or the doubler, hook the scope across the mpx detector and peak the 19-kHz and 38-kHz stages for maximum amplitude.

For the service technician who is going into the profitable field of FM stereo work, the MX11 will make his jobs simpler. Best of all, it's really in the right price range.—*Jack Darr*

Price: $99.50 END



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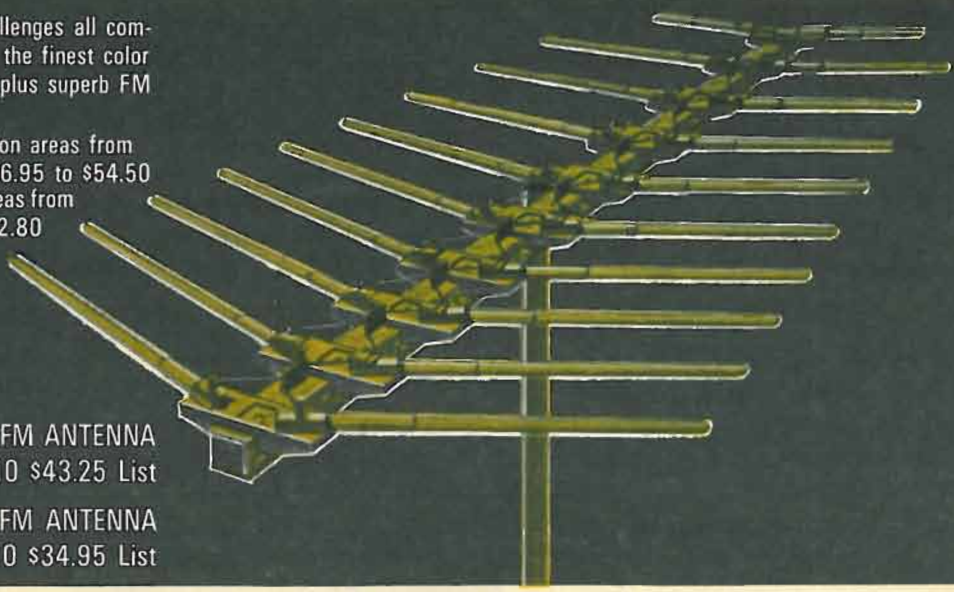

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Circle 34 on reader's service card

NEW SEMICONDUCTORS, MICROCIRCUITS & TUBES

This month's developments are highlighted by several advanced transistor types, switches and FET's. The A477 and A473 are new silicon planar epitaxial transistors for TV video i.f. amplifier service. Their unusually low feedback capacitance—150 fF (femtofarads or thousandths of a picofarad, sometimes called millipicofarads or mpF) and 220 fF (0.220 pF), respectively—make it possible to design an unneutralized three-stage video i.f. amplifier with an overall minimum gain of 90 dB.

Typical f_T is 350 MHz for the A467 and 400 MHz for the A473. Both types have high breakdown voltages. V_{CEO} is 30 and 35 volts, respectively. The transistors are in TO-18 cases. TV i.f. circuits, application notes and detailed specifications can be obtained from Amperex Electronic Corp., Semiconductor and Special Purpose Tube Div., Slatersville, R. I. 02876.

The 2N4127 and 2N4128 are new high-power rf transistors for use in 25-volt mobile and aircraft applications. The 2N4127 has a power output of 13.5 watts at 175 MHz with 8 dB gain. The 2N4128 delivers 25 watts with 9 dB gain at the same frequency. These TRW Semiconductors transistors are in low-profile molded silicone packages with stud mounts. The high-power unit costs $45 in quantities less than 100 and the low-power unit $24. Prices can be expected to drop as more applications are developed. They should be ideal for portable and mobile amateur radio vhf applications.

The type 8643 tube is another new product that should find its way into amateur mobile gear. It is an Amperex twin tetrode with a revolutionary type of cathode designed for relative immunity to variations in heater supply voltage. The cathode delivers 90% of rated power with heater voltages ranging from 10 to 16.

The 8643 is designed for rf amplifier, oscillator and frequency multiplier applications up to 175 MHz. Rated for PTTS (push-to-talk service—maximum duty cycle: 1 minute on, 4 minutes off) at 175 MHz, it delivers up to 135 watts output with less than 4 watts drive as a push-pull FM amplifier. Under ICAS conditions, it delivers 123 watts with 3.5 watts of drive.

Two new developmental RCA npn transistors (TA2669 and TA2669A) are especially suited for switching-control amplifiers, power gates, switching regulators, converters and inverters, and rf amplifiers and power oscillators. The 0.5 μsec (max) turn-on time makes them useful as switches handling up to 15 amps. Both can dissipate up to 140 watts at case temperatures of 25°C.

Characteristics are:

	TA2669	TA2669-A	
V_{CBO}	120	150	volts
V_{CEV} (sus)	120	150	volts
V_{CER} (sus)	80	110	volts
V_{CEO}	60	90	volts
V_{EBO}	7	7	volts
I_C	20	20	amps
I_B	10	10	amps

Philco's Solid-State Products Operation at Spring City, Pa. has developed a high-speed germanium diode capable of demodulating the output of lasers used in optical communications systems in the 0.5—1.8-micron range.

The L-4250 optical-detecting, photomixing diode is expected to find greatest use with 1.06-micron neodymium and 1.15-micron helium-neon lasers. It has a peak spectral response at 1.4 microns, a .03 sq. mm. light-sensitive area and a cutoff frequency of 1.5 GHz. The diode is most efficient with 6 volts or more of reverse bias. Cost is $135 in quantities of 1 to 9.

G-E has introduced the D13D1 SUS (*S*ilicon *U*nilateral *S*witch) and D13E1 (*S*ilicon *B*ilateral *S*witch). The former is a diode thyristor with electrical characteristics approaching the ideal four-


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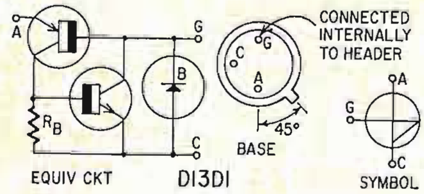
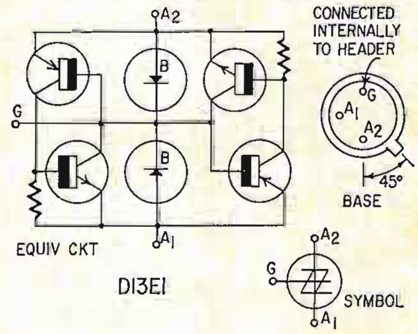
layer diode. Designed for monostable and bistable circuitry such as telephone switching, SCR triggering, and a variety of memory and logic applications. The D13E1 is a silicon planar multijunction device with a symmetrical negative-resistance characteristic, designed for stable switching characteristic over a wide temperature range. A gate lead (see diagrams) gives access to the Zener and p-n-p base node. Suitable for half- and full-wave triggering in low-voltage SCR and Triac phase control circuits. Pertinent characteristics are:

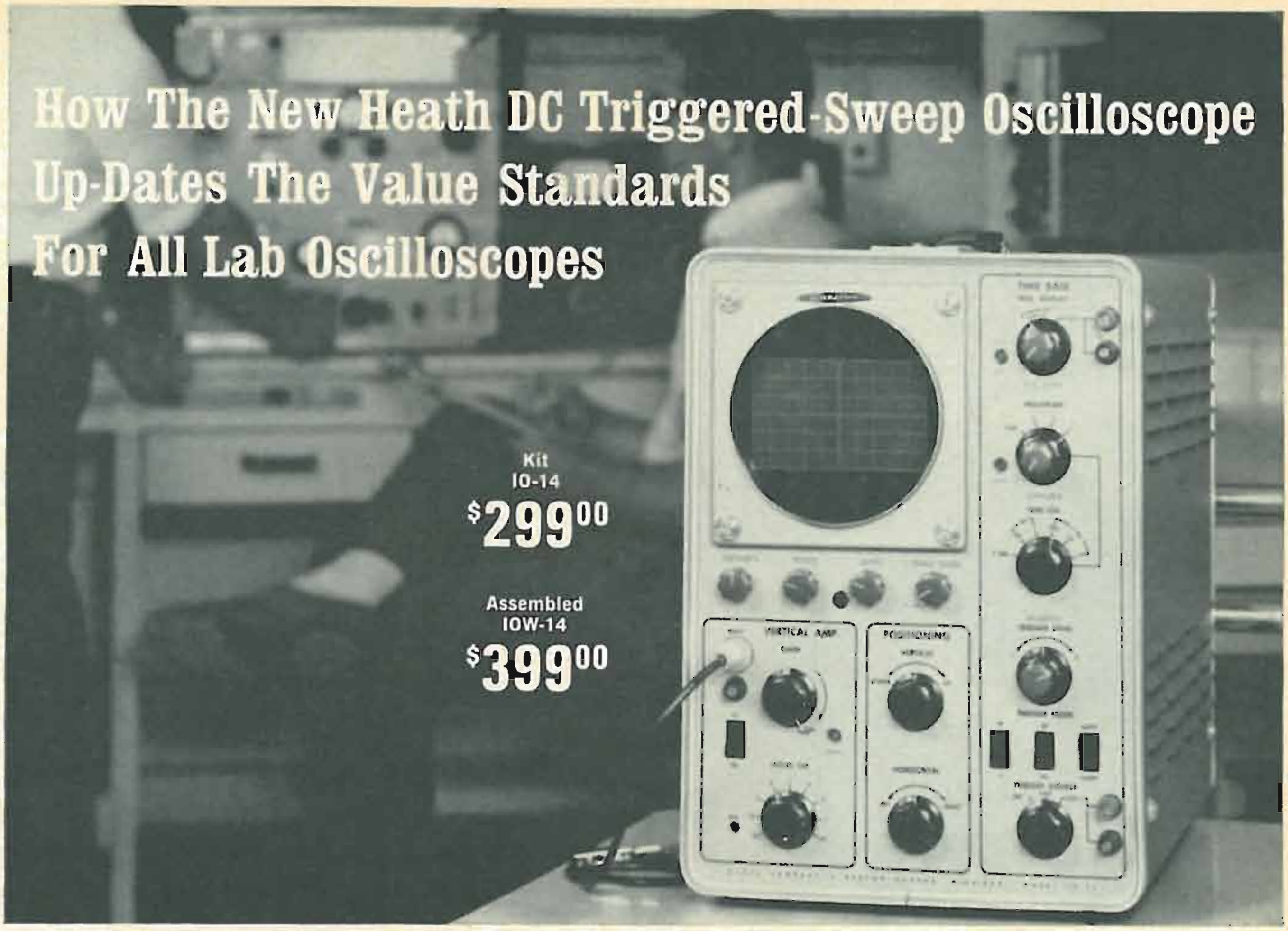


D13D1
Forward switching voltage, V_S
6 volts (min)
10 volts (max)
Forward switching current, I_S
500 μA
Reverse current,
$V_R = -30$, $T_A = 25°C$
0.1 μA
Forward current,
$V_F = 5$, $T_A = 25°C$
1.0 μA
Forward voltage drop,
$I_F = 200$ mA 1.75 volt
Turn-on time, t_{on} 1.0 μsec
Turn-off time, t_{off} 25.0 μsec
Capacitance,
(O volt, f = 1 MHz)
2.5 pF



D13E1
Switching voltage, V_S
6 volts (min)
10 volts (max)
Switching current, I_S
500 μA
Absolute switching voltage,
$(V_{S2} - V_{S1})$ 0.5 volt
Absolute switching current,
$(I_{S2} - I_{S1})$ 50 μA
Holding current, I_H 1.5 mA
Current (off state when
$V_F = 5$, $T_A = 25°C$)
1.0 μA
Turn-on time, t_{on} 1.0 μsec END

How The New Heath DC Triggered-Sweep Oscilloscope Up-Dates The Value Standards For All Lab Oscilloscopes



THE NEW HEATH IO-14 OSCILLOSCOPE OFFERS TRULY SOPHISTICATED CAPABILITIES. It features a high-quality flat-face 5" CRT with an accurately-ruled 6 x 10 cm graticule • DC to 8 MHz bandwidth with 40 nanosecond rise time • 0.25 microsecond vertical signal delay through high-linearity delay line circuitry • 3% calibrated vertical attenuation — from 0.05 v/cm to 20 v/cm • 3% calibrated time base — from 0.2 microseconds/cm to 0.5 seconds/cm • Forced air cooling for the toughest industrial applications • Input for Z axis modulation • Input for direct access to vertical deflection plates • Highly-stable fiberglass circuit board construction • Wiring options for 115/230 volt, 50-60 hertz operation • The IO-14 is designed with modern circuitry, engineered with high-quality close-tolerance components, and capable of satisfying the most critical demands upon its performance specifications.

THE HEATH IO-14 INCLUDES ENGINEERING FEATURES YOU EXPECT ONLY IN HIGH-PRICED OSCILLOSCOPES. For example, switches are ball-detent type; all major control potentiometers are precision high-quality sealed components; all critical resistors are 1% precision; and vertical signal delay is provided through precision coaxial delay lines — circuitry considered by all knowledgeable electronic engineers to be the most desirable for high linearity and maximum frequency response.

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Is Color a TV-Man Job?

Customers, dealers, technicians all still have serious doubts about color television. This article should lay many of them to rest

By WALLACE WANER

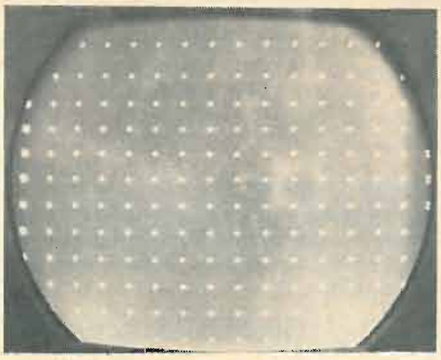
IT USED TO BE SAID THAT INSTALLING A black-and-white TV set called for no particular knowledge, skill or equipment—but that installing a color receiver was something that could be done only by a competent technician with adequate equipment.

This may no longer be strictly true. Self-degaussing receivers *can* be put in without special equipment, and possibly without too much skill. But there is still a lot of difference between black-and-white and color receivers. The average user doesn't notice slight imperfections in a black-and-white set. The picture width and height may be overextended a little; contrast and brilliancy levels somewhat off; focus may not be even over the entire picture area; and the linearity can be far from perfect. These weaknesses get by anyone but the trained technician, a critical observer or the finicky customer.

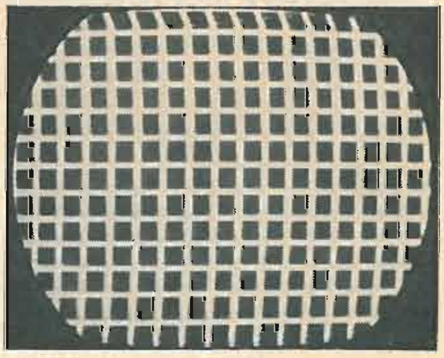
Color adds further problems: Is the purity good? How about convergence? Is the antenna system good enough for color? These factors are prominent, together with a few not-so-obvious items.

How does a competent technician meet those problems? He is likely first to inspect the antenna system to see if it looks like one that will pick up color, and that there are no loose connections, broken rods, or corroded terminals. He may immediately decide that it will not handle color. Some high-gain antennas clip sidebands. The effect cannot be noticed on a black-and-white set with a bandwidth of 2.5 to 3.2 MHz. It might be entirely useless for color reception where the bandwidth has to be 4 MHz.

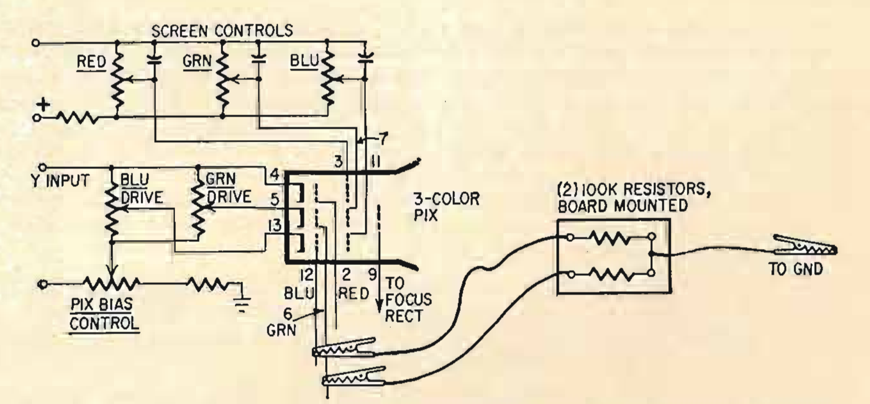
A color technician might also consider a rotator for ghost elimination, which shows up much worse on color than on black-and-white. For the lower-priced sets it is still necessary to demagnetize (degauss) the receiver when installing it and on later service calls.



A typical dot pattern is used for preliminary adjustments and for dc convergence.

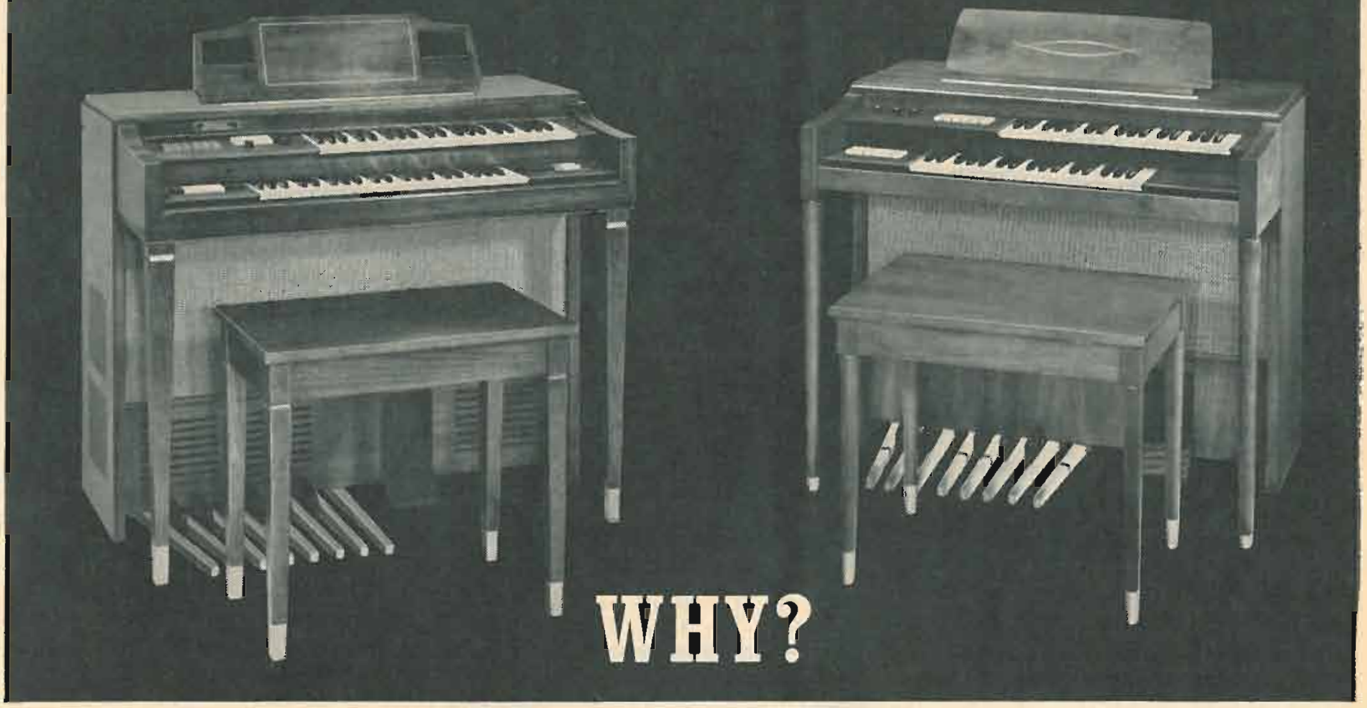


Crosshatch patterns like the one above are used to adjust dynamic convergence.



Color controls and grid-shunting resistors (top) used in setting up a color set.

In an age when time is of the essence, thousands of people have spent 50 to 70 hours building their own Heathkit®/Thomas Organ



Savings
It is a proven fact that significant savings can be realized. Savings amounting to several hundreds of dollars. This, indeed, is strong motivation for all.

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Building your own Heathkit organ permits you to stretch your budget to afford the purchase of a superior instrument at the cost of an ordinary one. And Thomas organs are renowned for their excellent voicing, fine mechanical construction, and advanced electronic circuitry.

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If you haven't tried it, you cannot realize the exhilarating fun of constructing as complex an instrument as an organ. Yet, you need no special skills or knowledge to accomplish it. We show you how, completely. No unanswered questions, no technical jargon. Just one of the most satisfying do-it-yourself activities ever!

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Its professional features also include 28 notes of chimes — worth $500 to $2000 as an extra on other organs; 2-speed rotating Leslie speaker plus 2-unit main speaker system; two 44-note keyboards; 13-note bass pedals; attack and repeat percussion; handcrafted walnut cabinet and bench; all-transistor circuit.

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The assembly takes about 50 hours, and you save up to $150 over a comparable factory-built model.

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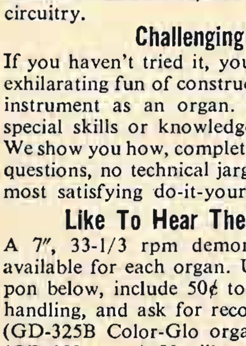

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On these same sets it will be necessary to degauss whenever the set is moved, and occasionally when it has been exposed to strong magnetic fields. Turning a vacuum cleaner off or on when near the receiver, for example, is an excellent way to magnetize the tube.

On sets with self-degaussing circuits (automatic color purifiers, etc.) the set is degaussed every time it's turned on, or in some sets any time the owner wants to push the button.

Purity and convergence adjustments are a great improvement over what they were a few years ago. But proper adjustment still requires the correct equipment, and is helped a great deal by the experience of the technician. It is possible to *check* the purity without any more equipment than a pair of 100,000-ohm grid-shunting resistors. The blue and green grids are shunted to leave only red. If the purity is not good, adjustments can often be made, following the instructions given by the manufacturer in the manual for that particular set.

After the red field is checked, the blue and the green ones can be handled in the same way. Red is usually the critical color, especially on the older, low-efficiency picture tubes.

Some jobs demand equipment

Convergence is one job for which you must have the proper tools—a dot-bar generator or equivalent. A grid-test generator is also very useful, especially for dynamic convergence. The cross-hatch pattern indicates overscan, linearity defects, etc. Some modern generators, of course, supply all these together with single lines or assembling point.

Of course, if the set is not picking up any black-and-white well, it will not receive color. It's a good idea to go on to black-and-white and adjust the controls for good highlights in white areas—in other words make sure that you're getting a good black-and-white picture. Newer receivers have a setup or NORMAL-SERVICE switch, that cuts vertical sweep and sets picture-tube bias at a predetermined level for gray-scale tracking. The screen controls are then adjusted so that each one just barely produces a horizontal line.

There is a great deal you can do to a color set without dragging in several pieces of equipment. END

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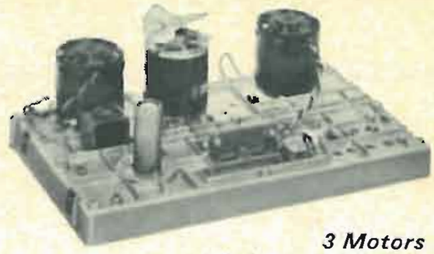

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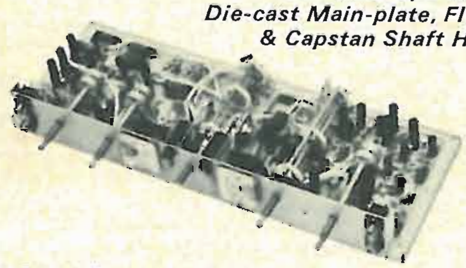

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Add to this Magnecord's years of pioneering and developing tape equipment for the broadcasting and recording industries, and you have a sophisticated recorder that will give you years of professional quality and reliability.

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With the 1020, you can record "live" from microphones, or from auxiliary sources like tuners, phonographs, TV's, etc., and playback . . . in 4-track stereo or mono at either 7½ or 3¾ ips. And you can make sound-on-sound, or sound-with-sound (mixing) recordings, or create interesting echo effects.

Professional Tape Transport

The tape transport is powered by 3 separate motors. The hysteresis synchronous capstan motor has a dynamically balanced flywheel and a ballbearing inertial stabilizer mount for constant, accurate speed. Two permanent split-capacitor type motors drive the reels. With the convenient push-button controls, you can change operational modes instantly and gently with the touch of a button. Compliance arms insure correct tape tension at all times.

The military-type differential band brakes are solenoid operated for instant, gentle stops. And when the tape runs out an automatic switch shuts off all motors and retracts the tape pressure roller eliminating unnecessary motor wear and prevents deformation of rollers. The tape gate and pressure roller also are solenoid-operated for positive action.

3 Professional Tape Heads

Selectable ¼ track erase, record and play. Engineered and lapped to a precise hyperbolic curve for smooth low frequency response . . . made with a deep gap, deposited quartz for high frequency response and long life. Removable shields afford double protection against external magnetic fields. Protective, snap-mounted head covers provide easy access for cleaning and de-magnetizing. And for quick, accurate editing, there are center-line marks.

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All parts mount on a thick, die-cast main-plate that won't warp, reduces wear, provides rigid support and stable alignment. Two V.U. meters for visual monitoring of signal levels from either tape or source . . . allows quick comparision of source with recorded signal. Inputs for microphones and outputs for headphones are all front-panel mounted for easy access. Digital counter with push button reset. Low impedance emitter-follower outputs deliver 500 millivolts or more to amplifier inputs. Individual gain controls for each channel. And all solid-state circuitry . . . 21 transistors and 4 diodes . . . your assurance of cool, instant operation, long reliable life.

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Free booklets, "Pocket Guide to Real Earnings," and "Electronics in Space Travel."

ELPA MARKETING INDUSTRIES, INC. (Pg. 90) Circle 113
Information on Editabs splicing method.

FINNEY CO. (Pg. 71) Circle 34
Information on Finco 75 ohm Color Ve-Log Antenna.

GRANTHAM SCHOOL OF ELECTRONICS (Pg. 107) Circle 129
Information on FCC licence preparation.

HALLETT MANUFACTURING CO. (Pg. 23) Circle 20
Complete guide for adding noise-free miles to the reception range of CB and FM receivers through use of Hallett "Signal Savers," which shield all ignition noise.

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Information on Hallicrafters CB-20 transceiver.

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Catalog and registration application.

HEATH COMPANY (Pg. 77, 79, 81) Circle 41
Catalog.

INTERNATIONAL CRYSTAL MFG. CO., INC. (Pg. 112) Circle 148
Complete Catalog of equipment.

INTERNATIONAL RADIO EXCHANGE (Pg. 90) Circle 114
Complete list of equipment in stock.

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Information on the new X-40 ultra compact loudspeaker system.

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Literature on Metro Color 82 channel antennas.

JOHNSON, E. F. (Pg. 7) Circle 10
Literature on complete line of CB transceivers and accessories.

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LAFAYETTE RADIO ELECTRONICS (Pg. 93-94) Circle 118
Catalog.

LAMPKIN LABORATORIES INC. (Pg. 87) Circle 108
Booklet "How to Make Money in Mobile Maintenance" and information on Lampkin meters.

MERCURY ELECTRONICS CORP. (Pg. 95) Circle 119
Information on Model 801A CRT color tester-reactivator.

MUSIC ASSOCIATED (Pg. 76) Circle 39
Information on Music Associated sub carrier detector for "Music only" programs on FM Broadcast Band.

NOVA-TECH (Pg. 88) Circle 110
Booklet on 4-band 12-transistor portable with direction finder for airplane, airport, police, shortwave and marine broadcast bands as well as standard AM.

OLSON ELECTRONICS, INC. (Pg. 90) Circle 112
Catalog.

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Britener Selecter Chart for base type of every picture tube.

POLY PAKS INC. (Pg. 111) Circle 132
Catalog on Semiconductors, Poly Paks and Parts.

PRECISE ELECTRONICS (Pg. 66) Circle 27
Information and technical data about the complete line of power instruments, scopes, VTVM's, signal generators, tube testers, decade boxes, probes.

PYRAMID ASSOC., INC. (Pg. 86) Circle 107
List of tubes.

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RCA INSTITUTES, INC. (Pg. 28-31) Circle 25
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Booklet on "How to Read Faster and Retain More."

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Information on "Clever Klips 30" test probe.

S & A ELECTRONICS, INC. (Pg. 16) Circle 16
Information on Target Antennas.

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WARREN ELECTRONIC COMPONENTS (Pg. 106) Circle 128
Information on silicon rectifiers.

WELLER ELECTRIC CORP. (Pg. 97) Circle 121
Literature on dual heat soldering guns and kits.

WINEGARD CO. (Pg. 76) Circle 38
Literature on distribution amplifiers.

NEW PRODUCTS

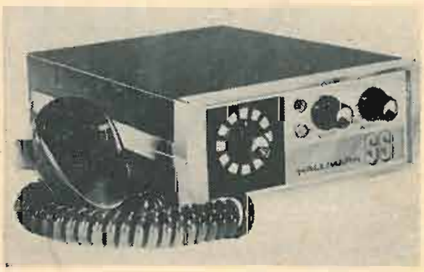
More information on new products is available free from the manufacturers of items identified by a Reader's Service number. Turn to the Reader's Service Card facing page 82 and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.
Hz = hertz = cycle per second; kHz = kilocycles; MHz = megacycles

WOW AND FLUTTER METER, *models ME-101/102.* Power: 110–125/220–240 volts, 40–60 Hz. Oscillator unit: measuring frequency 3,150 Hz (constant 1 x 10^3 after warm-up period); output voltage approx. 0.4Vrms at test output connector, 20mV at auxiliary calibrating output. Measuring unit: input voltage 30mV to 30 V, 3,150 Hz ±5%; input impedance 10,000 ohms; measuring ranges, *ME-101:*

±.02 to ±0.5% and ±0.1 to ±2.5%, *ME-102:* ±0.01 to ±0.15% and ±.05 to ±0.75%. Frequency response of tone fluctuation: linear position: 0.50 to 500 Hz (−3-dB points); weighted position according to CCIR standard with external filter as required. Drift indication max. ±4.5%. Auxiliary output: 20 volts peak-to-peak at 22,000 ohms. 7 x 8 x 11¾ in., 11 lb.—**Gotham Audio Corp.**

Circle 46 on reader's service card

12-CHANNEL CB TRANSCEIVER, the *Hallmark SS*, uses prealigned plug-in circuit modules. Receiver uses germanium transistors, has crystal-controlled oscilla-



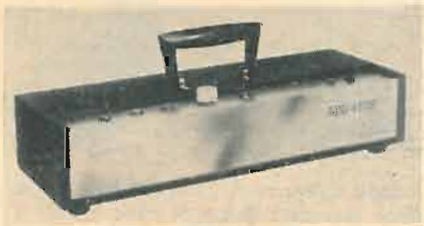
tor, linear rf amplifier. 95% to 100% modulation; 3.7 watts rf power output for maximum talk power. Regulated power supply available.—**Hallmark Instruments**

Circle 47 on reader's service card

DUAL-TRACK CAPSTAN-DRIVE MONAURAL TAPE RECORDER, Aiwa portable *model TP-719.* 3 speeds; holds 7-inch reels. Ac bias recording and erase system. Less than 0.25% wow and flutter at 7½ ips. 5 x 3-in. PM oval speaker. 1.5

watts output. Power source: 8 D-cell batteries; 117 volts, 60 Hz; 12-volt car battery. Accessories: earphone, mike, batteries, car battery adapter, ac cord, 7-in. supply reel with tape, 7-in. takeup reel. 16½ x 13 x 3⅝ in., 16 lb, 8 oz.—**Selectron International**

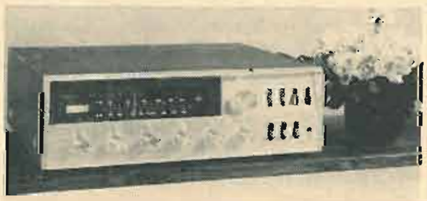
Circle 48 on reader's service card



REVERBERATION ACCESSORY, the *Add-Verb II,* has 4-transistor circuit and a Hammond reverberation unit. Includes 1 mike input, 2 instrument inputs, mixer control, foot switch jack, input jack, pilot light, permanently connected output cable for connection to any instrument amplifier, phonograph or tape recorder. 17 x 1¼ x 6¾ in., less than 5 lb.—**Gregory Amplifier Corp.**

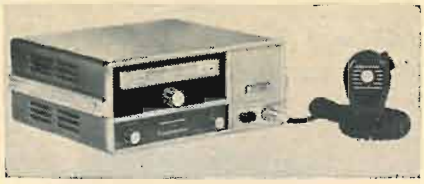
Circle 49 on reader's service card

120-WATT SOLID-STATE STEREO RECEIVER, *model LR-1200T.* Amplifier response ±1 dB, 20–50,000 Hz at 1 watt. Harmonic distortion less than 1% at full output; 0.125% at 1 watt. Power bandwidth: 11 Hz to 38 kHz. Phono sensitivity: 2, 5, 12 mV; aux.: 275 mV; tape monitor: 370 mV. Hum and noise: −58 dB on phono, tape head; −78 dB auxiliary. Equalization: phono RIAA; tape head, NAB. Output impedance: 4–16 ohms. Tuner IHF FM sensitivity: 1.5 μV. Image rejection: −70 dB. FM signal-to-noise ratio: −65 dB. FM distortion: 0.5% at 100% modulation. Capture ratio: 2.2 dB.



AM suppression: 53 dB on FM. Stereo mpx separation: 40 dB at 400 Hz. FM antenna impedance: 300 ohms balanced. AM sensitivity: 15 μV at 1,000 kHz.—**Lafayette Radio Electronics**

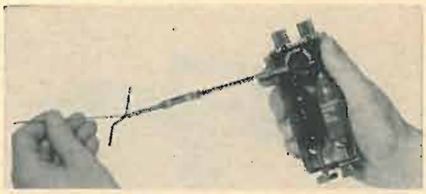
Circle 50 on reader's service card



MARINE RADIOTELEPHONE, the *MRT-50*. 50 watts, 12 FM channels, with automatic deviation limiting circuit to keep operator's transmission within FCC bandwidths. Transmitter cutoff switch reduces battery power requirements while permitting channel monitoring. All-angle mounting bracket on slide rail. 11½ x 4¾ x 10½ in., 20 lb. Vhf antenna less than 2 ft. tall.—**Pearce-Simpson, Inc.**

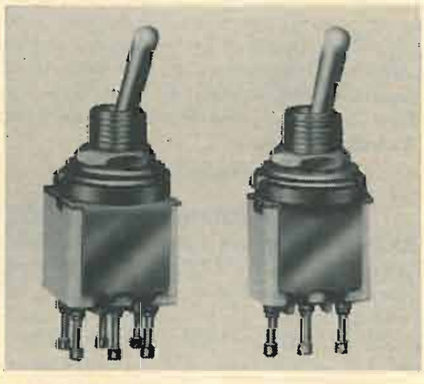
Circle 51 on reader's service card

PORTABLE SOLDERING TOOL, consists of *Microflame* gas welding torch plus new soldering-tip adapter. Torch uses self-contained miniature oxygen and



butant compressed gas cylinders to produce pin-point flame of over 5,000° F. This heats soldering tip, held in on–off adapter.—**Microflame, Inc.**

Circle 52 on reader's service card



SWITCHES, *E series*. Waterproof, rated 6 amps at 125 Vac. Life cycle: 100,000 on–off operations (spdt). Temperature range −50°C to 150°C for 1 hour. Voltage breakdown: 1,000 Vac between terminals and case ground for one minute. Wide silver contacts bonded on silver-plated copper turret terminals. Double high-voltage barriers.—**Alco Electronic Products, Inc.**

Circle 53 on reader's service card

PORTABLE TV CAMERA, *model HV-50*, has on–off trigger in a foldaway handle (10 in. long, 3-in. diameter, 3 lb) that remotely controls operation of any

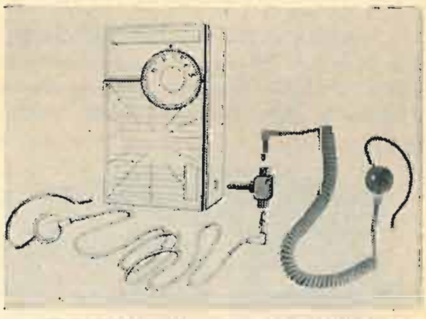
equipment associated with a camera, such as video tape recorder, video monitor, home TV receiver. Features: all silicon transistors, stabilized electric eye, accommodation for all C-mount lenses, both video and rf outputs. Not shown in photo: camera control unit, 6 x 7 x 2⅜ in., 3 lb. —**Shibaden Corp. of America**

Circle 54 on reader's service card

TRANSCEIVERS: *model HA-460* for 6 meters, model *HA-410* for 10 meters. Dual-conversion receiver with crystal-controlled second converter. Nuvistor rf amplifier combines with SCR-controlled noise limiter. 20-watt (dc plate input) transmitter features built-in vfo, low-pass

filter. Oscillator can be crystal-controlled with standard 8-MHz crystals. Built-in 117-Vac and 12-Vdc power supplies. Frequency coverage: *HA-460*, 50–52 MHz; *HA-410*, 28–29.7 MHz. Receiver sensitivity: 1 μV for 10-dB signal-to-noise ratio. Selectivity: 35 dB at 8 kHz. 12⅛ x 5⅛ x 3¾ in., 22 lb.—**Lafayette Radio Electronics Corp.**

Circle 55 on reader's service card



EARPHONE JACK ADAPTER, the *Tini-Tee*, enables two people to enjoy earphone listening. Plugs into phone jack.—**Switchcraft, Inc.**

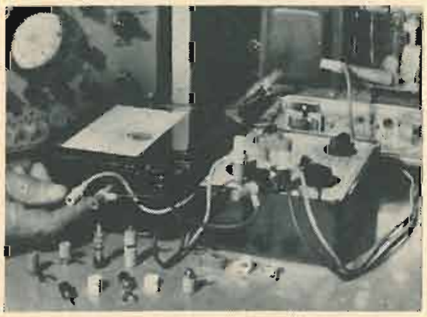
Circle 56 on reader's service card

TRANSCEIVER, the *Citi-Fone II*, uses car radio for second i.f. and audio, crystal-controlled; 5 watts input, 3 watts output; capable of 100% amplitude modulation; double-pi rf output circuit. Receiver: tuned rf amplifier; crystal-controlled oscillator/mixer; sensitivity ½ μV for 10 dB s+n/n ratio. Use with standard broadcast set results in 8 tuned circuits. 9 silicon transistors, 2 diodes.

Power: 12 volts dc; receive, .03 amp; transmit, 1.5 amps. 4⅜ x 1½ x 5¾ in., 3 lb.—**Multi-Elmac Co.**, 21470 Coolidge, Oak Park, Mich.—48237

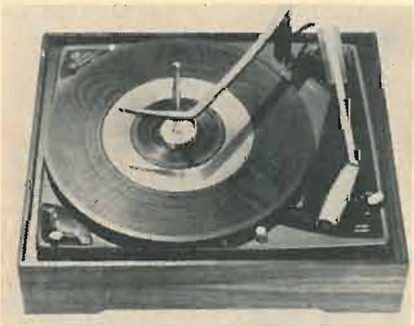
Circle 57 on reader's service card

TEST-LEAD TERMINALS, *Tes-Con-Ects,* for fast makeup of test leads with terminations needed to match any equipment under test. Terminals snap on



and off instantly. Types include alligator clips, spade tongue, phono and banana jacks, etc. Available with color coding.—**Waldom Electronics, Inc.**

Circle 58 on reader's service card



AUTOMATIC TURNTABLE, the *Crown Princess, model RCD-6,* 4-speed automatic/manual stereo with low-mass tone arm, full range of stylus pressure settings. Built-in stylus brush, automatic locking tone arm, 11-in. turntable with anti-static rubber mat, 4-pole dynamically balanced motor. Two audio cables and line cord.—**RFS Industries, Inc.**

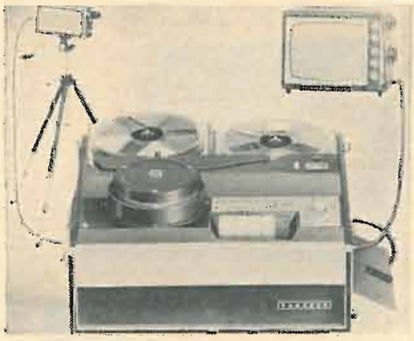
Circle 59 on reader's service card

VIDEO TAPE RECORDER, *model VX-1100,* uses cross-field bias-head longitudinal modulation system. Records at 30 ips on ¼-inch audio magnetic tape, 7- or 10½-in. reel; 100 minutes on 10½-in. reel of 7,200 feet. Video band-width: 60 Hz to 1 MHz ±6 dB. Signal-to-noise ratio more than 34 dB. TV signal: input and output 1.4 Vpp sync-negative 75 ohms. Audio (direct recording system) band-width: 50 Hz to 10 kHz. Signal-to-noise ratio more than 40 dB. Input and impedances: 600 ohms, 0 dB; 20K, —50 dB.

Output: 600 ohms, 0 dB. Power: 100, 110, 120, 200, 220, 240 volts switchable by variable transformer. 17⅖ x 16⅗ x 10⅓ in., 45 lb.—**Akai Electric Co.,** US agent **Califone/Roberts Electronics**

Circle 60 on reader's service card

VIDEO TAPE RECORDER, the *VTR-600,* uses helical-scan recording system with dual rotating heads; ½-in. tape at 12 ips, 7-in. reel. Recording time: 40 min. for 2,400 ft. Resolution better than 250

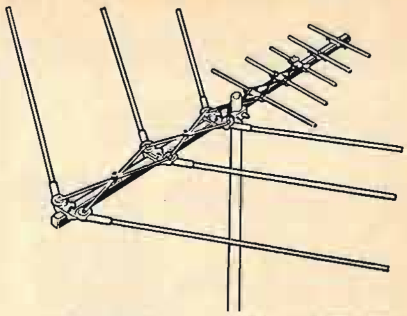


lines. Power: 80 watts. 10 x 17 x 16½ in., 52 lb. *VTR-600* augmented by camera *MTC-12* and TV monitor *MR-600.*—**Concord Electronics Corp.**

Circle 61 on reader's service card

STEREO HEADPHONES, *model PH-98,* feature air-filled headband for long periods of use. Ear cups padded with foam rubber which contains an air pocket. Impedance: 8 ohms. Response: 40–12,000 Hz.—**Olson Electronics, Inc.**

Circle 62 on reader's service card



VHF/UHF/FM LOG PERIODIC ANTENNA, the *LPV-VU5,* for urban use. 45-in long, response flat within ±½ dB on any channel. Sharp forward lobe in polar pattern for unidirectional pickup and high

Circle 108 on reader's service card

Circle 109 on reader's service card

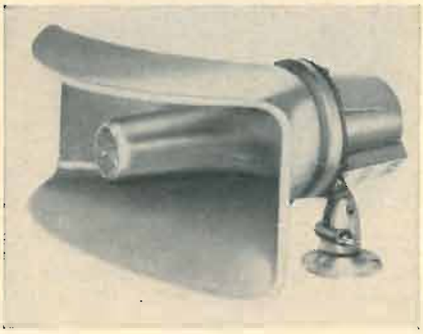
RADIO AND FINDER: With this 4-band, 12-transistor portable, you can pick up standard broadcasts, planes in flight, airport towers, police calls, short wave and the complete marine band. Its rotating antenna and null meter also combine to make it an accurate radio direction finder for your boat. The 2-lb., 8" x 5" x 2" unit can operate 4 ways—from internal batteries, external dry cell, house current or sun power from a solar cell bank. Write for FREE booklet: *Nova-Tech, Dept 49, Manhattan Beach, California.*

Circle 110 on reader's service card

front-to-back ratio on all channels. Indoor splitter included. Gold-coated aluminum. —**JFD Electronics Corp.**

Circle 63 on reader's service card

WIDE-ANGLE PAGING/TALK-BACK SPEAKER, the *APC-30T*. Built-in transformer and screwdriver-adjustable watts/impedance switch. Power up to 30



watts continuous. Power, equalized to frequencies above horn cutoff, 40 watts. Response 250–14,000 Hz. Sound level 123 dB measured 4-ft on axis at 30 watts input. Dispersion, 120° x 60°. 6 x 14 x 12⅞ in., 6 lb.—**Atlas Sound**

Circle 64 on reader's service card

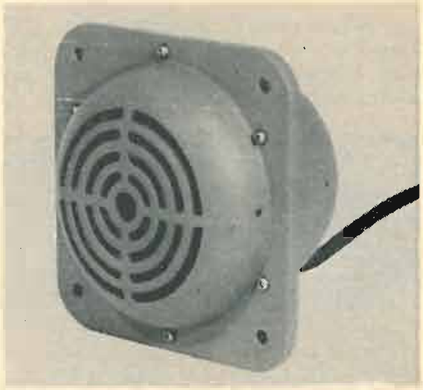
SOLID-STATE PORTABLE TAPE RECORDER, the *RK-142T*, more than 4 hours recording on long-play ½-mil 2,400-ft tape reel at 3¾ ips. Positive-acting lever-type record/playback motor control. 4 x 6-in. permanent-magnet speaker. Heads: ½-track lamination type record/play, ½-track double-gapped high efficiency erase. 7.5 and 3.75 ips speeds. Signal/noise ratio —40 dB or better at 7.5. Record playback response essentially flat with tone at max treble. Wow and flutter less than 0.25% rms at 7.5, less than 0.35% at 3.75. Power output ±2 watts. Power supply 117 volts, 60 Hz ac. 11⅞ x 6½ x 10¼ in., 16 lb.—**Lafayette Radio Electronics Corp.**

Circle 65 on reader's service card

2-WAY FM RADIO, the *Motrac*, for uhf-band operation with up to 70 watts output power. Receiver sensitivity: 0.3 mV for 20 dB of quieting, with —65-dB intermodulation protection. Frequency stability ±5 parts per million with standard channel elements. Interchangeable plug-in channel-element option gives stability of ±2 parts per million. 5 watts audio output

with less than 5% distortion.—**Motorola Communications Div.**

Circle 66 on reader's service card



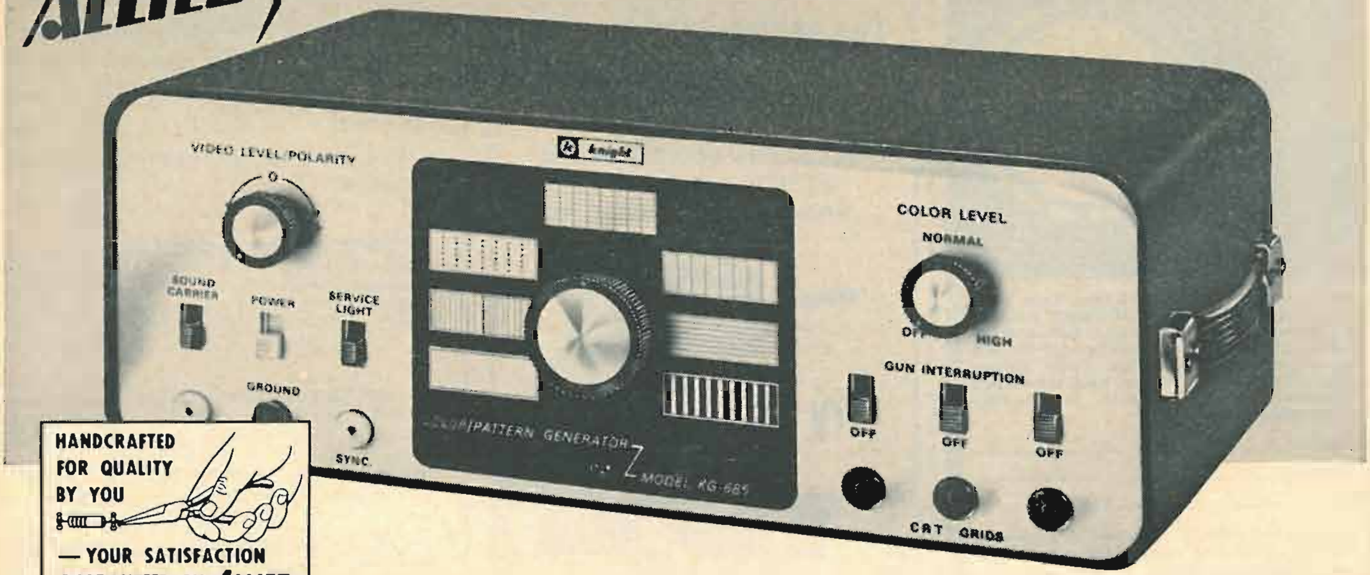
UNDERWATER LOUDSPEAKER, *UL-3*, provides music while you swim. Dynamic range: 50–20,000 Hz. Operational to depth of 16½ feet, temperature range 14° to 140°F.—**Pioneer Electronics U.S.A. Corp.**

Circle 67 on reader's service card

PUSH-TO-TALK MICROPHONES, *No. M-2* (250 ohms) and *No. M-3* (45,000 ohms). Sensitivity 1.2 mV/microbar; response 80–12,000 Hz. Microphone switch has positive lock action to hold circuit closed. High-impact rubber case. 2-in. dia.—**Audio Div. American Geloso Electronics, Inc.**

Circle 68 on reader's service card

NEW FROM ALLIED knight-kit® PORTABLE SOLID-STATE COLOR BAR/PATTERN GENERATOR



HANDCRAFTED FOR QUALITY BY YOU

— YOUR SATISFACTION GUARANTEED BY ALLIED

GIVES YOU 7 ACCURATE, STABLE, CRYSTAL-CONTROLLED PATTERNS

for speedier, easier, more accurate convergence and color adjustments

Purity Adjustment	Ten Color Bars	Small Dot Pattern	Exclusive 6-Position Gray Scale	Horizontal Lines	Vertical Lines	Crosshatch Pattern

You get the most for your money—outstanding performance, rock-like stability, plus day-in, day-out solid-state reliability with this great new Knight-Kit Color Bar/Pattern Generator. It's the perfect choice for both on-the-bench and in-the-home color TV servicing.

Generates 7 patterns—all displays needed for complete color set adjustments. Special 2-volt output for Zenith color sets. Every display is well-defined with extremely low background noise. Pattern for purity adjustments does not require usual tube removal or other quieting "tricks." Unique gray scale pattern provides 6 discreet levels of brightness for gun tracking adjustments. Horizontal display elements are only one raster line thick for ultimate definition. Crystal-controlled patterns eliminate any need for synchronization with TV set. Lead-piercing clips on gun interrupters allow fast, safe connection to receiver under test. Solid-state design provides instant operation.

Shaded light source on 3-ft. cable has handy clip mount for service adjustments in darkened room. Highly polished service mirror conveniently stores under bottom of case. Special power transformer with extremely low external field eliminates magnetic effects on color CRT. Rugged steel case measures 4⅝ x 9⅝ x 12". All parts, cables, instructions and 32-page operator's manual for just.............................. **$89.95**

MODEL KG-685 SPECIFICATIONS

7 Displays: purity, tracking, dots, crosshatch, vertical lines, horizontal lines, and color bars. *RF Output:* 10,000 microvolts minimum, tunable to channels 3, 4 or 5. *Composite Video Output:* ±2 volts peak-to-peak. *Composite Sync Output:* −2 volts. *Master Oscillator:* 189 kc, crystal controlled. *Color Oscillator:* 3.56 mc, crystal controlled. *Sound Subcarrier Oscillator:* 4.5 mc, crystal controlled. *Front-Panel Controls and Jacks:* Display Selector Switch, Sound Carrier On/Off Switch; Power On/Off Switch; Service Light On/Off Switch; Gun Interruption On/Off Switches (3—red, blue and green); Color Level Control (off through high, continuously variable); Video Level/Polarity (continuously variable level and choice of polarity); 6 Pin Jacks (3 signal output and 3 CRT grids). *Rear Panel:* Channel Tuning; Vertical Intensity (screwdriver adj.); Timing (5 screwdriver adj.); 6-circuit Test Jack. *Cables:* RF Output, 4-ft. long with alligator clips; Gun Interrupter, 4-ft. with lead-piercing, color-coded, alligator clips and ground lead; Service Light, 3-ft. with insulated mtg. clip, hi-intensity lamp and shade; Composite Video and Sync, 4-ft. with alligator clips and ground. *Power Requirements:* 110-130 v., 60 cycle AC. *Fuse:* Internal, ¼ amp quick blow. *Power Consumption:* approx. 10 watts.

COMPLETE KIT $89.95
Including 32-page Operator's Manual

Read this unique money-back guarantee . . . exclusive in the industry:

KNIGHT-KIT GUARANTEE

Build a Knight-Kit in accordance with our easy-to-follow instructions. When you have completely assembled the kit, you must be satisfied or we will return your money, less transportation charges, under the Allied guarantee of satisfaction.

ALLIED RADIO

Rush the coupon below for full details and Special Introductory Offer on the KG-685

Allied Radio, Knight-Kit Div., Dept. 2-JJ
P.O. Box 4398, Chicago, Ill. 60680

Please rush full details and Introductory Offer on the new **Knight-Kit Color Bar/Pattern Generator.**

Name______________________________
PLEASE PRINT
Address____________________________
City______________State________Zip________

Circle 111 on reader's service card

NEW LITERATURE

All booklets, catalogs, charts, data sheets and other literature listed here are free for the asking with a Reader's Service number. Turn to the Reader's Service Card facing page 82 and circle the numbers of items you want. Then detach and mail the card. No postage required!

MATV SYSTEM BROCHURE, *"Don't Get Caught in the TV Traffic Jam,"* describes system components which give any MATV system full 82-channel uhf/vhf/FM capability. Architects' and engineers' specifications.—**Blonder-Tongue**

Circle 69 on reader's service card

SOUND COLUMN TECHNICAL & INSTALLATION MANUAL, describes, with diagrams, methods of installation and arrangement of sound-column speakers in public-address systems.—**American Geloso Electronics Inc.**

Circle 70 on reader's service card

COLOR TV ELECTROLYTIC CROSS REFERENCE, *Form CTVX-651,* lists every color TV manufacturer's electrolytic part number and corresponding Aerovox exact replacement or equivalent. 14 pages, pocket size.—**Aerovox Corp.**

Circle 71 on reader's service card

PROFESSIONAL SERIES LOUDSPEAKERS CATALOG, *No. 1070-E,* 24 pages, photos, specs of line of speakers in applications from low power to superpower; hi-fi to maximum efficiency types. —**Jensen Mfg. Div./Muter Co.**

Circle 72 on reader's service card

TRANSISTOR RADIOS FLYER, *Standard* brand, including what is described as world's smallest radio (2 x 1½ x 13/16 in.). Illustrated.—**Mini-tronics**

Circle 73 on reader's service card

COIL CROSS-REFERENCE CATALOG, *No. 103,* 42 pages, looseleaf-punched, exact replacements for all manufacturers' TV and radio coil and transformer part numbers, available at most electronics distributors.—**Workman Electronics Products, Inc.**

Circle 74 on reader's service card

POLYESTER TAPE BROCHURE, 4 looseleaf punched pages, contains property tables on 10 Scotch polyester tapes, plus info on two capacitor-taping machines designed to use polyester tape.—**3M Co.**

Circle 75 on reader's service card

PERSONAL RADIO PAGING SYSTEM BROCHURE, *No. 90-57,* 14-page illustrated fold-out explains how personal paging differs from public-address paging; gives many applications.—**Motorola Communications & Electronics, Inc.**

Circle 76 on reader's service card

WIRELESS MICROPHONE, the *Vega-Mike,* brochure, data sheet and accessory information on one-piece microphone/transmitter and companion FM receiver.—**Vega Electronics Corp.**

Circle 77 on reader's service card

COMPACTRONS FOR COLOR TV, *Bulletin ETD-4359,* 12 pages with attached chain for hanging, is guide to selection of multifunctional compactrons for color and b-w TV. Charts, specs, diagrams, special features of compactrons.—**General Electric Co.** END

Circle 78 on reader's service card

Fix Your Burned-Out Ohmmeter Ranges

By WAYNE LEMONS

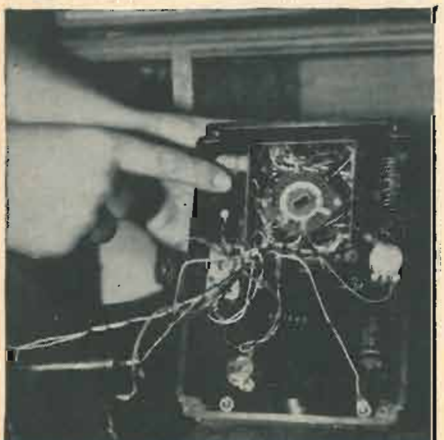
DO YOU HAVE AN OHMMETER THAT READS the same on the R x 1 scale as it's supposed to on the R x 100 or R x 1,000 scale? This trouble is usually caused by putting the ohmmeter leads on a circuit carrying several volts. What happens is more apparent if you check a typical circuit as shown in the diagram. (Perhaps you have hesitated to dig into it because the circuitry shown in the instruction booklet is in a form all its own.)

Note that meter ranges are changed by switching shunts across the test leads. These shunts bypass part of the current so that the meter becomes less sensitive. The meter will then read lower resistances more accurately, and on an expanded scale on the low-ohms ranges.

These shunts are always comparatively low resistances. When you attempt to read a rather large voltage with the vom switched to the ohms position, a heavy current passes through the shunt and often burns it out. When this happens, the effect is the same as if you had switched to a higher ohms range. Whatever range the shunt opens on will automatically take on the sensitivity of the highest ohms scale on the meter, and you will be misled about the value of resistance you're measuring if you don't realize the shunt is open.

How to find the trouble

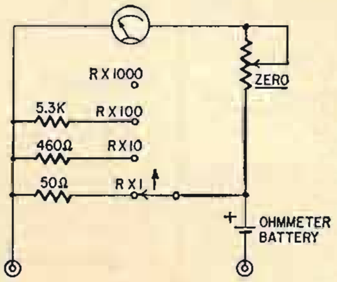
When you remove the back of almost any vom and see all the multiplier and shunt resistors you may at first despair of ever finding the one you're looking for. Don't give up—it isn't difficult. What you are looking for is usually just one open resistor. Since it is a shunt resistor it will be a low value, usually less than 100 ohms and maybe below 10. Fortunately, most vom manufacturers label the resistors with their values. All you need do is ferret out all the low-value resistors and check them with another ohmmeter—right in the circuit!



Somewhere in this mess is a burned-out resistor. Now you can find out which one!

Don't worry if you're not sure just which resistor you are looking for, check them all. You should be able to do that in 2 minutes or so. When you find the open one, you've found the trouble. It's usually best to switch the vom you're *testing* to a dc volts scale so you can't get any false shunt readings.

In some meters the shunts may be bobbin-wound and not marked. If so, and you can't determine the value of the resistor from the schematic or otherwise, find the open one with an ohmmeter. Then take a small carbon or wirewound potentiometer or a rheostat of about 50 ohms and connect it in the circuit in place of the open resistor. Set the range



Simplified typical ohmmeter circuit. The shunt values here don't belong to any particular meter—they're just representative.

switch on the vom to the defective scale and, with the test leads, measure a resistor of known value (a 1% resistor in another meter, for example). Adjust the pot until the meter pointer of the defective vom reads the correct value.

If there's room, you can just leave the pot in the circuit; if not, measure its value and replace it with an equivalent fixed resistor.

Using standard resistors

The ohmmeter resistors won't often be standard values, but with a little ingenuity you won't have to order one from the factory.

Let's suppose the correct value is 9.3 ohms. You won't have much trouble finding in a group of four or five a 10-ohm carbon resistor that will measure very close to the correct value. Sometimes you might use a slightly larger resistor, say 12 ohms, and shunt it with larger resistors (around 100 ohms) until you get the calibration close enough for practical purposes. I've never failed to find a standard resistor or network of them that will hold the calibration as good as or better than that of a factory-wound unit.

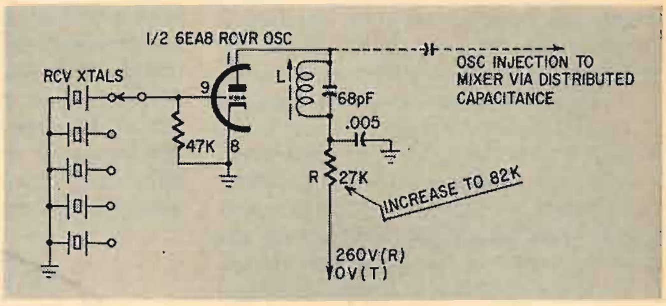
Next time your lower ohms scales get too sensitive, dive into your vom and check the low-value resistors—you'll save yourself time and money—and feel like an expert in the bargain. END

CB Troubleshooter's Casebook

Compiled by Andrew J. Mueller

Case 1: Receiver oscillator drifts; sometimes cuts off altogether.

Common to: E.C.I. **Fleet Courier**

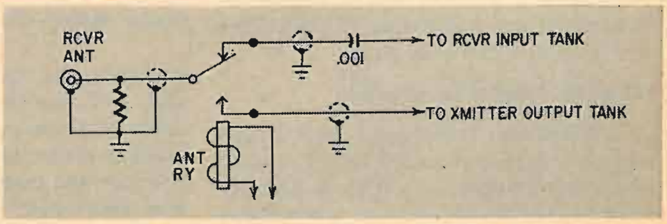


Remedy: Try new 6EA8 and receiver crystal. Realign coil L. If that fails, increase R to 82K.

Reasoning: In some of these units, there is too much plate voltage on the local oscillator. The grid bias is not enough to keep the stage in class-C operation and the stage becomes unstable. Increasing R reduces plate voltage and keeps oscillator well within class C instead of near the edge.

Case 2: Intermittent receive, transmit, or both.

Common to: Johnson **Messenger I and II**

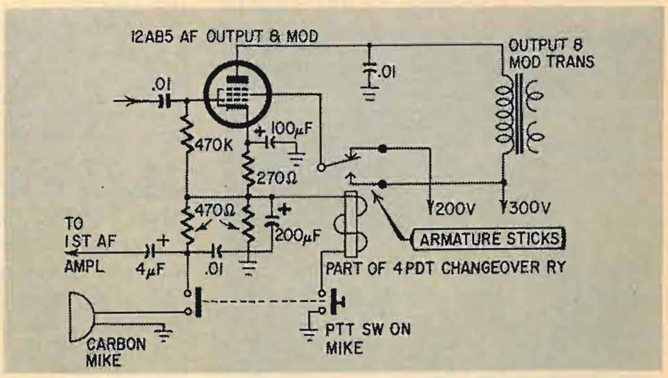


Remedy: Check plastic cap on antenna change over relay. Clean with paper or burnishing tool.

Reasoning: In late production runs, the plastic cap on the relay sometimes causes the contacts to stick. In older models, the relay contacts get dirty and need frequent cleaning.

Case 3: Does not transmit; receives OK. Clicks when the mike button is pushed.

Common to: Pearce-Simpson **Companion II**



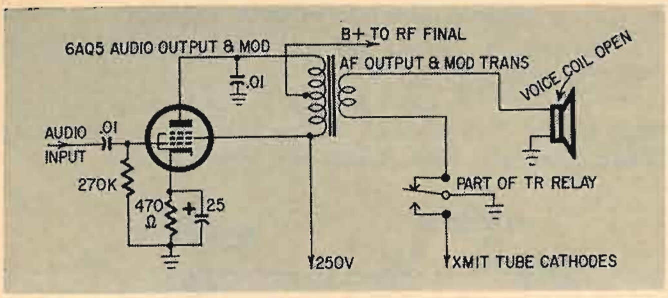
Remedy: Replace the TR (change over) relay.

Reasoning: These encapsulated relays sometimes jam or "hang up," and the unit will not switch to transmit. Since they are sealed, relay replacement is the easiest solution and almost always preferable.

continued on page 95

Case 4: Receiver sound intermittent. Transmit audio OK.

Common to: Heathkit **GW-10**

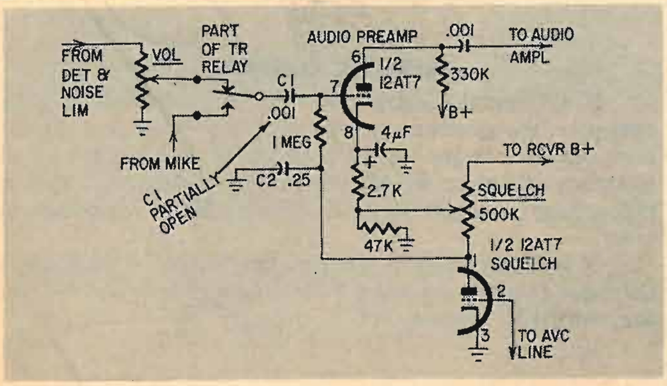


Remedy: Replace defective speaker.

Reasoning: There are two possible faults: speaker or TR relay. Easiest to check is the speaker, so do that first. When relay fails, proper operation can usually be restored by cleaning the contacts.

Case 5: 60-Hz hum on receive. Transmit and receive audio both weak.

Common to: Knight **C-27**

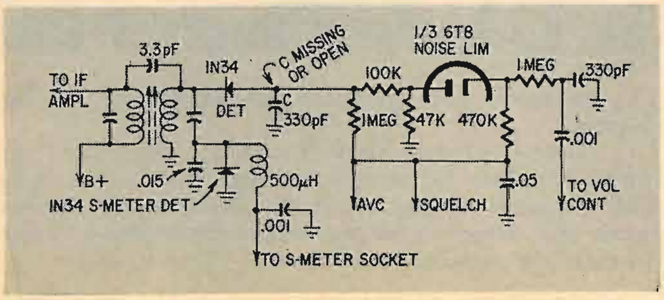


Remedy: Replace .001-μF coupling capacitor at grid of 12AT7 audio preamp.

Reasoning: Four possibilities: 12AT7 tube, C1, C2, or tube shield. The tube should always be replaced with a low-hum premium type. If not improved, substitute or check C1 and C2. In stubborn cases, C1 may have to be increased—up to 0.1 μF. Check tube-shield grounding.

Case 6 Receiver sounds like Donald Duck. Transmitter OK.

Common to: Pearce-Simpson **Companion II**



Remedy: Replace 330-pF avc detector filter capacitor C.

Reasoning: Rf should be bypassed to ground by C. With C open, rf modulates the avc line and noise limiter, causing audio distortion. Also, in some units this capacitor was accidentally omitted.

END

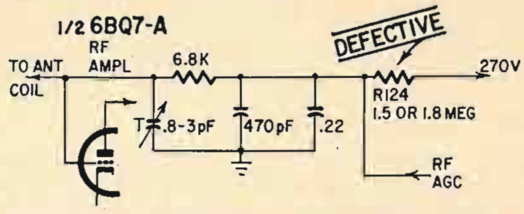
← *Circle 118 on reader's service card*

TECHNOTES

KCS83 CHASSIS: DOUBLE TROUBLE

At first, this chassis had hum symptoms, so I replaced bad filter capacitor C119.

When the new capacitor was in, the picture was just a little snowy. Not too bad, but something was still wrong. There must have been at least two troubles.



The antenna coils checked good, and so did tubes in the tuner and i.f. stages. Voltages in the tuner seemed close to what they should be. But the agc voltage, off-station, read 5 to 6 volts. With a station tuned in, the voltage rose to 9.

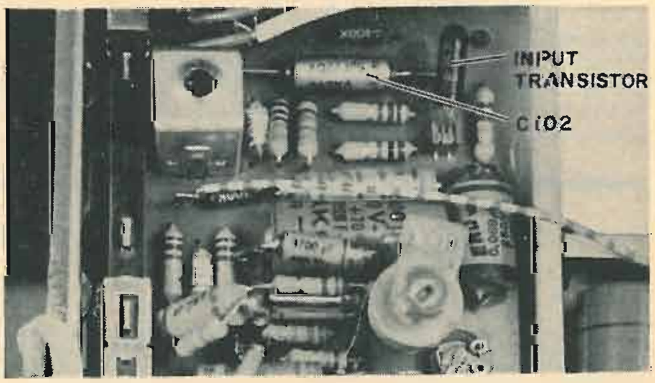
R124 resistance had doubled. A good 1.5 meg resistor was soldered in place, and the picture same back to normal. —*Homer L. Davidson*

REGISTER CONTROL

If a General Electric CR 7515 Register Control is inoperative, the electron-ray tube does not flicker and the two neon indicator lamps are both brightly lit, check first for lack of screen voltage on the 6J7 tube in the scanner head. Loss of this voltage is usually due to an opening in the 5,000-ohm divider.

If screen voltage is present, the trouble is probably a defective coupling capacitor between the plate of the 6J7 and the sensitivity control.—*R. C. Roetger*

KORTING MT158S STEREO RECORDER



Symptom: Low volume on left-channel recording and playback.

Fault: C102, base blocking capacitor, shorted or leaky. Check transistor for possible damage before reassembling unit. Chassis is released by retainer located at top end near motor and swings out for easy service. Photo shows location of defective capacitor on PC board.—*Steve P. Dow*

ERRATIC PERFORMANCE, G-E CB CHASSIS

A poor ground on the pulse winding of the flyback transformer in General Electric 21-inch CB chassis has caused unusual and erratic symptoms, the factory reports. The pulse winding supplies the burst gate, so intermittents in it can cause several defects:

Colored horizontal bars (sometimes intermittent
No color
Intermittent color
Greenish cast in lower part of picture
Neon lamp N701 lights intermittently or not at all

To correct the trouble, put a ground lug under the self-tapping screw that secures the flyback to the chassis. (This is at the bottom rear of the high-voltage cage.) Install a short wire between this lug and the eyelet that secures the end of the pulse winding. Solder well at both ends.—*G-E Service Talk*

KEEP MAGNETS AWAY FROM FERRITE ANTENNAS

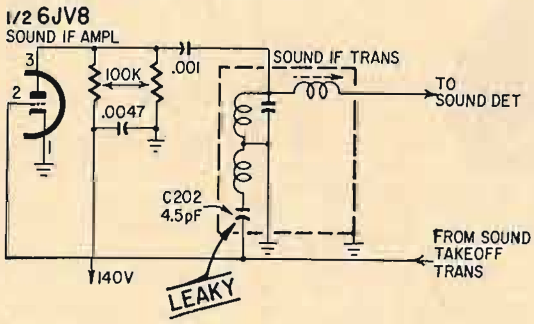
The speaker magnets in small transistor portables are often very powerful for their size. If you should have to disassemble such a radio, don't let the ferrite-core antenna come too near the speaker magnet. The field can reduce the permeability of the core, and hence the inductance of the antenna. That reduces the radio's sensitivity and may make it difficult to "track" the set properly during alignment.—*Siemens "Werkstatt Praxis"*

THE SWIFT-KICK APPROACH TO TV SERVICE

This RCA CTC7 would lose horizontal sync, then the horizontal oscillator would drop out and the horizontal output tube plates would get red hot. I checked and replaced everything from sync to flyback that seemed leaky or off-value. The set worked beautifully for 2 days, then the trouble started again.

My 4-year-old daughter gave me the clue. When her favorite cartoon showed lost sync, she would swat the set a good one. Bingo! Back in sync. I pulled the chassis again, looked everything over, put it back again. Same trouble.

Quite by chance, as I happened to be looking into the back of the set, I noticed the 6CG7 horizontal oscillator tube heater brighten noticeably when I rapped the cabinet. Turned out the pins were making poor contact—not poor enough to kill the heater, but just enough to affect afc and oscillation. Embarrassing!—*Charles Berold*



ADMIRAL 21C5-14C CHASSIS: SOUND TROUBLE

Sound and picture would not track properly. The picture had intermittent hum. The fine-tuning control just didn't do its job. A complete sound alignment didn't help.

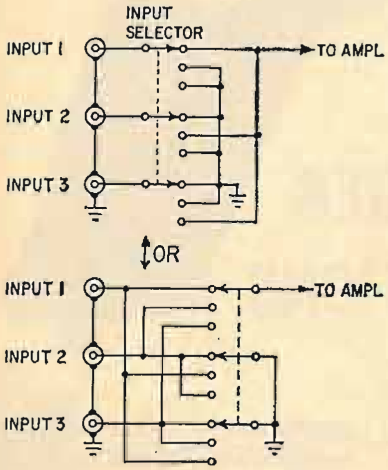
Voltages in the sound stages were close enough. Sometimes the trouble looked like agc, but I had the feeling that it was in the sound circuits. All resistors and capacitors were checked; C202 measured 2,000 ohms. Sure enough, this was the culprit.

To get at C202 is a job: the video output coil shield must be removed. The small capacitor lies down tight against the etched board.—*Homer Davidson* END

TRY THIS ONE

SHORT UNUSED AMPLIFIER INPUTS FOR LOWER NOISE

Most commercial hi-fi amplifiers have selector switches designed to short unused inputs to ground. As long as only the desired input is "hot," there can be no irritating feedthrough, or crosstalk, from the switched-out sources.



Selector switches designed to short unused inputs to ground usually have a section that is exactly the "inverse" of the normal selector section. Instead of a ring connected to the amplifier input with a tab on it that contacts only one point at a time, this shorting section is a grounded ring with a notch in it, and it *un*grounds only one point at a time. Contact sections like that are available as replacement items, but they are not always easy to get for home construction, nor always tailored to a particular application.

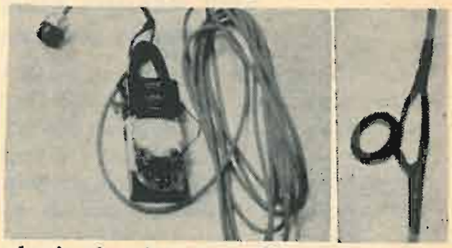
There is a way around, though. If you wire a switch as shown in the diagrams, you will have exactly the same thing, with only slightly more wiring and space. Note that you need as many switch *poles* as you have inputs. The number of poles may look extravagant, but single-section switches with up to three poles cost only very little more than single-pole switches with the same number of positions.

You can figure out schematics for four, five or any number of poles by remembering only this: Only *one* input must be ungrounded and connected to the amplifier at any one switch setting. All others are disconnected from the amplifier and grounded.—*Peter E. Sutheim*

ADAPT EXTENSION CORD FOR CLAMP-ON AMMETER

When servicing in the field, the idea is to take as few tools and instruments as possible to do as many jobs as possible.

A neat hook-on ammeter adapter can be made from an extension cord (see photo) by splitting the cord and inserting the ratio turns in one wire. The ratio turns are made up of enameled solid wire (the type used in motor winding). After winding the correct number of turns for the ratio desired, wrap the turns with cotton tape and then with



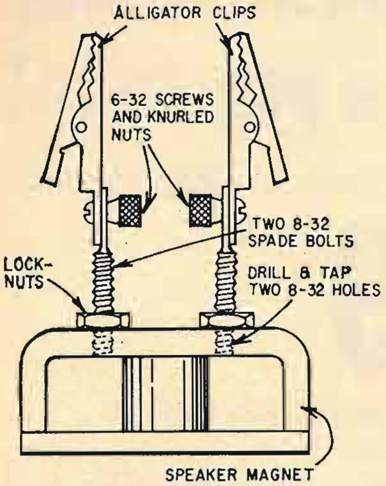
plastic electrical tape. The wire size for the ratio turns should be the same as that in the extension cord. Several ratio coils could be connected in series if several ratios are desired.

For a direct reading of the current, the meter can be clamped around the single separated conductor of the extension cord. To read small currents clamp the meter into the ratio coil.—*T. L. Bartholomew*

Circle 122 on reader's service card

MAGNETIC "THIRD HAND"

Here's a small-parts grabber that eliminates burned fingers and frazzled nerves from trying to solder small parts together.



Drill and tap two 8-32 holes in the back of the magnet assembly of an old PM speaker. Run nuts up onto two 8-32 spade bolts and fasten an alligator clip (the kind with a screw) to each as shown in the drawing. Hold the clip screws on with knurled nuts. Turn the clip–spade-bolt assemblies into the holes in the speaker frame and tighten the lock nuts.

The magnet will hold fast to any iron or steel surface, including a toolbox lid, and the clips can be rotated in various directions to accommodate all sorts of small parts.—*Peter Legon* END

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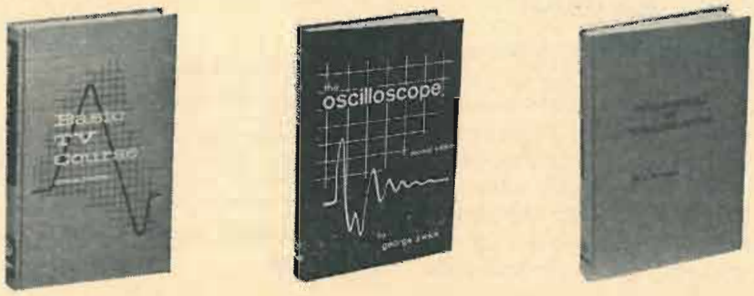

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WHAT'S YOUR EQ?

These are the answers. Puzzles are on page 53.

Remote-Control Circuit

With the switch in position 1, only RY1 is energized (via D1 and D2). In position 2, only RY2 is energized (via D3 and D4). In position 3, ac is fed to the line, energizing both relays. In position 4, neither relay is energized. Since there are four different combinations, appropriate contacts may be selected to operate four independent circuits.

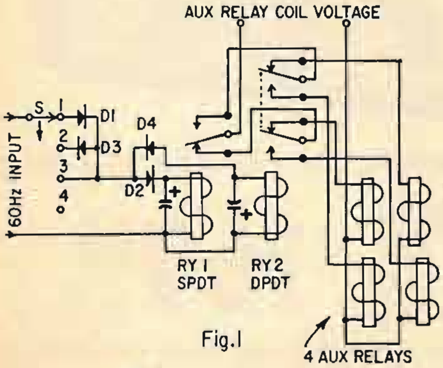


Fig.I

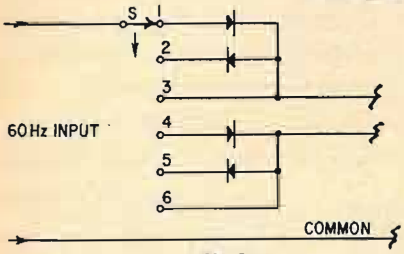


Fig.2

By duplicating this setup and using a three-conductor line (add a shield), six *independent* circuits may be controlled. (Fig. 2) The switch position in which neither relay is energized is eliminated as is one auxiliary relay. Otherwise, it is possible to have two load circuits energized simultaneously.

Bridge Resistance

The ohmmeter reads 10,000 ohms in both switch positions. As shown redrawn

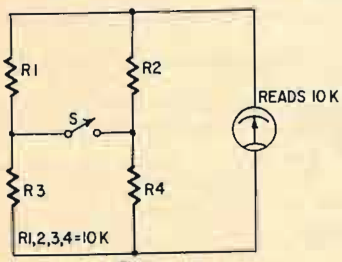


Fig.I

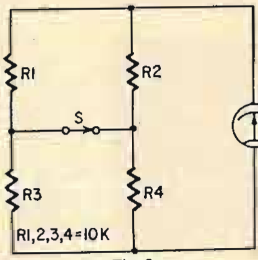
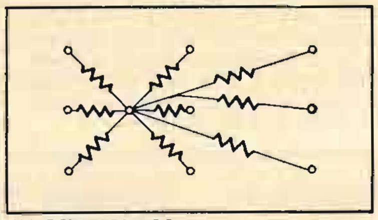


Fig.2

with S1 open (Fig. 1), the meter sees the four resistors in series-parallel—two 20K series legs in parallel totaling 10K.

With S1 closed (Fig. 2), the meter sees R1 and R2 paralleled to 5K in series with R3 and R4 paralleled to 5K for a total of 10K.

All 1-Ohm



ALL RESISTORS 1/2Ω

Simply connect one end of each ½-ohm resistor to a different terminal and connect the 9 free ends together. END

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Compensating capacitors on oscilloscope input attenuators are commonly adjusted with a square-wave input. If you do not have a square-wave generator, you can get the same results by using rectified sine waves from an audio oscillator. The sine waves can be obtained from the circuit shown in Fig. 1, using a semiconductor or vacuum-tube diode. Resistor R is not critical. It must be large enough not to load down the generator or put excessive current through the diode, and yet small enough not to be shunted appreciably by stray capacitances. Values between 10K and 100K are satisfactory.

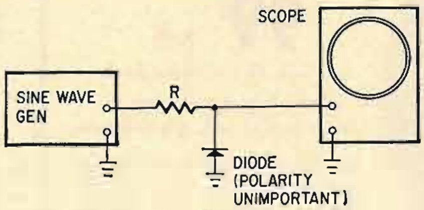


Fig.1

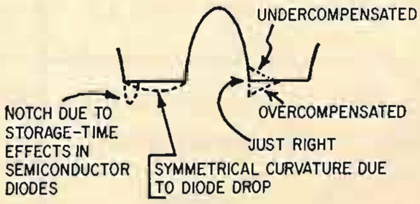


Fig.2

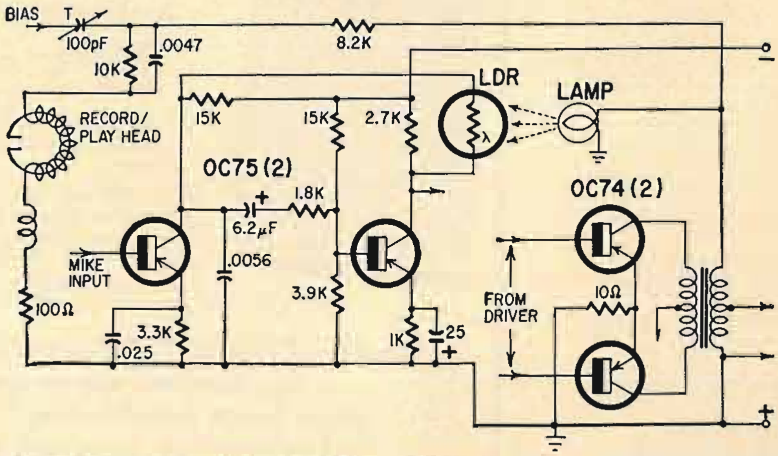
The waveform obtained is shown in Fig. 2. (It may be inverted, depending on diode polarity.) If the bottom of the wave is perfectly flat, the compensation is just right. Departures from correct compensation will give rise to asymmetrical curvature as shown.

The correct frequency to use depends on the R-C product of the attenuator. If the frequency is too low, the curvature will not be visible. (Moreover, extraneous curvature may be introduced by coupling capacitors in the scope amplifier.) If the frequency is too high, adjusting the trimmers will primarily vary the height of the complete waveform, and the changes in curvature will again be less noticeable. About 10 kHz was found to work well for a typical scope input attenuator, and 400 Hz was satisfactory for a typical attenuator probe.

Diode voltage drop can also give rise to curvature as shown, but this curvature is symmetrical and is readily distinguished from miscompensation. Storage-time effects in semiconductor diodes will produce notches, as shown, at high frequencies.

This technique is useful for adjusting or checking any video amplifier employing capacitive or inductive compensation.—*Charles Erwin Cohn*

AUTOMATIC RECORD-LEVEL CONTROL



Many of the newer tape recorders—particularly those designed for dictating and conferences—feature automatic recording-level controls. The diagram shows the basic circuit in the Philips EL3582 dictating machine. The important elements are the lamp across the output transformer and a photoresistor (LDR) in a feedback loop between the collectors of the first two preamplifier stages. (The LDR is a photoresistive, also called photoconductive, photocell whose resistance varies with the intensity of light falling on it. Typical of this type are the cadmium sulphide and cadmium selenide cells.)

Light intensity tends to rise as the input signal level increases. This light falls on the photocell and decreases its resistance. This decrease in resistance limits circuit gain through degenerative feedback and keeps the recording level fairly even. The time constant is suitable for speech.—*Steve P. Dow* END

NEW BOOKS

COMPUTERS AND THE HUMAN MIND, by Donald G. Fink. *Doubleday & Co., Inc., 277 Park Ave., New York, N. Y. 10017. 4 x 7 in., 301 pp. Paper, $1.45*

A masterfully written work, describing the how of computers and their languages, in terms readily understandable by the layman, but at a level that makes the book interesting to the engineer. The last chapters are devoted to the human brain, to human and nonhuman intelligence, and the question "Can machines create?"

SEMICONDUCTOR JUNCTIONS AND DEVICES: THEORY TO PRACTICE, by Dr. William B. Burford 3d and Dr. H. Grey Verner. *McGraw-Hill Book Co., 330 W. 42 St., New York, N.Y. 10036. 6 x 9 in., 316 pp, Cloth, $12*

Discusses the formation and behavior of junctions, and the principles of transistor circuits. Covers single and multi-junctions, point contacts, and transistor applications.

BASIC ELECTRICITY, by Gilbert L. Rainey. *Holt, Rinehart & Winston, 383 Madison Ave., New York, N. Y. 10017. 8½ x 11 in., 180 pp. Paper, $3.95*

One volume in a "Basic Industrial Electronic Series." All these are laboratory textbooks and are put together like workbooks. Each experiment is on some basic fundamental of electricity. Does not get into electronics in this basic text.

BASIC MICROWAVES, by Bernard Berkowitz, *Hayden Book Co., Inc., 116 W. 14 St., New York, N. Y. 10011. 6 x 9 in., 168 pp. Paper, $3.95, cloth $5.95*

Covers nature of microwaves, antennas and theory. Transmission lines and components. Fairly well-illustrated. Includes quite a bit of math, but understanding isn't entirely predicated on understanding the mathematics. Not for the beginner, but not at the engineering level either. END

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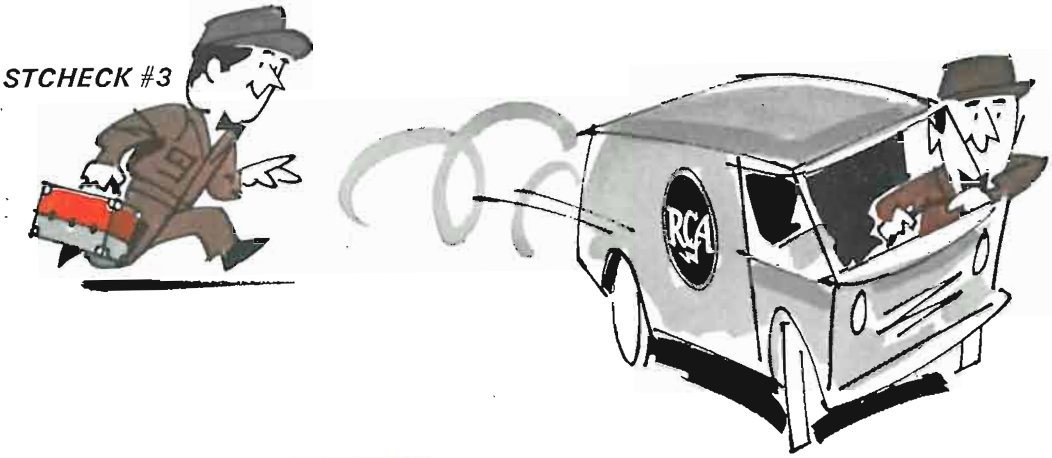
Circle 149 on reader's service card

RCA's COLOR TV FASTCHECK #3



Poor convergence?

...check the horizontal and vertical output stages first

Sometimes the problem of misconvergence can be due to changes of characteristics in the horizontal and vertical output circuits. If the set has poor convergence here's a short check list of preliminary steps that may save you some valuable time. So, take a few moments and follow these easy steps...

1. Check the raster to see that it fills the entire screen. If it does not, check the height and width adjustments, the vertical and horizontal-output tubes, and the high-voltage section.
2. Measure the high voltage with your RCA VTVM or VOM, and high voltage probe. Rotate the brightness control and check voltage at various levels. Voltage should hold at all settings. If it does not, check the high voltage regulator circuit.
3. With your convergence-pattern generator, set up a crosshatch pattern. Then check and adjust linearity, if required. The crosshatch rectangles should be of uniform size. If not, adjust the vertical and horizontal linearity until you get a uniform effect.
4. Re-check items 1, 2, and 3.
5. Check color purity. If required, degauss the set and reset purity.

If these checks do not clear up the misconvergence, then make convergence adjustments as described in the service data.

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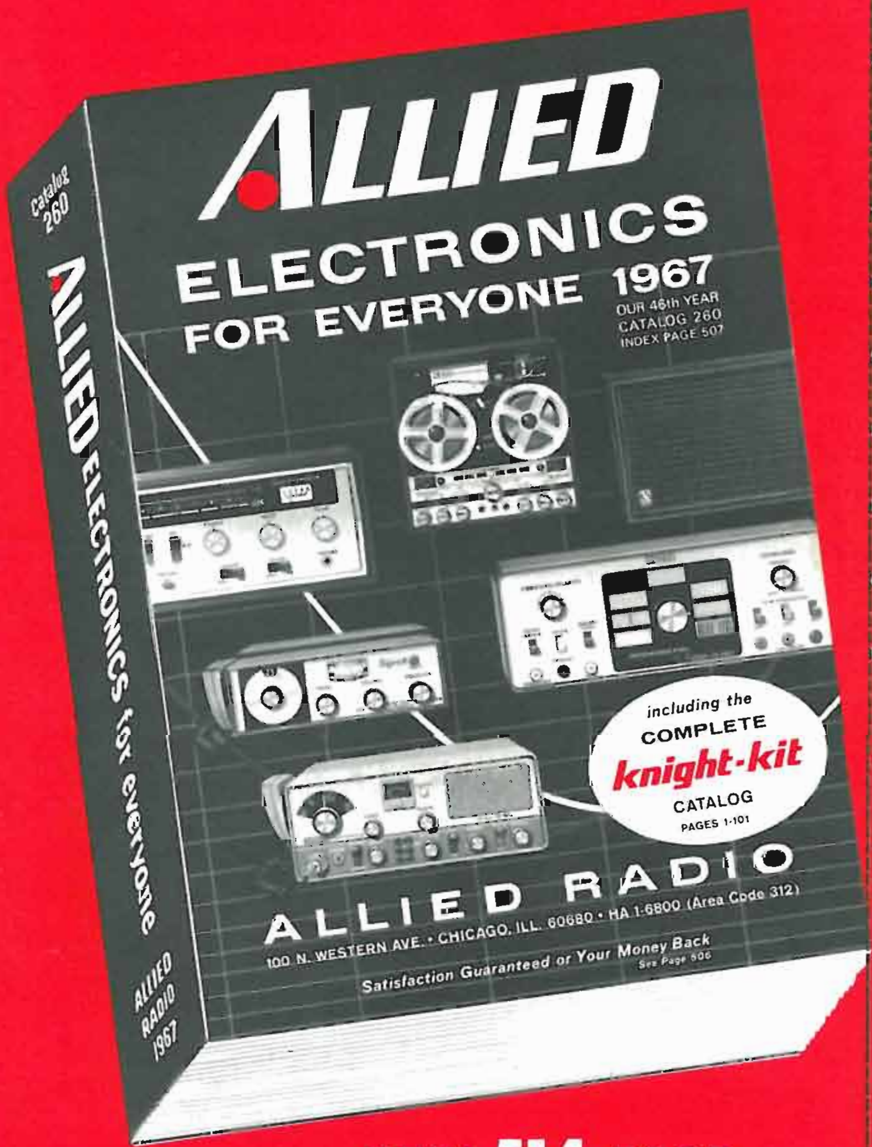

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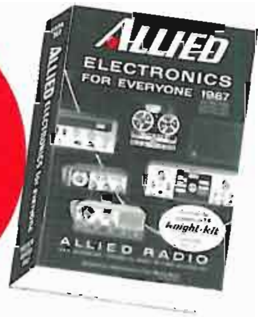

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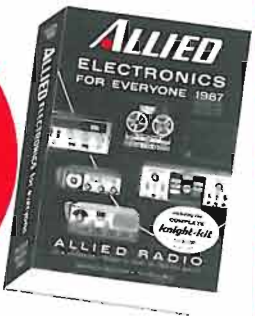

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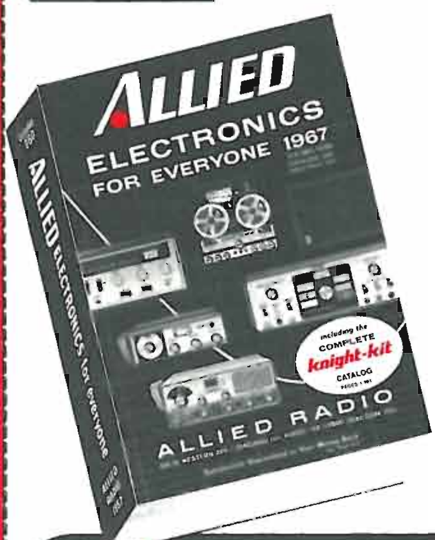

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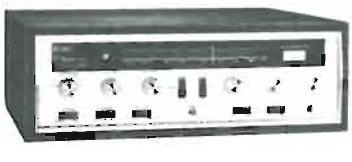

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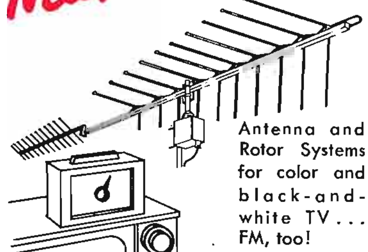

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