Electronics World

FEBRUARY, 1964
50 CENTS

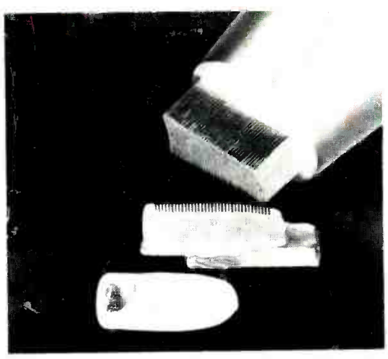
MODULATION CIRCUIT DESIGNS FOR SOLID-STATE CB TRANSMITTERS

CIRCUIT ANALYSIS OF NEW 35-W. TRANSISTOR POWER AMPLIFIER

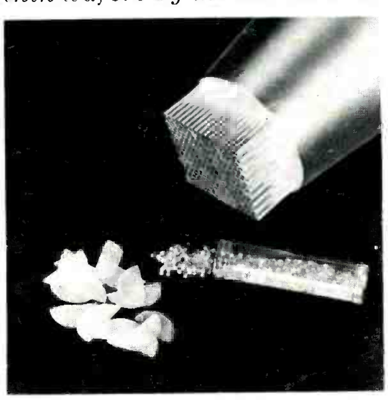
TRANSISTORIZED SIX-METER CONVERTER

U.H.F. CONVERTERS Circuits and Design

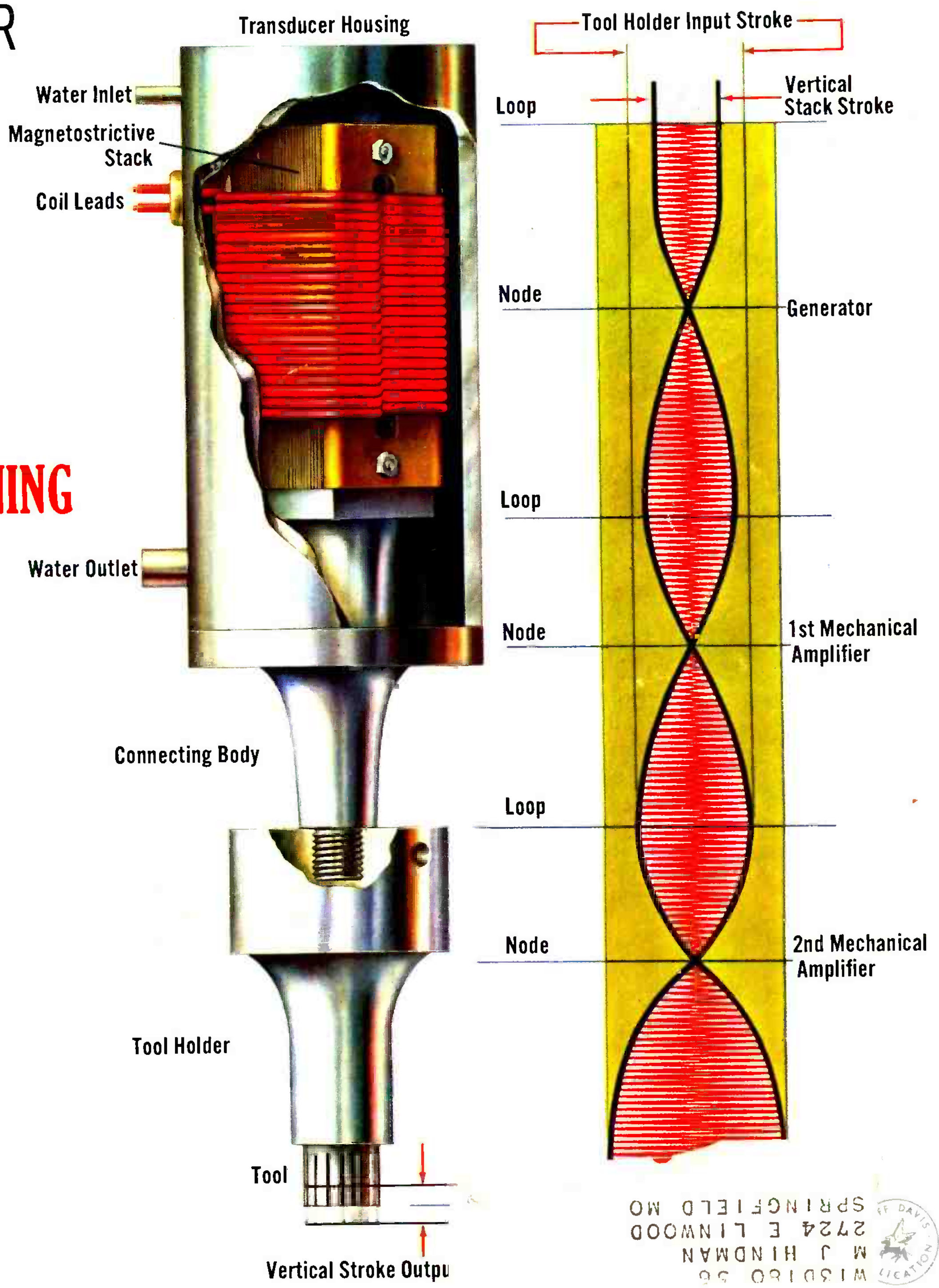
ULTRASONIC DRILLING & MACHINING



Sapphire boule is sliced into thin wafers by ultrasonic drill.



Wafers are diced into smaller rounds by multiple-tubed tool.



Cutaway of ultrasonic drill and graph of transducer action.

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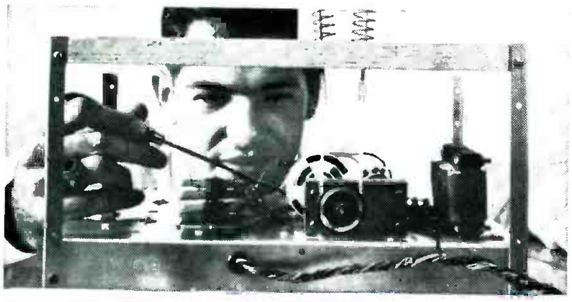

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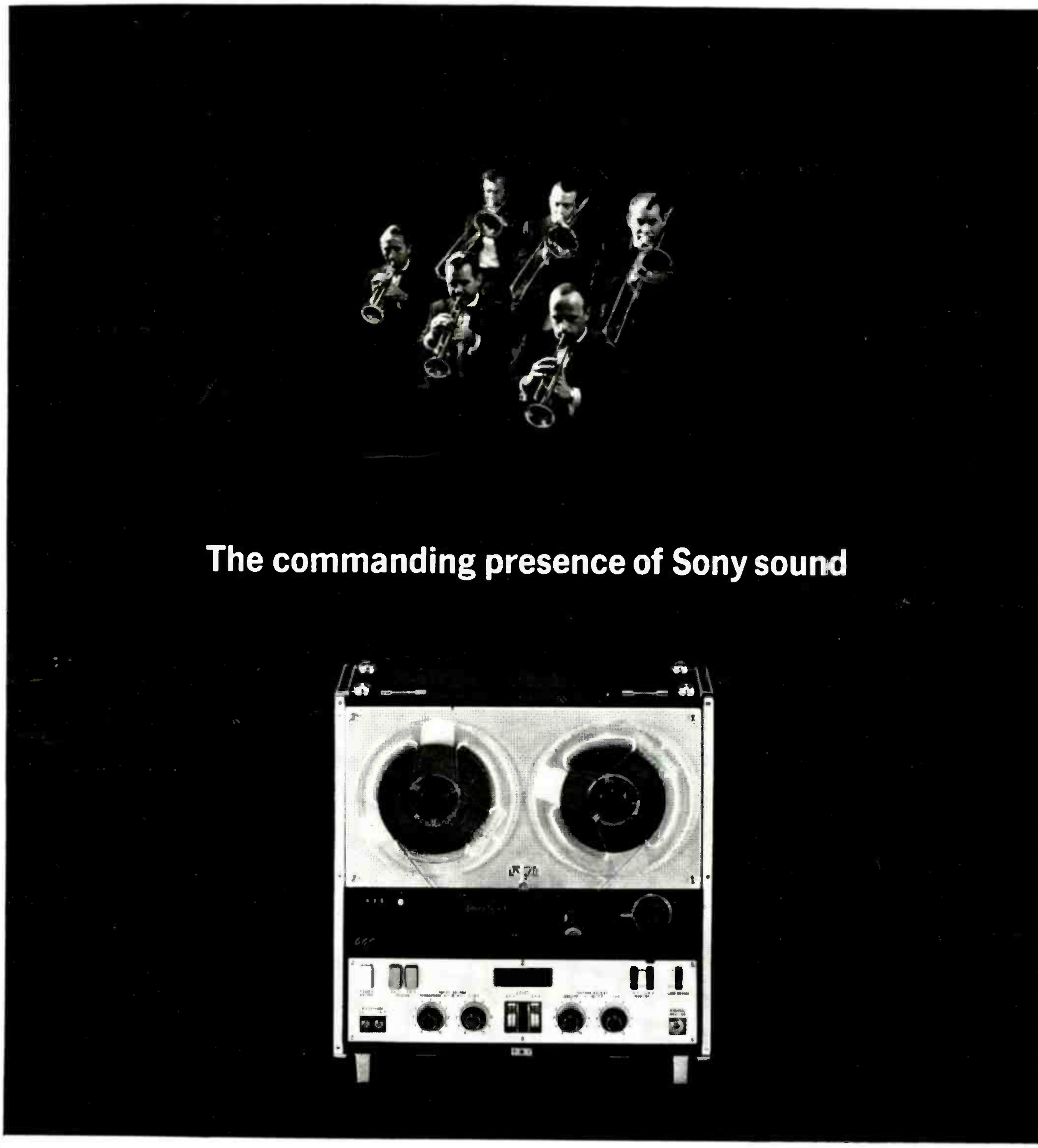

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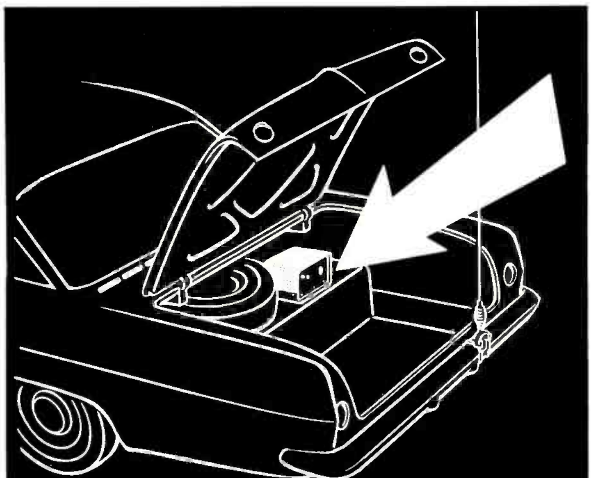

For . . .

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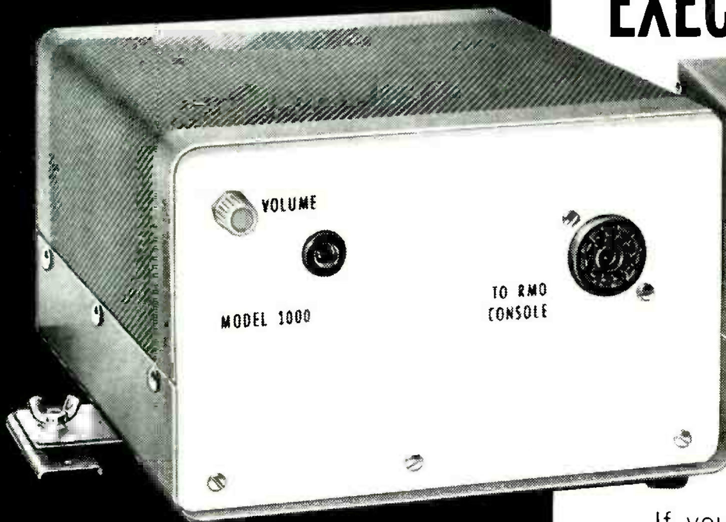
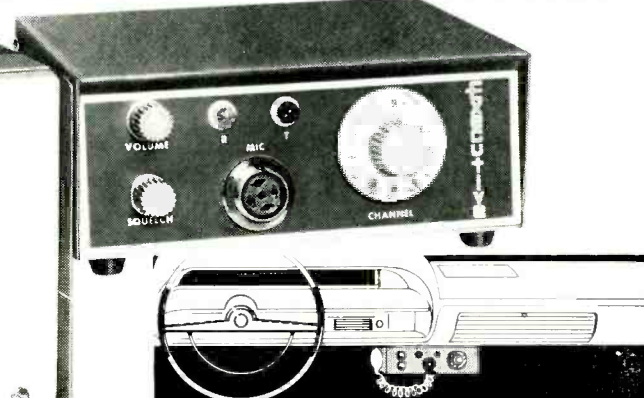
LIMITED SPACE INSTALLATION

you need the NEW MODEL 1000 EXECUTIVE TRANSCEIVER





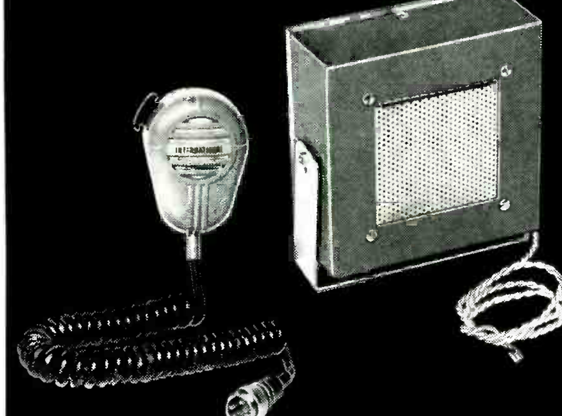
If you are looking for a citizens band transceiver designed for limited space or remote operation, then you need International's Model 1000* transceiver . . . the very latest in the Executive series of fine two-way radios.

Engineered for flexible installation, the Model 1000* may be used in a car, boat or plane. Operates on 6 or 12 vdc and 115 vac. Features include: series gate noise limiter, high frequency crystal filter for reducing adjacent channel interference, delayed avc system, speech clipper amplifier and crystal filter. All frequency control circuits are housed in International's new (RMO) remote console.

The console, 2½" H x 7" W x 5" D, mounts under the dash. Nine receive and nine transmit crystal sockets are provided for the selection of any desired channel. The illuminated Channel Selector (an International exclusive) makes channel selection easy. Console panel provides: on-off switch, volume and squelch controls, channel selector, microphone receptacle, transmit and receive indicator lights.

Model 1000, complete with remote console, mobile mounting brackets for transceiver and console, cables, 1 set of channel 9 crystals, microphone, speaker. Cat. No. 600-115 .... $259.50

***Model 500, similar features but does not contain delayed avc, speech clipper amplifier and crystal filter. Cat. No. 600-114 .... $179.50**



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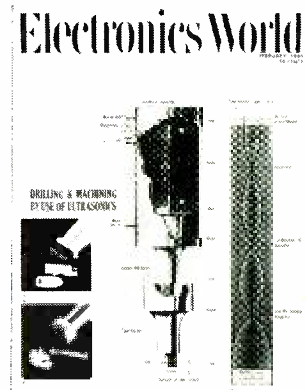
Electronics World CONTENTS

FEBRUARY 1964
VOL. 71, NO. 2

MONTHLY FEATURES



THIS MONTH'S COVER illustrates the construction and operation of an ultrasonic drill and shows some of its applications. A power oscillator is used to produce ultrasonic energy that is applied to the transducer. The magnetostrictive transducer converts this electrical energy into vertical mechanical motion of a tool brazed to the tool holder. The tool is able to drill, slice, and dice through the use of an abrasive slurry made of boron carbide in water. For details, see our lead story in this issue. Photographs from The Sheffield Corp. ....(Illustration by Otto E. Markevics.)

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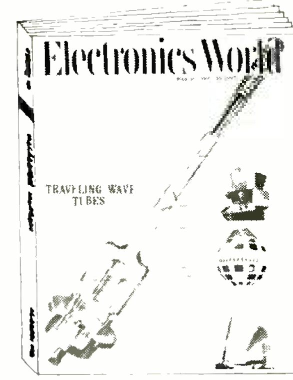

TRAVELING-WAVE TUBES
These not-too-familiar electron tubes play a vital role in telephone, TV, and communications transmission now but their greatest potential lies in defense and space communications applications, according to John H. Jarrett, chief of traveling-wave tube engineering at Western Electric.

TRANSISTORS FOR MUSIC
The importance of phase shift, transient response, damping factor, noise, and power in the design of a hi-fi amplifier is discussed by two engineers from Harman-Kardon—a firm strongly in favor of transistorized hi-fi.

WHY NOT U.H.F. TWO-WAY RADIO?
The 450-mc. two-way radio band offers many advantages over the lower frequency bands and Howard H. Rice of Motorola Inc. believes it offers the best chance of relief from present-day band crowding.

THE INTEGRATED AMPLIFIER-SPEAKER
Although the concept of designing an amplifier for a specific speaker is not new, package radio-phono makers have been doing it for years, it is new in the hi-fi field. Ken Gilmore advances the reasons why such a concept is suited to hi-fi applications and how such units are designed to meet performance criteria.

NEW TV DESIGNS FOR 1964
The new circuits used by some 13 television manufacturers in their 1964 lines are discussed by Walter Buchsbaum. Among the sets to be covered are two color receivers by Zenith and RCA.

HIGH-POWER PHOTOCELL
This new semiconductor unit by Motorola can control 100 watts of power and will operate small motors or large relays direct from the power line. Because of their low cost, technicians and experimenters will want to try them out in both old and developmental circuits.

ADVANCES IN ULTRASONICS
The concluding article of this two-part series covers such varied applications as ultrasonic welding, echo ranging, nondestructive testing, and medical uses.

NEW LOOK IN TRANSFORMERS
New core materials and new fabrication techniques are responsible for making modern transformers smaller and more efficient. If your last contact with transformers was five years ago, you are in for a number of pleasant surprises with this new breed.

*All these and many more interesting and informative articles will be yours in the MARCH issue of ELECTRONICS WORLD . . . **on sale Feb. 20th.***

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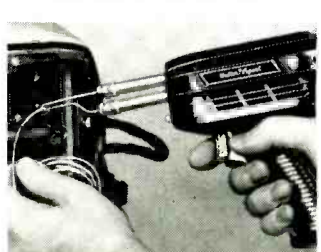

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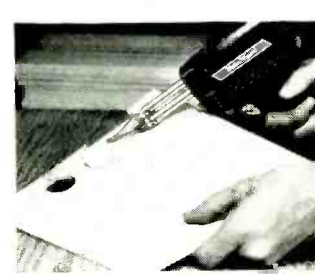

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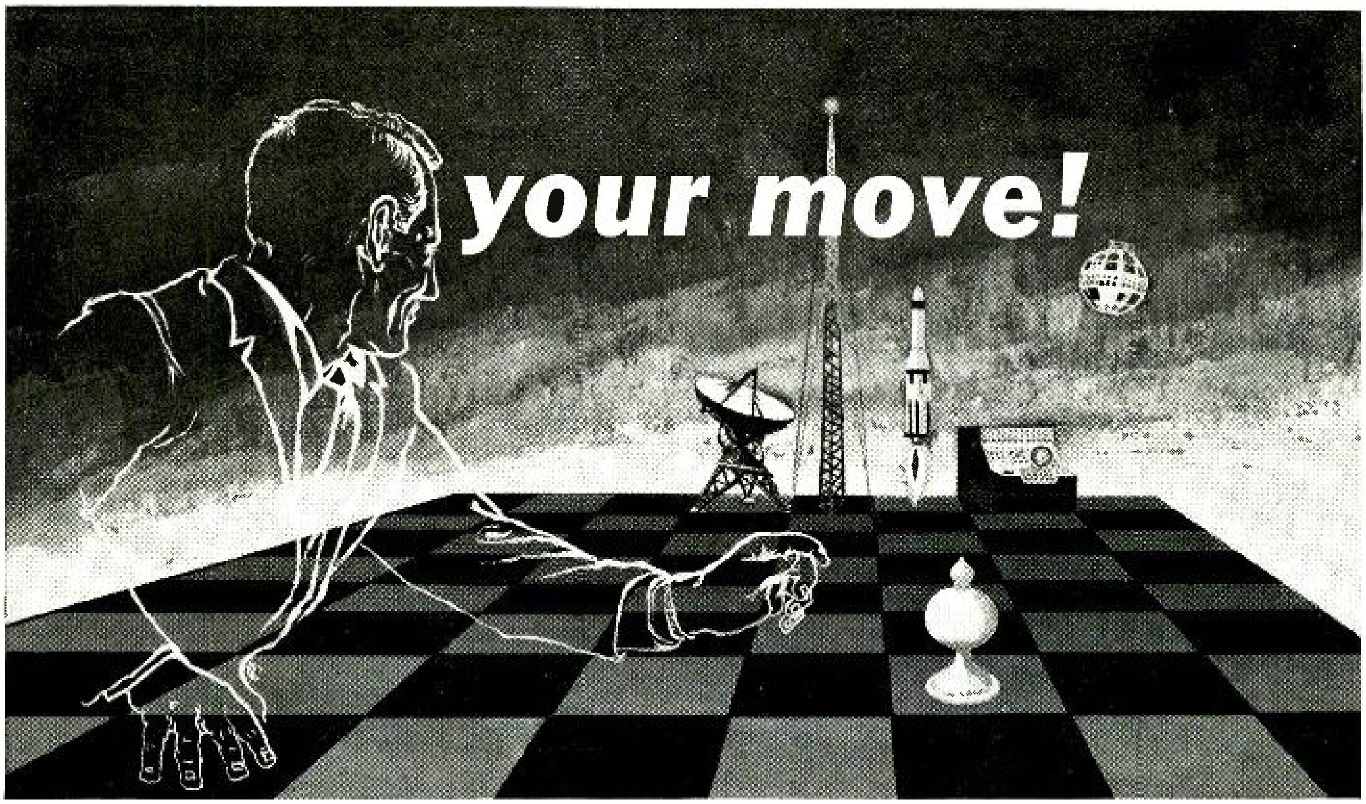

your move!

For the record

WM. A. STOCKLIN, EDITOR

SATELLITE COMMUNICATIONS

WE talked by phone to Jack Howard at the Goddard Space Flight Center the other day. Although that in itself is not unusual, the method of communications was. Jack placed the call from his office in Greenbelt, Maryland to the *ITT* Satellite Receiving Station in Lakehurst, New Jersey. From there the signal traveled to the "Syncom" communications satellite and back, and then it went by land lines to our New York office. This was not just a stunt, since communications *via* "Syncom," "Telstar," and "Relay" satellites have previously been successful, even between nations. But we had to be convinced that a two-way telephone conversation, using a high-orbit satellite like "Syncom," would not be seriously affected by the problem of time delay.

There have been differences of opinion on this point. *Bell Labs* has always felt that a low-orbit satellite, like its "Telstar" I and II, and *RCA*'s "Relay" satellite, would be the ultimate answer. There are no arguments that all types of communications, including wide-band TV, proved to be very successful with these satellites. But, is such a satellite system completely practical? Does it represent the best approach to a world-wide communications network? In view of "Telstars'" low orbits, 600 to 6700 miles, and their high relative speeds, actual communications contacts were limited to a maximum of 90 minutes out of an orbit. This would mean that perhaps 25 to 40 identical satellites would be required for world-wide, 24-hour communications service.

"Syncom," on the other hand, is a high-(22,300 mi.) orbit stationary satellite. Its velocity and altitude are such that it appears to be practically stationary with respect to a point on the earth. It was put into orbit over the equator and fluctuates about 6 degrees north and south. At the present time, it is drifting slightly to the west, but this drift is re-adjusted about every two weeks. In view of its height, it has an earth coverage of about 40% and, therefore, only three such satellites would be required for world-wide, 24-hour communications.

Obviously this approach seems to be the answer, that is, if the time delay resulting from the long travel time does not seriously affect two-way conversation. *Bell Labs* has made many tests to determine the effects of time delay produced artificially. But not until "Syncom" became a reality were we able to make actual tests on a communications system operating over such a great distance.

One of the longest transmissions to date covered 70,000 miles—from "Syncom" to the USNS "Kingsport" at Lagos, Nigeria, back to "Syncom," to Lakehurst, New Jersey, and then by land lines to *Hughes Aircraft Company* in Culver City, California. This particular transmission was not involved with the problem of time delay, since, for the most part, it was a one-way "live" telemetry data transmission originating from the satellite. The company's report stated: "There was no observable distortion in the received data . . . The highest fidelity tape recorders seldom receive a direct recorded signal-to-noise ratio of over 35 db and most of the 'Syncom' voice telemetry transmission received exceeds this quality before it is recorded . . . Background noise is often just that inherent in the magnetic tape itself."

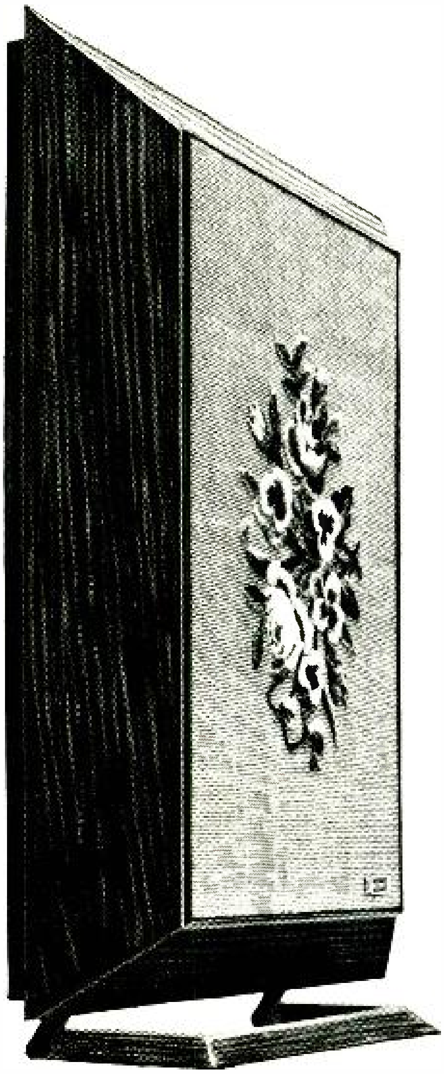
On the matter of delay time, there is disagreement as to how much delay from .1 second to 1 second can be tolerated for two-way conversation. Many more experiments must still be performed and this study is apt to go on for some time to come.

Our communication, that is, between our office and the Goddard Space Flight Center, covered about 45,000 miles. Considering the speed of electromagnetic radiation as 186,000 miles per second, the delay time was about .24 second. The results were outstanding—we were not aware of this amount of delay, and the voice quality, when proper satellite tracking was obtained, was sharp and clear with no noticeable background noise.

In view of these results, it seems that communications *via* a high synchronous orbit satellite covering 40% of the earth's surface is definitely feasible. Whether relaying communications through two or three similar satellites (.48-second and .72-second delay respectively) is feasible is yet to be determined.

With the launching of "Syncom II" on July 26, 1963, there dawned a new era in communications. Congratulations to *Hughes*, NASA, and the Goddard Space Flight Center. ▲

WHEN YOU NARROW IT DOWN IT HAS TO BE UNIVERSITY!



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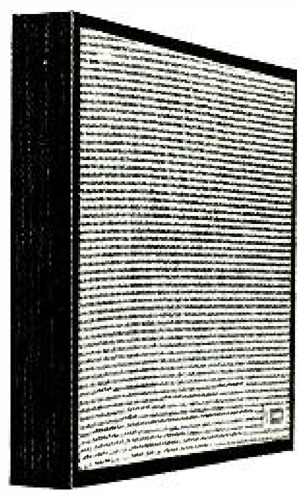
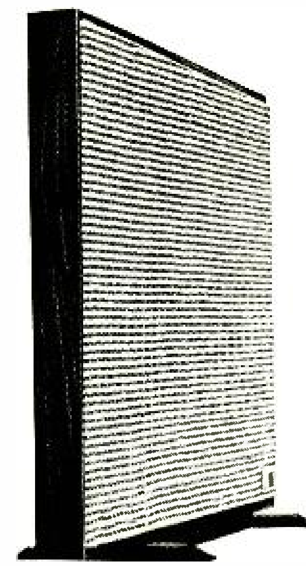


Mini



Tri-Planar

LISTEN to all the slim speakers. Base your decision on sound. That's what a speaker is for. University won't sacrifice reproduction quality regardless of speaker size or shape. Any of the three speakers in this ad will give you all the subtle magic Beethoven intended...all the dazzling color of De Falla or Stravinsky...all the individual virtuosity in a jazz combo. It's almost incidental that University decorator-thin speakers will adorn any wall, accommodate limited space or fit tastefully wherever larger units would seem obtrusive. It's the big sound (the true sound) we were after...and captured. Hear for yourself.

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For free University Catalog, write Desk S-2, LTV University, 9500 West Reno, Oklahoma City, Okla.

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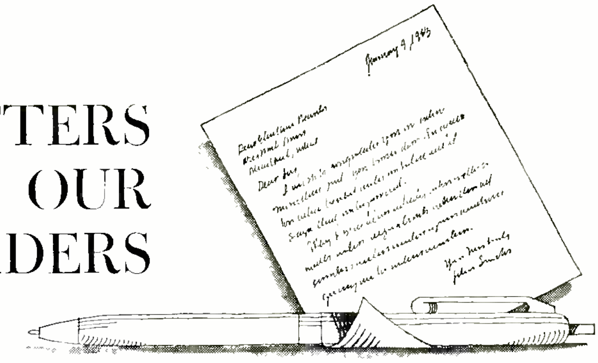
LETTERS FROM OUR READERS



TRANSISTORS VS TUBES

To the Editors:

For a number of months you have been running articles on the subject of tubes *vs* transistors; however, there didn't appear to be too much of a fight since the transistors usually came out on top.

While it may be true that transistors have an indefinite life and are used in our high-reliability space programs, my hi-fi amplifier is not about to be shot up to the moon. I am still a little worried about accidental shorts across my speakers or a little too much heat or lack of ventilation. Transistors just won't take as much punishment as my tubes will. What is more, the really good transistor amplifiers I have seen were at least as big and heavy as the tube versions and they cost two or three times as much. True there may be a measurable improvement in performance, but, after all, the tube amplifiers are down in the fractions of a percent distortion too.

So, until the transistor designers can come up with a simple, reliable four-transistor amplifier using a handful of resistors and capacitors that will give me an honest 50 or 60 watts output (which describes my present *tube* amplifier), and at a reasonable price, then I will stick with tubes for now!

Mel Somers
Baldwin, N.Y.

Any comments on the above from our readers who have had first-hand experience with hi-fi transistor amplifiers?
—Editors

* * *

AUDIO SQUARE-WAVE TESTING

To the Editors:

Von Recklinghausen, Linder, and Mason's comments ("Transistors for Hi-Fi," September, 1963) on wide-band audio are an old hassle which never seems to die away. As the editor's note implies, there is some strong disagreement on these points and has been for many years.

Their arguments are practical commercial design points, but tend to oversimplify things and to some extent, imply design contradictions. While it may be true that the ear is relatively insensitive to a simple-pattern, steady-state signal's component phase relations since it works as a sort of a comb-filter sampling device, this is not necessarily true where complex dynamic signal conditions and non-linear phase-shift are involved.

We find that where we get a sharp roll-off in amplitude-bandwidth skirts, there are related sharply non-linear phase excursions. The sharper the amplitude roll-off, the more non-linear the phase excursions and the greater the damped-oscillation "ringing" under transient-impluse signal conditions. It is largely this "dirty" ringing we wish to evaluate with our square-wave tests and not just simple linear phase shift, among other things.

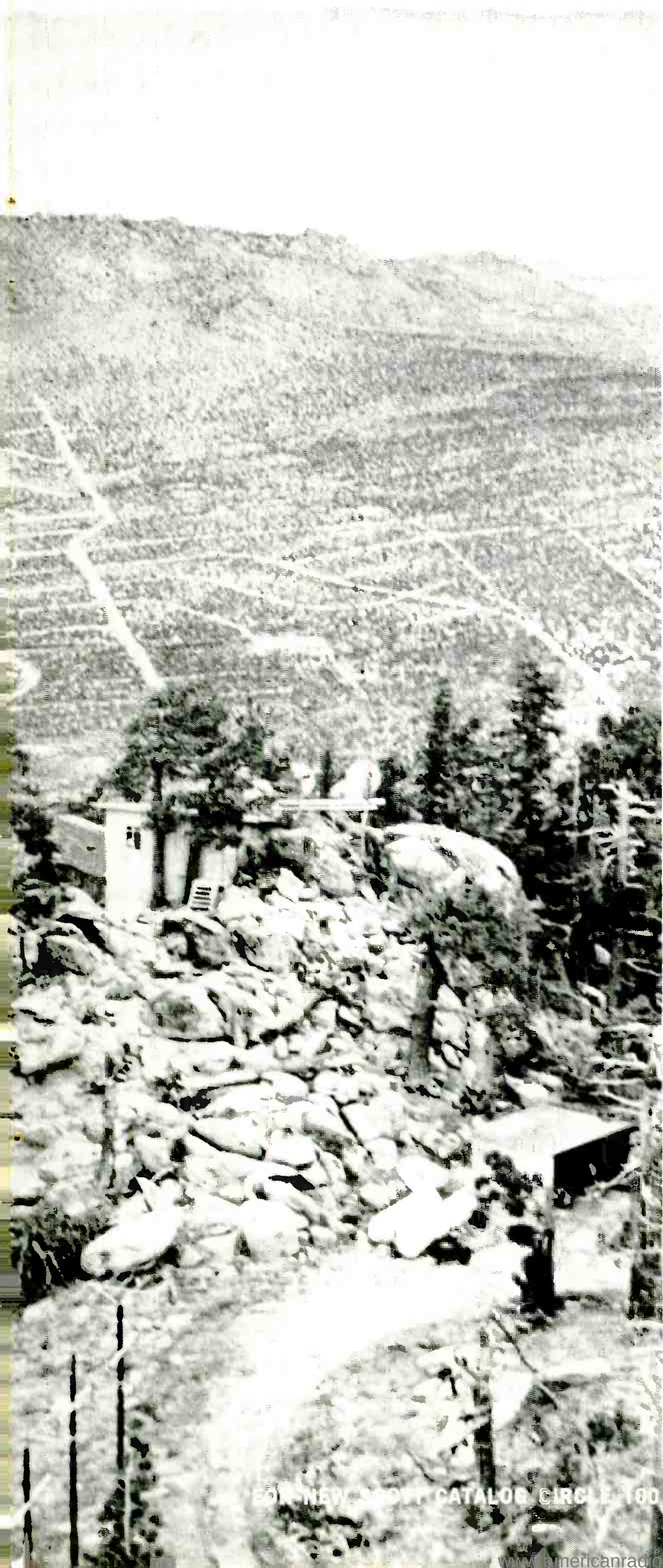
Now, if we say we want "distortionless" response in the so-called "audible" 20-20,000 cps passband (and some youngsters can hear much higher), we imply 0 db response. How do we get this without a gradual one-octave roll-off beyond the "working" passband? We need a gradual negative-slope roll-off to hold down highly non-linear phase deviations and heavy ringing. Furthermore, most audio design men use negative feedback. Again, how do we get low phase shift and stable feedback over the useful passband unless we go one or two octaves beyond it on both sides—especially if we loop around a "messy" reactive output transformer?

We can argue in directly the opposite direction. That is, it is patently unrealistic to talk of steady-state sine-wave testing, looking into a resistance load and talk of amplitude-distortion ratings of fractions of 1%, when we may be getting 10% overshoot ringing (transient distortion) due to non-linear phase shift; or if the loudspeakers are generating a very "dirty" 10% FM distortion.

Square waves simultaneously show up amplitude roll-off, both linear and non-linear phase shift, ringing, low-frequency recovery time, etc. and remain one of the most versatile and useful audio signal tests we have available today. The sine-wave burst, "grey" noise, and fast-sweeping FM oscillator tests all closely parallel the square-wave test, but less conveniently.

Ted Powell
Glen Oaks, New York

We feel sure that Mr. von Recklinghausen, et al, know and have used the



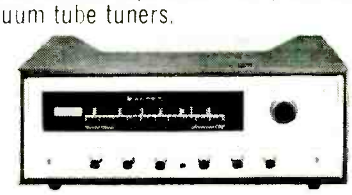
ON A DESERTED MOUNTAINTOP 10,000 FEET ABOVE THE CALIFORNIA DESERT THE SCOTT MONOPHONIC 310 IS ABOUT TO BE REPLACED... BY THE NEW TRANSISTOR 4312 STEREO TUNER

High atop Mount Santa Rosa, in California, the Palm Springs Television Company has been using monophonic Scott 310 broadcast monitors to relay FM programs from Los Angeles 105 miles away to the town of Palm Springs, directly behind the mountain. With the advent of stereo, new equipment was needed that would be as reliable as the 310, and provide the same performance . . . now in stereo. After an exhaustive study of available tuners, the brand new Scott 4312 transistorized tuner was selected for the job.

Like the 310's they are replacing, the new Scott 4312's will have to undergo a punishing ordeal on the mountaintop. Towering snowdrifts make these tuners completely inaccessible for many months of the year. There is no margin for error . . . these tuners have to work perfectly, with unvarying reliability. They cannot drift even slightly during the entire period.

Robert Beaman, Chief Engineer for Palm Springs Television Company, emphasized the two basic factors in the selection of the Scott 4312:

1. The radically new Solid State circuitry, designed by Scott, provides the optimum in stability and assures years of cool-running, trouble-free performance . . . a must for a remote location like Mount Santa Rosa.
2. New Scott transistor circuitry makes possible three-megacycle detector bandwidth which provides a new standard of stereo separation not previously achieved with vacuum tube tuners.



Here are the seven features that make the Scott 4312 the world's first truly reliable TRANSISTORIZED tuner.

1. Transistorized time-switching multiplex circuitry. Separation in excess of 35 db at 400 cps, a new industry standard.
2. 3-megacycle detector, widest of any tuner ever designed. Results in extremely good stereo separation, drift free performance, excellent capture ratio.
3. Nuvistor front end. Nuvistors chosen for their reliable performance and extremely low cross modulation, in excess of —65db. This outstanding design specification assures you that strong local stations show up only once on the dial.
4. Silver-plated RF circuitry. Assures sensitivity of 1.9 microvolts (IHF).
5. Sensitive tuning meter and antenna orientation indicator.
6. Transistorized Auto-Sensor circuitry instantly switches to stereo mode when stereo broadcast goes on the air.
7. Professional slide-rule tuning, with heavily weighted mechanism, and use of ball-bearings throughout. Assures true velvet-touch tuning. $365*

SCOTT®

H. H. SCOTT INC., 111 Powdermill Road, Maynard, Mass.
*Slightly higher West of Rockies. Accessory cases extra. Export: Morhan Exporting Corp., 458 Broadway, N.Y.C. Canada: Atlas Radio Corp., 50 Wingold Ave., Toronto

FOR NEW SCOTT CATALOG CIRCLE 100 ON READER SERVICE CARD *advantages of square waves. However, their point was that the phase errors in amplifiers that show up on a square wave are completely inaudible since the ear is insensitive to this type of distortion. Therefore they conclude that "any change in the appearance of a square wave used for testing of an amplifier does not indicate any change in listening characteristics of the amplifier."*

Other designers, who do not concur, will express their views in upcoming articles.—Editors.

° ° °

CERAMIC FILTERS FOR CB

To the Editors:

We have noted with interest your article "New Citizens Band Circuits" in the November issue of ELECTRONICS WORLD. You point out quite prominently that *Allied Radio* is using for the first time a ceramic filter for narrowing receiver bandwidth. We believe you will wish to be corrected, since the one-watt kit described is quite recent and our own *Cadre* five-watt solid-state transceivers have been using the same type of ceramic bypass filters for nearly 18 months. Of course the effect is the same in improving adjacent channel selectivity, which is to the advantage of the CB operator. In addition, our own C-75 hand-held 1.5-watt transceiver uses a *Clevite* ceramic bypass filter.

JOSEPH H. GIBBS
Sales Manager
Cadre Industries Corp.
Endicott, N.Y.

° ° °

SCR LIGHT DIMMER

To the Editors:

In your October issue, you have an article on silicon controlled rectifiers. I enjoyed the article, but I am puzzled about the schematic of the light dimmer on the bottom of page 30. I looked up the ratings of some of the parts, and found that the diodes (1N2611's) have a current rating of only .75 amp. Since they are connected in series with the load, I cannot see how the rating can be observed and still manage to control a 500-watt load.

JAMES P. WEILAND
Pinedale, Wyoming

Reader Weiland is correct, of course, in his assumption that the 1N2611 rectifiers are not suitable for controlling the current to a 500-watt load. These devices were used in the original prototype, which was required to handle only relatively light loads. To handle a maximum load, the rectifiers must be able to control at least as much current as the SCR. Suitable rectifiers, for example, are the press-fit type 1N3493, and the stud-mounted type 1N3210, rated at 25 amps and 15 amps respectively. Both of these types have a p.i.v. rating of 200 volts, making them perfectly suitable for this circuit.—Editors. ▲

P. R. MALLORY & CO. Inc.
MALLORY

Tips for Technicians

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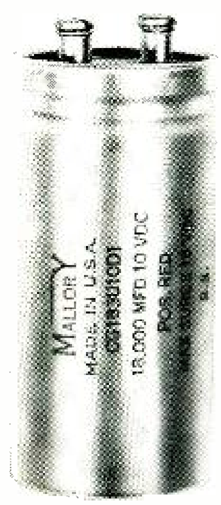
When you need a lot of microfarads...



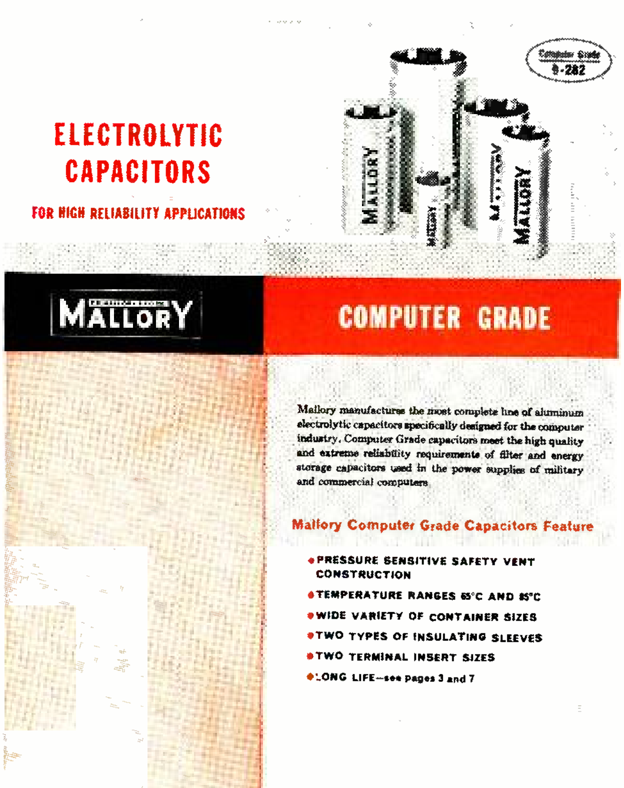
You may be occasionally confronted with the problem of finding a lot of capacitance. Maybe for a sound system where you want to squeeze the last bit of ripple out of a power supply. Or for brute-force filtering of low voltage, as in a DC supply for filament circuits.

If your first inclination is to round up a bunch of duals, triples and quads until they add up to the microfarads you need, then hook them in parallel—for the sake of your budget, resist the temptation and read the rest of our tip. For you can get a lot of capacitance in a single unit, at considerably lower cost, by using a Mallory Type CG Computer Grade Capacitor.

These are called computer grade because they were designed specifically for use in computer power supplies. But you don't need to own a computer to use them. What's special about them is the way they're made. Since they are expected to last practically forever, they are made of extra-pure materials and assembled with tender, loving care. All of which seems to pay off, for they turn out to be just about the purest microfarads you can find—very low in equivalent series resistance and d-c leakage. And life is almost unbelievable! We've tested them for the equivalent of *20 years* service at room temperature!

What *isn't* special about them is their price. In many instances, a single Type CG will cost less than half as much as the three or four conventional capacitors you would need to get the same rating. In standard stock case sizes, you can get as much as 75,000 mfd at 3 volts and 1300 mfd at 350 volts.

And best of all, you can get 'em when you need 'em at your Mallory Distributor. He's your best source for all electronic components.



Ask your Mallory Distributor for Bulletin 9-282 on Computer Grade Capacitors. It lists all ratings which he carries in stock.

CIRCLE NO. 129 ON READER SERVICE PAGE

NOW...GET THE FINEST STEREO TEST RECORD ever produced for just...$4.98

Featuring Tests Never Before Available Outside Of The Laboratory

Why We Make the Model 211 Available Now

Although there are many stereo test records on the market today, most critical checks on existing test records have to be made with expensive test equipment.

Realizing this, HiFi STEREO REVIEW decided to produce a record that allows you to check your stereo rig, accurately and completely, **just by listening!** A record that would be precise enough for technicians to use in the laboratory—and versatile enough for you to use in your home.

The result: the HiFi STEREO REVIEW Model 211 Stereo Test Record!

UNIQUE FEATURES OF HiFi/STEREO REVIEW'S MODEL 211 STEREO TEST RECORD

- **Warble tones to minimize the distorting effects of room acoustics when making frequency-response checks.**

  Warble tones used are recorded to the same level within ± 1 db from 40 to 20,000 cps, and within ± 3 db to 20 cps. For the first time you can measure the frequency response of a system without an anechoic chamber. The frequency limits of each warble are within 5% accuracy.
- **White-noise signals to allow the stereo channels to be matched in level and in tonal characteristics.**
- **Four specially designed tests to check distortion in stereo cartridges.**
- **Open-air recording of moving snare drums to minimize reverberation when checking stereo spread.**

Stereo Checks That Can Be Made With the Model 211

- ✓ **Frequency response—a direct check of eighteen sections of the frequency spectrum, from 20 to 20,000 cps.**
- ✓ **Pickup tracking — the most sensitive tests ever available on disc for checking cartridge, stylus, and tone arm.**
- ✓ **Hum and rumble—foolproof tests that help you evaluate the actual audible levels of rumble and hum in your system.**
- ✓ **Flutter—a test to check whether your turntable's flutter is low, moderate, or high.**
- ✓ **Channel balance — two white-noise signals that allow you to match your system's stereo channels for level and tonal characteristics.**
- ✓ **Separation—an ingenious means of checking the stereo separation at seven different parts of the musical spectrum—from mid-bass to high treble.**

ALSO: ✓
- **Stereo Spread**
- **Speaker Phasing**
- **Channel Identification**

PLUS SUPER FIDELITY MUSIC!

The non-test side of this record consists of music recorded directly on the master disc, without going through the usual tape process. It's a superb demonstration of flawless recording technique. A demonstration that will amaze and entertain you and your friends.

All Tests Can Be Made By Ear

HiFi/STEREO REVIEW's Model 211 Stereo Test Record will give you immediate answers to all of the questions you have about your stereo system. It's the **most complete** test **record** of its kind—contains the widest range of check-points ever included on **one** test disc! And you need no expensive test equipment. **All checks can be made by ear!**

Note to professionals: The Model 211 can be used as a highly efficient design and measurement tool. Recorded levels, frequencies, etc. have been controlled to very close tolerances—affording accurate numerical evaluation when used with test instruments.

DON'T MISS OUT—SUPPLY LIMITED

The Model 211 Stereo Test Record is a disc that has set the new standard for stereo test recording. Due to the overwhelming demand for this record, only a limited number are still available thru this magazine. They will be sold by ELECTRONICS WORLD on a first come, first serve basis. At the low price of $4.98, this is a value you won't want to miss. Make sure you fill in and mail the coupon together with your check ($4.98 per record) today.

FILL IN AND MAIL TODAY!

Stereo Test Record
Electronics World—Dept. SD
One Park Ave., New York 16, N.Y.

Please send me ________ test records at $4.98 each. My check (or money order) for $________ is enclosed. I understand that you will pay the postage and that each record is fully guaranteed. (Orders from outside the U.S.A. add 50c to partially defray postage and handling costs.)

Name ____________________________________
(Please Print)

Address __________________________________

City ______________ Zone ________ State ________

SORRY—No charges or C.O.D. orders!

EW-24

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PRINT your name and address on the coupon and mail it to:

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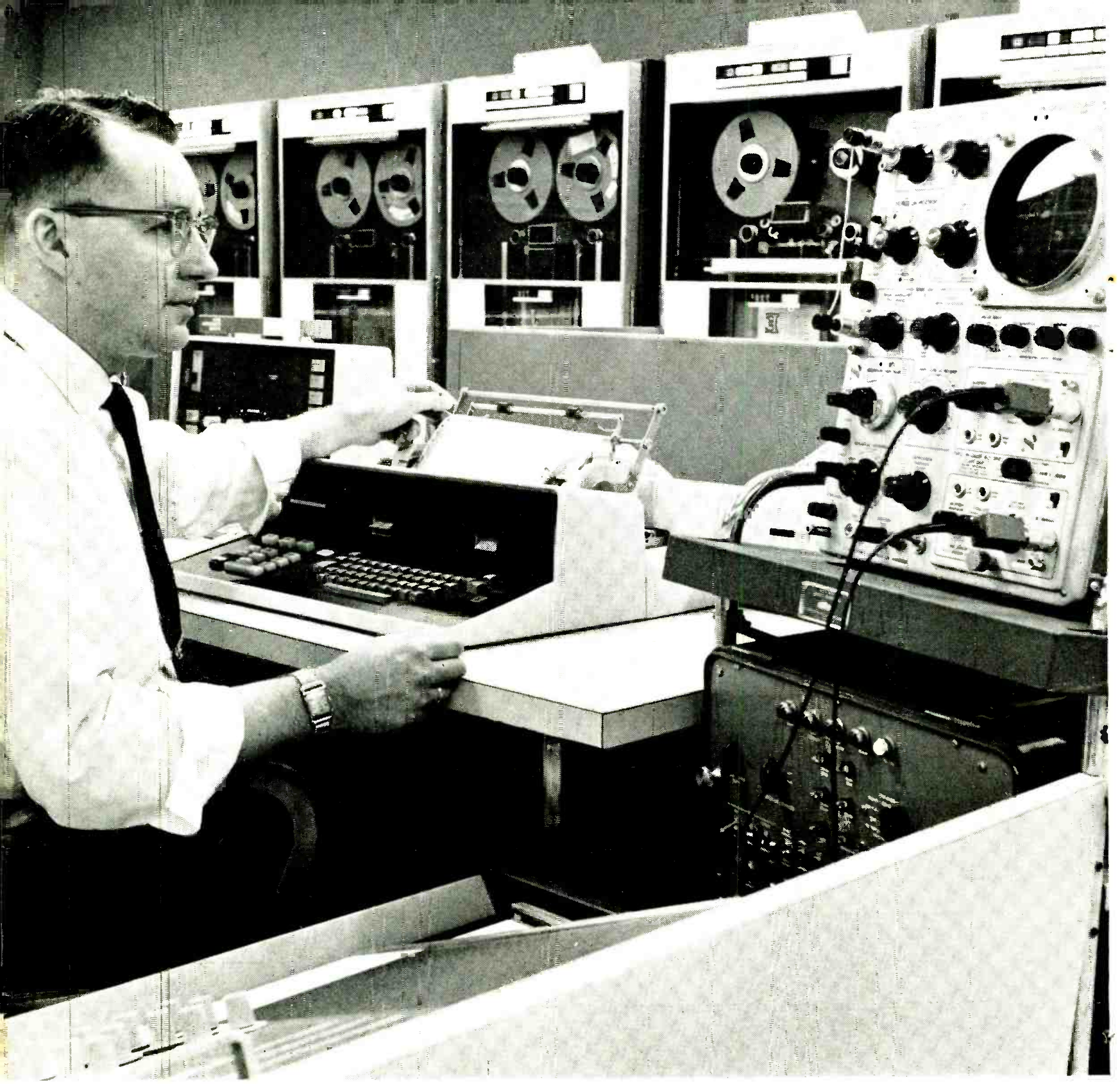

Why Fred got a better job . . .

I laughed when Fred Williams, my old high school buddy and fellow worker, told me he was taking a Cleveland Institute Home Study course in electronics. But when our boss made him Senior Electronic Technician, it made me stop and think. Sure I'm glad Fred got the break . . . but why him . . . and not me? What's he got that I don't. There was only one answer . . . his Cleveland Institute Diploma and his First Class FCC License!

After congratulating Fred on his promotion, I asked him what gives. "I'm going to turn $15 into $15,000," he said. "My tuition at Cleveland Institute was only $15 a month. But, my new job pays me $15 *a week* more . . . that's $780 more a year! In twenty years . . . even if I don't get another penny increase . . . I will have earned $15,600 more! It's that simple. I have a plan . . . and it works!"

What a return on his investment! Fred should have been elected most likely to succeed . . . he's on the right track. So am I *now*. I sent for my three *free* books a couple of months ago, and I'm well on my way to Fred's level. How about you? Will you be ready like Fred was when opportunity knocks? Take my advice and carefully read the important information on the opposite page. Then check your area of most interest on the postage-free reply card and drop it in the mail *today*. Find out how you can move up in electronics too.

How You Can Succeed In Electronics
. . . Select Your Future From Five Career Programs

The "right" course for your career

Cleveland Institute offers not one, but five different and up-to-date Electronics Home Study Programs. Look them over. Pick the one that is "right" for you. Then mark your selection on the reply card and send it to us. In a few days you will have complete details . . . without obligation.

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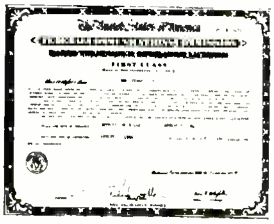
A comprehensive program covering Automation, Communications, Computers, Industrial Controls, Television, Transistors, and preparation for a 1st Class FCC License.

2. First Class FCC License

If you want a 1st Class FCC ticket *quickly*, this streamlined program will do the trick and enable you to maintain and service all types of transmitting equipment.



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Here's an excellent studio engineering program which will get you a 1st Class FCC License and teach you all about Program Transmission and Broadcast Transmitters.

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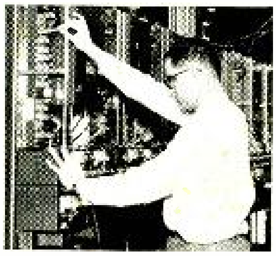
Mobile Radio, Microwave, and 2nd Class FCC preparation are just a few of the topics covered in this "compact" program . . . Carrier Telephony too, if you so desire.



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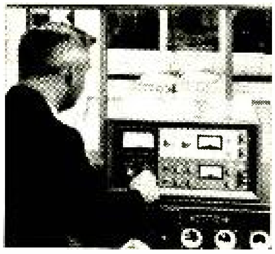
This exciting program includes many important subjects such as Computers, Electronic Heating and Welding, Industrial Controls, Servomechanisms, and Solid State Devices.



An FCC License . . . or your money back!

In addition to providing you with comprehensive training in the area indicated, programs 1, 2, 3, and 4 will prepare you for a Commercial FCC License. In fact, we're so certain of their effectiveness, we make this *exclusive* offer:

The training programs described will prepare you for the FCC License specified. Should you fail to pass the FCC examination after completing the course, we will refund *all* tuition payments. You get an FCC License . . . or your money back!

Cleveland Institute's new "Check-Point Plan" helps you learn faster and better

Cleveland Institute uses the new programmed learning approach. This "Check-Point Plan" presents facts and concepts in small, easy-to-understand bits . . . reinforces them with clear explanations and examples. Students learn more thoroughly and faster through this modern, simplified method. You too will absorb . . . retain . . . advance *at your own pace.*

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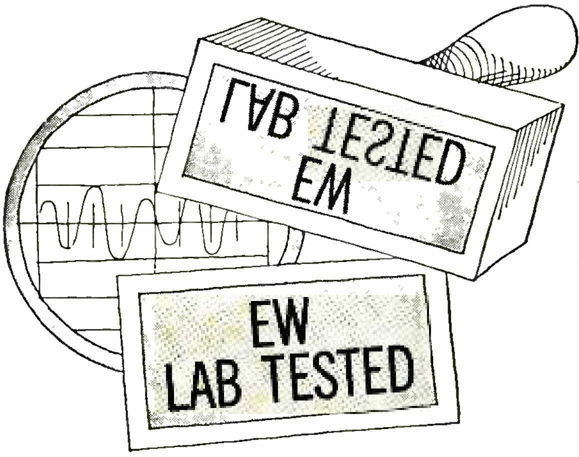


HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

Fisher 500-C FM-Stereo Receiver
Electro-Voice Model 664 Microphone
Audio Dynamics ADC-16 Speaker System

Fisher 500-C FM-Stereo Receiver

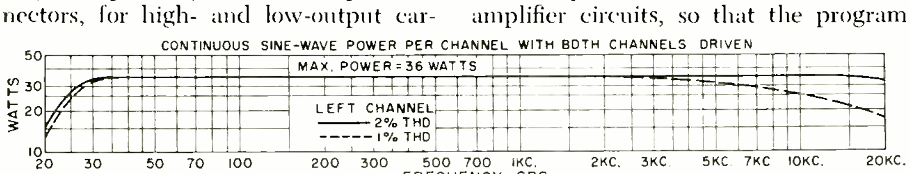
For copy of manufacturer's brochure, circle No. 45 on coupon (page 15).

THE *Fisher* 500-C stereo receiver is a newer and improved version of the Model 500-B which we reported on in this column almost two years ago (April, 1962). It was interesting to find that the improvements were substantial and worthwhile, despite the fact that the basic model designation remains unchanged and the price increased only slightly.

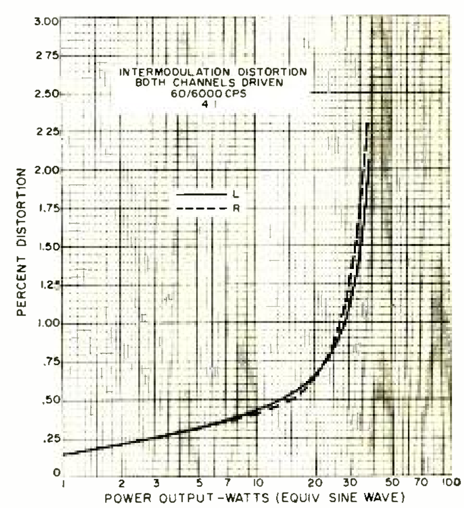
The 500-C is a highly sensitive FM-stereo tuner, with switching-type multiplex demodulating circuits, combined with stereo control amplifiers and a pair of 30-watt (continuous) power amplifiers in a single, attractively styled unit. The FM tuner features the "Stereo Beacon," an automatic stereo-mono selector which is actuated by the presence of the 19-kc. pilot carrier in the received signal. This operates a relay which switches the tuner from mono to stereo mode of operation and lights a lamp behind the dial face to signify stereo reception. The selector switch on the panel also has positions for full-time stereo and mono reception, for those occasions where weak signals or fluctuating levels make the automatic feature undesirable.

The other inputs include tape head, magnetic phono (two sets of input connectors, for high- and low-output cartridges, are supplied), and an "Aux" input for tape playback amplifier, TV sound, or other high-level input. The volume control has switchable loudness compensation. Other controls include concentric tone controls, a balance control, and a speaker selector which channels the receiver's outputs to either of two pairs of speakers, to both combined, or shuts off all speakers for headphone listening. A headphone jack is located on the front panel, with suitable level pads so that stereo phones will not be overdriven by the amplifiers. A group of slide switches operate high- and low-cut-off filters, a multiplex subcarrier filter, and the tape-monitoring facility.

The receiver has a unique switching system for use with a three-head tape recorder having separate recording and playback amplifiers. The playback amplifiers are connected to the "Mon" inputs and the recording amplifiers are connected to the "Rcdr Out" jacks. Any program source selected by the input selector is fed to the recorder without passing through any of the receiver's controls (except the "Low Filter"). Setting the "Tape Monitor" switch to "on" feeds the outputs of the recorder's playback amplifiers to the balance of the amplifier circuits, so that the program may be monitored while making a recording, and compared to the original program by operating the "Tape Monitor" switch, without interrupting or affecting the recording. When listening to previously recorded tapes, the input selector is set to "Aux," which causes the playback amplifiers to pass through all the receiver's control circuits and disconnects all other signals such as the tuner output. The input switching circuits accomplish this without the need to change the recorder output leads from the "Mon" to "Aux" jacks.

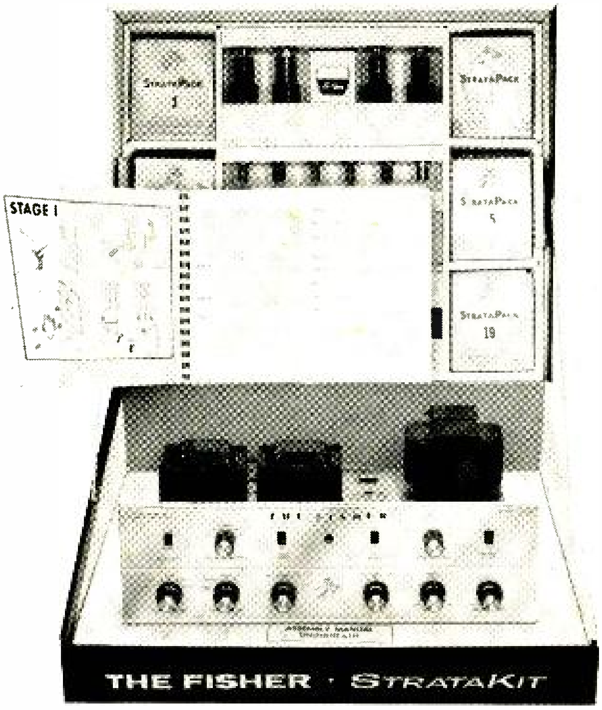


The FM tuner, featuring the "Golden Synchrode" tuner front end, is rated at 1.8 μv. IHF usable sensitivity. We measured it as 2 μv., which is within the normal spread of experimental error. This



places the unit among the top ranks of FM tuners in regard to sensitivity. Its limiting action was virtually complete with only 4-μv. input, and the distortion was less than 1% at that level and for all higher input levels. Warm-up drift was too small to measure. The residual hum of the tuner was −61.5 db referred to 100% modulation, which is approximately the inherent hum of our signal generator.

The FM-multiplex section was similarly fine in its performance. The stereo separation was better than 30 db from 90 to 9500 cps, and reached 42 db at



This is the beginning of the Fisher KX-200 StrataKit.

This is the end. The absolute end in stereo control-amplifiers.

You begin the Fisher KX-200 StrataKit with the most logically organized kit package and the clearest, most detailed assembly manual in the entire field of high fidelity kits.

The StrataKit method of kit construction is a unique Fisher development. Assembly takes place by simple, error-proof stages (Strata). Each stage corresponds to a *separate* fold-out page in the manual. Each stage is built from a *separate* packet of parts (StrataPack). Major components come *already mounted on the chassis.* Wires are *precut* for every stage—which means every page. All work can be checked stage-by-stage and page-by-page, before proceeding to the *next* stage.

As a result, you end up with an 80-watt stereo control-amplifier that is completely indistinguishable from a factory-built Fisher unit.

The KX-200 has enough power to assure peak performance with the most inefficient speakers and incorporates exclusive features like a laboratory-type d'Arsonval bias/balance meter and a third-speaker output with separate volume control. Price, $169.50.* The Fisher KX-100, a 50-watt stereo control-amplifier kit of advanced design, costs only $129.50.*

FREE! $1.00 VALUE! The Kit Builder's Manual, an illustrated guide to high fidelity kit construction, complete with detailed specifications of all Fisher StrataKits.

The Kit Builder's Manual

Fisher Radio Corporation
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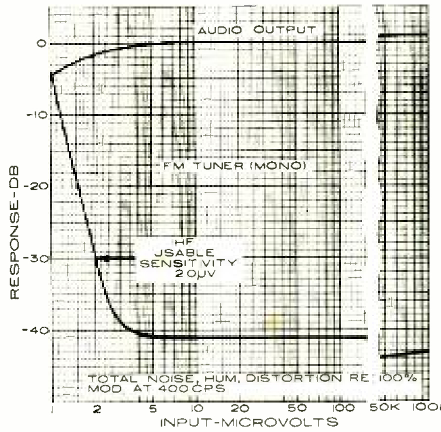
07211

*Walnut or mahogany cabinet, $24.95; metal cabinet, $15.95. All prices slightly higher in the Far West. Overseas residents write to Fisher Radio International, Inc., Long Island City 1, N.Y. Canadian residents write to Tri-Tel Associates, Ltd., Willowdale, Ont.



mid-frequencies. The "Stereo Beacon" worked perfectly, although it has a slight time lag of about 1 second in its operation which requires the receiver to be tuned at a moderate rate when searching for stereo broadcasts.

The audio section is rated at 75 watts total IHF music-power output or 60 watts total continuous output with both channels driven. We measured the continuous output as 72 watts for both channels with 2% distortion, and 70 watts with 1% distortion. The power bandwidth was from 22 to 20,000 cps at 1% distortion and to well beyond 20,000 cps at 2% distortion. IM distortion was under 0.5% up to 15 watts per channel, reaching 2% at a total output of 75 watts continuous. Hum was inaudibly low, ranging from −65 db on tape head inputs to −84 db on auxiliary inputs, referred to 10 watts output. The high and low filters have 12 db/octave slopes which, combined with their well-chosen cut-off frequencies of 6000 cps and 60 cps allow them to eliminate most extraneous noise from poor records without affecting the program material.

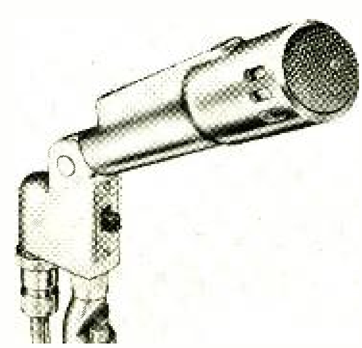
A comparison between the 500-C and its predecessor, the 500-B, shows the following differences: it has appreciably more power output, higher sensitivity, more flexible tape-recording facilities, provision for two sets of speakers and/or headphones, and automatic FM-stereo indication and selection. It lacks channel reversing, phase reversing, and phono level setting adjustments. The first two are of little importance now that stereo recording standards are well established, and the latter, although certainly desirable, has been partially handled by having two sets of phono inputs for cartridges of differing outputs.

All in all, the unit proved to be a top-notch stereo receiver, just about as sensitive as they come, and with amplifiers of sufficient quality and power output to do justice to any type of speaker systems. It was very easy to tune and handle, being not at all critical in its adjustment for proper FM-stereo reception.

The 500-C sells for $389.50. A wooden cabinet for the receiver sells for $24.95. ▲

Electro-Voice Model 664 Microphone

For copy of manufacturer's brochure, circle No. 46 on coupon (page 15).

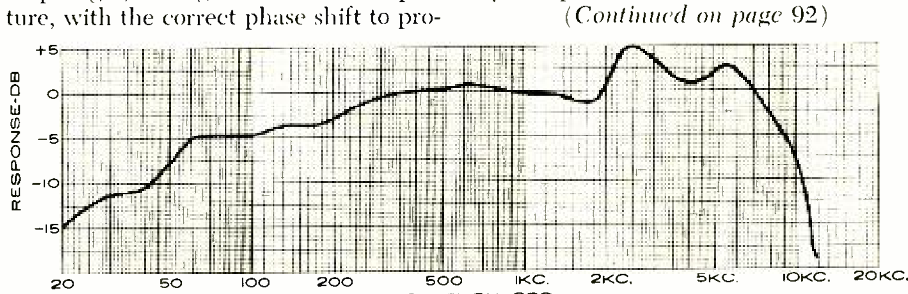


THE *Electro-Voice* Model 664 is a dynamic microphone, with a cardioid pattern, designed specifically for public-address applications. A cardioid response is commonly obtained by allowing some sound to reach the rear of the diaphragm, through an additional aperture, with the correct phase shift to produce a cancellation of rear response. The Model 664 has three such sound entrances, which effectively change their distance from the diaphragm inversely with frequency. This results in a cardioid pattern which is relatively uniform over a wide frequency range.

The microphone is a large, ruggedly built unit. Finished in satin chrome, it is over 10 inches long, including the mounting fixture, and 1⅞ inches in diameter. It weighs 1 pound, 10 ounces exclusive of cable. It has a built-in transformer to provide high-impedance and 150-ohm outputs. Either can be selected by appropriate wiring of the cable connector. An 18-foot shielded cable is included, fitted with an *Amphenol* MC4M connector.

We measured the frequency response by comparison with our calibrated lab-

(*Continued on page* 92)



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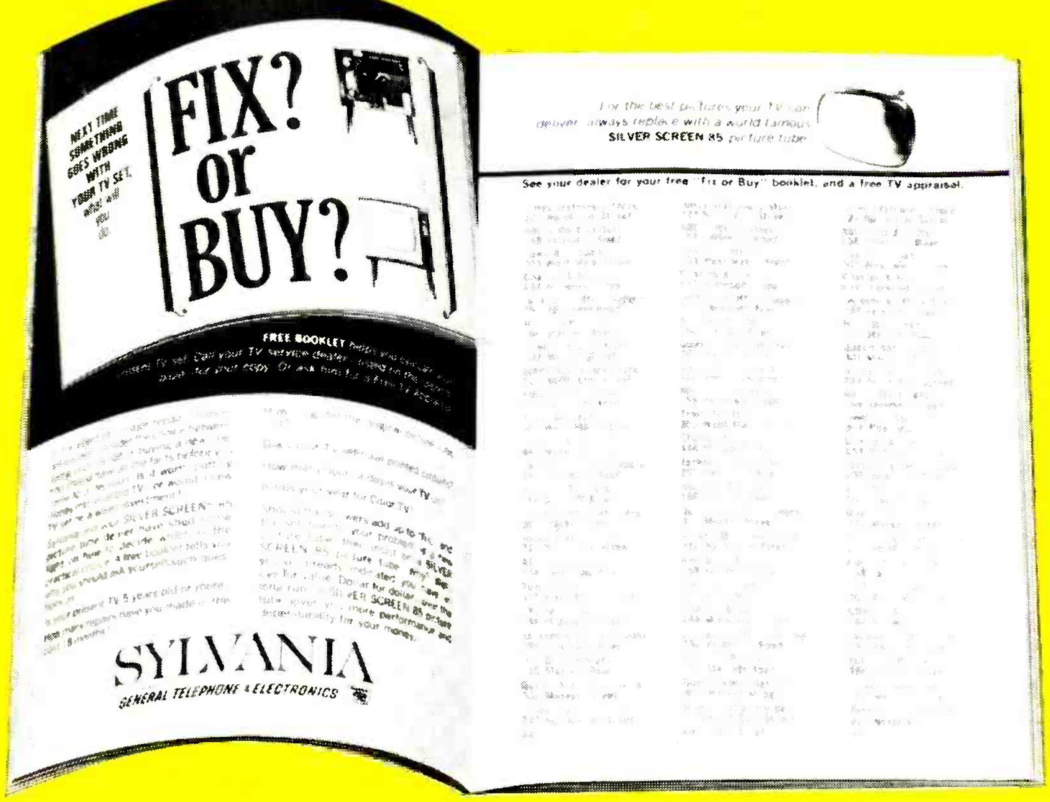

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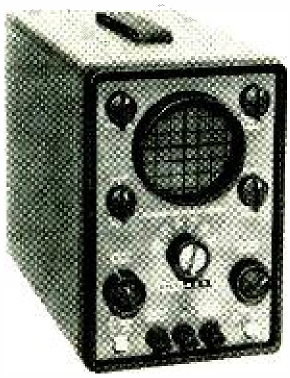

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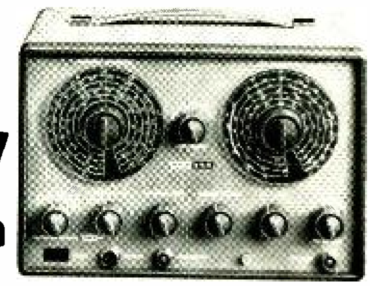

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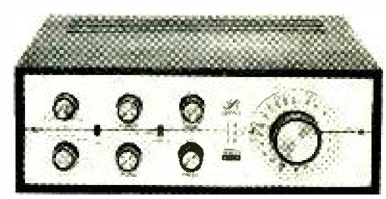

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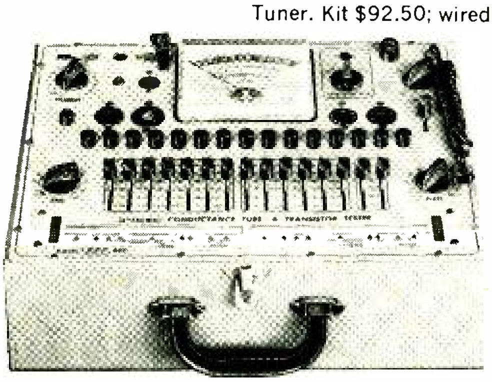

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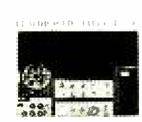
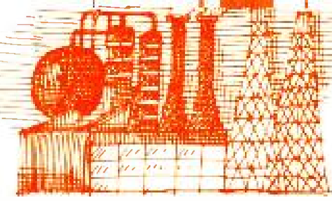
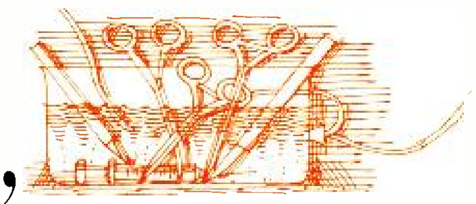
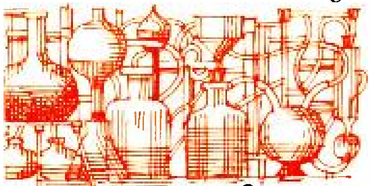


Industrial,  medical,  military,  and experimental 

 applications for "silent sound" are increasing steadily. Here is a survey of the latest and most important......

ADVANCES IN ULTRASONICS

PART 1-CLEANING, MACHINING, SOLDERING

By CYRUS GLICKSTEIN / Author: "Basic Ultrasonics"

ULTRASONIC applications continue to expand steadily. Under water, on land, and in space "silent sound" waves are used in an amazing variety of applications—from underwater sound gear used in anti-submarine warfare to experiments for controlling the combustion of solid-fuel missiles, from welding metals to delicate brain surgery, from automatic parking systems to burglar detection devices, from remote control TV channel selectors and garage door openers to new techniques for cancer detection, and many, many more.

To anyone unfamiliar with ultrasonic principles, it may seem rather strange that vibrational (mechanical) energy above the range of human hearing can be so versatile. It may be helpful to review some of the basic principles as background before discussing current applications.

Ultrasonics makes use of "sound" waves above the range of human hearing, that is, above about 16,000 cps. The fact that ultrasonic vibrations can be applied to solids, liquids, or gases at low or high power provides the basis for dozens of diverse applications in many fields.

Initial Developments

Ultrasonics received its first big impetus in 1917. During World War I, French scientist Paul Langevin found that ultrasonic waves could be used in underwater echo-ranging to locate enemy submarines. Further developments were continued in this area after the war. In World War II, Sonar (*S*ound *N*avigation *a*nd *R*anging) used more refined methods of generating, transmitting, and receiving ultrasonic waves and was one of the decisive factors in winning the Battle of the Atlantic against German submarines.

The principle of underwater echo ranging is simple (Fig. 1). Pulses of ultrasonic energy are transmitted through the water in a focused beam (comparable to snapping a light beam from a flashlight on and off or to a pulsed electromagnetic beam from a radar set). An object like a submarine, which is a dissimilar medium (metal) from the surrounding medium (water), causes a reflection (echo) of some of the energy in the beam back to the source. This is detected in the receiver and displayed on equipment which is calibrated for range and bearing of the target.

The echo-ranging principle was subsequently applied to solids and used for flaw detection (non-destructive testing) in metals, thickness gaging of metal pipes, and in many different types of medical applications where x-rays are not practical or possible. Ultrasonic energy is also used in related echo-ranging applications such as guidance for the blind. Interestingly enough, bats use ultrasound for much the same purpose—as a guide during flight to prevent collision with obstructions as well as to home on a target.

Cavitation is the second major area of ultrasonic applications. Cavitation occurs when high-power ultrasonic energy from a generator is applied through a transducer to liquids, whether the liquid is water, molten metal, or a paste (Fig. 2). Cavitation is a "cold boiling." The high-power ultrasonic energy causes intense agitation of the molecules in the liquid. Vapor bubbles form and implode continuously in step with the alternating rarefaction and compression cycles of the vibrational energy applied. As a result, tremendous local forces are released in the liquid medium. Ultrasonic cavitation in liquids is the basis for applications such as ultrasonic cleaning, drilling, soldering, and numerous others. In related applications, such as ultrasonic welding of metals and sealing of plastics, the ultrasonic energy applied to the surface of

This type of ultrasonic drill (machine tool) is used for a wide variety of applications—drilling, slicing, dicing, and machining.

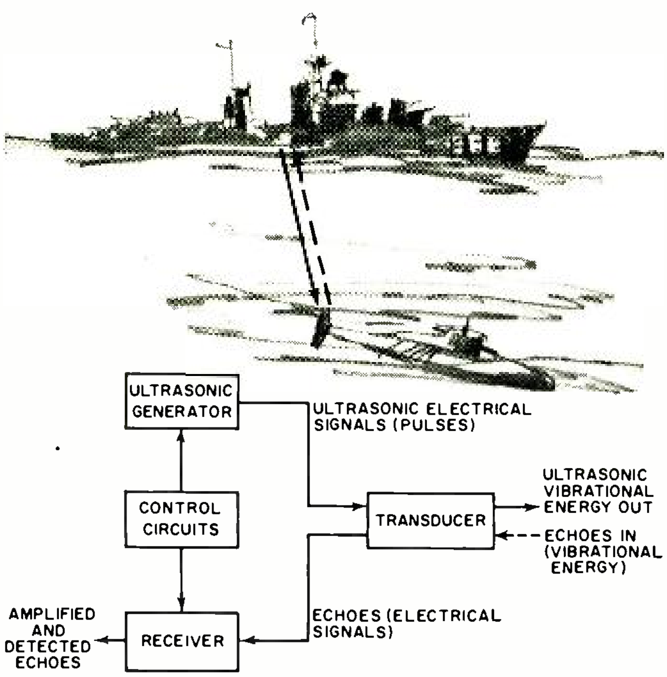


Fig. 1. Principle of underwater echo ranging using ultrasonics.

the materials breaks up the surface film (oxides, contaminants, etc.). This causes a diffusion-type of molecular interaction at the point of contact. A weld results without producing or requiring enough heat to melt the materials.

Cavitation involves high power, echo ranging comparatively low power applied to the transmission medium. Specialized applications not falling readily into either of these categories commonly use low power.

Ultrasonic Transducers

How is ultrasonic energy generated and applied? Two basic ingredients are required—an electric or electronic generator (usually the latter) and a transducer. The electronic generator is simply an oscillator plus, when necessary for greater power output, amplifiers. A transducer is an energy converter. Ultrasonic transducers convert the electrical energy at an ultrasonic frequency to vibrational energy at the same frequency or *vice versa*. A loudspeaker is a familiar example of a typical transducer in the sonic range; it transforms audio electrical energy to sound waves by vibrating against the transmission medium (air). A loudspeaker can also convert sound waves to electrical impulses, as is the case in most intercoms.

Piezoelectric and magnetostrictive transducers (Fig. 3) are used in ultrasonics. Piezoelectric materials include quartz crystals, lithium sulphate, Rochelle salt, ammonium dihydrogen phosphate (ADP), barium titanate, and lead zirconium titanate. Piezoelectric transducers have the quality of electrostriction—they change shape when a voltage is applied. If an a.c. voltage is applied, they change shape (vibrate) in step with the signal. Conversely, they produce electrical signals when vibrations are applied. The action of a quartz crystal in a crystal oscillator is a familiar example. Piezoelectric ceramic transducers such as barium titanate and lead zirconium titanate are widely used because of high conversion efficiency and relatively low cost, although they are not able to withstand as high a temperature as magnetostrictive transducers.

Magnetostrictive transducers may be made of any one of a number of materials (mainly metals) that can be magnetized—steel, iron, cobalt, nickel, and a number of alloys. In becoming magnetized, these materials exhibit the property of magnetostriction—a change in physical size. Alternating current at an ultrasonic frequency is applied to an electromagnet wound around laminations of the metal (nickel or one of the other magnetostrictive metals). The alternating magnetic field produces vibrational energy which is applied to the load. In the same way, vibrations applied to the transducer will induce an electrical signal into the coil around the transducer and so transform vibrational energy into electrical energy. To prevent doubling of the generator frequency, a continuous polarizing bias current is applied to the electromagnet.

Why is ultrasonic energy used rather than sound energy? In many applications sonic vibrations could be used and in a few cases are actually used. But, for the most part, the volume of sound output even for comparatively low-power applications would be intolerable to the human ear. In addition, the higher ultrasonic frequencies have shorter wavelengths as compared to sound. This permits detection of smaller flaws in applications such as non-destructive testing (NDT). Finally, higher frequencies permit more directional beams with smaller transducers, an important consideration in many echo-ranging applications.

Cavitation Techniques

Currently, ultrasonic cleaning is probably the most widely used ultrasonic application. Many different types of ultrasonic cleaners are manufactured, from small units suitable for cleaning watches to outsized units for cleaning missile components. Frequencies commonly used in these cleaners range from 20 to 40 kc., although higher frequencies (around 90 kc.) are used in some units designed to clean miniature parts. Readily available commercial units range from a small generator rated at 35 watts with a ½-gallon tank to generators rated at 3 kw. with a 75-gallon tank capacity. Units may be manual or automatic (go through a complete wash and rinse cycle automatically). Cleaners may have separate generator and transducer-tanks or may consist of an integral unit in which the generator, transducers, and tank are combined in a single unit such as an automatic cleaner for surgical instruments.

The ultrasonic electrical signal from the generator (oscillator) is applied to transducers which are cemented or bolted outside the tank or immersed inside the tank (using waterproof connectors). The transducers convert the electrical signal to vibrations which cause cavitation in the liquid medium in the tank. The forces generated by cavitation literally blast off impurities from the surface of the material being cleaned. So explosive is the force that the material itself would be gradually eroded if left for too long a period in the cavitating solution. Most ultrasonic cleaning is performed in a relatively short time—generally less than 10 minutes and in many applications less than 1 minute. The type of liquid used (water, water plus cleaning agent, hydrocarbon, etc.) depends on the type of material to be cleaned and the nature of the soil. A wide variety of cleaning agents is available for specific cleaning problems.

Today ultrasonic cleaning is used in almost every branch of industry including electronics. Electronic manufacturers clean printed-circuit boards after fabrication, precision items such as gyroscope parts, transistor and vacuum-tube parts, subassemblies prior to final assembly, and missile subassemblies. Whole units such as typewriters are efficiently cleaned quickly and thoroughly without disassembly. Ultrasonic energy is able to reach into hidden crevices of assemblies, wherever the liquid is able to make contact and apply agitational forces.

Ultrasonic cleaning may, in the near future, be introduced to the home appliance field. Large ultrasonic dishwashers are now in production for commercial use but they are too bulky and expensive. as compared to conventional models, to make them widely acceptable for home use at this time. While ultrasonic clothes washers may eventually be available, the fact that soft fabrics tend to damp ultrasonic energy presents at least one basic design problem to be solved.

Ultrasonic Drills

Other ultrasonic applications that are increasingly common are ultrasonic drilling, grinding, welding, and plastic sealing. Ultrasonic drills are, in many respects, like miniature compressed-air drills such as those used to break up street pavements. Instead of compressed air, ultrasonic vibrations are used at frequencies of 19 to 25 kc., the amplitude of vibration is much smaller (about .003 inch) and the over-all drill in many cases measures less than one foot.

A drilling unit (more accurately, a machining unit) consists, essentially, of an ultrasonic generator in a separate container and a combination stand and drill head. The drill head consists of a transducer and tapered stub (see cover illustration). Interchangeable drill bits are connected, as required, to the tapered stub. Ultrasonic signals from the generator are applied to the transducer (generally magnetostrictive), which converts the electrical energy to mechanical vibrations. The tapered stub acts as a mechanical transformer so that the vibrations at the wide end are amplified at the narrow end where the drill bit is connected.

(Our cover illustration shows the implification of the ultrasonic energy from the transducer and the regions of minimum and maximum vibration. Note that maximum vibration occurs at the end of the bit).

The bit is applied to liquid-borne abrasive grains on the work surface. The abrasive liquid carrier is supplied by a recirculating pump. The cavitation in the liquid plus the tiny trip-hammer impacts permit drilling through the hardest and most brittle materials. Ultrasonic drills are used to cut specially shaped holes through exceptionally hard materials like tungsten carbide or brittle materials such as glass and ceramics. The shape of the hole follows the shape of the bit point. Since ultrasonic drilling produces a negligible amount of local heat, there is no change in the chemical or physical properties of the material.

The most commonly used abrasives are boron carbide, silicon carbide, and aluminum oxide in various degrees of fineness. The finer the abrasive, the finer the tolerance which can be achieved in machining to close specifications. In many cases, a coarser abrasive is used initially, followed by a fine abrasive for completing the work. In ultrasonic drilling, the tip is not worn too much no matter how hard the material. Bits of abrasive material become embedded in the point and take up most of the wear.

Closely related applications are ultrasonic cutting, dicing, and grinding. By using the proper tools applied to the ultrasonic drill, a number of parallel cuts can be made simultaneously to slice materials into thin wafers. These wafers, in turn, can be diced into minute rounds. Grinding operations involve shaping the contours of the work to specific dimensions and providing a given finish.

In ultrasonic soldering, the soldering iron contains a heating element just as in the usual iron as well as an ultrasonic transducer which applies ultrasonic vibrations to the tip. The heated tip melts the solder as usual while the ultrasonic energy applied to the tip causes cavitation in the molten solder. This breaks up any film at the joint and at the same time prevents an oxide from forming as the result of the applied heat. A clean joint is obtained without the use of flux, thereby eliminating contaminants, possible corrosion, and cleaning problems.

Next month, we will cover additional important applications of ultrasonics: including ultrasonic welding, echo-ranging devices, non-destructive testing, medical uses, and others.

(Concluded Next Month)

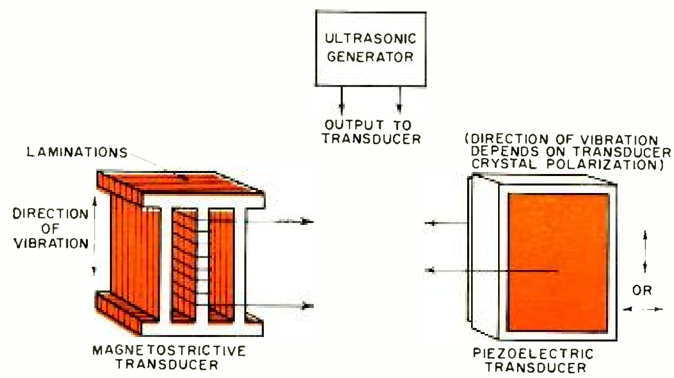
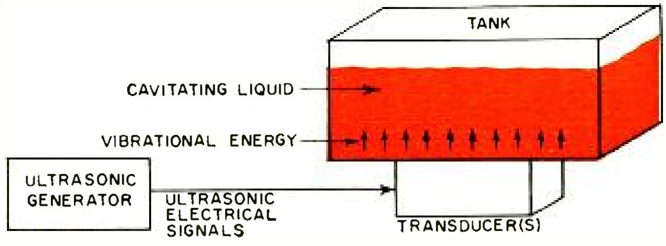


Fig. 3. The two main types of transducers used in ultrasonics.

A commercial ultrasonic cleaner with integral generator, transducers, and tank operating with an automatic cleaning and rinsing cycle. This unit is used for cleaning surgical instruments.

Fig. 2. Cavitation or "cold boiling" of a liquid medium.



MODULATION CIRCUITS for SOLID-STATE CB TRANSMITTERS

By WILLIAM A. RHEINFELDER/Chief Engineer, Ameco, Inc.

Design of novel, linearized base-modulation and double-modulation circuits which feature low current drain, low distortion, light weight, and small size.

RECENTLY improved transistors which permit the full legal d.c. power input of 5 watts into the final stage became available. For this reason, a modern, high-quality circuit can be built with just three transistors: one each for crystal oscillator, driver, and final stage. A further simplification would be possible by combining the crystal oscillator and driver stage. However, this scheme leads to more inherent FM modulation and somewhat higher envelope distortion. Disregarding some of these circuit variations, there seems to be no bar to the satisfactory design of the r.f. portion of CB transmitters for even highest quality requirements. The circuits to be discussed can be built completely pre-tuned and constructed in minimum space. Current drain is low and performance and reliability are generally excellent.

Because of these r.f. circuits, it is rather disappointing to examine a complete CB transmitter using conventional modulation circuits. Most conventional methods of modulation appear strangely out-of-date, and there is much room for improvement. With this in mind, new modulation circuits have been developed.[1] Application of these circuits to Citizens Band transmitters has provided rather gratifying results.

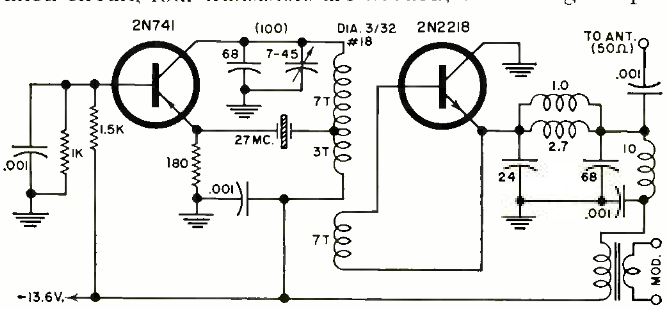
Conventional Modulation Circuits

Let us first consider the basic shortcomings of most conventional modulation circuitry. In a typical collector-modulated circuit, four transistors are needed; two voltage amplifiers and a pair in a push-pull class-B stage for current economy. The circuit design of such a modulator is straightforward but has the following shortcomings:

1. *Excessive current drain*: It can be shown that for 100% modulation, an audio modulation power of exactly one-half the d.c. input into the final stage is required. With the normal efficiencies obtainable in class-B audio amplifiers, current drain for the transmitter is about doubled.

2. *High distortion*: The high-quality r.f. circuits mentioned previously can be modulated with less than 1% envelope distortion at 100% modulation. However, it is costly and difficult to design a modulator to match the quality of the r.f. circuit. This involves an expensive modulation transformer, additional stages, and feedback. The same considerations apply to frequency response. Experiments show that poor speech quality can usually be attributed to the modulator.

3. *Large size and weight*: This is due to the necessary audio transformers and the added battery weight. This precludes the use of conventional modulation circuits in hand-held equipment, particularly for 5-watt transmitters. Some of the problems can be overcome by more expensive design, but these attempts must be regarded as brute-force methods.

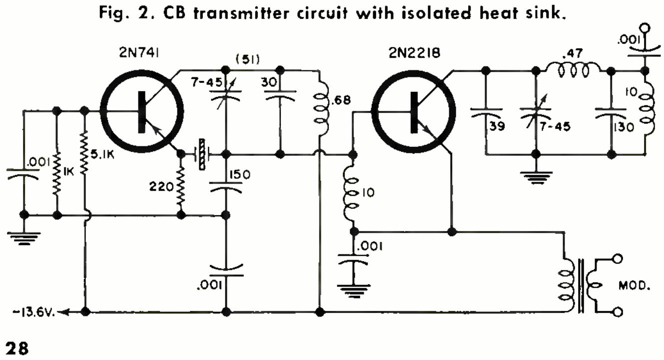


	MODULATED	UNMODULATED
R.F. POWER OUTPUT	780MW.	640MW.
TOTAL CURRENT	110 MA.	101 MA.
SUPPLY VOLTAGE	13.6 V.	13.6 V.
MODULATION INDEX	90 %	–
DEMODULATED AUDIO	6.5 V.	–
DISTORTION	5.7 %	–
FINAL CURRENT	78 MA.	75 MA.
D.C. POWER, FINAL	1.06 W.	1.02 W.
MODULATING POWER	300 MW.	–
LOAD FOR MODULATOR	300 OHMS	–

(ALL CAPACITANCE VALUES IN pf. EXCEPT DECIMAL VALUES WHICH ARE IN μf. INDUCTANCE VALUES ARE IN μhy.)

Fig. 1. Circuit of 1-watt boot-strapped transmitter.

Fig. 2. CB transmitter circuit with isolated heat sink.



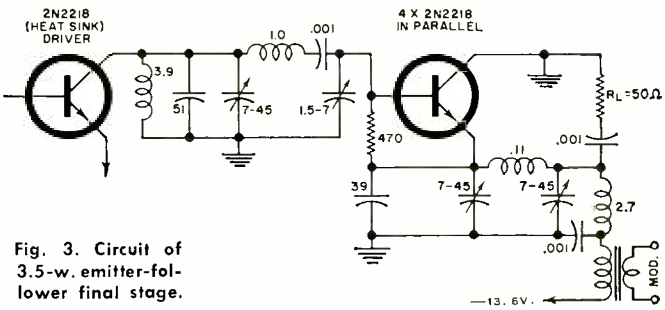


Fig. 3. Circuit of 3.5-w. emitter-follower final stage.

	MODULATED	UNMODULATED
R.F. POWER OUTPUT	3W.	2W.
DEMODULATED AUDIO	16.5 V.	–
DISTORTION	3 %	–
FINAL CURRENT	250 MA.	235 MA.
TOTAL CURRENT	317 MA.	300 MA.
SUPPLY VOLTAGE	13.6 V.	13.6 V.
MODULATION INDEX	100 %	–
D.C. POWER, FINAL	3.5 W.	3.2 W.

R.F. Circuitry

Before discussing new modulation circuits, let us cover briefly the r.f. portions of the circuit examples given here. Typical 1- and 3.5-watt circuits are shown in Figs. 1, 2, and 3. A comparison with earlier circuits[2] is revealing.

The crystal oscillator is a standard Colpitts with the crystal operating in the series mode and connected into the feedback path. This leads to low current in the crystal and produces excellent frequency stability. The Colpitts capacitors are used simultaneously for matching into the driver stage. In the other circuits shown without a driver stage, the analogous Hartley oscillator was used with mutual-inductance coupling into the final stage. The coil is wound continuously in a single layer, in one direction, with taps brought out for primary and secondary.

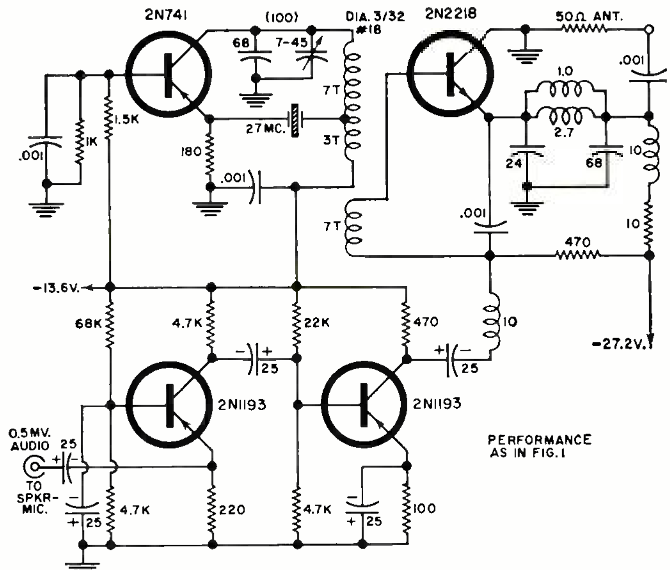


Fig. 4. Complete 1-watt circuit with base modulation.

CIRCUIT OF FIG.	1,2	3	4	5	6	7
R.F. Power Output	.780 w.	3 w.	.780 w.	1.8 w.	2.2 w.	2.9 w.
Demodulated Audio	6.5 v.	16.5 v.	6.5 v.	14 v.	15 v.	17 v.
Distortion	5.7%	3%	5.7%	5.2%	3.2%	6.6%
Final Current	78 ma.	250 ma.	78 ma.	180 ma.	180 ma.	262 ma.
Driver & Osc. Current	32 ma.	67 ma.	32 ma.	72 ma.	71 ma.	8 ma.*
Supply Voltage	13.6 v.	13.6 v.	27.2 v 13.6 v.	27.2 v. 13.6 v.	27.2 v. 13.6 v.	27.2 v. 13.6 v.
Audio Input Power	300 mw.	1000 mw.	—	—	—	1 mw.
D.C. Power, Final	1.06 w.	3.5 w.	1.06 w.	4.32 w.	4.57 w.	3.6 w.
Audio Input Res.	300 ohms	150 ohms	100 ohms	1000 ohms	2000 ohms	115 ohms
Audio Input Volt.	—	—	0.5 mv.	2 mv.	8 mv.	—

*Oscillator current

Table 1. Comparative performance data for various circuits.

The secondary should be polarized for best performance. Driver and final stages use standard pi-matching networks. In some cases two chokes are shown in parallel; this is merely a fine adjustment of inductance since standard epoxy-encapsulated chokes were used. A single coil of proper inductance may be substituted.

The transistor for the final stage was originally made up of four driver types connected in parallel, however, new transistor types have since become available for this application at reasonable cost, so only a single transistor is needed for the final stage. Types from *Motorola, PSI, TI,* and other manufacturers are available for this particular application.

New Modulation Techniques

An elegant engineering solution to the modulation problem is provided by the circuits of Figs. 4, 5, 6, and 7. All circuits, except Fig. 7, use a newly developed linearized base-modulation system. Base modulation produces an inherently high degree of envelope distortion. It was found that by partial rectification of the audio signal in the base-emitter junction of the final r.f. stage, good bias control is possible. This action is controlled by the total d.c. resistance, base-to-emitter, in the r.f. stage. In addition, series current feedback, effective at audio frequencies only, is used in the final r.f. stage. This method, together with re-alignment of the r.f. stage, led to very satisfactory results and is probably the best modulation method.

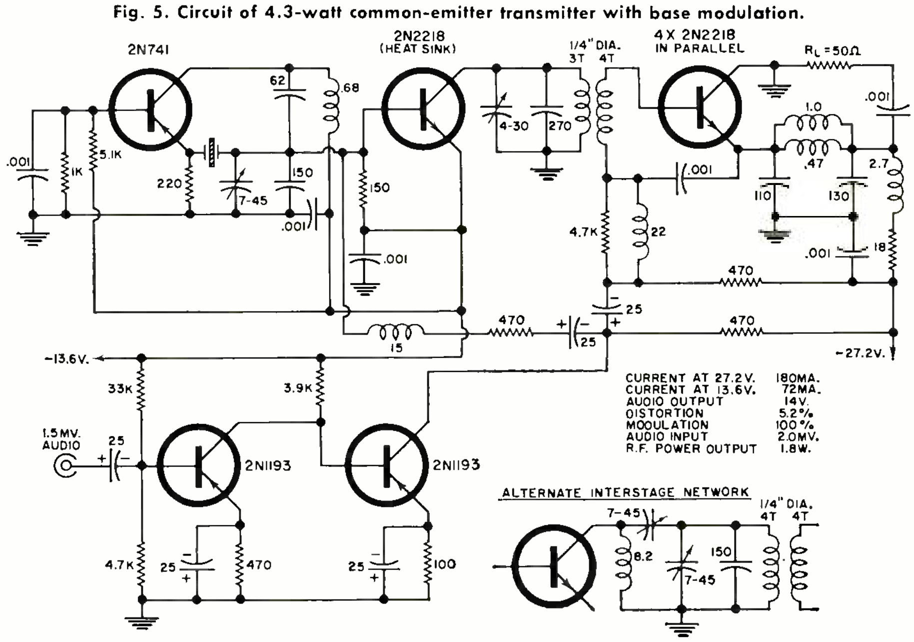
It should be mentioned that the supply voltage must be doubled with base modulation since, unlike collector modulation, no increase in collector voltage is possible by addition of modulating voltage. This higher supply voltage requirement is not a problem with portable equipment since the current drain is reduced proportionately and the total power consumption is practically the same. In the circuit of Fig. 4, only two small-signal transistors, Type 2N1193, are needed to fully modulate this 1-watt transmitter. In conventional collector modulation, this circuit requires two additional power transistors, one rather heavy modulation transformer, and a driver transformer. Even with this bulkier and more expensive conventional circuit, performance was below that of the circuit of Fig. 4 in speech intelligibility, due to harmonic distortion and poor frequency response. Total power consumption of the transmitter of Fig. 4 is about one-half that of a conventional circuit. Complete performance data on the circuits is given in Table 1.

Modulating Higher Power Transmitters

In high-power transmitters, inclusion of the driver stage leads to the possibility of applying the double-modulation principle.[3] This results in a further reduction of distortion and a saving of modulation power. In Fig. 5, base modulation is used for both the driver and final stage. The proportion of modulation for each has been carefully adjusted to obtain the best point of operation. Two supplies are used in the circuit of Fig. 5. This does not present a problem as the circuit is designed to operate from two 15-volt batteries connected in series, with the crystal oscillator and first audio stage connected to the tap.

In three-transistor circuits, sometimes excellent results can be obtained by modulating the driver only. A typical circuit is shown in Fig. 6. Due to decreased emitter resistance in the final stage, a higher power output was actually achieved. Also the output stage was converted to an emitter-follower, thereby eliminating the r.f. interstage transformer which is critical in its coupling coefficient and inductances and might present construction problems where instruments are lacking. This circuit, then, represents the utmost in simplicity for a high-power CB transmitter. It can be duplicated easily and does not require critical adjustments. Compared to the circuit of Fig. 5, it has somewhat less audio gain and may be inadequate for low-sensitivity speaker-microphones. In this case, the first audio stage of Fig. 4 should be added. This provides

Fig. 5. Circuit of 4.3-watt common-emitter transmitter with base modulation.



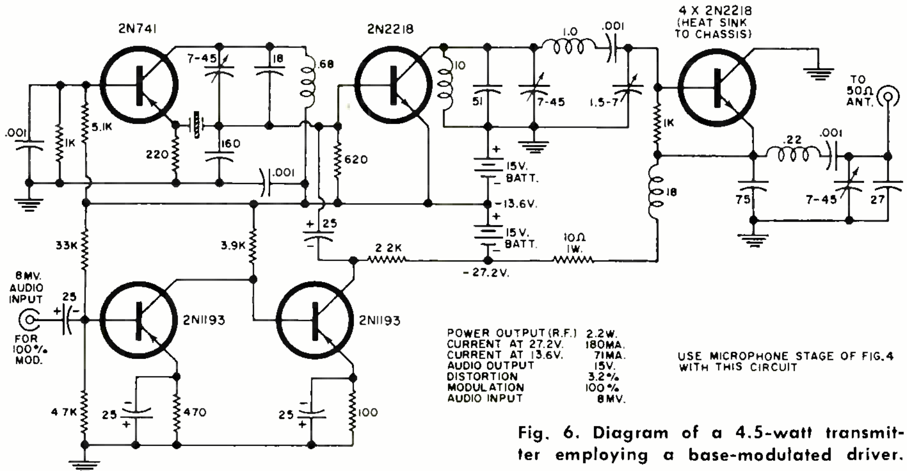
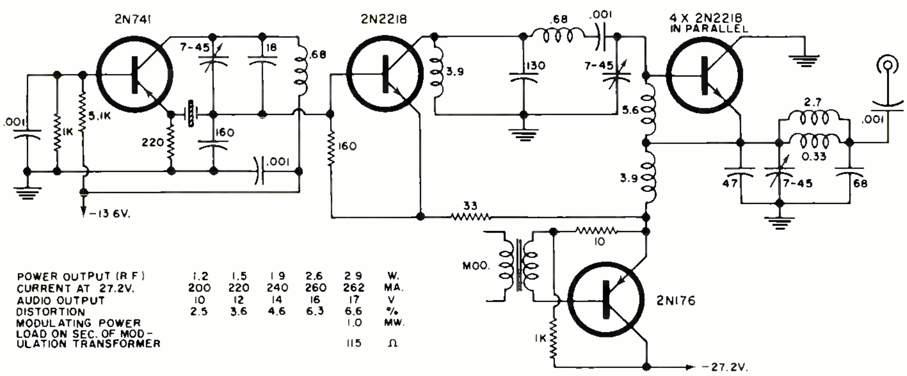


Fig. 6. Diagram of a 4.5-watt transmitter employing a base-modulated driver.



POWER OUTPUT (R.F.)	1.2	1.5	1.9	2.6	2.9	W.
CURRENT AT 27.2V.	200	220	240	260	262	MA.
AUDIO OUTPUT	10	12	14	16	17	V
DISTORTION	2.5	3.6	4.6	6.3	6.6	%
MODULATING POWER					1.0	MW.
LOAD ON SEC. OF MODULATION TRANSFORMER					115	Ω

Fig. 7. Circuit diagram of 3.6-watt transmitter with series collector modulation.

additional gain reserve so that a volume control may be used if the builder desires.

In order to further reduce the battery drain for portable, hand-held equipment, a controlled-carrier transmitter was developed by the author. This principal is normally used only in high-power commercial transmitters to conserve energy. In controlled-carrier transmission, the modulation percentage is kept nearly constant at all times, usually between 80 and 100%. On modulating the transmitter, the carrier level actually adjusts itself automatically to the audio signal level, as required for the distortion-free transmission of intelligence. These transmitters have a greatly reduced battery drain when used with normal speech signals. This is, of course, not true with constant audio signals from an audio generator when testing the circuit.

In the circuit of Fig. 7, d.c. collector modulation is used with a series power transistor. Normally half the supply voltage is dropped across the audio power transistor. Because this is a form of collector modulation, the total current drain, even with controlled-carrier operation on a steady audio signal, is similar to that of the circuit of Fig. 6. But the r.f. efficiency is very high. From Table 1, the efficiency is 2.9/3.6=81%. This circuit has the small disadvantage of requiring an audio driver transformer and added gain stages in the modulator. However, it has the highest r.f. power output for the legal d.c. power input into the final stage, due to the high efficiency of the final stage. Double modulation is employed into the driver stage. This is a highly reliable circuit design.

Controlled-carrier operation sometimes causes problems in associated receivers, with a.g.c. circuits becoming sluggish due to the change in carrier level. Also, because of the high modulation index which is maintained automatically, distortion in the receiver may be high unless the detector circuit has been designed to accept high modulation percentages. With this in mind, this controlled-carrier transmitter shows excellent possibilities.

Alignment

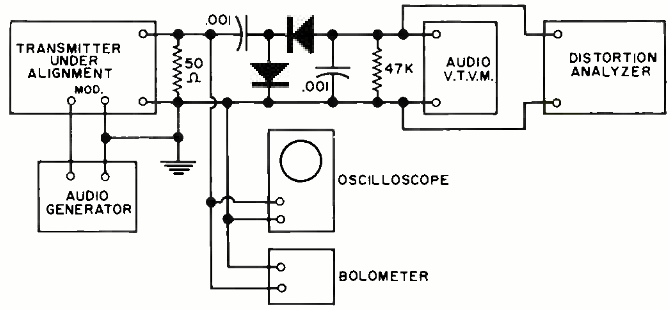
Normally, when aligning transmitters only power output is maximized. Power output is indicated by a light bulb, simple rectifier circuit, or bolometer. This form of alignment invariably leads to poor performance in an AM transmitter, that is, the distance which can be covered is small and intelligibility is low. The reason for this behavior is that a distorted (clipped) envelope contains more r.f. power, but also less intelligence. Therefore, all methods involving the peaking of output power result in the highest dissipation in the final stage for a given transmitted signal. This alignment method is still commonly used, probably due to lack of the instruments required for a really good alignment job. Fig. 8 shows a test setup which permits alignment to the highest standards. A less elaborate setup is possible. For example the audio v.t.v.m. can be replaced by the meter in the distortion analyzer. This involves constant recalibration of the distortion analyzer and is much less convenient as the distortion null may be hard to spot. Also, instead of the distortion analyzer, a simple 1-kc. bridge-T filter might be used. The bolometer could be omitted by measuring the rectified d.c. current in the 47,000-ohm diode load resistor and then calculating the power.

Generally good alignment is possible just by observing the modulation envelope on an oscilloscope. If only a low-frequency oscilloscope is available, the modulation envelope can be observed in the i.f. strip of the CB receiver. For the ultimate in performance, the rectified audio voltage is peaked while the envelope distortion is nulled. At the same time, the r.f. power output and, with it, dissipation in the final is minimized. *The real criterion of good transmission is maximum demodulated audio signal at low distortion.* It will be found that normally rather broad tuning adjustments become sharp and distinct when envelope distortion is minimized.

However, the experimenter with less elaborate instruments need not despair since, in the circuits shown, most of the critical adjustments have been eliminated and replaced by fixed components. There is an adjustment in the crystal oscillator which is made for maximum oscillator current (oscillator power) and an alignment in the tank circuit which may be set for minimum collector current in the final stage. This procedure insures acceptable performance.

Adjustments during experimentation should be made into a 50-ohm load. Alignment with an antenna connected may be performed only by a licensed technician. It is generally preferable to use a separate pi-network to match the antenna to 50 ohms. This operation (*Continued on page* 91)

Fig. 8. Setup employed for alignment of the transmitters.



DELTA-Y TRANSFORMATION NOMOGRAM

By A. L. TEUBNER

A triangular connection of resistors (delta or pi) must be converted into a Y or T network in order to apply Ohm's law to the solution of resistive bridge networks. This chart solves the problem graphically.

MANY times a resistive circuit cannot be analyzed by the old standby rules for series and parallel resistances, because it contains a triangle of resistors called a delta or pi network, depending on how it is drawn. A familiar example of this is the so-called bridge circuit shown in Fig. 1 (top left). As the diagram shows, if the delta is transformed to a "Y" (or a pi to a "T"), the resistance between the two external terminals can be found.

This nomogram is designed to make the conversion. The formula on which it is based and which is shown on the chart, can be stated in words as follows: The impedance connected to any terminal of the T-network equals the product of the two impedances connected to *that terminal* in the pi-network, divided by the sum of the three pi impedances.

An example problem is solved on the nomogram to demonstrate its use. The three resistors in the pi circuit are 4,6, and 10 ohms. On the left side of the chart, a line is drawn between 6 ohms on the scale labeled "Z_A" and 10 ohms on the "Z_B" scale, and continued until it cuts the uncalibrated turning line in the center of the nomogram. A second line connects this intersection with 20 ohms on the "S" scale, the sum of the three pi-network resistors. This second line crosses the "Z_1" scale at the 3-ohm graduation. Thus, the terminal which had the 6- and 10-ohm resistors of the pi-network connected to it requires a 3-ohm resistor for the equivalent T-network. The same process is repeated for the other two terminals, giving 1.2 ohms and 2 ohms, as shown.

Several additional details should be pointed out. First, the "Z_A" and "Z_B" scales are interchangeable. In the solution described, the 10 ohms could have been on the "Z_A" scale and the 6 ohms on the "Z_B". Second, to solve problems with larger resistors, multiply all scales by the *same* power of ten. Third, the reverse problem, T to pi, can be solved by the same process if all impedances are first converted to admittances, where Y_i equals $1/Z_i$. The values found are, of course, admittances, and must be reconverted. ▲

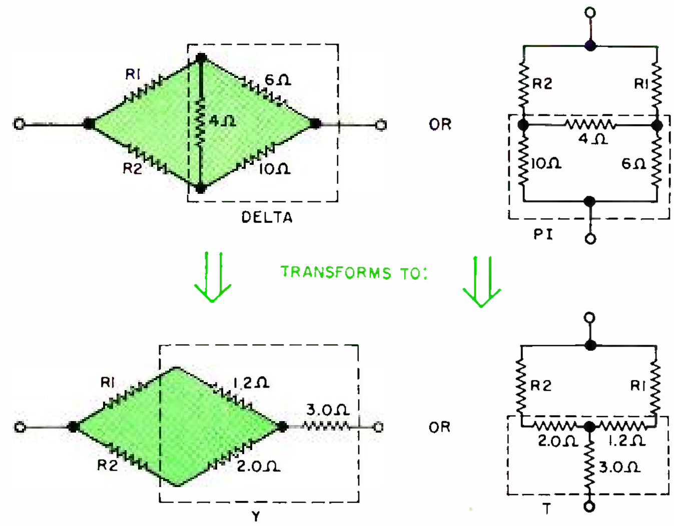
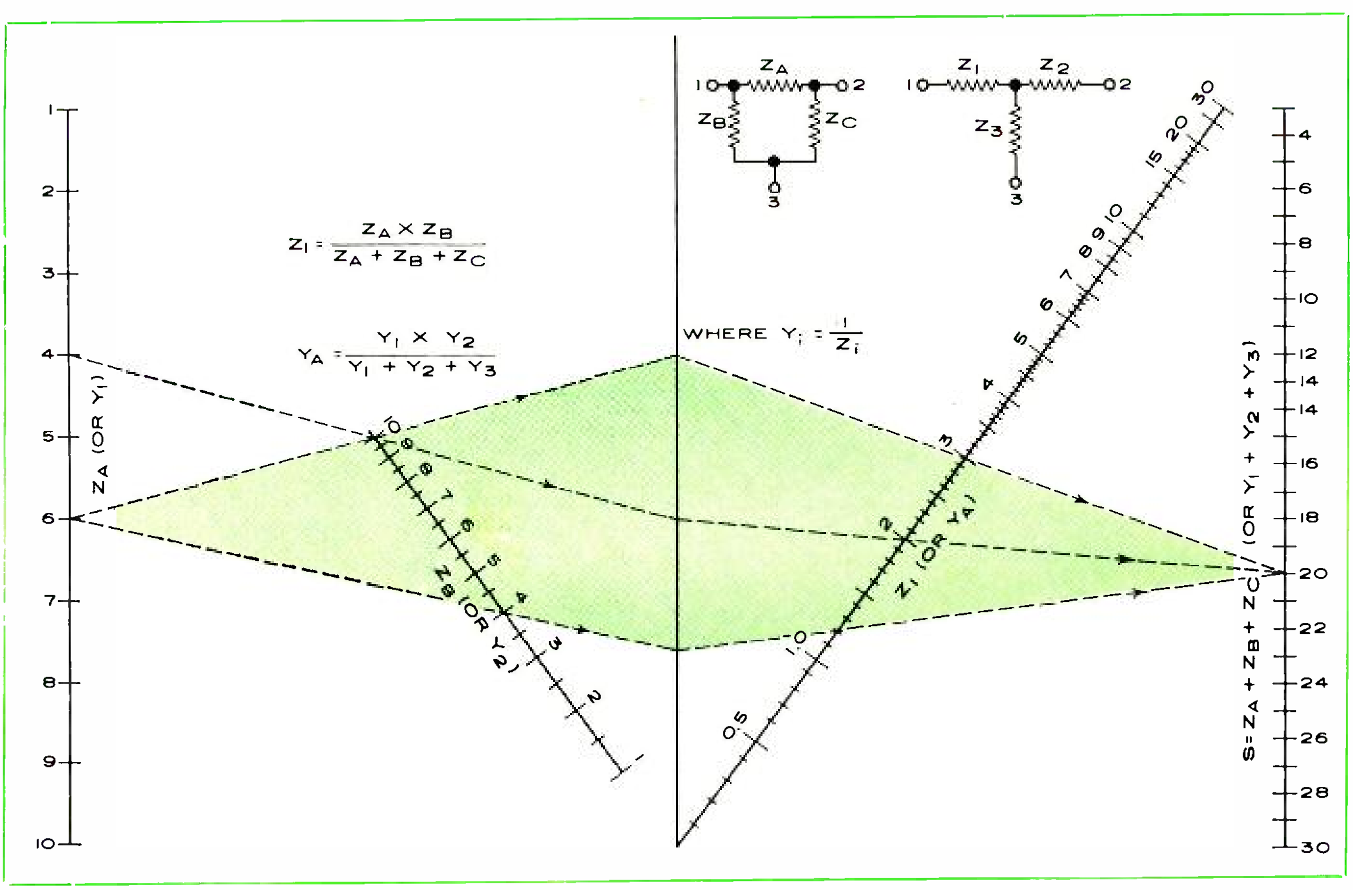
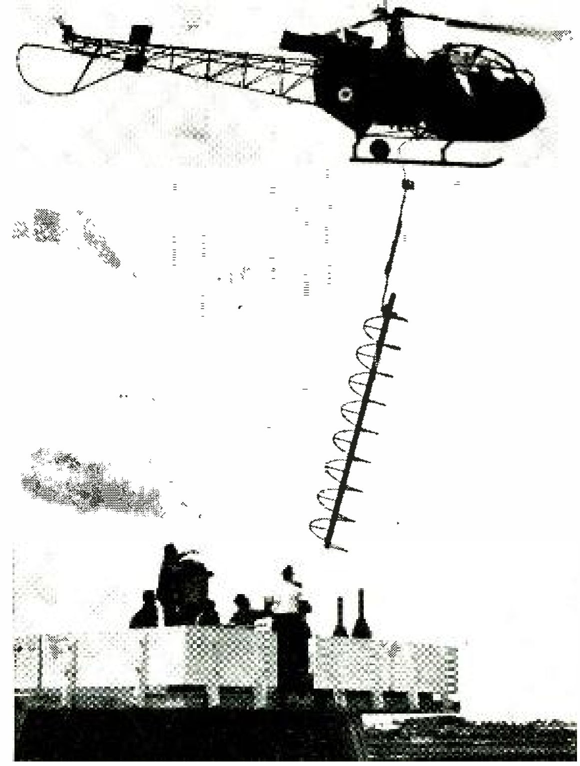


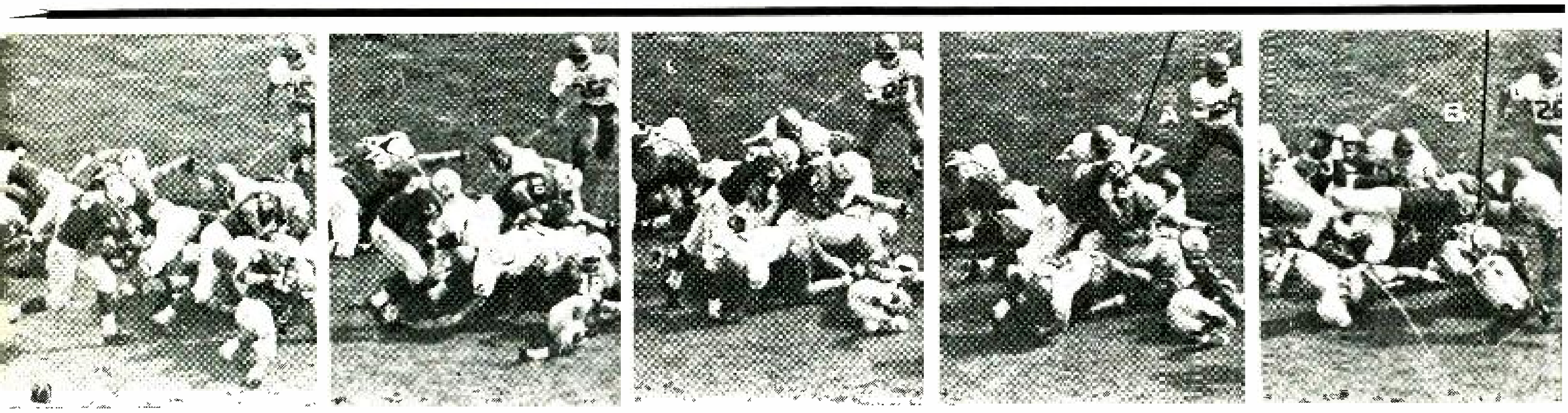
Fig. 1. Example of delta-Y transformation discussed in text.



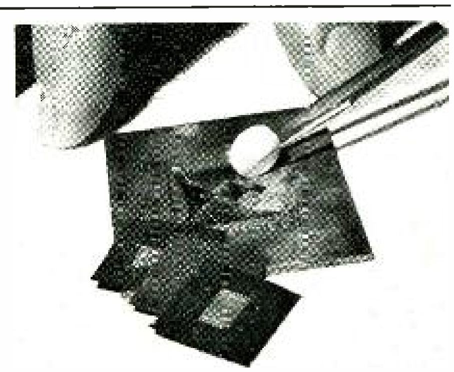
Helicopter-Installed Helical. (Right) A helicopter installs a helical receiving antenna to complete the first foreign-owned automatic picture taking station equipped to receive pictures from weather observation satellites. The station, purchased by the French government from Fairchild Stratos, is one of 42 to provide a worldwide network that will operate with "Tiros," our weather satellite.... **Physiological Monitoring.** (Below) Compact sensors worn by a patient measure blood pressure, respiration, temperature. Information is displayed on bedside unit and central console. This Executone-Gulton system is now in use at Perth Amboy (N.J.) Hospital.



RECENT DEVELOPMENTS

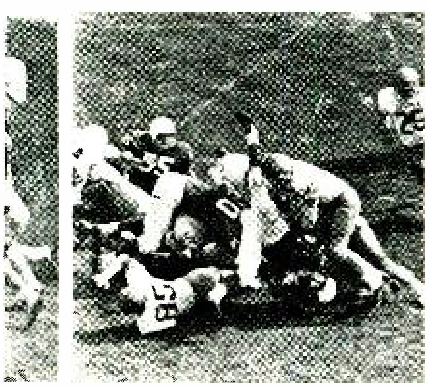


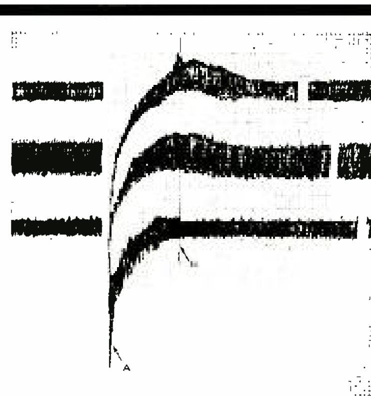
Laminated Computer Memory. Dwarfed by an aspirin, the square unit at the right is a high-speed memory produced by a new manufacturing process borrowed by RCA from the plywood manufacturing industry. Using thin laminated sheets of ferrite, the unit shown is capable of storing up to 256 bits of information permanently. In the foreground are typical ferrite sheets, in their unfinished form, from which the new memories are built by a series of "doctor-blading," silk-screening, lamination, and high-temperature techniques.



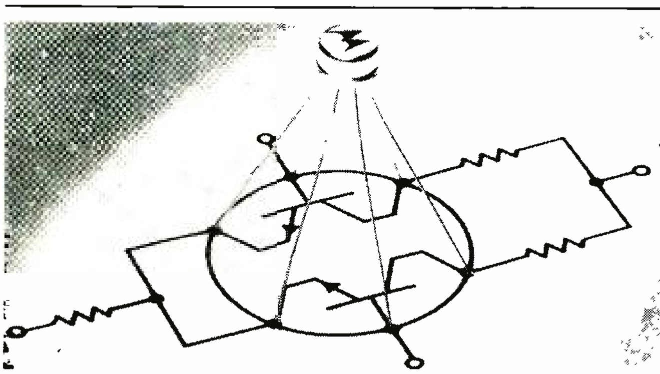
U.H.F.-TV Klystron. (Left) A new, air-cooled power klystron, rated at 11-kw. sync-power output, has been introduced by Amperex. The TV transmitting tube is said to be the first u.h.f. power klystron to employ permanent-magnet focusing and air cooling. The construction is such that the tube can be mounted outdoors on a TV transmitting tower.... **Solid-State Space Radar.** (Below) An advanced all-solid-state radar system for space missions has been built by Westinghouse. The radar, operating at X-band frequencies, measures velocity by sensing Doppler frequency shift and measures distance by range tracking. The system's interrogator and transponder are shown. The radar's operating range is said to be in the order of 500 miles; it is designed to help perform a space rendezvous mission.

IN ELECTRONICS

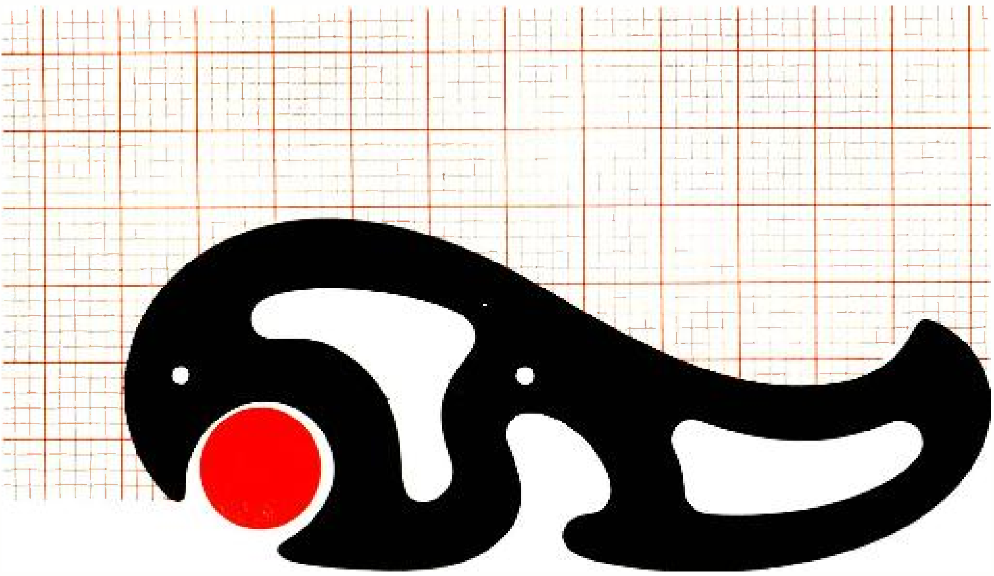




Football-Field Telemetry. A Northwestern University fullback with a pressure transducer in his helmet and an FM transmitter in his shoulder pad is helping medical men study the problem of head injuries in football. The shock impulses produced are telemetered to a receiver in a press-box booth, where they are recorded on a Honeywell high-speed, direct-writing oscillograph. A study of the recording at the left shows a 3660-G impact (A) on the helmet when the player is hit hard from the left side. An instant later, a 680-G secondary impact (B) is recorded. Prior to the use of the oscillograph, the impact data was applied to a tape recorder. This information later was monitored with an oscilloscope and the wave patterns photographed so they could be analyzed. This led to tedious data processing and in incomplete data.



Matched Twin Transistor. The unit shown at the left is one of a line of dual silicon transistors encompassing both "n-p-n" and "p-n-p" devices housed in 6-lead TO-5 packages. Some of the dual transistors, made by Motorola, have closely matched parameters suitable for differential amplifiers, while others provide space savings in switching and amplifier applications. The company also has packages with up to 16 diodes.



DESIGN OF A HIGH-QUALITY TRANSISTOR POWER AMPLIFIER

By ROBERT E. FURST / Vice-President, Engineering, Harman-Kardon, Inc.

Objectives in design, and circuitry employed in new Harman-Kardon dual 35-watt solid-state amplifier.

THE evolution of high-fidelity instruments is moving with relentless certainty toward transistorization. As a result, the subject of semiconductor applications is, without a doubt, the most interesting topic of the day. Considering the varied applications, as in tuners, preamps, and power amplifiers, design engineers will be discussing the merits of one circuit over another for years to come. Since manufacturers are working independently, it is understandable that there are many varied design philosophies.

It is our conviction at *Harman-Kardon* that the application of transistors in amplifiers and tuners is not just another merchandising gimmick to stimulate sales, but the realization of a new level of sound quality. We now know that the "listenability" of an amplifier is not only determined by harmonic or intermodulation distortion, but to an equal and possibly larger extent by the freedom from phase shift in the audible spectrum, and the intimate coupling of the amplifier to the loudspeaker, as expressed in its damping factor. It is in these areas in particular where transistors, properly applied, can vastly exceed the capabilities of present commercial vacuum-tube amplifiers.

General Considerations

Extensive listening tests in our laboratories have clearly indicated a deterioration of tone quality with the introduction of either interstage or output transformers. Since transformers disturb the phase linearity of the amplifier, this is easily understood.

It therefore became our aim to develop a reasonably simple transformerless circuit with excellent phase linearity and high damping factor, particularly in the frequency spectrum from 10 cps up to cover the area of speaker resonance. It may be said here that vacuum-tube amplifiers usually have their damping factors rated at 1000 cps. At the resonant frequency of the speaker the damping is severely curtailed by the output transformer primary inductance.

Another controversial topic is the selection of the audio output transistor. Three types have been considered.

The first one is the alloyed germanium transistor commonly found in automotive radios. This is a rugged, mass-produced device, not suitable, however, above 10 kc.

The second and most commonly used type is the diffused junction, which has a superior high-frequency characteristic. The major drawback of this device is a phenomenon called "secondary breakdown." This tendency toward sudden failure has not been too well understood until very recently. When exposed to high-frequency tone bursts, the junction will funnel the electron flow through a constricted passage, causing a hot spot and subsequent rupture.

The third type of transistor, although far more costly, is the silicon single diffused junction. This device has adequate high-frequency response and a complete lack of secondary breakdown. Its junction temperature can be pushed to 200 degrees C (392 degrees F) without causing any damage, and due to its low reverse leakage current there is no tendency to thermal runaway. Its high saturation resistance prevents instantaneous failure under load short-circuit conditions. This was the type of transistor chosen for our amplifier.

Shown in Fig. 1 is the power output and driver stages of one channel of our Model A1000T integrated stereo amplifier. Although it may appear to be the simplest of all possible designs, it does produce a continuous sine-wave power of 35 watts per channel at extremely low distortion and can be used with 4-, 8-, or 16-ohm speakers. The output stage, consisting of Q6 and Q7, is a so-called "totem-pole" (single-ended push-pull) design.

Referring to Fig. 2, which shows an equivalent circuit diagram, note that when the positive alternation of an a.c. signal is applied to Q6, its resistance drops materially and "Point X" could reach the value of the supply voltage, 80 volts. On the following half-cycle when the positive alternation is applied to Q7, the opposite effect is obtained; that is, the resistance of Q7 drops to almost zero and "Point X" approaches 0. In

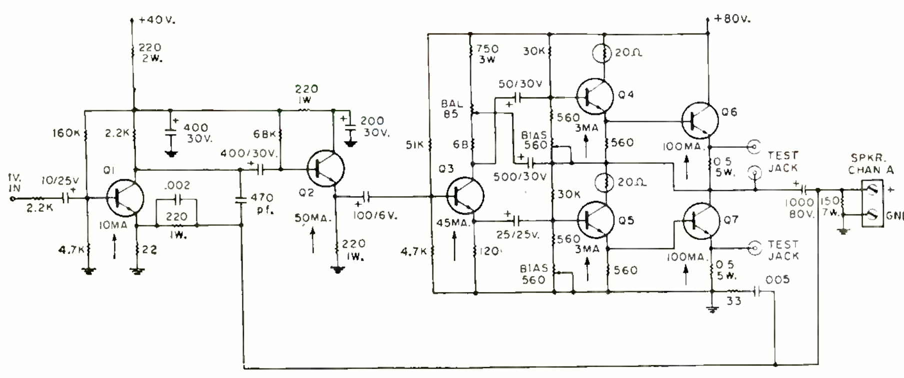


Fig. 1. Circuit diagram of power amplifier portion of integrated stereo unit. One of two identical channels is shown. Transistors are specially selected switching types for which factory replacement is required. Thermistors in collector circuits of Q4 and Q5 protect these transistors from excessive currents in case of short across speaker; high current increases thermistor resistance. Output transistors do not require such protection as they can handle the amount of current that would flow under such conditions. RC network (33 ohms, .005 μf.) across speaker improves high-frequency stability, prevents ringing.

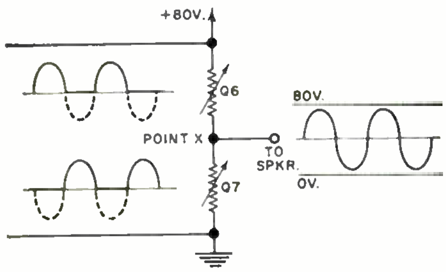


Fig. 2. Equivalent circuit of output transistors. In class-B operation the negative half-cycles are cut off.

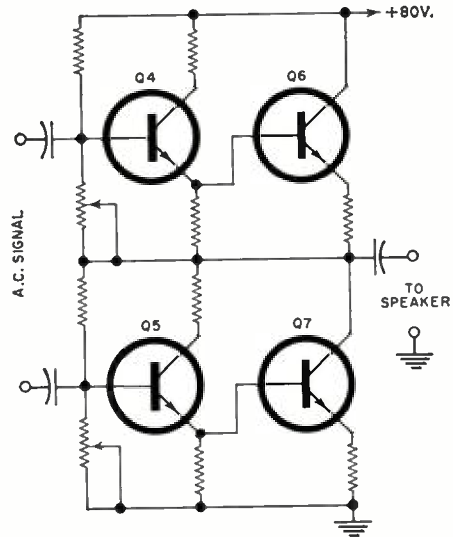


Fig. 3. Partial schematic of output stage.

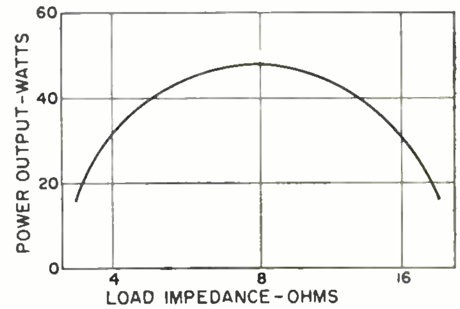


Fig. 4. Maximum power occurs at 8 ohms.

class-B, negative half-cycles are cut off.

This type of circuit has the potential of producing close to 80 volts peak-to-peak across the speaker. This is about the maximum output possible with this design to date, considering the type of transistors available at the present time. It should be obvious that lower power outputs could be obtained by reducing the power-supply voltage.

Transistor power amplifiers, in general, are being operated in the class-B mode. In this mode little or no current flows through the output transistors under quiescent conditions. With increasing signal amplitudes, current increases through the output transistors. As a result, the power dissipation in the output transistors is kept to a minimum and is proportional to the signal. This prevents transistors from running too hot and extends their useful power range. Unfortunately, class-B operation introduces an objectionable form of distortion, called "switching" or "crossover distortion." This distortion occurs when one of the output transistors has stopped conducting and the opposite one is about to start taking up the signal, thus causing an interruption or discontinuity in the signal. This phenomenon is particularly severe on low-level signals. Although switching distortion can be minimized by judicious design and application of feedback, its raucous sound effect cannot be eliminated entirely.

Our approach has been to operate with a somewhat raised idling current in the output transistors. As a result, the amplifier is operating in a class-A mode up to 2½ watts, eliminating switching distortion at a power level where this form of distortion has been particularly disturbing. At the higher power levels where switching transients are far less audible, the amplifier reverts to class B, with the switching distortion reduced below the threshold of audibility. This change in operation comes about, not by any change in the amplifier's bias operating point but merely by virtue of the change in signal level. For low-level signals, collector current flows for the entire input cycle; at higher signal levels, more of the negative half-cycles are cut off, resulting in class-B operation. As a result of this type of operation, the A1000T amplifier lacks the harsh tone quality usually associated with "transistor sound" in poorly designed amplifier circuits.

Circuit Description

Fig. 3 shows a partial schematic diagram of the power-output section of the amplifier. The basic function of the output transistors has already been explained. Q4 and Q6, as well as Q5 and Q7 are connected in a Darlington circuit. Since silicon output transistors have a very low *beta* (current gain), Q4 and Q5 are needed to act as *beta* multipliers and, as a result, furnish adequate current amplification. Individual bias-adjust pots (see also Fig. 1) set the idling current in the output transistors. They are set for an idling current of 50 ma. when the transistors are cold or for a voltage drop of 25 mv. across each of the 0.5-ohm output emitter resistors.

Q3 functions as a conventional split-load phase inverter. An a.c. balance potentiometer is provided here to equalize the signals fed to the output stage. Since there is no voltage gain in the output pairs, the phase inverter must be capable of swinging through the entire 80-volt range. It can do this with minimum distortion only if it is driven from a very low source impedance. Q2, connected in an emitter-follower configuration, provides such a low impedance. An emitter-follower is the transistor analog of a tube cathode-follower and generally fills the same functions. Q1 operates in a conventional circuit and provides the necessary voltage gain.

Since the amplifier is inherently phase linear, it can withstand approximately 50 db of feedback. The circuit actually employs only 30 db and therefore provides a very large margin of stability. The feedback is supplied from the speaker connection in the output *via* an *RC* network to the emitter resistor of the first stage.

The power supply uses two 3-amp silicon rectifiers in a full-wave circuit arrangement, with 3000 μf. of electrolytic capacitors for filtering. (Note that the currents shown on the schematic were obtained after 1 hour of operation with no signal.) Despite its simplicity, the supply has excellent regulation and the required low source impedance.

Amplifier Performance

Unlike their vacuum-tube counterparts, solid-state amplifiers are not limited to one load impedance for optimum operation. They function as a constant-voltage source similar to a high-capacity battery. For practical considerations, our amplifier has been limited to optimally drive speakers varying in impedance rating from (*Continued on page 76*)

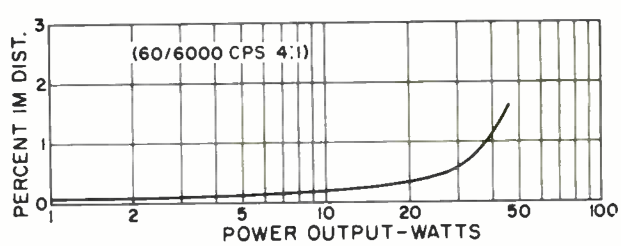
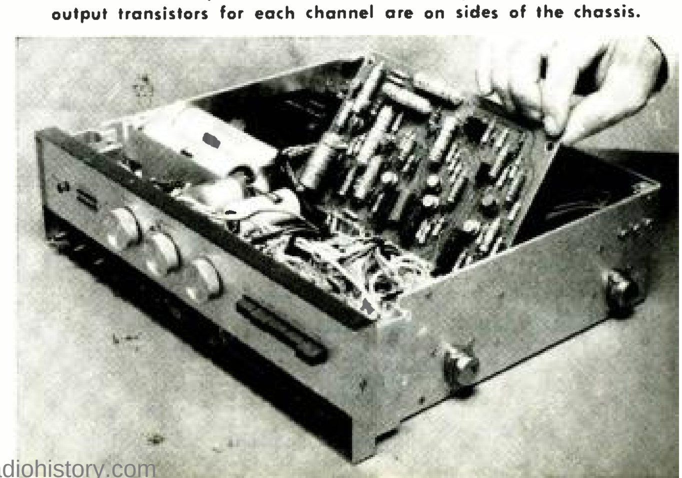
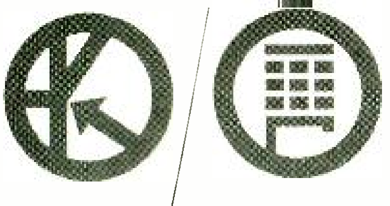


Fig. 5. The intermodulation-distortion curve of the amplifier.

One of the two glass epoxy circuit boards used in the amplifier is swiveled away from the chassis for easy accessibility. Two output transistors for each channel are on sides of the chassis.





By WAYNE W. CHOU, C/M Laboratories

TRANSISTORS vs TUBES for HI-FI

Circuits should be designed with direct coupling, rapid overload recovery and protection, and high damping factor.

Editor's Note: Our author is the designer of the new C/M Laboratories' all solid-state 100-watt (dual 50-watt) stereo power amplifier. Many of the concepts discussed by Mr. Chou in the following article have been embodied in the design of this unit.

THE major advantages of transistor hi-fi components, when properly designed and used, lie in their inherent long-term stability, low heat, and subsequent long life. There are, however, many unseen advantages in that their use allows certain features to be incorporated easily. Direct coupling, for instance, although known for many years, was not practical and was therefore only incorporated in the most sophisticated types of electronic tube equipment. The advantage of using direct-coupled circuits is that optimum bias levels, set for minimum distortion, cannot shift due to overloads. Such overloads in conventional capacitance-coupled circuits would produce effects immediately after these transients—ranging from distortion due to the shift in bias to the complete blocking of the amplifier for some period of time thereafter. Direct-coupled circuits—because of their instantaneous recovery—are inherently without these problems and account for one of the reasons why transistor amplifiers sound better.

Direct coupling, also, is good at frequencies down to d.c. without phase shifts. This allows more feedback to be used without instabilities, such as under-damped, low-frequency oscillations (usually inaudible) and/or "motorboating." Again, this type of disturbance causes distortion in the amplifier due to the shift in bias levels from the optimum at these low-frequency rates. Allowable feedback without these undesirable side effects will lower distortion and improve the damping factor.

The absence of an output transformer is another advantage which transistor amplifiers have over tube types. The output transformer must have a very wide frequency response, not because it is necessary to reproduce music at inaudible frequencies but because, for technical reasons, phase shift and cut-off frequencies necessarily must go hand in hand. If the transformer should have too much phase shift within the audio band, the amplifier would be unstable when feedback is applied. Therefore, the major cost of a tube unit is in the output transformer. It must have a wide frequency response with very little phase shift, it should not have unusual peaks or dips in its frequencies of interest, and it must be able to deliver rated power at all audio frequencies without appreciable distortion.

The transistor amplifier which utilizes an output transformer is obviously not taking full advantage of the transistor. A transistor can easily drive a loudspeaker load directly without an intermediate component. A tube can be made to do what the transistor inherently possesses. However, a tube amplifier built with the same design philosophy may very well be several times its present size, with several times the number of tubes (and associated heating), and may even be costlier than a transistor unit having identical power rating.

There is no reason to assume, however, that the consumer would necessarily be better off with a transistor unit rather than a tube amplifier if the ratings and the pricing were the same. In fact, the transistor unit is generally priced higher than an "equivalent" tube amplifier in any price category. The cost of the transistor itself is high today. Its price has been steadily decreasing and will be even lower in the coming years. However, it is our opinion that there is no point in competing against the tube amplifier unless the transistor unit is just as good as the tube amplifier and then some. The higher cost at present must be justified to the consumer in some manner, and when the glamour has faded, these units must continue to perform well.

Also, there is no apparent reason why a transistor preamplifier would necessarily be a better choice than a tube preamplifier. There are more reasons than less hum and long life for one's choice and it would depend a great deal on the internal design of the unit rather than a matter of "tubes *vs* transistors."

Some transistor amplifiers sound better than tube units. Others sound several times worse. It is unfortunate that some manufacturers are capitalizing on the glamour of the market rather than on the device itself. As a result, many consumers and dealers have had sad experiences with transistor equipment in the past. Admittedly, the transistor is still in its infancy. However, with proper design and with education on the part of the user, equipment now available will give consistently good performance throughout his lifetime if carefully selected.

Transients and Square Waves

Transient response and the measurement of it is usually taken as the speed of response on the leading and trailing edges of the square wave. The faster the rise and fall without undesirable effects, such as ringing and overshoot, the "better" the transient response. A transient, as defined and as occurs in program material, is a non-recurrent phenomenon unlike that of square waves. In addition, transients may be either fast or slow; a drum beat, for instance, contains a slow transient. However, a square-wave response is useful in the measurement of amplifier frequency response and in the observation of amplifier stability when excited by steep wavefronts. An extremely steep waveform of a square wave at the output is indicative of the upper frequency limit of the amplifier. A rise time of a few microseconds is equivalent to an upper frequency limit of several hundred kilocycles per second. (It has been found empirically that: *high-frequency cut-off* (*mc.*) = 0.35 to 0.45 / *rise time* in *μsec.*) A 10% droop or tilt of a low repetition rate square wave is equivalent to a lower frequency limit of a few cycles per second.

The square-wave response has too often been misused as the yardstick of an amplifier's listening performance. All the frequencies in "perfect" square (*Continued on page 80*)

R. F. RESPONSE MEASUREMENT

By JOSEPH TUSINSKI
Senior Technical Instructor, Old Dominion College Technical Institute

Novel technique for measuring narrow r.f. bandwidth that does not require use of elaborate lab equipment.

AT some time or another most technicians have tried to measure the r.f. response of a communications receiver or even a simple broadcast receiver only to find that their equipment seems to be inadequate for the job. In a simple broadcast receiver the technician knows that the circuits have been optimized for a 10-kc. response. But his TV sweep generator will not reach the low i.f. frequency of 455 kc. Then if he tries to interpolate the low-frequency r.f. signal generator dial in increments of possibly a kilocycle, he would be at a loss in most cases.

The method that will be described does not have to be confined to receivers, since any filter or narrow-band network may be checked as well.

A functional diagram of the equipment used and a conventional superheterodyne receiver are shown in Fig. 1.

Use of Audio Generator

The basic problem is to insure that the r.f. signal-generator frequency is varied in known increments. Then the output voltage can be measured with each change in frequency and a graph of this output voltage *versus* frequency will indicate bandwidth of the system measured. A typical response curve, obtained with the method to be described, is shown in Fig. 2.

The accuracy of the frequency changes is dependent, for the most part, on the audio oscillator used; however, even the most inexpensive audio oscillator's scale can be interpolated to at least 100 cps or better. If there is any doubt regarding the calibration of the audio oscillator, it may be checked against the power-line frequency, using Lissajous figures. This arrangement is shown in Fig. 3.

Note in the third pattern of Fig. 3B that a horizontal line would touch the three loops and only one would be touched by a vertical line. Thus, the frequency ratio is 3:1 and, in this case, the audio generator is set to exactly three times the reference frequency, or 180 cps. When the ratio becomes very high, it is difficult to count the loops; however, if two audio oscillators are available the frequency of the second can be set accurately at some higher multiple of 60 cps and the two generators are "walked-up" to the higher audio frequencies. Higher standard audio frequencies, such as 440 cps and 600 cps broadcast by WWV, can also be used. Other ratios are possible to check other points on the dial by the use of Lissajous figures.

Another important consideration, just as in the alignment of TV receivers, is to disable the a.v.c. system. The reason is that if the response of the i.f. amplifier falls off, the a.v.c. voltage also drops and, in turn, the amplifier's gain will increase, trying to restore the original signal level. A TV bias-box can be used for the substitute fixed bias in this case. Amount of bias can be determined by measuring the a.v.c. voltage with a v.t.v.m. when the receiver is operating normally. Then the bias-box voltage is adjusted to this value and placed across the a.v.c. bus.

It is possible to overload the r.f. stages with a.v.c. inoperative, the lowest signal that will give usable readings on the output meter should be employed.

Measurement Procedure

Now that we have some of the preliminary information in mind, we can proceed with the measurement. Note that in Fig. 1 a second signal generator (or b.f.o. in a communications receiver) is loosely (*Continued on page 90*)

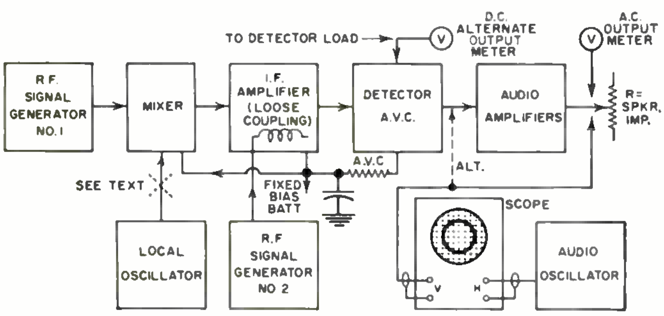


Fig. 1. Basic setup used for over-all response measurement.

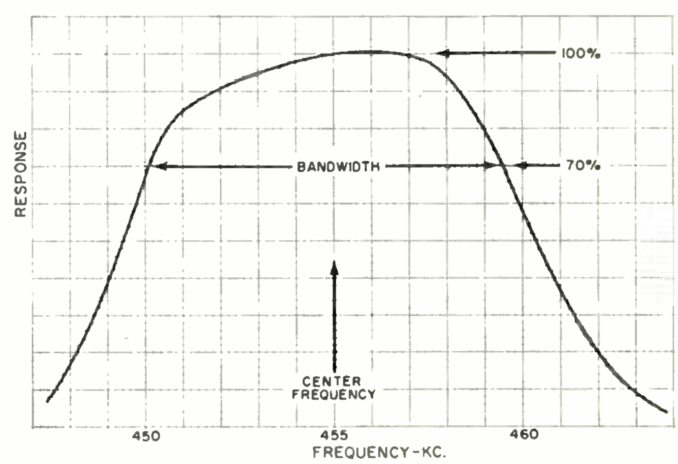
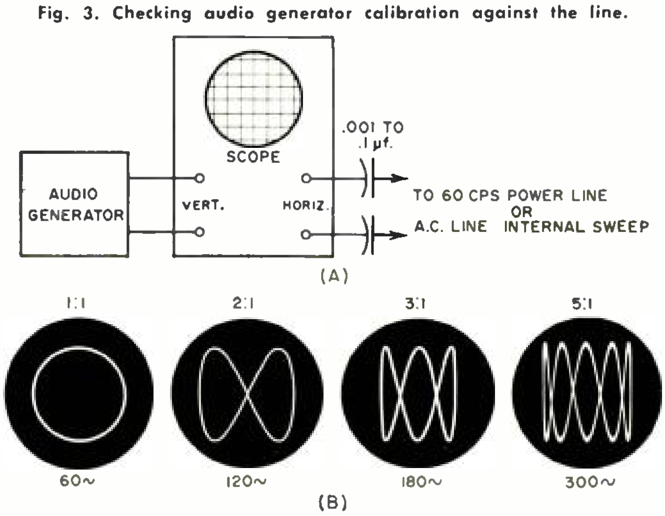


Fig. 2. Typical response curve obtained by method described. The bandwidth is measured between the points where the output voltage is 70 percent (-3 db) of that at the center frequency. The output power at these points has been reduced to one-half.

Fig. 3. Checking audio generator calibration against the line.



Electronic Switch for your Oscilloscope

By STANLEY E. BAMMEL

Construction of a transistorized switch with 1 kc. and 10 kc. switching frequencies. The response is 3 db down at 10 cps and 300 kc.

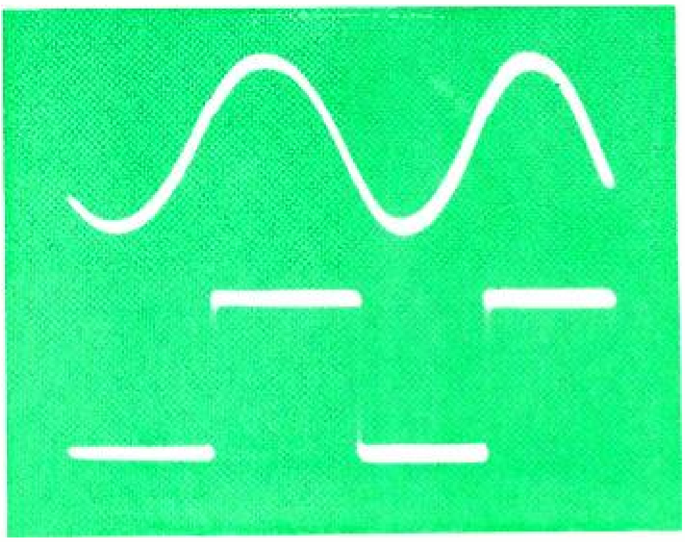


Fig 1. Sine and square waves displayed with author's switch.

IF YOU want to display two signals simultaneously on an oscilloscope, generally there are two ways to go about doing it. You can use a dual-beam scope or some type of switch. The dual-beam scope is, of course, best but it is also many times more expensive than a switch. A mechanical switch such as a relay might be used but it is not as versatile and its operation is limited to a very slow switching rate. Electronic switches, on the other hand, are much more versatile and do not have a low-switching-speed limitation. The use of transistors instead of tubes affords the obvious advantages of small size and portability.

This switch has two switching frequencies: 1 kc. and 10 kc. The signals to be observed can be either above or below the switching frequency and can be displayed either separated or superimposed. The frequency response of each channel is identical: −3 db at 10 cps and 300 kc., but response is useful beyond 1 mc. The input can be as low as 50 mv. before noise and switching transients become a problem. Input impedance is moderately high: 25,000 to 100,000 ohms depending on the setting of the input attenuator (R_3, R_4). Cost is less than $15 and construction time just an evening or two.

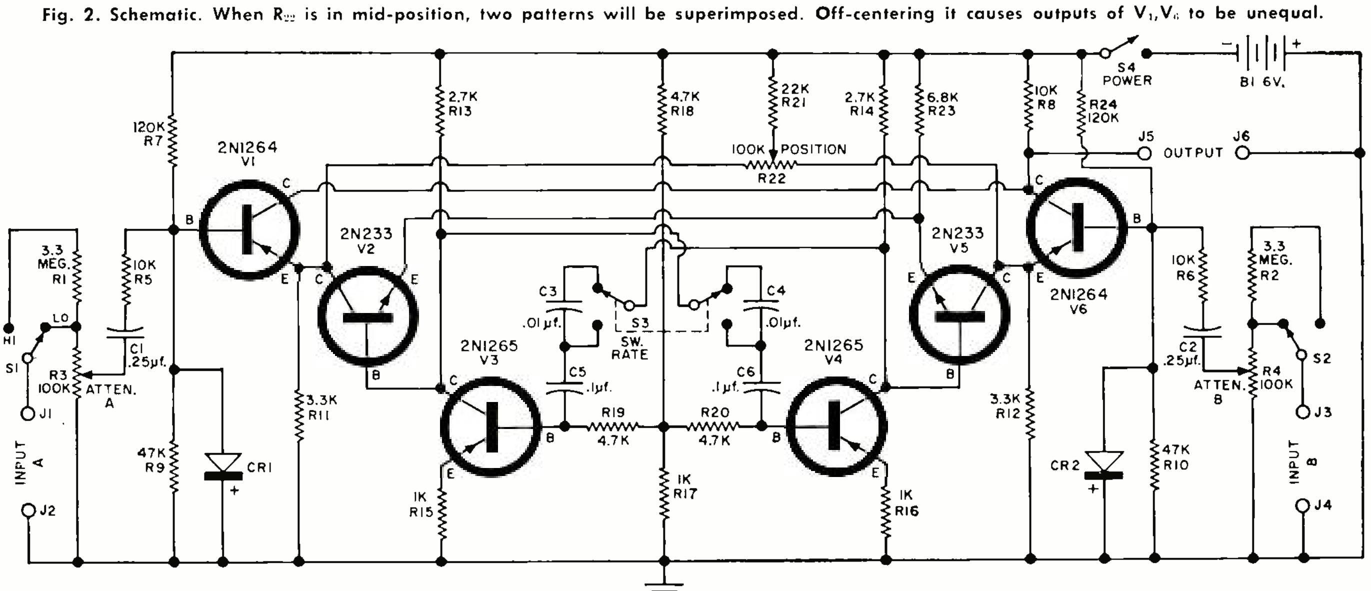
One type of electronic switch uses a bistable multivibrator which is triggered by pulses from the sweep circuit of the oscilloscope to generate the switching frequency. This method of synchronization with the scope necessitates a more complicated circuit and a connection to the scope sweep circuit. This switch uses a free-running or astable multivibrator and no attempt is made to relate its frequency to the frequency of either input signal. The scope is synced by one of the signals to be observed, but this is only a slight inconvenience.

The Circuit

V_3, V_4, and associated components constitute the free-running multivibrator. Its frequency is either 1 kc. or 10 kc. depending on whether C_5 and C_6 or C_3 and C_4, respectively, are switched in the circuit by S_3. Since the output of the multivibrator is neither of sufficient amplitude nor sufficiently square to be a good switching voltage, V_2 and V_5 square it up and increase its amplitude.

V_2 and V_5 alternately switch V_1 and V_6, respectively, off and on. Consider the instant when V_2 is off and V_5 is on.

Fig. 2. Schematic. When R_{22} is in mid-position, two patterns will be superimposed. Off-centering it causes outputs of V_1,V_6 to be unequal.



R_1,R_2—3.3 megohm, ½ w. res.
R_3,R_4—100,000 ohm audio-taper pot
R_5,R_6,R_8—10,000 ohm, ½ w. res.
R_7,R_{24}—120,000 ohm, ½ w. res.
R_9,R_{10}—47,000 ohm, ½ w. res.
R_{11},R_{12}—3300 ohm, ½ w. res.
R_{13},R_{14}—2700 ohm, ½ w. res.
R_{15},R_{16},R_{17}—1000 ohm, ½ w. res.
R_{18},R_{19},R_{20}—4700 ohm, ½ w. res.
R_{21}—22,000 ohm, ½ w. res.
R_{22}—100,000 ohm linear-taper pot
R_{23}—6800 ohm, ½ w. res.
C_1,C_2—.25 µf., 600 v. capacitor
C_3,C_4—.01 µf., 25 v. capacitor
C_5,C_6—.1 µf., 25 v. capacitor
S_1,S_2—S.p.d.t. slide switch
S_3—D.p.d.t. slide switch
S_4—S.p.s.t. slide switch
CR_1,CR_2—1N34, 1N60, or 1N295 diode
J_1-J_6—Five-way binding posts
B_1— 6 v. battery
V_1,V_6—"p-n-p" transistor (2N1264)
V_2,V_5—"n-p-n" transistor (2N233)
V_3,V_4—"p-n-p" transistor (2N1265)

V_1 is forward biased by R_7 and R_9 and a signal at its base will appear at its collector. As far as V_1 is concerned, V_2 does not exist at this instant. At the same moment, the current through V_3 causes a voltage drop across R_{12}. Therefore, the emitter of V_4 is about two volts more negative than its base. The emitter-base junction of V_4 is then reverse biased, cutting it off. A signal at the base of V_4 at this instant will not appear at its collector. At the next instant, conditions will be reversed, that is V_4 and V_2 will be on and V_1 and V_3 will be off. The collectors of V_1 and V_4 have a common load resistor, R_5, from which the output signal is taken. If the value of R_{22} is too high, V_2 or V_3, when on, will not pass enough current to adequately cut off V_1 or V_4, respectively. There will then be noticeable crosstalk between the channels, as shown in Fig. 4, left.

R_{22} is the position control. Consider operation when its arm is near the end connected to the emitter of V_1. At the instant when V_1 is on, some of the current through R_{11} goes through R_{21} and R_{22} leaving less to go through V_1. V_1's collector is then more negative than normal. At the next instant when V_4 is on, not as much of the current through R_{12} goes through R_{21} and R_{22}, allowing more to go through V_4. V_4's collector is then less negative than the collector of V_1 was an instant ago. This creates a square wave with one channel displayed on the upper peak and the other on the lower. Figs. 1 and 4, right, show the effectiveness of the control.

CR_1 and CR_2 in conjunction with R_3 and R_6 protect V_1 and V_4, respectively, from accidentally high, potentially damaging input signals. Since CR_1 and CR_2 are reverse biased during normal operation, they don't affect normal operation. Since input impedance is high, R_3 and R_6 introduce only a negligible loss.

Consider a high-amplitude positive input pulse to V_1. This reverse biases both junctions. If breakdown is reached, significant current flows. R_3 alone offers a little protection by limiting current, but because the voltage across the transistor is quite high, the power can be destructive. However, if CR_1 is in the circuit, it is forward biased long before breakdown of V_1 is reached and no more than a fraction of a volt will be applied to V_1. R_3 limits current through CR_1 to a safe value.

If there is a negative input pulse, the junctions of V_1 are forward biased and CR_1 remains reverse biased. Because the forward biased junctions of V_1 conduct at low voltage, only a fraction of a volt is applied. Again, R_3 limits the current to a safe value. V_4, CR_2, and R_6 operate the same way. With this arrangement, inputs of 200 v. a.c. with the attenuator (R_2 or R_5) set to maximum, have caused no damage.

S_1, R_1, and R_2 and S_2, R_4, and R_5 constitute the input attenuators. When S_1 and S_2 are in the "Hi" position, the input is attenuated about 30 times or about 30 db.

Construction

Construction is straightforward. The author made his own printed-circuit board, however a standard perforated circuit board and flea clips will work just as well. Mounting the circuit board above the chassis with long screws is rugged and leaves room at the bottom for batteries.

Using The Switch

In use, the oscilloscope is synchronized by connecting one of the signals to be observed to the scope external sync jack. If you attempt to internally sync the scope, there will be a tendency toward sync with the switching frequency which will cause instability. External sync gives a more stable display. There may be a problem when the input frequencies are close to the switching frequency. This will be apparent as a slow beat signal that momentarily blanks out part of the input signals. To correct this, change to the other switching frequency.

(*Continued on page 62*)

Fig. 3. Author's switch was built in metal cabinet, six inches wide.

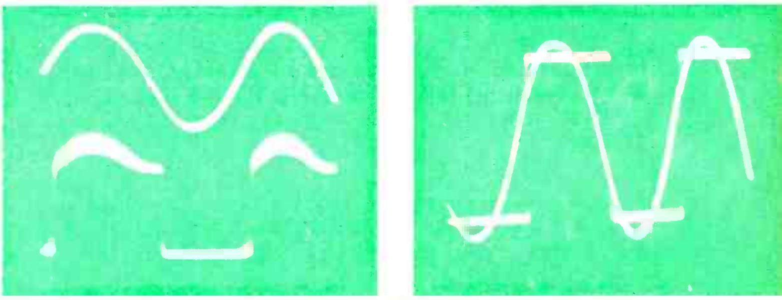


Fig. 4. (Left) Crosstalk between channels when R_{22} is too large. (Right) Signals are superimposed when R_{22} ("Position") is centered.

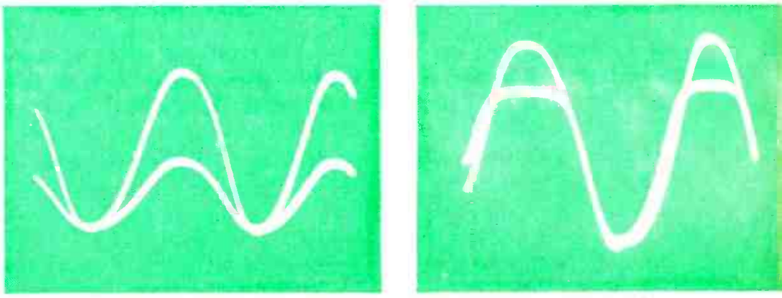


Fig. 5. (Left and Right) Two signals were displayed superimposed by positioning R_{22}, in order to make a comparison of amplitudes.

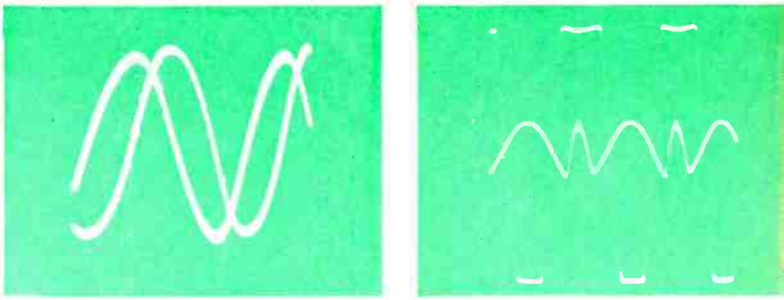


Fig. 6. (Left) Two equal-amplitude signals are 90° out-of-phase. (Right) Waveform distortion caused by deliberate switch overload.

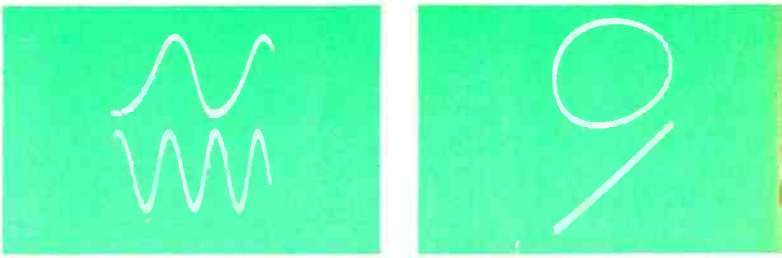


Fig. 7. (Left) Two-to-one frequency ratio. (Right) Third signal was applied to horizontal input for comparison to displayed signals.

WHICH CHANNEL IS IT?

By LEO G. SANDS

To determine on which channel a mobile business radio set operates when there is no frequency information, all you need is the operating FM receiver and a good AM communications receiver.

PRACTICALLY everyone servicing mobile radio equipment has, or has access to, a frequency meter. Such an instrument will tell if the transmitter being serviced is on frequency, or off frequency by a certain amount. But, it won't necessarily tell if it is on the correct channel.

When servicing a transmitter that has been operating in a system and its signals have been picked up by receivers used in the system, it is obviously equipped with a crystal for the correct channel. But, you may be called upon to service a transmitter whose frequency is unknown or whose transmitter crystal may be defective or incorrectly labeled.

With a continuously tunable heterodyne-type frequency meter, you can attempt to measure the frequency of the transmitter output signal. However, it is possible to detect several zero beats and an educated guess is required to determine the right one.

A typical frequency meter of this type consists of a tunable oscillator, a mixer, and a beat-frequency amplifier, as illustrated in Fig. 1. The transmitter signal (unknown frequency) is picked up and mixed with a harmonic of the instrument's tunable oscillator. When the oscillator is tuned to obtain an aural zero beat, the dial reading is noted and reference is made to a chart to determine frequency.

Assume that the tunable oscillator is set to 2.7 mc. to get a zero beat. The transmitter might be on 162 mc. (60th harmonic), 159.3 mc. (59th harmonic), 156.6 mc. (58th harmonic), or any frequency that is a multiple of 2.7 mc.

A deviation-type frequency meter uses a crystal-controlled reference oscillator, a mixer, and a beat-frequency measuring circuit, as shown in Fig. 2.

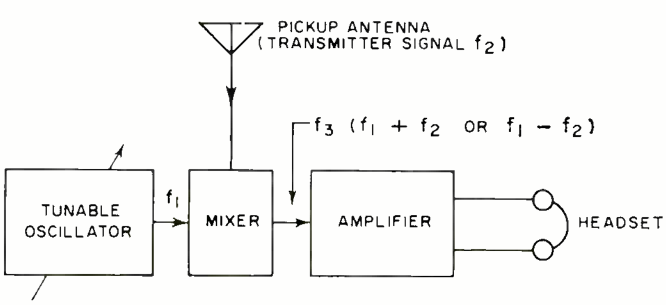
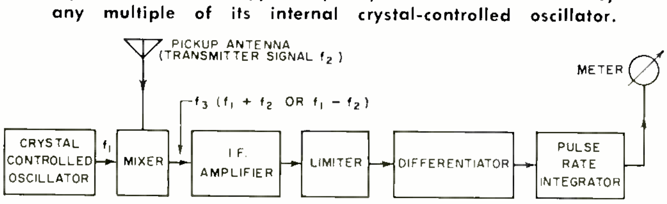


Fig. 1. A continuously tunable heterodyne frequency meter can be in error by any harmonic of its internal oscillator.

Fig. 2. A deviation-type frequency can also be in error by any multiple of its internal crystal-controlled oscillator.



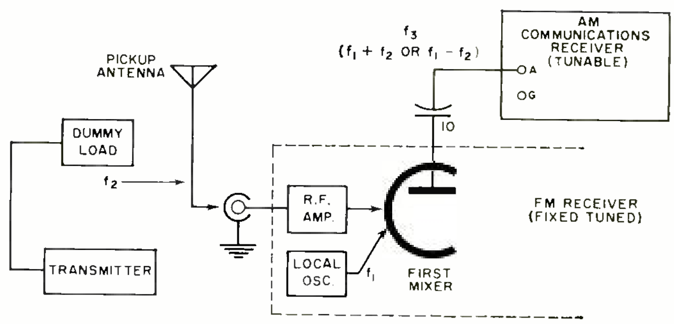


Fig. 3. The AM set picks up the i.f. beat resulting from the mixing of the set's local oscillator and the external signal.

The transmitter signal (unknown frequency) is picked up and mixed with a harmonic of the reference oscillator (known frequency). The beat signal (the difference between the two frequencies) is amplified, converted into a square wave by a limiter, then differentiated into a train of pulses, whose rate is measured by a pulse-rate integrator and indicated on a meter calibrated in cycles and kilocycles of deviation from the reference oscillator.

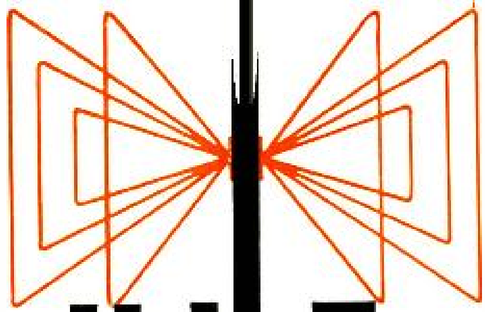
The frequencies that can be measured depend upon the crystals installed in the meter. Some have capacity for only four crystals, while others can accommodate up to 24 or 48 crystals. Since there are hundreds of channels in the three mobile bands, only those frequencies for which the meter is equipped can be measured.

While the chances of error are small, they can occur. If the meter employs a 4-mc. crystal, for example, there may be difficulty in differentiating between 152, 156, 160, 164, 168, and 172 mc., which are all multiples of the 4-mc. crystal frequency.

If the meter is equipped with a 9.47656-mc. crystal for measuring 151.625 mc., and an on-channel indication is present, it is possible to get the impression that the transmitter is on the 151.625 mc. channel while it is actually on the 161.1-mc channel. If the meter reads 1.4 kc., indicating that the transmitter signal is within 1.4 kc. of 151.625 mc., it may actually be on 161.1014 mc.

A heterodyne or deviation-type frequency meter of at least 0.00025% accuracy is required to measure 150-174 mc. and 450-470 mc. band frequencies, and to set transmitters on frequency to conform with FCC regulations, once you have established which channel they are on. Most of the time, however, you will know with fair certainty that you are on the correct channel.

But, if you don't know which channel you're on, there's an easy way to find out. You need a multi-band, short-wave AM communications receiver with a built-in or external 100-kc. calibrator and an FM receiver for the band of interest. The bench set-up is shown in Fig. 3. (*Continued on page* 84)



U.H.F. CONVERTERS/CIRCUITS & DESIGN

By LESLIE SOLOMON
Associate Editor

There are three basic types of u.h.f. converters. Here is a discussion of these types, how they work, why certain circuits were chosen, and some general information on converter design.

EFFECTIVE April 30, 1964, all new TV sets must be capable of receiving the 82 allocated u.h.f.-v.h.f. channels. The question then arises—what about the millions of v.h.f.-only sets made prior to this date that have no provisions for u.h.f.? The answer is an external u.h.f. converter operating in conjunction with the v.h.f. set with the combination then being capable of receiving all allocated channels.

Simply, the converter accepts a u.h.f. transmission occurring between channels 14 (470 - 476 mc.) and 83 (884 - 890 mc.), mixes it with an internal local oscillator, and produces an i.f. output at either v.h.f. channel 5 or 6, depending on which of these two channels is the clear channel in the viewer's area. The v.h.f. set is switched to one of these channels and the u.h.f. converter can then be tuned to receive the desired channel between 14 and 83.

Converter design is reasonably similar among manufacturers, and falls into three categories: a premium unit having an r.f. amplifier, low-noise diode mixer, local oscillator, and a post i.f. amplifier tuned to either the channel-5 or channel-6 i.f.; a middle unit consisting of a tuned r.f. preselector, diode mixer, local oscillator and a post i.f. amplifier; and a low-priced unit, for use in strong signal areas, having a tuned r.f. preselector, mixer, and local oscillator.

I.F. Output

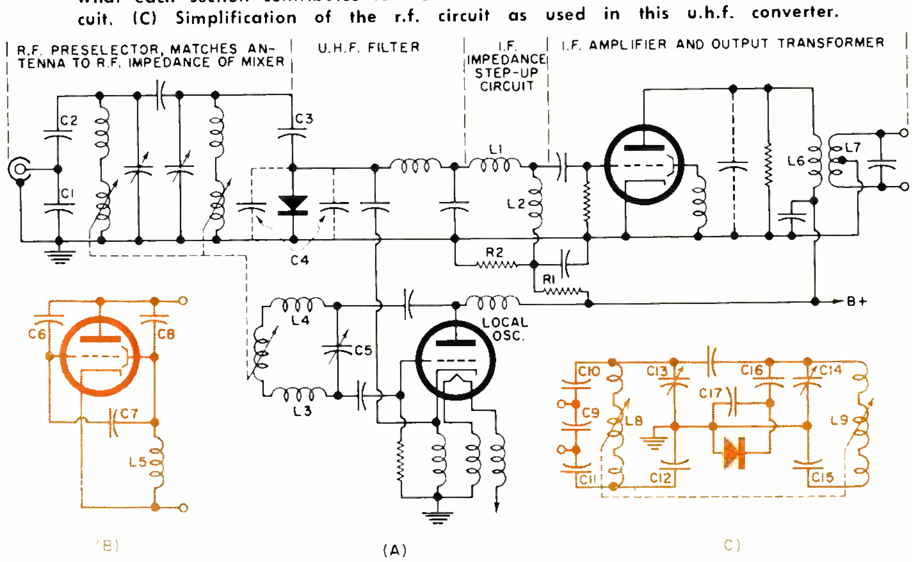
Most u.h.f. converters use either v.h.f. channel 5 or 6 as their output. Choice of these two particular channels is a result of satisfying a number of needs. The higher the i.f., the less the possibility of image interference because then the images will be far enough away from the received channels so that they can easily be rejected by the input tuned circuits; oscillator radiation is less severe at the higher frequencies, and there is less chance of oscillator harmonics interfering with reception; converter gain usually decreases as its output frequency increases; and noise becomes less severe as the i.f. is lowered thus producing a better signal-to-noise ratio. The area between channels 5 and 6 (76 to 88 mc.) satisfies most of these criteria, so either of these channels can be used. However, some converters use other i.f. output frequencies for special applications.

It is FCC policy not to assign two frequency-adjacent channels in the same area. To avoid reader confusion, channels 4 and 5 are *not* frequency adjacent as a look at the frequency allocations will show that there is a 4-mc. segment separating these two allocations. This 4-mc. gap, used for other than TV services, starts at 72 mc. (end of channel 4) and runs to 76 mc. (start of channel 5). Therefore, either channel 5 or channel 6 is assigned in an area.

Weak-Signal Reception

Almost any u.h.f. converter can be used in a strong-signal area. For such applications, there is no need for low noise figure or high gain. Converters with just a mixer and local oscillator can be used even though they have conversion loss (conversion loss in a typical crystal mixer can be 8 or 9 db)

Fig. 1. (A) Simplified circuit of the Blonder-Tongue BTU-2T u.h.f. converter shows what each section contributes to the over-all circuit. (B) I.f. neutralization circuit. (C) Simplification of the r.f. circuit as used in this u.h.f. converter.



and therefore attenuate the signal level as they convert.

Weak-signal reception, however, can be a problem. Here we are dealing with two basic factors; sensitivity and noise figure. The characteristics of the TV set greatly influence the performance of the converter. Some of the newer TV sets have so much gain and are so sensitive that they provide maximum contrast on the noise (snow) even when no signal is present. When a converter is used with a set such as this, no amount of converter amplification will improve the picture contrast. The only way to improve such a picture is to improve the signal-to-noise ratio. This means that the converter must have a lower noise figure than the TV set. However, most modern TV tuners have as good a noise figure as the best u.h.f. converters and amplifiers.

If the TV set is a year or so old, and is still using the original tubes, or has low sensitivity or a high noise figure, a good u.h.f. converter can improve reception a great deal as both gain and signal-to-noise ratio will be improved. On the other hand, a new TV set with excellent noise figure and very high gain may not only need a simple converter having a mixer and local oscillator to produce acceptable pictures.

Preamplification

Most people feel that signal preamplification will always improve signal reception in weak-signal areas. This is far from true. Although the preamplifier will improve the average weak-signal installation, it may not improve weak-signal reception noticeably when used with a sensitive TV set and a low-noise converter. This is because no further signal gain may be needed and the noise figure of the preamplifier is no better than the noise figure of the converter. (Tube noise figures are no better than those of good mixer diodes.) Any increase in gain would only improve picture contrast on a TV set with low gain. In any case, increased gain is attained more easily and economically with an i.f. stage.

However, a mast-mounted u.h.f. preamplifier is another story. Under dry weather conditions, an average 300-ohm transmission line can have about 1 db loss per hundred feet of length at 100 mc. At 500 mc. (low end of u.h.f. band), the same line may have approximately 3 db loss while at 900 mc. (high end of u.h.f. band), the loss may increase to about 5 db. Totally immersed in water, some types of transmission lines can lose up to approximately 70 db per hundred feet. Preamplification at the antenna eliminates the deterioration in signal-to-noise ratio caused by the down-lead loss, and will definitely improve reception in weak signal areas.

U.H.F. Wiring

Once across the u.h.f. border, some components are not always what they seem to be. For example; a piece of ordinary hookup wire 4 inches long and a diameter of .04-inch (#18 gauge) has an inductance of .1 μhy. At 1 mc., the inductive reactance is .63 ohm. However, at u.h.f. (500 mc.) the reactance of this bit of wire rises to 314 ohms, while at 900 mc., the reactance increases to 565 ohms. Also, in conjunction with its distributed capacitance and inductance, at the higher frequencies, this piece of wire starts to behave like a tuned circuit.

Even an ordinary-looking chassis takes on a new electronic look at u.h.f. At these frequencies, the very metal may have sufficient inductance and resistance between two grounding points to offer an appreciable impedance to the u.h.f. signal currents. This is why common-ground points are used for each stage and why these should never be disturbed.

That crinkly looking piece of flat braid (usually silver plated) may look a little sloppy just hanging there. Take care —it may be an inductor specially bent to that crinkly shape to suit a particular purpose.

Some capacitors, especially local oscillator-to-mixer couplings, may be just a wire "gimmick" and in some cases look just like a piece of wire connected to one socket connection and terminating near another. The amount of capacitance (therefore the amount of oscillator injection voltage) is determined by the proximity between the loose end of the wire and the socket connector that it is supplying with a signal.

A section of transmission line, as commonly used in tuned circuits at u.h.f., can act as both inductor and capacitor. A quarter-wave line with a short-circuit termination is equivalent to a parallel-resonant circuit whose resonant frequency is adjusted by varying the effective length of the line with an adjustable short-circuiting slider.

The lesson here is—don't touch or redress components or wiring as you may throw the converter out of alignment.

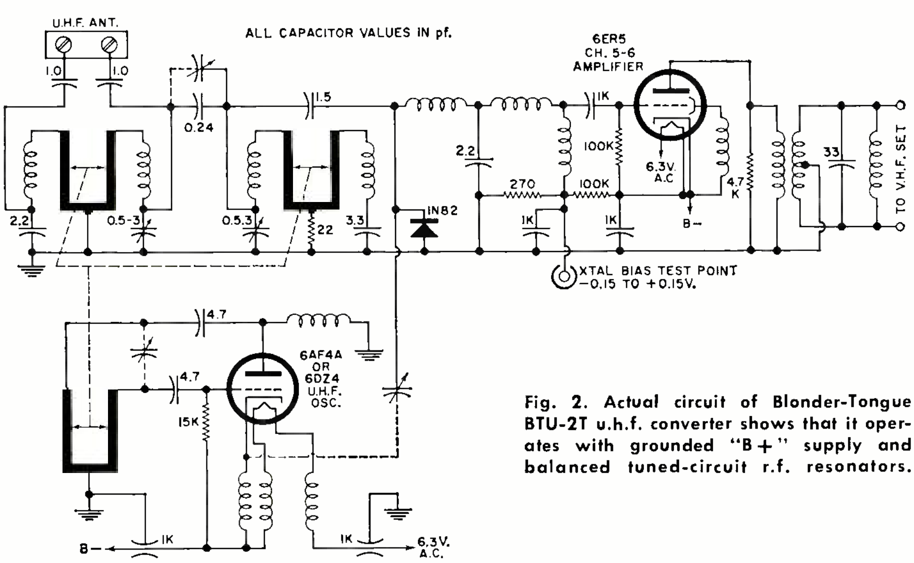
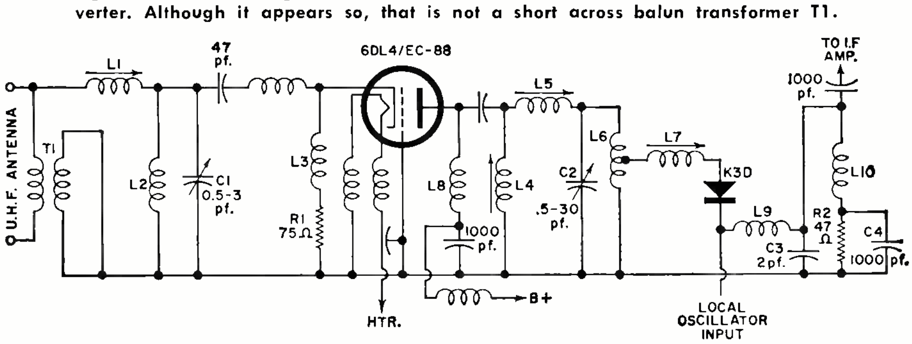


Fig. 2. Actual circuit of Blonder-Tongue BTU-2T u.h.f. converter shows that it operates with grounded "B+" supply and balanced tuned-circuit r.f. resonators.

Fig. 3. The grounded-grid preamplifier as used in the Jerrold "Ultra-Vista" converter. Although it appears so, that is not a short across balun transformer T1.



Typical U.H.F. Converter

Operation of a typical u.h.f. converter can more easily be explained with the aid of an actual converter schematic diagram.

Because of the frequencies involved at u.h.f., it is not difficult to obtain the desired 6-mc. passband. As the local oscillator and the desired frequency are closer together in percentage at u.h.f., skirt selectivity becomes important to discriminate against signals just outside the passband. It is necessary to provide rejection of image signals, other spurious responses, and i.f. feedthrough. An especially strong spurious response eliminated by tuned r.f. preselection is the conversion formed when the second harmonic of the local oscillator beats with an incoming u.h.f. channel. Another advantage of tuned preselection is that it reduces the strength of unwanted off-channel signals arriving at the mixer, thus reducing possibility of cross-modulation.

A simplified circuit of the *Blonder-Tongue* BTU-2T is shown in Fig. 1A. The balanced r.f. circuits are shown single-ended and a conventional negative-ground power supply is used. (The actual circuit is shown in Fig. 2.)

The converter input consists of a capacitively coupled, double-tuned r.f. preselector. The low antenna input impedance is stepped up by capacitive network $C1$ and $C2$ to match the primary tuned circuit, then stepped down in the secondary by $C3$ and $C4$ to match the impedance of the mixer diode. $C4$ represents the stray capacitance appearing across the mixer diode.

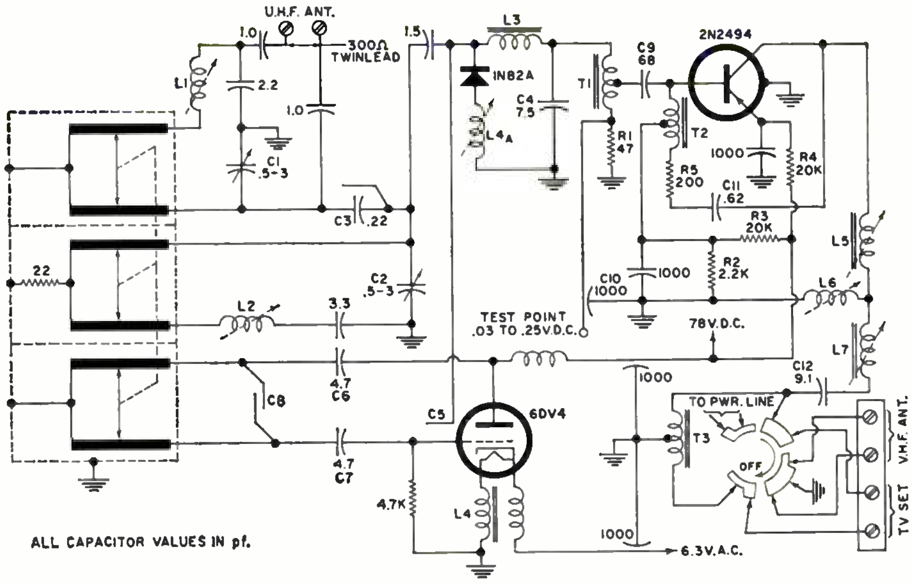


Fig. 4. The Jerrold "Super-Vista" converter uses a neutralized semiconductor i.f. amplifier. Oscillator injection is capacitive (C5) and magnetic (bifilar L4-L4A).

The r.f. preselector is capacitively coupled to provide greater rejection below resonance, thus reducing oscillator feedthrough to the antenna. The oscillator frequency is below that of the incoming signal to prevent frequency inversion. Because of the shape of their i.f. response curves, some TV receivers will distort signals that are inverted at their antenna terminals.

The local oscillator is a conventional ultraudion circuit. R.f. chokes are provided both in the heater and cathode leads to permit the cathode to float at a potential determined by its stray capacitance to ground. If the plate were grounded, it would be a simple Colpitts oscillator. Capacitor $C5$ trims the tuning at the low end, while inductors $L3$ and $L4$ control the high end. The oscillator is capacitively coupled to the mixer through a twisted-wire "gimmick."

The mixer diode beats the incoming frequency with the oscillator frequency. A crystal diode is usually used because it requires no heater power thus reducing generated heat, generated random noise is less than that of a vacuum tube, and a crystal diode mixer requires less oscillator injection than a vacuum tube, thus minimizing oscillator radiation with its accompanying interference signal.

In this converter, the crystal mixer is d.c.-biased by voltage divider $R1$ and $R2$. Resistor $R1$ is set for a current of about 1 ma. while $R2$ is adjusted for best average performance across the band.

The u.h.f. filter portion of Fig. 1A has approximately constant impedance at the i.f. frequency. It passes the difference frequency (i.f.) between the incoming signal frequency and the local oscillator frequency, rejecting the sum and two fundamental frequencies. The i.f. signal is then stepped up by the i.f. impedance step-up circuit. The impedance step-up of this circuit is controlled by the ratio of $L1$ to $L2$. This ratio is adjusted to present the optimum impedance to the grid of the i.f. amplifier, resulting in the best possible noise figure.

The i.f. amplifier uses a shielded-grid triode in the interests of best noise figure. This particular circuit uses a patented neutralization circuit with a simplified circuit shown in Fig. 1B. Grid-to-plate capacitance, as represented by $C6$, is neutralized by $C7$, $C8$, and $L5$. To visualize circuit operation, imagine a voltage applied between the plate and ground. A capacitive current will flow through $C6$ to the input. Assuming that the reactance of $L5$ is lower than the reactance of $C8$, the voltage at the shield electrode will be 180° out-of-phase with the applied voltage. Therefore, if this voltage is of the correct amplitude, it will feed a current through $C7$ that is equal to, and 180° out-of-phase with, the current through $C6$. Thus, complete neutralization is achieved. While this circuit is frequency sensitive, it is wide enough to pass the desired i.f. passband (76 to 88 mc.).

As shown in the actual schematic of Fig. 2, the unit operates with a grounded "B+" supply and the r.f. resonators used are balanced-tuned circuits. Fig. 1C shows a simplification of the r.f. circuit. The stray capacitance of the 300-ohm input terminal screws is used as $C9$. The main resonating capacitors are $C12$ and $C13$. This balanced single-tuned circuit is capacitively coupled to a similar circuit consisting of $C14$, $C15$, and $L9$. Capacitors $C13$ and $C14$ are ceramic trimmers used to adjust tracking at the low end of the band. The small coils at the ends of $L8$ and $L9$ perform a similar function at the high end of the band. In the actual schematic,

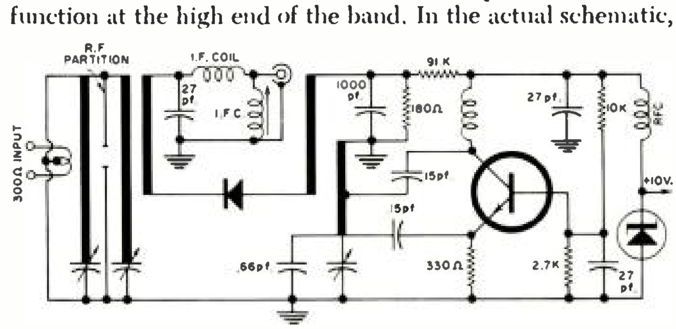


Fig. 5. Semiconductor u.h.f. converter by G-E includes voltage regulator.

the center of each tuning coil is grounded either directly or through a resistor. This connection does not affect the operation of the input circuit at the frequency to which it is tuned, but it suppresses any parasitic resonance. This is because both impedance and voltage of a half-wave balanced circuit such as this approach zero at the center and therefore is not affected by a connection at that point. The output from the tuned circuit is single-ended. The actual tunable inductors are silver-plated stamped rings with sliding spring-silver contacts that are rotated for frequency selection.

R.F. Amplifiers

A typical example of r.f. preamplification is shown in Fig. 3. This particular circuit is used in the *Jerrold* "Ultra-Vista" converter. The 300-ohm antenna input is converted to 75 ohms by the balun transformer $T1$. The input frequency is then single-tuned to the center frequency by resonating $L1$ and $L2$ with $C1$ and the input capacitance of the cathode of the grounded-grid amplifier. The cathode bias resistor $R1$ is

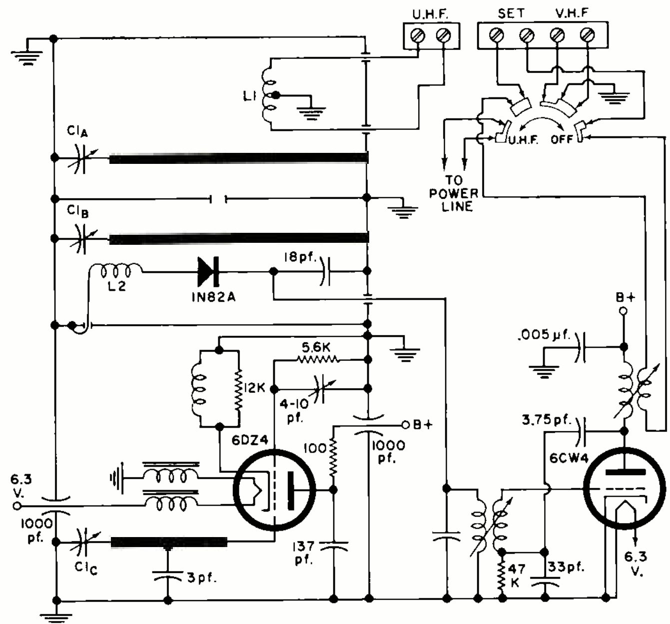


Fig. 6. The General Instruments Corp. TC-20 u.h.f. converter uses three high-"Q", end-tuned, coaxial transmission lines and variable capacitors for preselector and oscillator tuning.

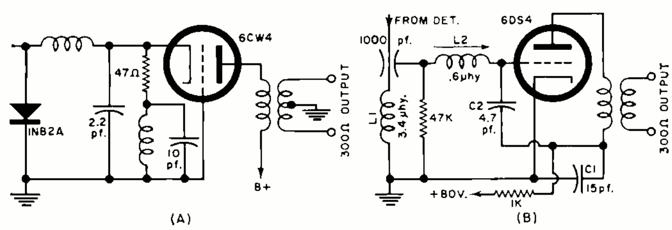


Fig. 7. Two types of i.f. amplifiers. (A) Gavin Instruments' Model G-4 uses a grounded-grid amplifier requiring no neutralization. (B) Model A by Standard-Kollsman uses a triode that is capacitively neutralized as the i.f. output amplifier.

r.f. isolated from the cathode by the impedance of choke L3.

The plate circuit of the r.f. amplifier is a double-tuned network set to the center frequency by L4 with the bandwidth adjusted by L5 and symmetry controlled by the transmission-line stub composed of L6 and C2. The signal is inductively coupled into one side of the mixer diode through L7. Plate voltage is supplied through u.h.f. plate choke L8.

The local oscillator is coupled to the mixer diode with the difference frequency flowing through the low-pass filter composed of L9 and C3 and impressed on the base of the transistor i.f. amplifier. L10, R2, and C4 d.c. ground the mixer diode. The junction of L10 and R2 is the oscillator test point.

Semiconductor Amplifiers

With the advent of new u.h.f. transistors, it appears that u.h.f. converters, boosters, and built-in u.h.f. tuners may go completely solid-state in the not-too-distant future. At the present time, some manufacturers are using transistors in a few of their latest u.h.f. converters. One such typical unit is the *Jerrold* "Super-Vista" converter whose schematic is shown in Fig. 4.

Here, a tunable filter matches the 300-ohm input circuit to the mixer diode. Double-tuning action is accomplished by C1 and C2 tuning the stub lines. For ease in tracking the higher frequencies, coils L1 and L2 are affixed to the ends of the stub lines and are made adjustable. Bandwidth is adjusted by varying C3. Low-pass filter L3 and C4 keep the oscillator and the u.h.f. frequencies from passing through to the i.f. stage. Oscillator injection is both electrostatic (C5) and magnetic through bifilar coils L4 and L4A.

The oscillator is a modified Colpitts with a decoupled anti-resonant circuit consisting of C6 and C7. The variable stub line is tuned by C8 and the grid-to-plate capacitance of the 6DV4 nuvistor. L4 presents a d.c. ground for the oscillator cathode, yet offers a high r.f. impedance from cathode to ground.

The converted output from the mixer flows through the low-pass filter (L3 and C4) and is then transformed from 300 to 75 ohms through the bifilar transformer T1 and capacitively coupled through C9 to the base of the i.f. amplifier. The junction of R1 and C10 is used as the oscillator test point.

The transistor i.f. amplifier is base-biased by the voltage divider R2 and R3 while the emitter is biased through R4. The transistor is neutralized by the combination of C11, R5, and the bifilar transformer T2. The collector output is a T-section filter consisting of L5, L6, L7, and C12. The unbalanced output is then transformed to 300 ohms by T3.

In the *G-E* all semiconductor u.h.f. converter shown in Fig. 5, a transistor is used as the local oscillator.

Coaxial Tuning

The u.h.f. converters made by *General Instruments Corp.*, are based on that company's u.h.f. tuner that has been in use for many years. The basic difference between the tuner and the u.h.f. converter is that the converter oscillator tunes from 384 to 815 mc. and the i.f. output transformer now tunes to approximately 82 mc.

The circuit of the TC-20 u.h.f. converter is shown in Fig. 6. The design consists of two high-"Q," end-tuned coaxial transmission lines used as r.f. preselectors with another end-tuned line acting as the oscillator tuned circuit. Tuning is accomplished with the ganged three-section variable capacitor, C1, therefore eliminating sliding contacts. The 300-ohm antenna input is coupled to the first coaxial transmission line by L1. The interstage shield between the two preselector tuned circuits has a hole in it to couple energy from one circuit to the other. A portion of the diode mixer coil L2 lies parallel to the second coaxial transmission line and couples the r.f. signal to the mixer diode. A small portion of coil L2 projects into the oscillator compartment to pick up the necessary oscillator signal. The i.f. signal is picked off the mixer diode circuit and passed through the i.f. transformer to the neutralized 6CW4 nuvistor i.f. amplifier. Some models do not have the i.f. amplifier.

As an example of some typical gain figures, when this circuit is used without the i.f. amplifier, there is a 9-db conversion loss. However, when used with the i.f. stage, there is a conversion gain of 8 db, therefore the i.f. stage is worth 17 db of signal, showing the value of such amplifiers.

Other I.F. Amplifiers

The Model G-4 converter, made by *Gavin Instruments Inc.*, uses a grounded-grid i.f. amplifier that requires no neutralization and is shown in Fig. 7A. The output from the mixer is passed through a low-pass filter that removes both the original u.h.f. frequency and the local oscillator frequency. Bias for the amplifier is through the 47-ohm resistor that goes to ground through an r.f. choke which, in turn, is bypassed by a 10-pf. capacitor. This holds the cathode at the correct d.c. potential while keeping it at a high impedance with respect to ground.

The plate load of the amplifier is the primary of a transformer that provides the 300-ohm balanced output to the v.h.f. television receiver.

The neutralized i.f. amplifier as used in the "Model A" by *Standard-Kollsman*, is shown in Fig. 7B. Here, i.f. coil L1 provides the d.c. ground return for the mixer crystal and the i.f. signal is picked up by a coupling capacitor and passed to the i.f. amplifier through L2. This coil is tuned to an i.f. of approximately 83 mc. The triode amplifier is neutralized by capacitors C1 and C2. Once again, the plate load of the i.f. amplifier is a coupling transformer that delivers a 300-ohm balanced output to the v.h.f. set. ▲

WORLD'S LARGEST RADAR TELESCOPE

Recently placed in operation near Arecibo, Puerto Rico, this massive radar telescope is built into the earth.

IMAGINE an antenna having a reflector area of almost 785,000 square feet, a gain of 60 db, a beamwidth of .6 degree, a diameter of 1000 feet, with the antenna feed located almost 500 feet above the reflector surface. Furthermore, imagine driving this antenna with a 2.5-million-watt radar set, making the effective radiated power of this combination a staggering 2,500,000,000,000 watts.

This is precisely what is happening at the latest radar telescope recently placed in operation at Arecibo, Puerto Rico. The installation has been made to help scientists create a detailed profile of the ionosphere, the shell of ionized particles surrounding the earth, which plays a very important role in radio communication, satellite and missile tracking, and which may also play an important part in creating weather.

The antenna can also be used to make observations within our own solar system, make detailed maps of the heavens, and study distant electrical phenomena.

Arecibo was chosen because it met a number of criteria: it is located within 20 degrees of the equator thus easing observation of the sun and planets; there was a natural bowl in the mountains thus simplifying construction; the area has a very low background noise level; and it is easily accessible to the continental United States.

Antenna System

After the excavation was roughly shaped, the huge reflector was formed from steel-mesh panels which were secured to steel cables and tie-downs that also serve to maintain the spherical shape. Each panel was bonded to the other to form a good electrical contact.

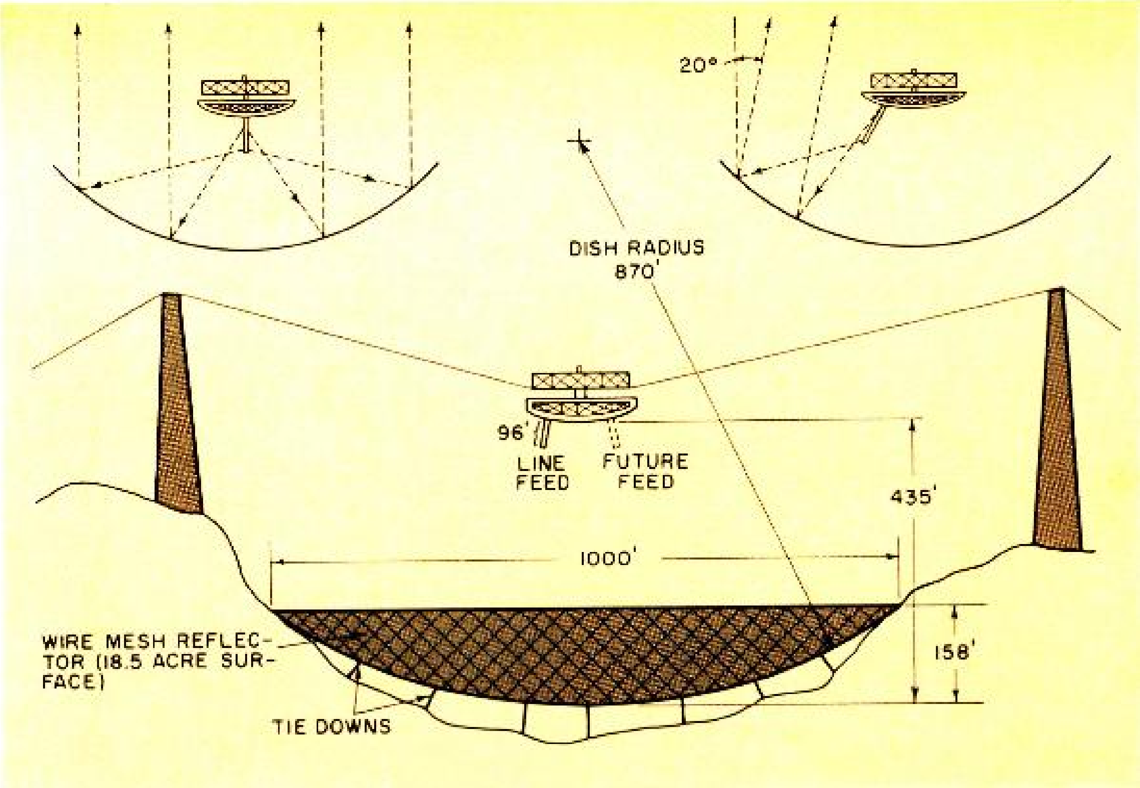
Three massive towers were erected about the rim of the bowl and these are used to carry the heavy steel cables which, in turn, support the 500-ton feed structure high above the center of the reflector. The actual transmitter and receiver are housed in an operations building, located near the base of one of the towers.

Most conventional reflectors, such as used in radar or other microwave systems, are shaped like a parabola and use a point-source r.f. feed. If such a parabola is not moved, then it can only receive at its focus, rays coming from only one direction. This is fine when only a single direction is intended for the microwave beam or when the reflector can be moved to point the beam. However, in an antenna of Arecibo's dimensions, moving the reflector is out of the question. To enable this antenna to move its beam in many directions, the spherical-section reflector is made fixed and its feed, or focus, a movable line. A sphere has the property of focusing parallel rays on points along a radius in the direction of the rays, up to a distance one-half the radius from the surface. By moving the feed along a curved support, the beam can be tilted 20 degrees each side of the vertical center line.

The r.f. is coupled to a 96-foot-long phased-array line feed that uses radiating slots along its length to control the phase of the r.f. energy reaching the reflector to produce an equal-amplitude wavefront. (See illustration.)

The feed can be moved away from the vertical by 20 degrees and also can be rotated about the center line thus permitting operation within a cone 40 degrees across, centered on the vertical center line. Provisions have also been made on the support structure for the addition of another feed antenna sometime in the near future.

The over-all structure has been designed so that the end of the 96-foot feed will not shift position by more than six inches in the presence of a 30-knot wind. Although the surrounding hills offer some (*Continued on page 57*)



TRANSISTORIZED SIX-METER CONVERTER

Construction of converter, using inexpensive mesa transistors, that permits signals of under ½ μv. to be copied with ease.

By ROY C. HEJHALL, K7QWR

GOOD performance can be obtained on six meters with a transistorized converter which uses inexpensive transistors and is easy to construct. The converter described in this article uses three *Motorola* 2N963 *p-n-p* mesa transistors which can be purchased for about the same price as a set of tubes for a vacuum-tube converter. Over-all gain of the converter is in excess of 30 db. Sensitivity is about 1 microvolt for a 10-db signal-to-noise ratio at the receiver audio output with a 30% modulated signal, and well-modulated signals of less than ½ μv. can be copied with ease. For comparison, the same laboratory test setup was used to measure the sensitivity of both a simple pentode vacuum-tube converter and a two-r.f.-stage nuvistor converter. The results were over 5 μv. for the pentode converter and 0.7 μv. for the nuvistor converter.

The total parts cost (including transistors and the 43-mc. crystal) is under $20.00 if all new components are used.

The Circuit

The circuit consists of an r.f. amplifier, a mixer, and an oscillator. See Fig. 1. The r.f. amplifier is a neutralized common-emitter stage. The mixer is also common-emitter, and base injection of the oscillator signal is used for simplicity. The crystal oscillator is a Colpitts type using a third-overtone crystal to generate the required 43-mc. oscillator signal directly. The intermediate frequency is 7 to 11 mc., which allows the 40-meter receiver bandspread to be used for the low end of six meters. Input impedance of the converter is 50 ohms, and it will work satisfactorily into load impedances ranging from about 50 to a few hundred ohms.

Single-tuned circuits are used throughout. Double-tuned circuits were considered and would have provided improved rejection to i.f. feedthrough. However, the single-tuned circuits simplify construction and alignment, and rejection of i.f. feedthrough has proved adequate.

Power requirements are 9 volts d.c. at about 8 ma. Either a power supply or a 9-volt transistor radio battery may be used to power the converter. The power-supply leads are filtered to reduce spurious responses in the units.

Construction

The converter was constructed on a copper chassis, which was cut and formed as shown in the photos, so that the completed converter could be enclosed in a gray *LMB* 5¼" x 3" x 2⅛" chassis box. Copper was selected for the chassis only for ease in soldering components directly to it and an aluminum chassis could have been used with equal success. Each end of the chassis was slotted for type BNC coaxial connectors. The connectors serve as input and output signal jacks and also clamp the chassis to the box. Care must be given to vertical placement of the chassis in the box, since the crystal above and coil forms below the chassis leave little clearance when the box is assembled. Two banana jacks were mounted in the box for power-supply leads.

The usual precautions in v.h.f. wiring, such as short leads and minimum chassis current paths, should be observed. The photograph of the bottom of the chassis can be used as a guide for layout. It is suggested that the general layout of the r.f. stage, including the shield between base and col-

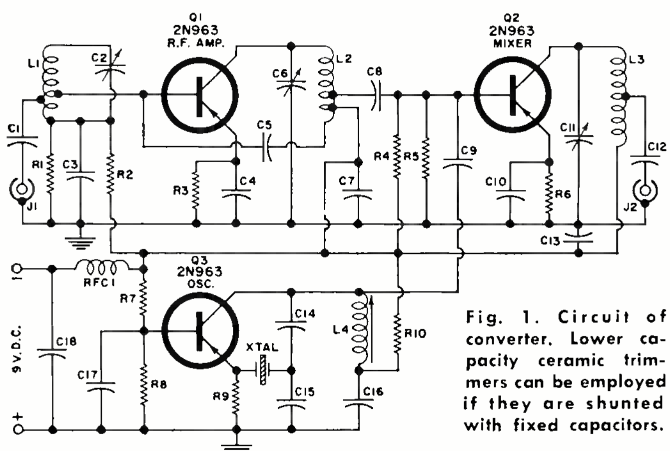
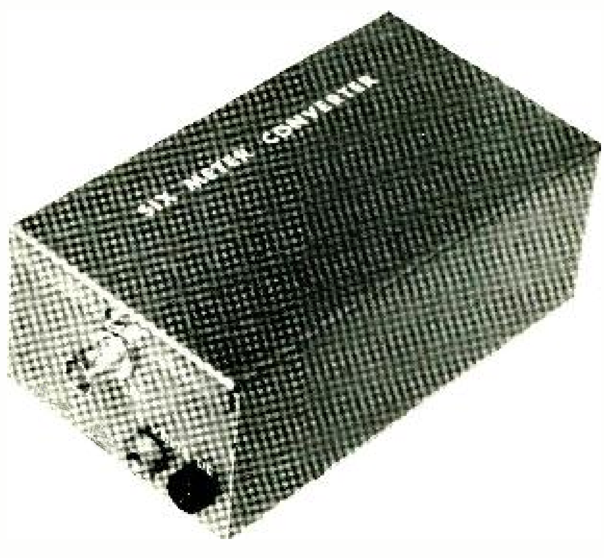


Fig. 1. Circuit of converter. Lower capacity ceramic trimmers can be employed if they are shunted with fixed capacitors.

R1—5100 ohm, ¼ w. res.
R2—8200 ohm, ¼ w. res.
R3—1200 ohm, ¼ w. res.
R4—11,000 ohm, ¼ w. res.
R5—10,000 ohm, ¼ w. res.
R6—2000 ohm, ¼ w. res.
R7—12,000 ohm, ¼ w. res.
R8—2200 ohm, ¼ w. res.
R9—470 ohm, ¼ w. res.
R10—1000 ohm, ¼ w. res.
C1—.003 μf. disc ceramic cap.
C2, C6—5-80 pf. mica compression or ceramic trimmer
C3, C7—0.1 μf. disc ceramic cap.
C4—0.01 μf. disc ceramic cap.
C5—18 pf. mica capacitor
C8—.001 μf. disc ceramic cap.
C9—5 pf. mica capacitor
C10—.05 μf. ceramic cap.
C11—25-280 pf. mica compression or ceramic trimmer
C12, C13, C16, C17, C18—0.02 μf. ceramic capacitor
C14—12 pf. mica capacitor
C15—82 pf. mica capacitor
L1—5 t. #20 en. wire, ¼" dia. close-wound; tapped 1 t. & 2 t. from cold end (0.15 μhy.)
L2—8 t. #20 en. wire, ¼" dia., close-wound; tapped 2 t. & 4½ t. from cold end (0.19 μhy.)
L3—26 t. #28 en. wire, ¼" dia., close-wound, center-tapped (2.3 μhy.)
L4—10 t. #26 en. wire, ¼" dia., close-wound, slug-tuned (0.55 to 0.85 μhy.)
Note: A set of prewound coils is available from Frank Davis, 2110 North McAllister, Tempe, Arizona for $3.50, postpaid in the U.S.A.
RFC1—18 μhy. r.f. choke
J1, J2—BNC coax connector
Xtal—43-mc. third-overtone crystal
Q1, Q2, Q3—2N963 "p-n-p" transistor



Converter was enclosed in a 5¼" x 3" x 2⅛" chassis box.

lector, be followed. Minor changes will be insignificant, but a radically different layout may affect neutralization. There are no special precautions to be followed in the construction of the mixer and oscillator stages. The r.f. stage shield should also function to shield local oscillator signal from the r.f. stage input.

The coils are wound on ¼-inch diameter coil forms. The oscillator coil is slug-tuned; the other coils have no slugs. Another version of the converter has been built using no coil forms in the r.f.-stage input and output circuits, since the #20 wire used is rigid enough to support itself.

Building the converter on this size chassis did cause some crowding of components, and a slightly larger chassis and box could be used, particularly if it is desired to power the converter with an internal battery.

Alignment and Testing

Before attempting alignment, a check for correct d.c. operating conditions should be made. About the simplest check is to measure total current drain; it should be about 8 ma. Emitter current of each transistor should be about 2 to 2.5 ma.; this can be checked by measuring voltage drop across the emitter resistors.

The first step in alignment is to tune the r.f. input and output circuits and the mixer output circuit to approximate resonance, using a grid-dip meter. This can be done with the power to the converter off. Couple the grid-dip meter to *L*1 and tune *C*2 for resonance at 50 mc. In the same manner, couple to *L*2 and tune *C*6 for resonance at 50 mc. Then couple to *L*3 and tune *C*11 for resonance at 7 mc. In each case a definite dip should be obtained if the circuits are operating properly.

The next step is to adjust the oscillator coil slug (*L*4). Set the slug about mid-range in the coil. Connect an r.f. signal generator to the converter input jack and connect the converter output to the antenna terminals of any receiver which will tune to 7 mc. Connect a 9-volt d.c. power source to the converter. Apply a 50-mc. modulated signal to the converter and locate the signal with the receiver tuned to 7 mc. If the oscillator is detuned too far it may not oscillate, so if the signal cannot be located at first, continue to search for it while slowly moving the oscillator slug. Once the signal is located, adjust the slug for maximum audio output in the receiver.

Next, with the 50-mc. signal still applied to the converter input, tune *C*2, *C*6, and *C*11 for maximum signal output. This completes the alignment.

If the converter is constructed in a box, placing the cover on the box has a slight effect on alignment. Therefore, holes should be drilled in the box to allow the final peaking of *C*2, *C*6, and *C*11 to be done with the box assembled.

If no grid-dip meter is available, it is possible to skip the first step by tuning *C*2, *C*6, and *C*11 all about mid-range and using a strong signal from the signal generator until the signal is located with the receiver. Once the signal has been located, the remainder of the alignment is carried out as described.

If no signal generator is available, tuning *C*2, *C*6, and *C*11 to approximate resonance with a grid-dip meter should be done first as before. Then connect the converter input to a 6-meter antenna and perform the remainder of the alignment as previously described, except that on-the-air signals are used in place of the signal generator.

Alignment may be performed at any frequency in the 6-meter band where maximum sensitivity is desired. The 3-db bandwidth of the converter is 1.6 mc., and if the alignment is done at 50.8 mc., the converter will provide optimum performance from 50.0 to 51.6 mc.

Once proper alignment has been completed, it probably will never have to be repeated, since transistor characteristics normally do not change with age and the life expectancy of the transistors is greater than that of the person constructing the converter. Also, the circuit operates at room temperature so there is no heat present to degrade other components used in the construction of the converter.

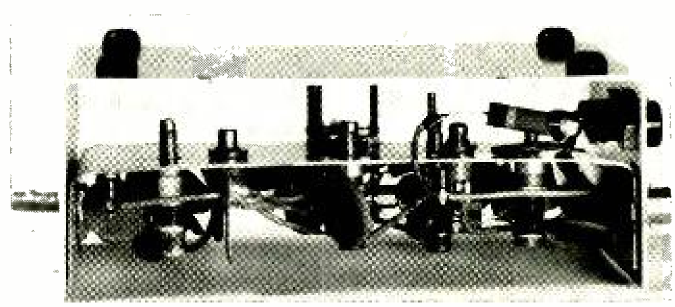
Performance

Performance data on the converter constructed by the author is given in Table 1.

Some spurious responses may be encountered from strong TV or FM broadcast stations mixing with oscillator harmonics. The best cure for this is to place a trap for the offending station or a 6-meter low-pass filter ahead of the converter.

It must be emphasized that the design objectives in this project were to determine what performance could be obtained using low-cost transistors and reasonably simple circuitry, and the results were gratifying. For those who demand the ultimate in performance, today's newer high-frequency transistors enable solid-state converters to be built with performance equivalent to that of the very best vacuum-tube converters.

The author wishes to express his thanks to Frank Davis, K7VKH, for his valuable assistance throughout this project. ▲



Side view of converter shown here with cover removed. Note that unit has been turned over for this particular photo.

Bottom view of the converter. A full-width shield cuts across the Q1 socket.

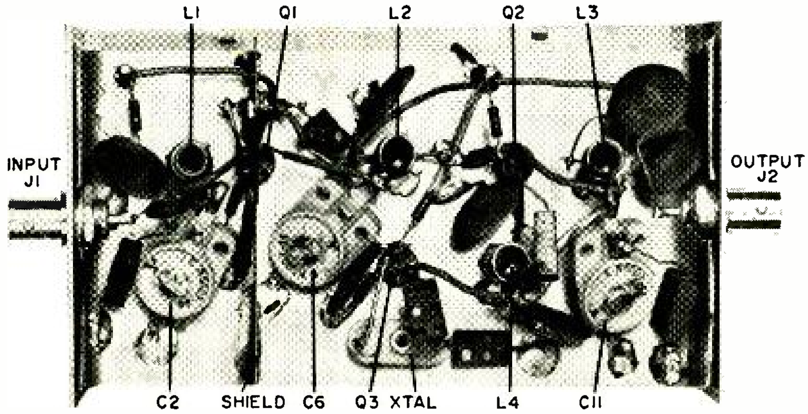


Table 1. Performance data on converter constructed by author.

Over-all Gain	31 db
3-db Bandwidth	1.6 mc.
I.F. Feedthrough	54-db down
Sensitivity (for 10 db signal-to-noise ratio at receiver audio output with 30% modulated signal)	1.2 μV.

STATE-POLICE MICROWAVE

By MARSHALL LINCOLN

Description of the 794-mile, 9-terminal-station system used by Indiana State Police for communications. The entire system is maintained by only six full-time electronics technicians who travel close to 4000 miles each month to do troubleshooting and routine servicing.

ELECTRONICS has been a godsend to modern police departments whose problems have been multiplying even faster than our population. Two-way mobile radio, once used only by portions of the big-city police departments, has rapidly become commonplace throughout the nation. Even the small-town police force with a handful of men now has a full complement of mobile and, often, even portable equipment.

It is only natural that progressive police departments be on the lookout for new electronic techniques to improve their efficiency in dealing with their law-enforcement problems. Microwave, a communications tool extensively utilized in industry, is also being adapted to police communications requirements.

The Indiana State Police is a pioneer in this field with one of the first state-wide police microwave systems in operation in the United States.

A state police department, charged with the responsibility of a great variety of enforcement problems over a large geographical area, needs a rapid, accurate, direct point-to-point communications system for maximum effectiveness. A department that aims at keeping abreast of technical developments needs a system that will be adaptable to new uses in the future without complete overhauling.

Microwave meets this need easily, its users have found.

The Indiana system, started in 1957 and completed in 1961, has filled the need that existed for it when it was planned and has demonstrated its capability of dealing with future problems which are still in the crystal-ball stage.

Before Microwave

Before the availability of microwave, the ISP (Indiana State Police) used either c.w. or its 42-mc. mobile frequency for most of its communications between General Headquarters and the 20 district headquarters locations and posts scattered over the state. Some messages went by teletypewriter over conventional telephone circuits on an individual-call basis. No regularly established teletypewriter network existed in the department.

Several developments have intensified the limitations on these methods. Police departments, as well as commercial firms, are finding it increasingly hard to obtain c.w. operators. As problems requiring police attention have increased, the department has increased in size to meet them, and additional police cars on the road put an increasing load on the 42-mc. mobile frequency. Some point-to-point messages could still move by teletypewriter over conventional telephone lines, but the cost and delay of moving very many messages this way is a distinct drawback to the use of this method.

ISP communications personnel logically turned to microwave for the additional message capacity they needed.

The first link in what became a state-wide system was installed in early 1957 between General Headquarters in Indianapolis (the state capital) and District 4 headquarters at Pendleton, about 25 miles away.

Microwave rapidly proved its usefulness and the system was extended to all other district headquarters and all posts. (The ISP divides the state into 11 districts for administrative purposes, with most districts also divided into two or three post areas if the district is extensive.)

The entire state-wide system consists basically of four legs extending northwest, northeast, southwest, and southeast from Indianapolis, which is in the center of the state. *RCA* installed the northwest, northeast, and southwest legs under a "turnkey" contract. This type of contract is far different from that commonly associated with police matters. In this case, it meant *RCA* installed the system and turned the key over to the ISP, giving the department sole control as well as maintenance responsibility.

ISP radiomen slated to maintain the system took a two-week *RCA* course in microwave techniques, then set to work installing the southeast leg of the system themselves.

The ISP helicopter, used mainly in searches for fugitives and for traffic observation duties, was a handy tool in determining the location and height of the microwave antenna towers needed.

The completed system has a total path length of 794.1 miles, and contains nine terminal stations, seven through repeaters, ten drop repeaters, and seven junction stations, plus the central control point and switchboard at General Headquarters in the State Office Building at Indianapolis. The average distance between repeaters is 24.3 miles.

Although most industrial communications specialists would say it can't be done, the ISP maintains the entire system, with no outside help, with only 6 full-time maintenance men.

These men live at various locations scattered over the state and each travels an average of 3500 to 3800 miles a month to do troubleshooting as well as routine maintenance.

A radio operator at General Headquarters uses the microwave dispatch channel, which provides simultaneous communication with all Indiana State Police posts and district headquarters in north half of state. The wall phone on panel at the left is also part of microwave system. With it, operators can carry on private conversations with police personnel at any of the department's stations anywhere in state. Boom mike feeds 42.42-mc. transmitter, used for mobile communications.

Voice & Teletypewriter Channels

The microwave system currently carries two basic modes of radio transmission: these are voice and teletypewriter.

The teletypewriter equipment consists of machines at each post and district headquarters location and at General Headquarters, with direct keyboard and tape-sending capabilities and tape perforators at each point.

There are three types of voice channels in the system. These are private line, party line, and dispatch channel. Each of the nine district headquarters locations and each of the nine post locations has its own private-line voice channel. Each half of the system has a party-line voice channel common to all locations in that half of the state. These voice channels terminate in telephone-type instruments in each ISP radio room throughout the state as well as on desks of command and administrative personnel.

When any point in a given half of the system is using a party line, anyone at another point in that half of the state picking up a party-line phone will get a busy signal, but will be unable to hear the conversation that is taking place one the line.

The dispatch channel is a voice channel common to all posts and district headquarters locations in the north half of the state. Any voice signal on this channel is heard at all other locations in the north half of the state. This circuit terminates in a speaker and mobile-type push-to-talk mike at the radio operator's console in each district headquarters and post in the northern half of the state as well as the radio room at General Headquarters. The dispatch channel serves as a quick, ready means for point-to-point communications without the necessity for dialing a call or using the busy mobile frequency. It has not been extended to the southern part of the state pending a decision on whether it might become too congested to be of too much practical value.

The ISP system uses *RCA* equipment throughout and operates with FM carrier frequencies of 1865, 1905, 1925, 1945, 1965 and 1985 mc.

These carrier frequencies are distributed through the system in such a way that no repeater transmits on the same frequency on which it receives from the opposite direction. This eliminates the chance of a receiving location receiving two signals of the same frequency, slightly out of phase because they came from different repeaters in a line with the receiver. Further isolation is accomplished by appropriate use of vertical and horizontal polarization.

For example, if stations A, B, and C were approximately in a straight line and A and B both transmitted with the same carrier frequency, station C might receive signals from both A and B, but slightly out of phase. To eliminate this possibility, A transmits a carrier of, say, 1905 mc. horizontally polarized. B receives this signal and retransmits to C on 1985 mc. vertically polarized. Thus C can't possibly receive any signal from A.

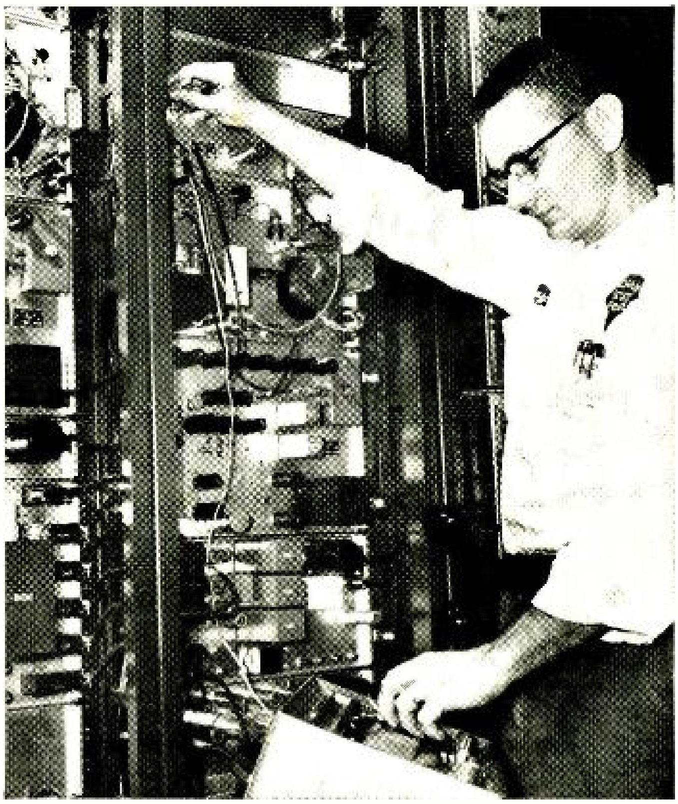
Voice channels in the baseband use single-sideband suppressed carrier which, in turn, frequency modulates the microwave carrier for actual transmission. Teletypewriter signals are single-tone on-off signals keyed by the five-level teletypewriter code.

Audio bandwidth in the baseband is about 300 to 3500 cps, with each voice channel assigned a 5-kc. segment of the baseband, including guard band. Teletypewriter signals are between 4.5 kc. and 10 kc. in the baseband, with all voice channels above 10 kc., except for the service channel which is below the teletypewriter channels and is directly modulated from the audio frequencies of the source without the need for multiplexing. All other voice channels are heterodyned up to their assigned frequencies in the baseband by means of the multiplex equipment.

The service channel is a voice channel used by maintenance men. It is terminated in a telephone handset in each station equipment rack. This channel also carries single-tone "fault" signals whereby automatic reports of equipment failures at all repeaters, both manned and unmanned, are sent to General Headquarters, located in Indianapolis.

These fault signals are 2800-kc. tones inserted in the service channel in coded pulses. These pulses are initiated by a motor-driven commutator switch in an equipment rack of each repeater. When a portion of the repeater fails, the motor starts and the commutator switch forms the appropriate pulses, which are read out on a series of lights at the General Headquarters microwave station. From there, servicemen can determine, from which of the lights are on, the location and the nature of the fault.

Types of faults reported are: receiver-modulator failure, transmitter failure, loss of commercial power, tower-light failure, and illegal entry into the station.



A technician checks frequencies of microwave equipment on the top floor of the State Office Building in Indianapolis. Six men, stationed at various locations over the state, perform all routine and emergency maintenance on the entire system.

Equipment Employed

The microwave transmitters throughout the ISP system use 2C39 lighthouse tubes with cavity resonators for tuning. Final output power from each transmitter is approximately three watts.

Most antennas use either 4- or 6-foot diameter dishes, with two 10-foot diameter dishes used where a very short tower or additional gain was required.

The antennas are fed with Heliax, a coaxial line using a helical dielectric to support the center conductor within the shield. Air spaces in the helix lower dielectric losses. Air pressure to prevent accumulation of dampness in these lines is obtained from a ¼-inch copper tube inserted into the air stream of the blower used for cooling tubes in the equipment racks.

Most towers in the system are between 200 and 400 ft. tall. Most district headquarters locations already had 300- or 400-foot tall towers before the microwave installation was made. They were used for supporting antennas for point-to-point and point-to-car transmissions, so microwave dishes were added to the tops of these. Additional guy wires had to be installed to prevent these towers from twisting, even slightly, in a horizontal direction, with resultant microwave signal attenuation.

The way the system is presently "wired," all channels appear at all stations in the system, with appropriate multiplex equipment at each station to read out the channels intended for that particular station.

Most of the stations in the northern part of the state, installed earliest in the development of the system, have narrowband equipment with a capacity of 24 voice channels. The baseband of these units goes up to 160 kc. The remainder of the system has wideband equipment, with the baseband extending to 600 kc. and with a capacity of 96 voice channels, of which 24 are now in use.

A rerouting of two legs of the system now underway will effectively split the stations in the north half of the state from those in the south half. This will permit channel frequencies used in one half of the state to be reused in the other half of the state, giving the system added capacity without modification of equipment. The two halves will still be linked by the General Headquarters switchboard.

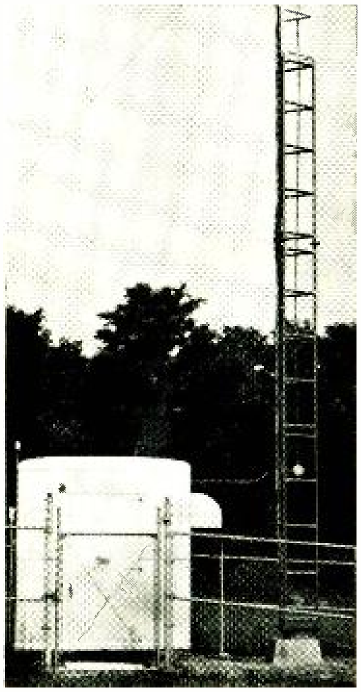
This switchboard, fully automatic, resembles telephone PBX boards and performs the function of "calling up" the intended stations when a call is initiated, either by voice or teletypewriter.

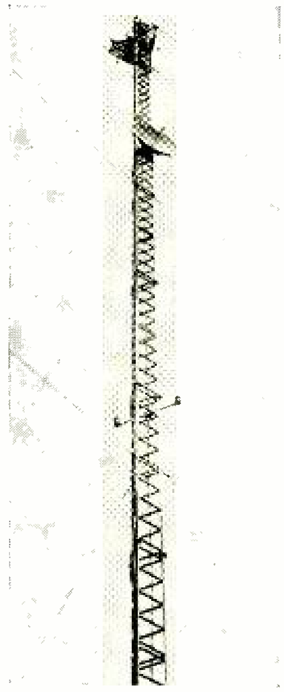
Voice terminal units, except for the dispatch channel, are conventional *Stromberg-Carlson* telephones with 10-digit dials. Teletypewriter call selection is done by coded pulses actuated by teletypewriter keys.

All repeater and terminal stations throughout the system have standby receiver-modulator units, transmitters, and power supplies, and have motor-generator units which are switched in when a commercial power failure occurs. At all unmanned stations and most manned stations, this switching is done automatically.

Many of the motor-generator units use propane rather than regular gas, eliminating the problems of stored gas becoming stale and the varnish accumulation in carburetors.

(Left) Unmanned repeater station, one of 14 used to cover distance between posts and district headquarters locations, is housed in this small structure. Both the building and the gate are kept locked and equipment inside can signal General Headquarters of the Indiana State Police of an illegal entry. (Right) Antenna towers such as this, most of them 300-400 ft. tall, can support microwave dishes. At post or district headquarters locations, they also support ground-plane antennas for communications with police cars and other agencies.





Batteries for all motor-generator units are kept on trickle chargers, insuring full power for starting.

In addition to telephone desk or wall sets for radio operators and command personnel, each post and district headquarters location and the General Headquarters radio room has a Teletype machine, with both keyboard and punched tape sending capability, and a *Remington Rand* "Synchrotape" typewriter.

The "Synchrotape" machine can be used as a tape perforator for preparing tapes for later Teletype transmission. Such messages can include tabular or spaced materials which will reappear in its original form after being transmitted by teletypewriter and fed through a "Synchrotape" machine at the receiving station.

In addition to all communication modes already mentioned, there is an additional channel in use at three locations in the state for a special purpose peculiar to certain areas. At these locations, there are local shielding problems, so-called "dead spots," which make it difficult for troopers to maintain radio contact with their post or district headquarters on the 42.26-mc. car-to-base frequency.

In such locations, a 42.26-mc. receiver at an unmanned microwave repeater feeds this signal by microwave to the nearest post or district headquarters location, as the case may be.

Formerly this relay function was handled by a different type of automatic unmanned repeater at an elevated location in the "dead spot." This repeater converted the modulation of the 42.26-mc. signal from a police car to a specially assigned frequency in the 453-mc. police band which in turn was monitored at the nearest district headquarters location.

Possible Future Uses

It's easy to see the Communications Section of the Indiana State Police has done a thorough job of utilizing modern microwave techniques to solve the specialized problems of a state-wide police organization. Several additional ways in which the existing system could be used have been considered but not put into use because the need doesn't exist as yet.

One possible future use of the microwave network would be the transmission of facsimile. The department experimented with facsimile between General Headquarters and Pendleton on the first leg of the system shortly after it was installed. Officers hoped they could transmit fingerprints with this system, but the photographic image resolution possible with equipment then available was insufficient for the use of standard-size police fingerprint file cards. Photographic enlargements had to be made to get the required detail. Handwriting and typewriting samples from questioned documents, as well as pages of printed information for use by policemen, presumably could also be transmitted this way if better equipment is developed.

Data bits for computer use could easily be transmitted, but the need for this type of information has not yet developed in Indiana. Officials say if drivers' license and vehicle registration data is someday stored in a computer memory device, the microwave system could be used by men in the field to obtain needed information much more quickly and accurately than the present manual filing system.

A very dramatic use for the microwave net would be as a state-wide alarm. ISP communications personnel say this could be done by linking the microwave system to the 42.42-mc. transmitters used at each post and district headquarters location for communicating with patrol cars. In the event of a serious crime requiring action by officers over a wide area, the information could be simultaneously broadcast from a single point (either General Headquarters or any post or district headquarters) to all other stations and state police cars throughout the state. This would really be an appropriate use for that old Hollywood B movie line—"Calling all cars!" ▲

AUDIO LEVEL CLIPPERS & LIMITERS

By THOMAS R. HASKETT

Survey of circuits used in communications, recording, and other audio areas to prevent overload, improve signal-to-noise ratio, and reduce interference.

THE wide dynamic range of the human ear—120 db. or about a trillion to one in power—is far too great to be handled by most electronic circuits. Thus, in many areas, such as two-way communications, public-address, recording, and broadcasting, it becomes necessary to restrict volume levels. The advantages are prevention of overload and distortion, better signal-to-noise ratio, and minimum interference to other services. Many devices are used, with each designed to suit a particular need.

Peak Clippers

Where clearly understood speech is the only desirable quality—as in AM two-way communications—certain liberties can be taken. For instance, in ordinary speech, vowel sounds contain a lot of power, but they are *not* what causes you to understand words. Consonants *are;* and even though they contain little power, they are the key to intelligible speech. If you alter the speech waveform to decrease vowel power as you increase consonant power, you will obtain greater intelligibility. The speech may sound unnatural, but you will be able to understand it. And most important—you'll put more audio in the listener's receiver for the same carrier power.

The clipper-filter. Operating instantaneously, the clipper chops a speech waveform when it exceeds a certain amplitude. This limits volume, although it also introduces a lot of harmonic distortion. But distortion can be filtered out so it isn't transmitted. Fig. 1 illustrates clipper function. As *V1A* cathode swings positive (below the value of its plate voltage) the tube conducts until cathode and plate potentials are equal. Current flow through the combined load resistor *R4*, couples the signal into *V1B*, where it appears across *R2* and the output. During the input signal's positive peak, when *V1A* cathode is positive with respect to its plate, current flow through *V1A* is nil, and no signal is coupled to *V1B* or to the output. During the negative half-cycle, increased current flow through *R4* causes a voltage drop equalling the applied plate voltage. Since *V1B* plate is no longer positive with respect to its cathode, conduction through *V1B* ceases and the negative peak does not appear in the output. Hence, both positive and negative peaks are clipped at a level established by *R3*.

Typical clippers provide up to 20 db clipping. Much distortion is generated (by square-wave action) and this is usually removed by a pi-section filter, together with small values of coupling capacitors, as shown. Thus frequency response of the average two-way communications system is about 300 to 3000 cps.

Automatic deviation limiting. In FM two-way radio, overmodulation is not possible in the same sense as in AM. But channels are few and crowded and FCC rules limit deviation to avoid mutual interference and to increase talk power. Therefore, FM communications transmitters use the clipper-filter described previously. Only the name is changed, it's now called automatic deviation limiting (ADL).

Peak Limiters

Where fidelity of reproduction is desirable, as in recording and broadcasting, the peak clipper obviously can't be used. The original signal waveform must be preserved, to minimize

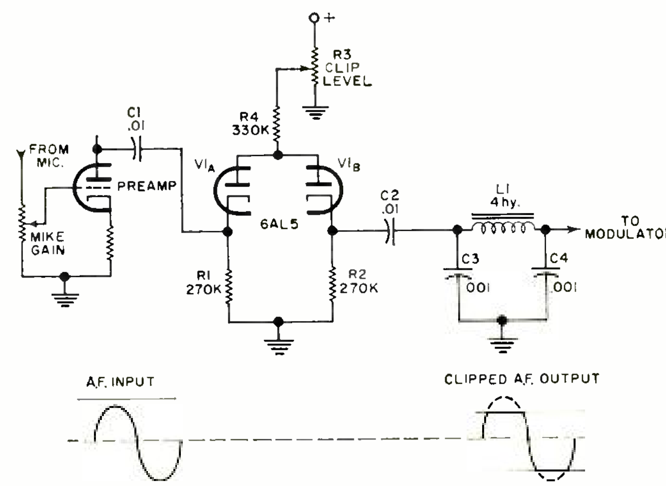


Fig. 1. Example of one type of simple clipper-filter circuit.

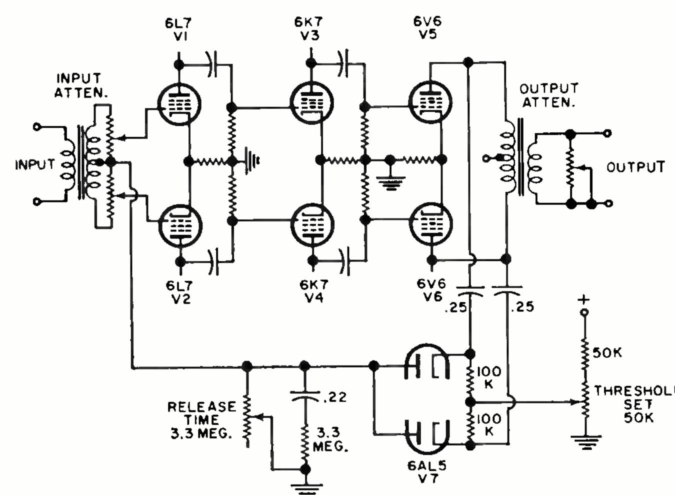
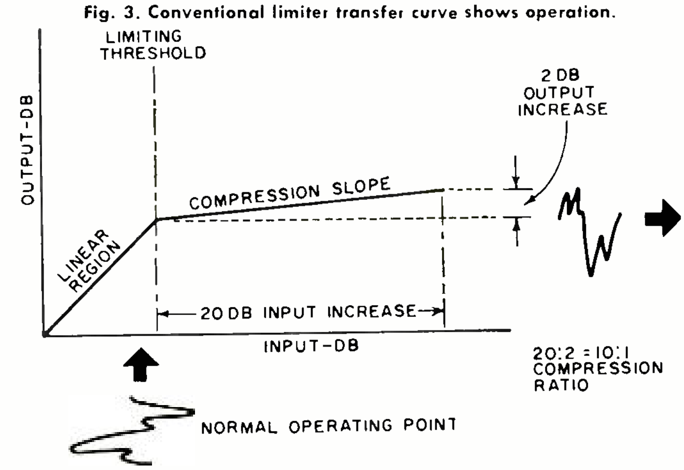


Fig. 2. Conventional peak-limiter circuit is all push-pull.

Fig. 3. Conventional limiter transfer curve shows operation.



the distortions that would be produced if the peaks of the original waveform were chopped off.

The standard limiter. Fig. 2 illustrates the circuit, push-pull throughout. The first stage is variable-gain, the other two are fixed gain. The output signal is rectified by control diodes *V7* (made full-wave to provide limiting even on asymmetrical waveforms) and the resultant d.c. furnishes control bias for the first stage. To establish a limiting threshold, *V7* receives cathode bias so it won't conduct until signal exceeds this value. Below threshold, all signals are amplified linearly. An *RC* network in the control-voltage line sets attack and release times.

Below threshold, a limiter's output is directly proportional to input, as in Fig. 3. Above threshold, output is much reduced for input increases. (No limiter is perfect, and there is always *some* slight rise in output for an input increase.) The relation between input and output variation is called compression or limiting ratio. If the input increases by 20 db and the output by 2 db, the ratio is 10:1. When a peak hits the amplifier, it takes time for limiting to occur. This is called the attack time. When the input signal drops below the peak, more time elapses before the gain returns to normal—this is called release time. While a fast attack is preferable to prevent overload (a few milliseconds is common), release time depends on desired action. Half a second to several seconds is found on most units. Fast release is used on voice and on pop and jazz music, but slow release is better for classical and religious music. A compromise circuit is often used; single, short peaks trigger fast release, but a long peak or a succession of short ones causes slow recovery.

The R.F.-A.F. limiter. Developed recently by *General Electric*, this circuit is used to overcome thump and motorboating problems. Incoming audio from the preamplifier is converted to r.f. sidebands at the balanced modulator, and the carrier removed. Gain-controlling action takes place only for these sidebands, which are then detected by a synchronous detector. Thump, hum, and other transients induced in the limiting process can't be passed on with the signal, for the detector is insensitive to everything but r.f. And with the input signal controlling output, rather than the other way around, there is no danger of motorboating. A constant-amplitude, 10-mc. carrier is produced in the r.f. unit and supplied to both the modulator and the detector.

Recovery time depends on program material. A slope control and delay bias control establish the limiting threshold so that control voltage increases as input signal increases. A program-controlled recovery diode receives fixed cathode bias to provide a 6-db platform above threshold. In this region, recovery time is long. Above 6 db, recovery time is fast for short-duration peaks, but long following a succession of short peaks. Hence rise and fall of background noise with speech is minimized.

The variable-frequency limiter. In recording and FM broadcasting, a 75-μsec. pre-emphasis curve is used, which boosts the highs and provides a better signal-to-noise ratio. Unfortunately, this causes problems. When a limiter is used ahead of the cutter head or transmitter to raise average level, high-frequency audio is boosted by pre-emphasis and may overdrive and distort. If the limiter is used *after* pre-emphasis, occasional program material may contain excessive highs, which will cause limiting of the highs, the mid-range, and the lows, although the latter two may not need limiting. The result is an unnatural-sounding decrease in gain.

Recent limiters cope with this problem by adjusting the gain to fit high-frequency program content. In other words, if the input audio contains only normal highs, response is flat. But if high-amplitude, high-frequency signals occur, response is rolled off by a 75-μsec. de-emphasis network, the reverse of transmitter or cutterhead pre-emphasis. Hence, you can maintain a high modulation level without overload or distortion.

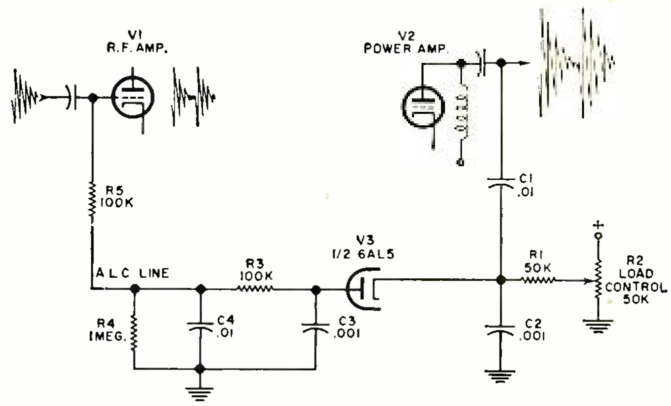


Fig. 4. Automatic load control systems are often used in SSB transmitters. This is similar in operation to receiver a.g.c.

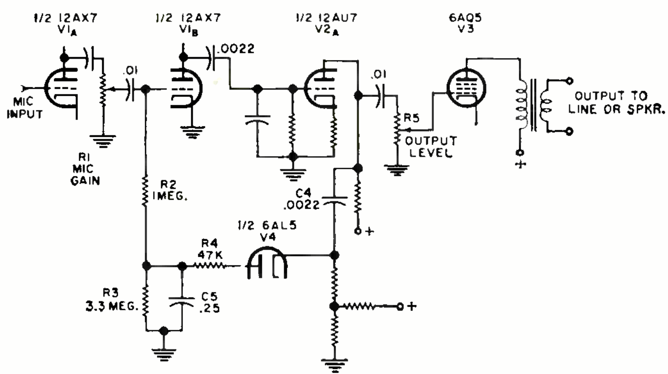


Fig. 5. The single-ended compressor is often used in communications. However, this system generates harmonic distortion.

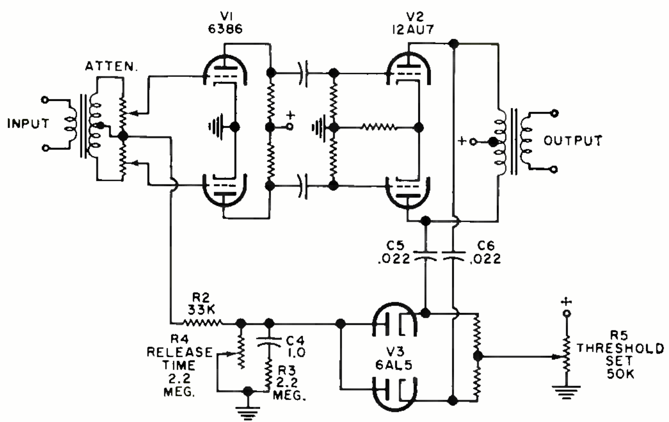
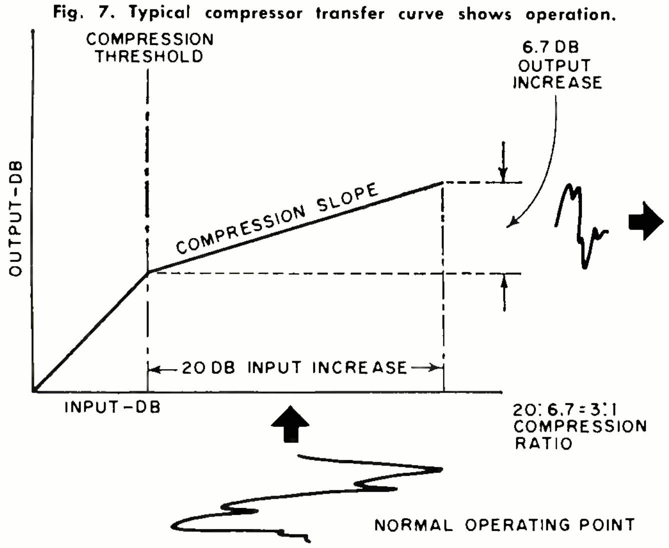


Fig. 6. Conventional push-pull, vacuum-tube type compressor.

Fig. 7. Typical compressor transfer curve shows operation.



Compressors

While peak clippers and limiters set ceilings on volume level, they do not raise the level of low-amplitude signals. Compressors do; they compress volume range by amplifying low level signals *more*, high levels *less*.

Single-ended vacuum-tube type. In single-sideband communications transmitters, automatic load control (ALC) is used, as shown in Fig. 4. Similar to receiver a.g.c., ALC consists of a feedback loop to an earlier r.f. stage. The power amplifier r.f. output is developed across capacitive voltage divider *C*1 and *C*2. *C*2's portion is rectified by *V*3 producing negative d.c. filtered by *C*3-*R*3. Charge-discharge time constants are established by *R*3-*R*4 and *C*3-*C*4, and the resultant d.c. becomes grid bias for *V*1. "Load Control" *R*2 establishes threshold for the ALC by biasing *V*3 cathode and no control voltage appears until the power amplifier's envelope peaks exceed this value. Beyond this point, *V*1 gain decreases to compensate for rising audio, maintaining envelope peaks at consistent level.

Distortion incidentally generated by this system is removed by the sideband filter between *V*1 and *V*2. Some SSB transmitters also use an audio a.g.c. loop, wherein control voltage is fed to an early a.f. stage for grid-bias purposes. This gives much tighter control over various talk levels.

Audio compressors occasionally employ the single-ended configuration in communications work. As shown in Fig. 5, audio output is rectified by control diode *V*4 to furnish grid bias for *V*1*B*, the controlled stage. However, the process generates harmonic distortion and is not compatible where fidelity is desired, as a filter must be used to remove distortion.

Push-pull vacuum-tube type. By employing the push-pull circuit of Fig. 6, harmonic distortion cancels in the output transformer. Such devices are widely used in public-address, background-music, recording, and broadcasting work. It is quite similar to the peak limiter, except that the limiter has fast and drastic gain-controlling action (average 1-msec. attack time, 12:1 compression ratio), while the compressor is an averaging device (24-msec. attack time, 3:1 compression ratio). By comparing Fig. 7 to Fig. 3 you can see the difference. The limiter operates *below* the knee of the curve, while the compressor operates above it. Hence, a limiter normally amplifies linearly and limits only on peaks; whereas a compressor reduces gain constantly, compressing high-level signals *more* and low-level signals *less*. This is also shown in Fig. 8.

Transistor type. When transistors are substituted for vacuum tubes in the standard push-pull compressor, circuit function is identical. However, a single-ended transistor compressor is available (see Fig. 9), which clips and compresses at the same time. When power is applied, *C*1 and *C*2 charge through *D*1 and *D*2, respectively. At this point they furnish bias to the diodes. When speech signals exceed this bias, the diodes conduct and their impedance is lowered by current passing through them. Since the diodes are across *T*1, the transformer primary impedance drops, attenuating the signal. But the waveform is rounded off and compressed more than clipped or chopped.

Shunt-diode type. From the above systems it is but a short step to the controlled diode of Fig. 10. Output signal, at a level set by *R*3, is amplified by *V*3*A* and fed in push-pull to *V*4. The balanced d.c. output of *V*4 goes to *V*5, the controlled-impedance diode. *R*4 adjusts static current through *V*5 to set a high impedance at *V*5 with no signal through the amplifier. When audio exceeds the level set by *R*3, d.c. through *V*5 lowers its impedance, attenuating the signal to *V*1*B*. Because this losser system is used, signal-amplifier stages run at constant gain, precluding trouble from harmonic distortion, thump, or instability.

Shunt-photoresistor type. This method, shown in Fig. 11, is the shunt-diode type using a light-sensitive losser. Incoming audio appears across "Gain" control *R*1, and *PC*1, a photoresistor, in parallel. The following stages are conventional and fixed-gain. Degree of compression is set by *R*2. The control voltage is then amplified by *V*3*A* and *V*4 and is fed to lamp *PL*1, which is close to *PC*1, within a shielded enclosure. When output signal increases, so does the control current through *PL*1. This causes an increase in brilliance, which causes a *decrease* in *PC*1 resistance. The result is an attenuation of incoming audio. As above, the resistive compression method prevents distortion or thump during gain reduction.

Special Circuits

A number of devices exceed the simple, standard systems

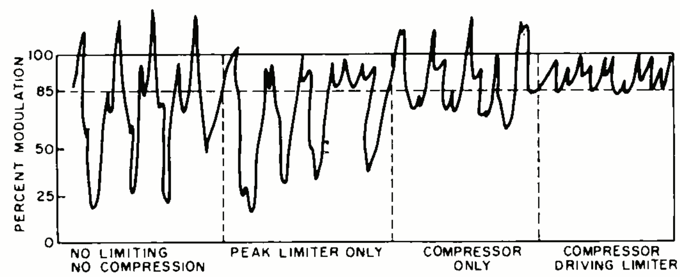


Fig. 8. Operation with both limiter and compressor action.

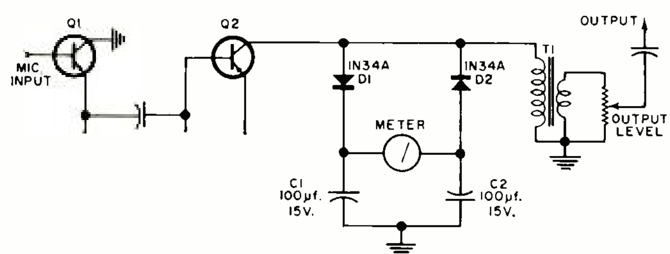


Fig. 9. Single-ended transistor clipper-compressor circuit.

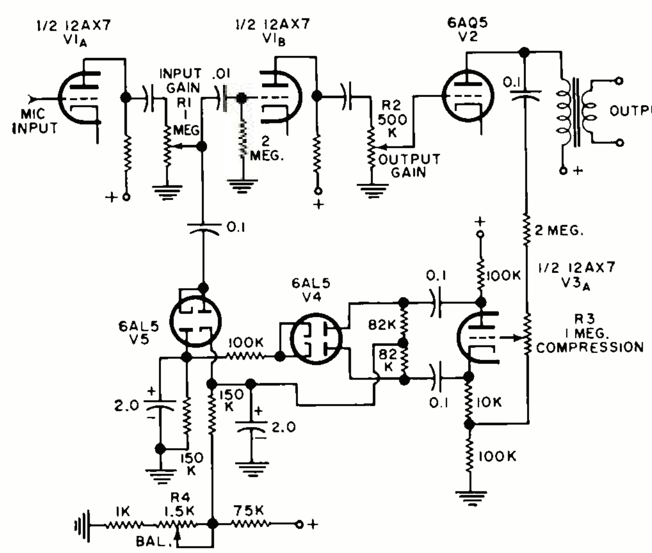
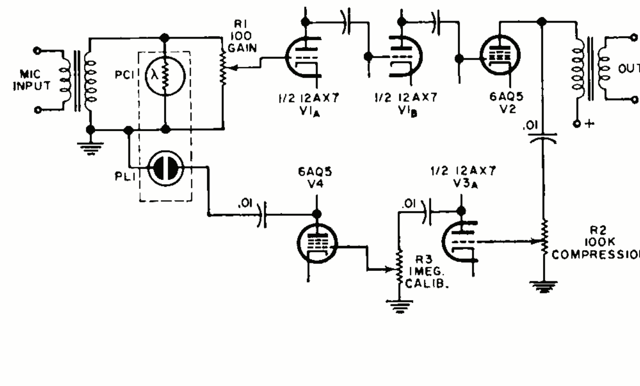


Fig. 10. Typical shunt-diode compressor uses losser system.

Fig. 11. This compressor uses a shunt-photoresistor approach.



described. Each further refinement is made to suit a specific application.

AGAMP (*automatic gain adjusting amplifier*). Developed for wire and radio telephone work, AGAMP is a syllable-controlled, variable-gain, speech amplifier with an input range of 40 db, an output variation of 4 db, and a bandpass of 250 to 3000 cps. High-level signals are compressed, and low-level signals are expanded. Furthermore, gain-increasing action occurs *only* on speech—not on noise. And at high input levels, gain-increasing action is fast; while at low levels, it is slow.

Fig. 12 illustrates AGAMP operation. The "Input Atten." and "Preamp." are conventional. Following these, speech signals pass through the "Variolosser" and "Output Amplifier."

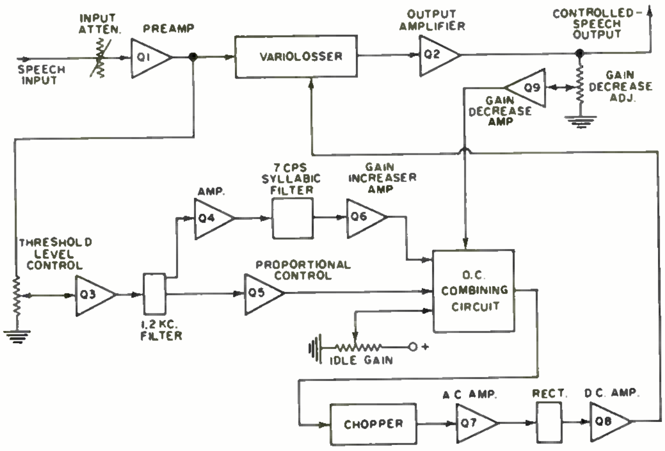


Fig. 12. Automatic gain adjusting amplifier (AGAMP) operation.

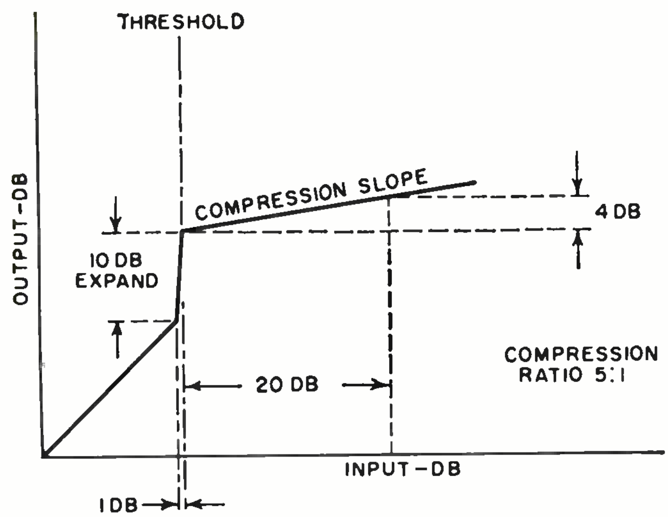
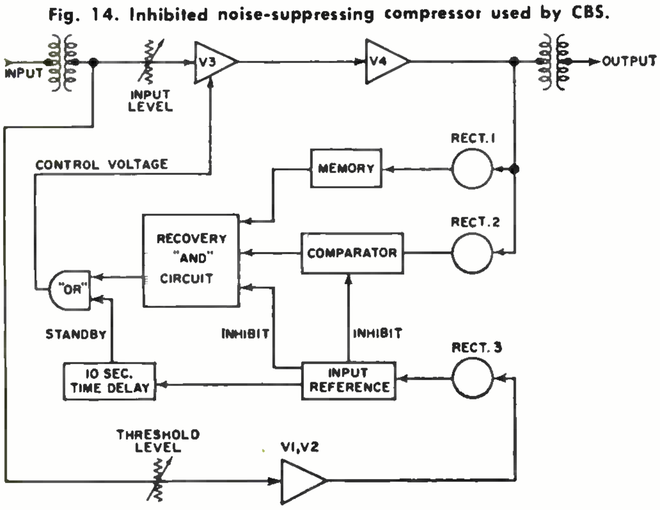


Fig. 13. Typical noise-suppressing compressor transfer curve.

Fig. 14. Inhibited noise-suppressing compressor used by CBS.



The "Variolosser" is simply an 8-diode bridge, the impedance of which is varied by control current, thus attenuating speech signals.

Control is by feeding a portion of the "Preamp." output to the "Threshold Level Control," which sets the point at which gain-increasing action occurs. (Most speech is above threshold and noise below; hence signal-to-noise ratio is bettered here.) Speech signals then pass through another amplifier to the "1.2-Kc. Filter," which restricts control-voltage sampling to speech frequencies, rejecting high- and low-frequency noise. Then the "1.2-Kc. Filter" output is split. One line is further amplified and fed to the "7-cps Syllabic Filter," restricting output to speech syllables. This line is passed through the "Gain-Increaser Amp.," rectified, and furnished to the "D.C. Combining Circuit" for use in controlling the "Variolosser."

The other output of the "1.2-Kc. Filter" is amplified by the "Proportional Control" (PC). This circuit furnishes, to the "D.C. Combining Circuit," control voltage of the opposite polarity to that from the "Gain Increaser Amp." But, there is no output until a difference between AGAMP input and output signals exists. Where this is so, PC output is proportional to that difference. Hence PC permits gain to increase for signals at threshold, but as signal level rises, amplifier gain decreases. At nominal input level, PC inhibits gain-increasing action. PC also contains a time-delay circuit. At low input levels, the time required for a signal to reach full output level is great (16 syllables); at high input levels, this time is much less (1 syllable).

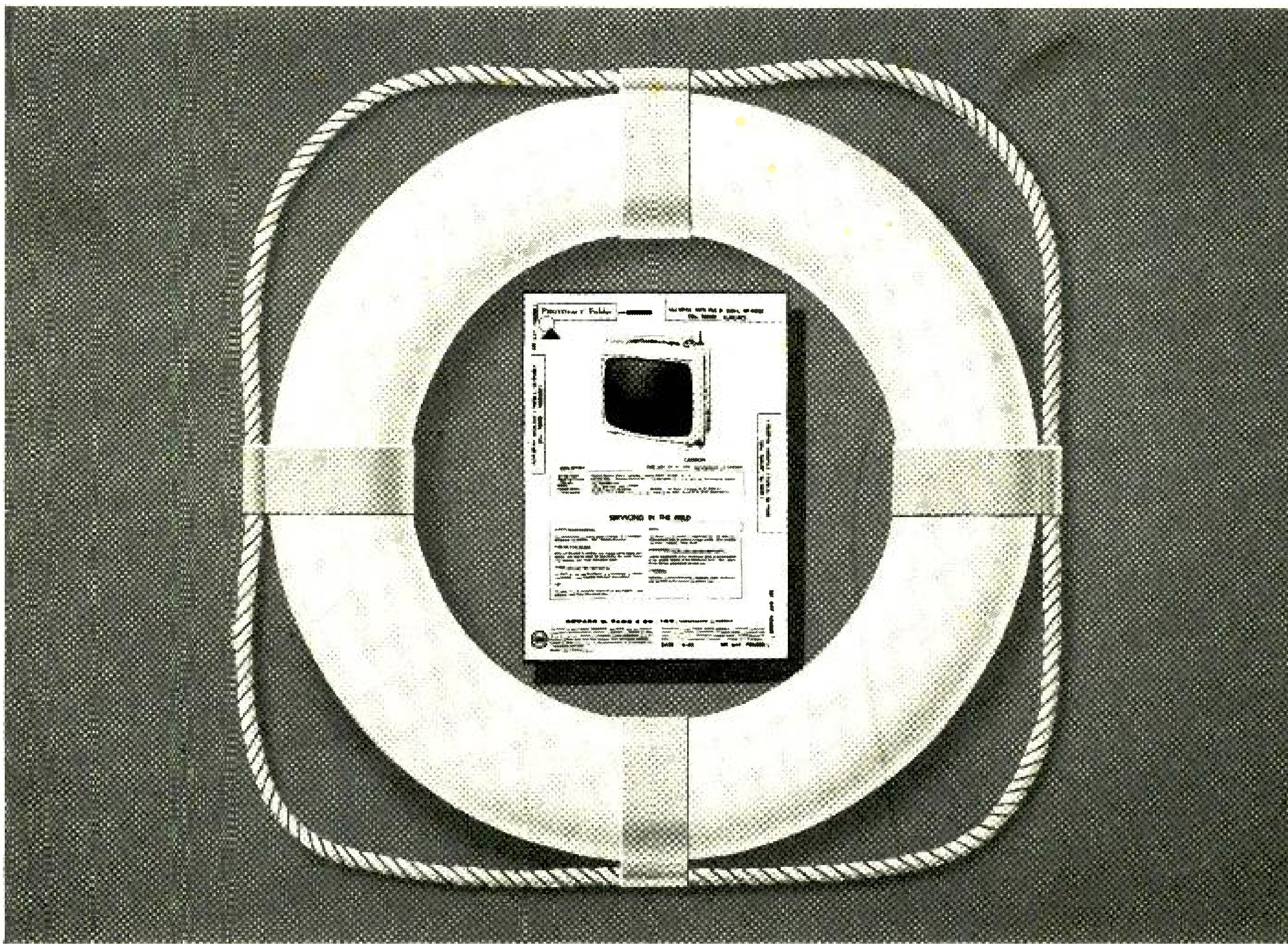
The "Idle Gain" adjusts static operating gain, by furnishing fixed d.c. to the "D.C. Combining Circuit." The "Gain Decreaser Amp." is a conventional volume-limiting feedback loop across AGAMP output. This circuit contains no filters and therefore functions on all output signals (including noise) to prevent overload of following equipment. The "D.C. Combining Circuit" output is chopped, amplified, and rectified (to avoid instability problems inherent in d.c. amplifiers), then fed to the "Variolosser," to control impedance and signal level.

Compander. Another common device in voice circuits is the compressor-expander. In this type of circuit, a conventional compressor restricts dynamic range of input signals, following which this compressed audio is fed to wire lines or transmitters. Since the signals are compressed, they may be handled much closer to the upper limits of amplifiers without danger of overload, thereby raising the signal-to-noise ratio. At the other end of the line, an expander reverses the process. Incoming speech reaches the amplifier while some input voltage is rectified and used to control variolosser attenuation, thus increasing gain. The output signals are restored to their original dynamic range.

Noise suppression and gain control. In recording and broadcasting, the usual combination of a compressor driving a limiter produces a problem. During pauses in program material, the gain-control circuits increase background noise objectionably. To overcome this, several devices provide for differentiating between noise and program material. Unlike AGAMP, these circuits must handle both speech and music, without impairing fidelity or frequency response.

One circuit combines a compressor and an expander and Fig. 13 shows its transfer curve. Note the knee in the curve. Below the threshold, amplification is linear, above the threshold, signals are expanded into the compression region. This provides 10 db signal-to-noise isolation, when program material is above threshold. Background or studio noise is thus held behind voice or music.

Another device, developed by *CBS Laboratories*, compresses average audio slightly over long periods of time (10 seconds or so). Instantaneous peaks are still limited, where they do not exceed one second. This establishes a compression platform, which follows mean (*Continued on page* 85)



JOHN FRYE

Technical know-how is important but "packaging" your skill is equally important if you hope to become truly successful.

SHOWMANSHIP IN SERVICING

"SOME people really slay me!" Barney exclaimed, throwing down the nut-driver he had been using to tighten chassis bolts on a radio.

"What brings this on?" Mac, his employer, inquired.

"Last night I stopped in at my cousin Harry's for a look at his new color set. It was working beautifully, but you should have heard him gripe. And do you know what about? He was bellyaching because the service technician who came out to set up the receiver used a cracked service mirror in making some of the purity and convergence adjustments!

" 'Here I pay seven hundred clams for that color set,' says my cousin Harry, 'and they send out a clown with worn-out equipment and a cracked mirror to adjust it. All that jazz the salesman gave me about how I was buying the finest color set, assembled in the most modern factory by the finest craftsmen, and then some dope goofs up the whole thing by squinting into a cracked mirror while messing with those little knobs!' "

"I told cousin Harry I knew the technician who did the set-up and that he was far from being a dope. I explained he only used the mirror for making rough adjustments necessary at the rear of the set and that the crack could not possibly make any dieffrence in these. Really critical adjustments were made with the technician looking directly at the face of the tube. But Harry wasn't buying. No one will ever convince him his color set is working correctly simply because the technician used a cracked service mirror. Doesn't it make you sick the way some customers will latch onto some unimportant action on the part of the technician or some irrelevant item of his equipment or appearance—something that has nothing whatever to do with his competence—and condemn his whole performance because of that one measly little nit-picking (quote) fault (unquote)?"

"Let's not hasten to condemn the customer for being hasty in condemning the technician," Mac suggested with a grin. "Take a look at things from his point of view. He's not a technician; so he can't be expected to know what's important and what's not in work done on his set. All he can do is fall back on things he *does* know something about: the neatness and cleanness of the technician, the appearance and quantity of his equipment, his professional deportment or lack of it, and his attitude toward his work. From observation of these things the customer forms an opinion about the technician that, right or wrong, is very important. It determines whether the technician will be called again, and it dictates what the customer says to his friends about the technician. The fellow who performed the set-up with the aid of a cracked mirror may be a cracker-jack technician, but he would be wise to put more showmanship into his work."

"Oh come *on* now!" Barney objected. "Don't tell me you're advocating that service technicians waste a lot of time going through useless hocus-pocus just to impress the customer!"

"Showmanship is not useless hocus-pocus," Mac said calmly. "Neither does it have to be cheap, misleading, unethical, or anything else of which you need be ashamed. Showmanship is simply presenting your wares, your abilities, or your message in the clearest and most effective light possible. The housewife calls on showmanship when she arranges a salad to appeal to the eye as well as the palate—and the meal is more enjoyable for her effort. Presidential candidates who put on makeup before appearing in front of TV cameras to debate great and serious issues are using showmanship."

"Guess I was a little offside," Barney grudgingly admitted. "I suppose there's nothing wrong with putting your best foot forward—and making sure the customer sees that foot. You got some specific ideas about how a service technician can use showmanship?"

"That I have. The basic idea is simply to convince the customer of your ability, your preparation, and your good intentions as far as fixing his set is concerned. You want to impress him subtly but unmistakably on all three counts. There should be no need to mention neatness and cleanliness. If the technician needs to be told about these matters, he's in the wrong business. No one wants a dirty, unkempt man in his living room, no matter how much he knows about electronics. If he doesn't care about himself, it's pretty hard to believe he cares about anything else.

"But cleanliness and neatness should extend beyond his person to include his equipment. We know a grease-smudged meter face and frayed test leads have nothing to do with the accuracy of the meter's readings, but the customer does not know this. For his benefit, test equipment should always look shining-new and show evidence of having been treated with tender, loving care. Obviously, a cracked service mirror is out!

"This brings up another point. Some technicians pride themselves on being able to perform a high percentage of home service calls with only the aid of a v.o.m. They are making a mistake. You would not be favorably impressed by a garage that had only a screwdriver, a monkey wrench, and a ballpeen hammer in the way of tools, now would you? The technician who employs a minimum of instruments is not impressing the customer with his superior technical ability. The idea being planted is that you need to invest very little money in equipment to do service work!

"When a technician carries in a full tube caddy, a neatly arranged tools-and-parts kit, a tube tester, a v.o.m. or v.t.v.m., and complete service data on the customer's black and white receiver, he is announcing without actually saying a word: 'See; I've spared no expense to equip myself completely to service your set.' Moreover, with the equipment right at hand, the technician will find real use for most of it. The tube tester will spot marginal tubes otherwise overlooked and possibly causing a call-back. Reference to the service data will save time in identifying adjustments, locating check points, and even in replacing tubes in blind sockets. As more and more work is performed in the home, fewer and fewer customers ever see the equipment we have here in the shop; so it's increasingly important they be shown we're not 'screwdriver mechanics.' After they catch a glimpse of our fragile and expensive equipment in operation, they will be better pre-

prepared to pay a reasonable service charge."

"You said something about the technician's attitude toward his work. Where does showmanship get into that?"

"I think we both know technicians who try to impress others with their technical sophistication by down-grading practically every receiver they work on. They snarl at flimsy printed circuits and at hard-to-remove tubes. They are contemptuous of small speakers, light cabinets, and production shortcuts of any kind. When you see them in action, you get the impression they suspect the set manufacturer, the set itself, and maybe even the customer of being in league just to annoy and frustrate them.

"Now this is no good. Criticizing a customer's set hacks away at his pride of possession and impugns his judgment in buying the receiver in the first place.

"A smart technician keeps disparaging opinions of the receiver to himself. He works in a cheerful, unhurried, thorough manner; and he shows respect for the customer's receiver by the careful way he handles it. Whenever possible—which is practically always—he notices and corrects small defects in the performance of the receiver the customer has not seen for himself. I mean things like improper centering, slight pincushioning, poor linearity, slightly noisy sound, or poor focusing. He conveys the impression he likes service work and is a perfectionist. Incidentally, if you need to be convinced of the importance of seeming happy at your work, just notice the determined smiles on the faces of commercial givers, singers, and even acrobatic dancers on TV. And remember performing artists are old hands at showmanship."

"It seems to me all this showmanship is designed simply to improve the image of the service technician," Barney suggested.

"If you insist on using a word that's becoming a little fly-blown, yes," Mac agreed. "The picture that pops into the average man's mind when he hears 'service technician' might be called an image, but that image is very likely to look exactly like the fellow who fixes the average man's TV set. Building an image is an integrating process very similar to building the vertical sync pulse in a receiver. The image is composed of all the individual technicians with whom the public comes in contact. Only when these technicians present uniform high quality impressions will those impressions add together to produce a satisfactory image. That means all of us must be constantly and keenly aware of the impression we are making on our customers. We must build our own image. No copywriter can do it for us."

After a little pause, Mac continued with a grin: "I was just thinking of a good example of what showmanship can do for a technician. A few years back we had a real radio nut in this town. Norm was a young bachelor who ate, drank, and breathed electronics. He was so busy studying and experimenting with electronics he had little time for anything else. He seldom combed his hair; his clothes were usually missing a button or so; it seemed he always needed a shave. He ran a little hole-in-the-wall service shop to keep from starving, and he worked for practically nothing, but he did know his electronics.

"Finally a girl saw something in him others missed and married him. They moved away, and I did not see him for four or five years; and when I did see him I scarcely knew him. He was neat as a pin, well-dressed, driving a fine car; and he had a very responsible well-paying job with an airways company. That girl had used showmanship to repackage the electronic know-how inside Norm, and there were plenty of takers."

"I get the message!" Barney interrupted. "All I have to do if I want to succeed is to brush my teeth, keep smiling, and get married. I'm not sure it's worth it!" ▲

Largest Radar Telescope

(*Continued from page* 45)

protection from the high winds, the reflector surface is guyed down so that its tolerance is ± 1 inch.

Electronics

The transmitter used in this installation has an output of 2.5 megawatts peak and 150 kw. average power. It is also capable of transmitting a 100-kw. c.w. signal for special purposes. Shaping and timing circuits enable the operator to tailor the transmitted pulses to any desired values.

Operating frequency is presently limited to 430 mc. with a stability better than 2.5 parts in 10^{9}. This frequency was chosen because it best suits the needs of the present observations. At some later date, other frequencies will be added.

As the actual transmitter and receiver are located alongside one of the support towers, the transmission waveguide is over 500 wavelengths long and consists of about 1300 feet of waveguide. Total run from the transmitter to the antenna is about one-third of a mile with system attenuation less than 1.8 db.

The receivers are equipped with two low-noise front-ends to permit reception of both horizontally and vertically polarized signals simultaneously. Each includes a parametric amplifier, low-noise r.f. stages, crystal mixer and a 30-mc. i.f. amplifier. The remainder of the system is located within the operations building. ▲

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Electronic Switch

(*Continued from page 39*)

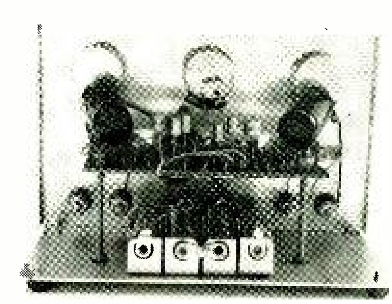
To compare amplitudes of the signals shown in Fig. 5, left, set both attenuators to provide equal gain by simultaneously applying one of the signals to both channels and adjust for a superimposed waveform. Then remove the connection from one of the inputs and connect the other signal. When it is necessary to determine which channel is which, momentarily disconnect one of them. Waveform differences are most apparent when the two signals are superimposed as in Fig. 5, right. Here, the distortion of an amplifier is being checked. The sine wave is the input and the distorted wave is the output.

If there is a phase difference between the input and output, it will look something like Fig. 6, left. Here the phase difference between the signals is 90°. Phase difference can be calculated with the following formula: $\theta = (C/D) \times 360°$. θ is the phase difference, D is one wavelength, and C is the fraction of a wavelength between corresponding peaks of the two waves. In Fig. 7, left, the frequency of the lower signal is twice that of the upper signal. This is obvious as there are twice as many cycles on the lower channel as on the upper. Note that the frequencies must be related by an integral ratio. The more complex the ratio, the greater the difficulty in interpreting results.

Fig. 7, right, shows how a third signal can be simultaneously compared with the other two signals. The third signal is fed into the horizontal deflection amplifier of the scope. The upper signal is 90° out-of-phase and the lower signal is in-phase with the horizontal signal. The switch produces a 180° phase shift, therefore the lower pattern is opposite to what it would be without the switch. The oscilloscope used for the photos has an upward and left deflection for positive input signals.

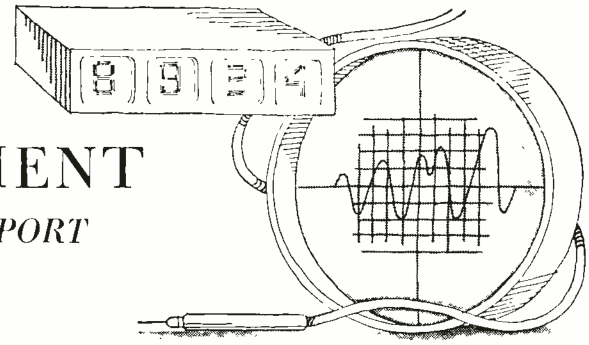
Fig. 6, right, shows the switch overloaded. This, however, is deliberate. Within the available range of attenuation, it will indeed be a large signal that cannot be sufficiently attenuated for an undistorted display. ▲

Fig. 8. Inside view. The author designed and built his own printed-circuit board.



TEST EQUIPMENT

PRODUCT REPORT



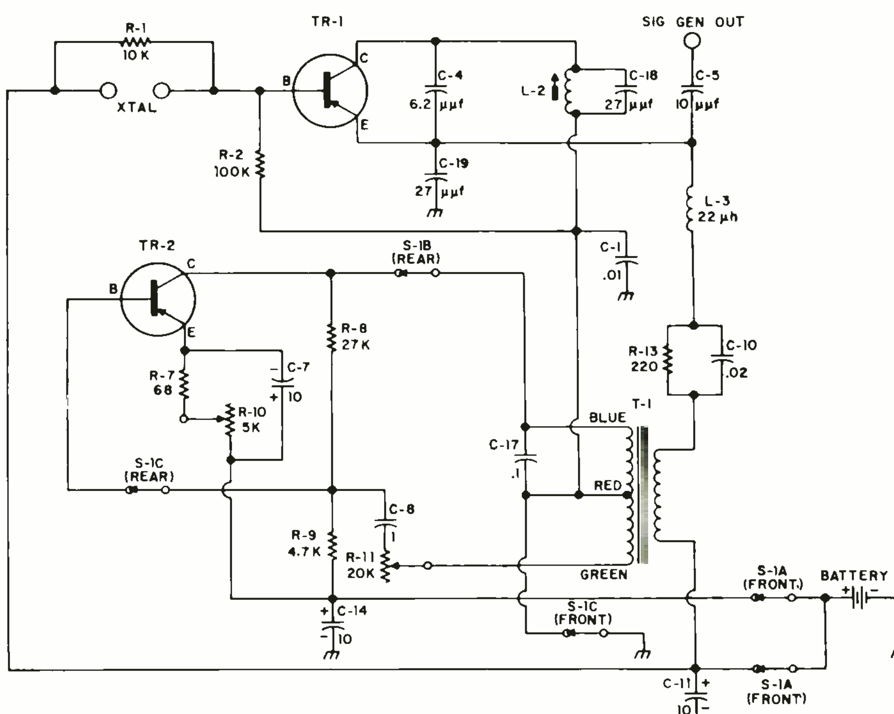
"Knight-Kit" Ten-2 CB Checker

For copy of manufacturer's brochure, circle No. 48 on coupon (page 15).

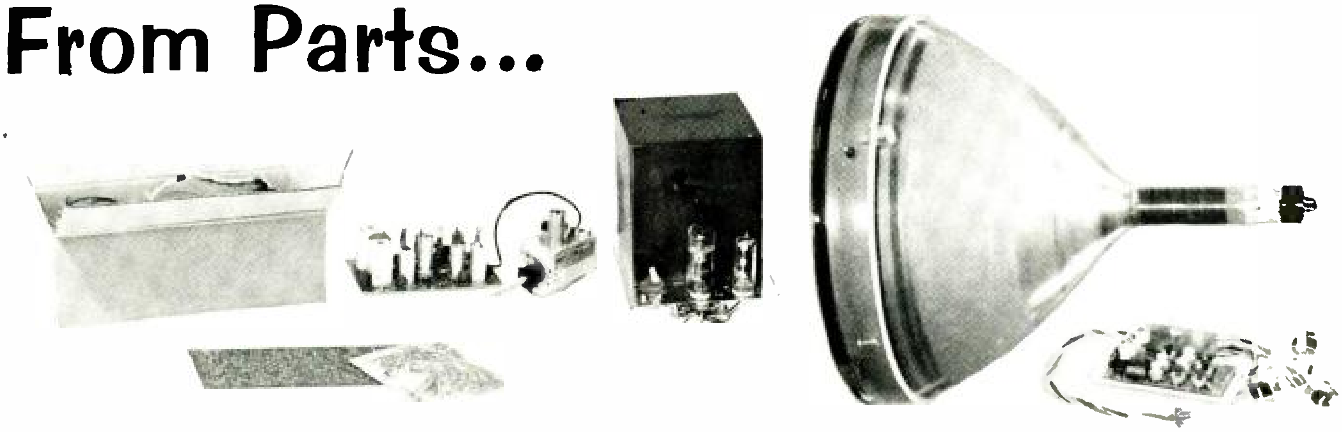
A HIGHLY versatile, multiple-purpose tester for the CB user and technician is the new *Allied Radio* "Knight-Kit" Model Ten-2. By using just two transistors, four crystal diodes, a 1-ma. meter, a multi-function switch, a handful of parts, and some ingenuity, the company has come up with an instrument that does just about everything for the CB-er.

The unit measures standing-wave ratios with the usual bridge circuit. (The antenna is one arm, while a pair of 50-ohm and a 51-ohm, 5% resistor are in the other arms.) It measures output power directly in watts using a built-in 50-ohm, 5-watt resistor. The audio-modulation signal is detected from the output of the CB transceiver for an indication of modulation percentage, both positive and negative. By using the built-in whip antenna, one of the diodes, the audio transistor, and meter, we have a field-strength meter and a signal monitor. To check crystal activity, we merely plug our crystal into the r.f. transistor oscillator circuit and read collector current.

The unit can be used to troubleshoot the CB receiver by providing an r.f. output signal (crystal oscillator using the r.f. transistor) that is modulated by means of an audio oscillator (using the a.f. transistor). Our schematic shows the arrangement used. The output of the audio oscillator is also available separately for signal-tracing the CB rig's audio stages. What is more, a key can be inserted into this circuit permitting its use as a code-practice oscillator. All in all, the tester performs no less than ten



From Parts...



To Picture In Just 25 Hours

Heathkit High Fidelity Color TV For As Low As $349

25 hours of relaxing, rewarding fun! That's all! And you've built the *new* Heathkit High Fidelity 21″ Color TV with the finest color circuitry, components, and performance possible today. Goes together quickly, easily. *No* special skills or knowledge required! So simple anyone can build it! You'll enjoy 21 inches of beautiful, high fidelity picture that reproduces every color naturally, realistically, faithfully... you'll enjoy high fidelity sound that's sharp, crisp, clean...and you'll enjoy features and performance comparable only to units costing 50% more!

Compare these Heathkit features with others: • 27 tube, 8 diode circuit with optional UHF • High definition RCA 70° 21″ color tube with anti-glare, bonded-face safety glass Automatic Color Control • Gated Automatic Gain Control for peak performance • 24,000 volt regulated picture power • Hi-Fi sound with outputs for speaker and hi-fi amplifier • Deluxe Nuvistor tuner with "push-to-tune" fine tuning for individual channels • 3-stage high gain video I. F. • Line thermistor for longer tube life and thermal circuit breaker for component protection • Degaussing coil and built-in dot generator for perfect picture adjustments • • All critical circuits factory-built and tested • Can be custom mounted or installed in handsome walnut cabinet • One year warranty on picture tube, 90 days on parts.

Save On Maintenance Costs! In addition to the initial savings you realize by building this set yourself, you'll save on expensive repair bills too. The simple-to-follow Heathkit instruction manual contains circuit diagrams and a "Servicing Hints" section so you can easily make adjustments and replacements should it ever become necessary.

Versatile Installation! The chassis, tubes, and front panel of the Heathkit Color TV can be mounted in the handsome GRA-53-1 walnut-finished hardboard cabinet. Or if you prefer, it can be mounted in a wall or custom cabinet, and the sound signals fed to an external amplifier unit. Required custom mounting space dimensions: 24-3/4″D x 22-1/4″H x 28″W. In this case the GRA-53-3 Custom Mounting Kit should be ordered to provide physical support between the chassis and front panel.

Optional UHF! An optional UHF tuner is available for coverage of channels 14 to 82.

Kit GR-53, chassis and tubes, 118 lbs. $349.00
GRA-53-1, walnut cabinet, 70 lbs. . . $49.00
GRA-53-2, opt. UHF tuner, 3 lbs. . . . $20.00
GRA-53-3, custom mounting kit, 10 lbs. $4.00

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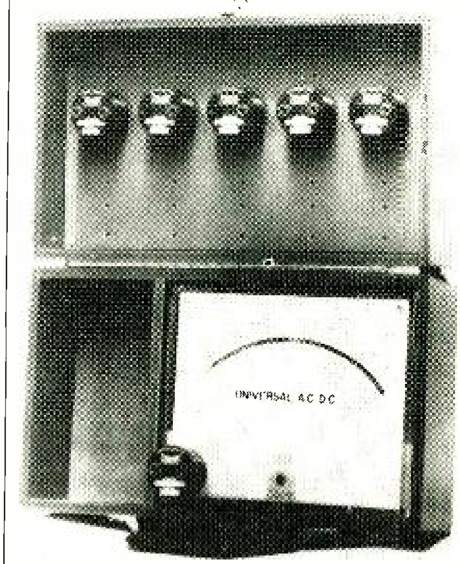
separate functions that are useful to the CB operator and technician. Over-all accuracy of the readings is about 10 percent.

The tester is completely portable and compact, measuring only 5⅜"x 7⅝"x 4¼" and weighing less than 4 lbs. The cabinet comes with a convenient carrying handle. The unit is operated by a single 9-volt battery that should last a fairly long time because of the low current drain. This battery can be checked by the tester itself; replacement is called for when the reading on the meter is below the "Batt" mark on the meter's power scale.

The assembly manual for the kit is extremely clear and easy to follow, while the operator's manual covers the various functions completely and analyzes each of the separate circuits incorporated into the tester. The Model Ten-2 is available from *Allied Radio* in kit form at $29.95, or factory-assembled at $39.95. ▲

A & M Instrument Model 1300 Universal Lab Standard

For copy of manufacturer's brochure, circle No. 49 on coupon (page 15).



THE Model 1300 performs a number of measurements at levels of precision ordinarily found only in single-function laboratory standards. The compact, lightweight, portable standard can be used for either a.c. or d.c. measurements as a voltmeter, ammeter, milliammeter, true r.m.s. voltmeter, and frequency meter. Accuracies from 1 percent full-scale up to 0.1 percent expanded scale are obtained.

The instrument gains its versatility by the use of *Expando* adapters, which change the scale ranges when plugged into the basic meter. Each adapter is designed to establish the desired end points for the various zero-based or expanded-scale ranges. The voltage, amperage, and frequency ranges are easily read on the wide 7-in. meter scale. This provides

high resolution and easy readability.

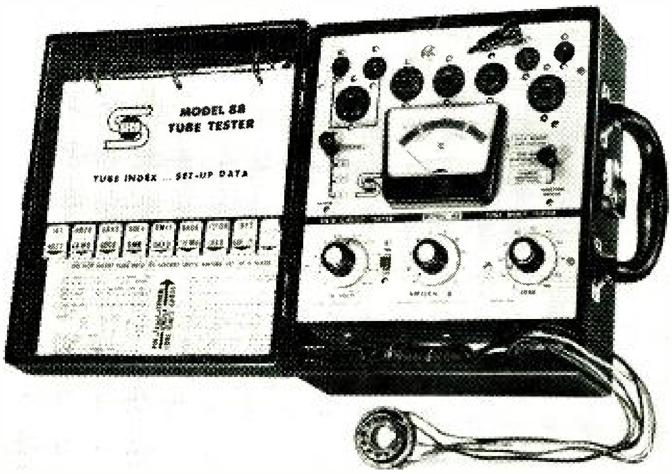
Expanded-scale plug-in adapters are available in standard ranges with center-scale values from 20 through 300 volts a.c., d.c. and true r.m.s. volts. Zero-quantity and expanded-scale adapters can also be plugged in for amperage ranges up to 10 amps full-scale. The standard adapters for frequency measurement are centered at 60 or 400 cps.

The expansion network consists of a balanced Wheatstone bridge using linear and non-linear elements. Coupled with appropriate resistors, the non-linear element (actually a zener diode) balances the bridge network at the desired low or starting voltage value. When the input exceeds the null value, the bridge goes out of balance, actuating the meter movement and causing the pointer to swing up-scale. A resistor is added to limit the meter deflection at the maximum value required.

The price for the basic meter and carrying case is $75. Single plug-in adapters are priced at about $25 for voltage, $37.50 for current, $42.50 for true r.m.s., and $60 for frequency measurements. ▲

Seco Model 88 Tube Tester

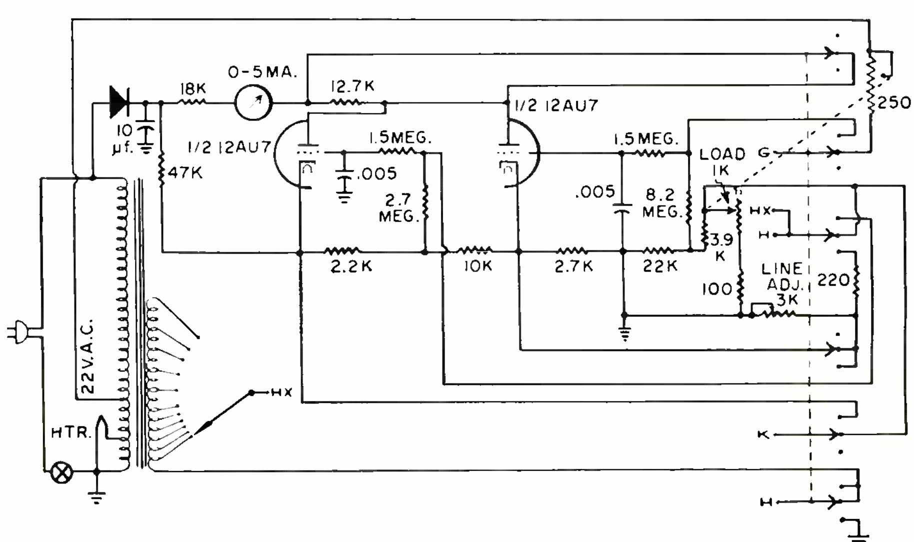
For copy of manufacturer's brochure, circle No. 50 on coupon (page 15).



THE *Seco* Model 88 is a compact tube tester designed to check modern radio, TV, industrial, and foreign tube types. As a new feature, it now includes tests for TV picture tubes.

The tube under test is introduced into a resistive bridge circuit. Various voltages are applied so as to yield information that is amplified by a 12AU7 tube (see circuit), whose output is metered. By using such a vacuum-tube meter circuit, very low test voltages (25 v. d.c. or 22 v. a.c., maximum) and current can be used. These eliminate shock hazard and the possibility of damage to either the tester or the tube being tested. This is particularly important when testing the new frame-grid types, which may easily be damaged by excessive voltages.

Three basic tests are available: (1) grid circuit; (2) tube merit; and (3) heater continuity. The patented grid-circuit test detects grid emission, reverse grid current, and evidence of gas content. Simultaneously it performs a compound inter-element leakage and shorts test. The tube-merit test applies 22 volts a.c. through current-limiting resistance to the tube elements. A tube emitting 65% of its rated emission will deflect the



meter into the "good" area. In the heater-continuity test, continuity will cause the meter to read "good."

The Model 88 comes equipped with a duodecal (12-pin base) picture-tube socket on a 20" cable that is wired for the above tests. With two universal socket adapters and the setup included in the flip chart, over 400 types of picture tubes can be tested, including the 110-degree deflection types.

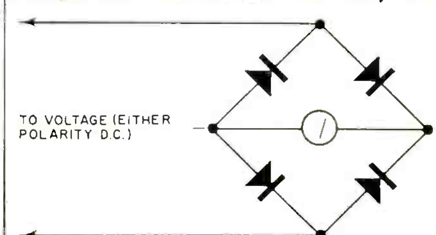
The tester is up-to-date for all receiving tubes including the new novars, nuvistors, 10-pin types, and compactrons. A detachable cover contains indexed set-up cards, pin straighteners, and operating instructions. Price of the Model 88 is $74.50. ▲

AUTOMATIC METER REVERSAL

By IRWIN MATH

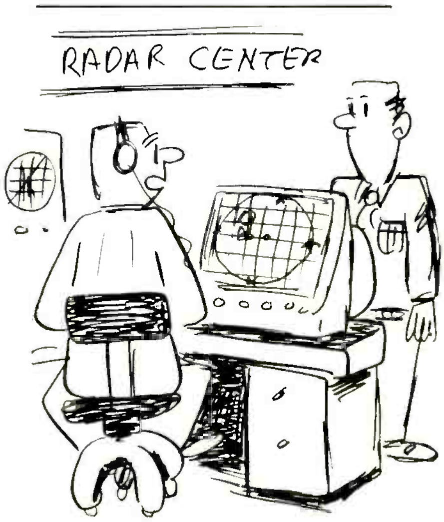
THERE are many instances when the polarity of a d.c. voltmeter has to be changed frequently. In such cases, a zero-center meter is usually used. This limits the available swing of the meter needle to only half scale. By using the circuit shown below, a common meter can be made to reverse automatically.

The meter is part of a four-diode bridge and conduction can only take



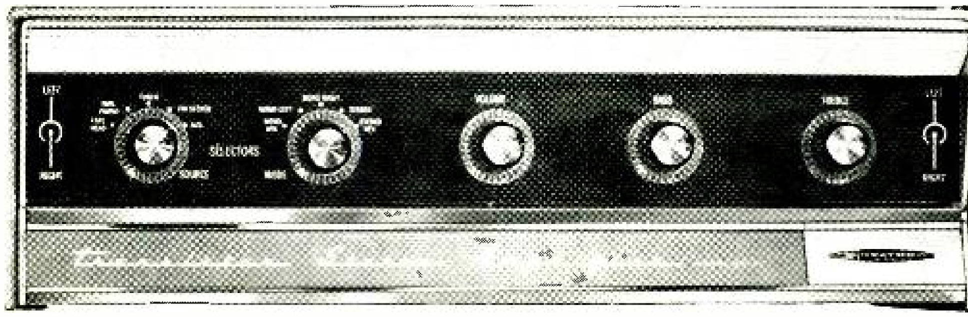
place in one direction through it. Irrespective of the polarity of the voltage to be measured, the meter will always read in the forward direction.

The diodes may be any silicon type that has the required breakdown. For meters up to 100 volts, 1N91 diodes can be used with good results. Linearity of the meter at voltages below 1 volt will depend on the diodes used. ▲

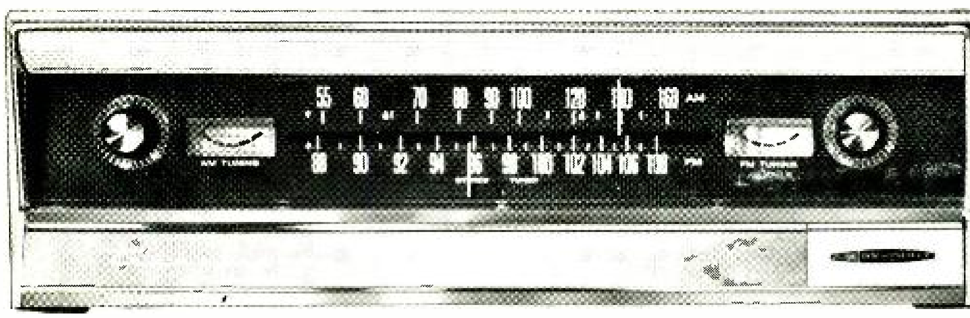


"Tell the Colonel his wife is coming in on the radar screen at ten o'clock with tow truck."

TAKE Heathkit's Deluxe Transistor Stereo Amplifier



ADD the Deluxe Transistor AM-FM Stereo Tuner



ENJOY Total "Transistor Sound" Performance

Each instrument with its characteristic sound reproduced realistically, faithfully, naturally. This is "transistor sound." No faltering, no fading, no compromising . . . just the quick, clean sound that only transistors can reproduce. You enjoy this totally different dimension in stereo listening with the *total* transistor performance of the Heathkit *deluxe* 70-watt Stereo Amplifier *and* matching AM, FM, FM Stereo Tuner.

Added performance features and luxurious decorator styling. You enjoy "extras" like the unique "push-push" off/on switch, concealed secondary controls to prevent accidental system changes, automatic switch-to-stereo feature of the tuner, and prebuilt, prewired encapsulated component modules in the amplifier for quick, easy assembly. You enjoy handsome matched tan vinyl-clad steel cabinet styling with polished aluminum trim and soft refracted lighting . . . complements any decor! Both units are easy to build . . . easy to own! Just a few of the reasons why you should move up to this all-transistor duo. Consider the AA-21 Amplifier . . .

Full 70 watts of continuous power, 100 watts music power at ±1 db from 13 to 25,000 cps. Additional features include 26-transistor, 10-diode circuitry for cool, "hum-free" operation, smooth power delivery, and fast effortless "transient response"; complete freedom from microphonics; front-panel mounted controls with 5-position dual concentric source switch, 5-position mode switch, and dual concentric volume, bass and treble controls; circuit breaker protection of output transistors and AC power; and encapsulated preamplifier circuits in 6 epoxy-covered modules, all factory wired and sealed, ready for easy installation. Check the AJ-43 Tuner . . .

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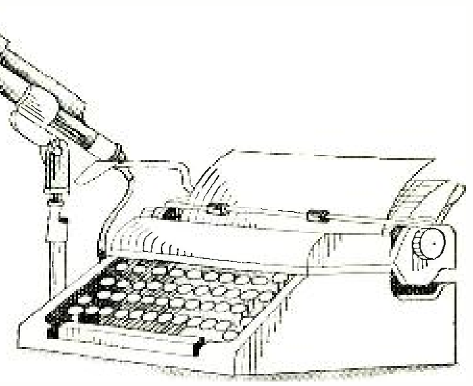
RADIO & TV NEWS



ONE of the major problems associated with some types of u.h.f. tuners and converters is the fact that the local oscillator acts as a low-power transmitter that radiates an interfering signal to a neighboring TV set.

The FCC has noted that operation of a set manufactured after Dec. 31, 1957 that does not have a label showing the unit complies with the radiation limits set down by the FCC is prohibited.

The level of this radiation was originally set at 500 microvolts-per-meter. However, a temporary grant of 1000 microvolts-per-meter has been allowed but will come to an end April 30, 1964, the date on which the all-channel TV law becomes effective.

The EIA will ask the FCC to extend the temporary 1000-microvolt radiation limit for one more year in order to give the industry time to test the widely held belief that the use of transistor tuners will reduce the radiation to the lower level sought by the FCC.

Recent laboratory tests strongly indicate that many present-day tube tuners cannot meet the 500 microvolts-per-meter radiation limits originally set down by the FCC.

During 1962, industry tests of 253 receivers using tube tuners showed that only 141 of them had radiation under 500 microvolts, while in similar tests conducted this year, only 110 out of 242 receivers were within the lower limit.

In a report on 11 sets using transistor tuners, only five were under the FCC 500-microvolt limit.

U.H.F. With Detents

All of the known u.h.f. tuners and converters on the market at this writing are continuously tuned; that is, there are no stops or detents to indicate when the tuner is at some particular channel.

During a recent visit to the midwest, we dropped in at *P. R. Mallory & Co.* to view some of their latest developments, including a detent-type u.h.f. tuner.

Using a rotating-wiper, tuned-line approach, *Mallory* engineers have come up with a simple-looking mechanical detent device that permits customer adjustment of the six detents provided. Other detents can be added as required.

The unit feeds the 40-mc. i.f. of any conventional v.h.f. TV set and uses a diode mixer and transistor local oscillator to provide a noise figure of about 12 db and image rejection of about 35 db. Because of the mechanical arrangement, the tuner can be remotely operated.

Smaller and Smaller

Looking at the innards of a present day multi-transistor radio or TV set, one wonders if it is possible to get any more parts in such a small space.

Some recent developments in thin-film techniques makes it look like the only service problem in future will be just to determine which module is at fault, then replace it with a good one. The faulty one is thrown away. Probably no more effort than replacing a tube.

For the uninitiated, thin-film techniques are similar to making smoked glass using a candle flame to deposit a layer of soot on the glass. If you place a mask on the glass before sooting, then when the mask is removed, only the silhouette remains. Instead of using a candle flame, various materials can be evaporated in a vacuum and deposited on a substrate (base material). Masks are used to delineate the desired pattern.

Such microminiature circuits came closer to reality as a result of developments made at the Army's *Harry Diamond Labs.*, where laboratory engineers recently fabricated and operated a pair of 30-mc. i.f. amplifiers made from vacuum-deposited thin-film conductors, resistors, capacitors, and an inserted coil and transistor. The amplifiers had power gains of 15.1 and 14.7 db, with a bandwidth of 10 mc.

The thin metal-film resistors are expected to be more stable than conventional screen-printed carbon composition types and the thin-film capacitors were made using a dielectric layer of silicon monoxide with aluminum electrodes.

The significant accomplishment of this work lies in the substitution of vacuum-deposited, thin-film resistors, conductors, and capacitors for the conventional printed and inserted parts.

When active elements such as semiconductors can be fabricated by thin-film techniques, and a complete thin-film circuit made, the potential of these devices will be realized. ▲

MINIATURE REGULATED POWER SUPPLY

By JOHN POTTER SHIELDS

Economical regulated power supply for small current drains also features variable voltage output level.

ORIGINALLY designed to fill the gap between simple gaseous VR tubes and the more expensive lab-type regulated power supply, this miniature unit is physically small enough to be included in a larger piece of equipment, yet it offers the advantages of variable voltage output (110-250 v.), superior regulation as compared to VR tubes, inherent electronic filter action, and a regulated current output to over 40 ma. The neon reference lamp can be mounted on the front of the chassis to serve both as a pilot light and regulation monitor.

Fig. 1 is the schematic of the complete power supply. The power transformer *T1*, in conjunction with *V1*, supplies pulsating d.c. which is smoothed by *C1*. *V2A* and *V2B*, the pentode and triode sections of an ECL-82, serve as series regulator and d.c. amplifier respectively. The ECL-82 is originally intended to be used as a voltage amplifier and power output stage in compact audio amplifiers. *PL1* is a NE-2 neon lamp enclosed in a pilot light housing, and serves to stabilize the voltage at the cathode of *V2B*.

In operation, the pulsating d.c. output from *V1*, smoothed somewhat by *C1*, is applied to the plate of the series pass tube *V2A*. The cathode of *V2A* is connected to the positive output terminal of the supply, so that *V2A* is effectively in series with any load connected to the output terminals. The operation of *V2A* can be understood if one considers it as instantaneously variable resistor. When the control grid of *V2A* is made negative with respect to its cathode, it will appear as a very-high resistance and, as such, will pass very little current. As the control grid is made less negative, *V2A*'s effective resistance will decrease and it will pass more current. Thus, the resistance and therefore the amount of current passed by *V2A* is dependent upon its value of control grid bias.

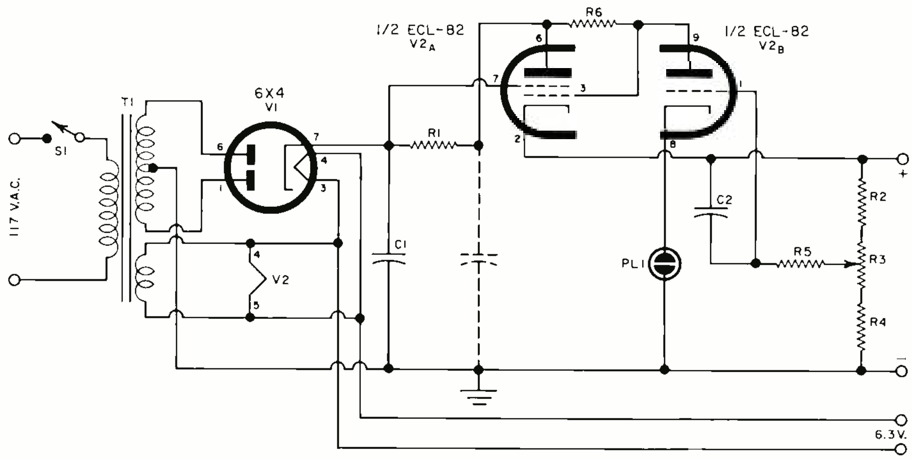
A voltage divider, consisting of *R2*, *R3*, and *R4*, is connected across the output of the supply. By means of this divider, the slider of *R3* "samples" a portion of the positive output voltage and applies it, through isolating resistor *R5*, to the control grid of d.c. amplifier *V2B*. Neon lamp *PL1* holds the cathode of *V2B* at a fixed positive voltage with respect to ground.

Assume that the load connected to the output terminals suddenly draws more current. This will cause a drop in positive voltage at the supply output terminals. This drop in voltage appears at the slider of *R3*, and hence at the grid of *V2B*. The tube "sees" this decrease in positive voltage as an increase in negative grid voltage *with respect to its cathode* and, as a result, its plate current will decrease. This will decrease the voltage drop across its plate load resistor *R6* and its plate voltage will increase. Since the control grid of the series "pass tube" *V2A* is directly connected to the plate of *V2B*, as the positive potential of *V2B* increases, so will the control grid voltage of *V2A*. The effective resistance of *V2A* will now decrease and more voltage will be available at the supply's output terminals.

The same effect, in reverse, occurs if the load current decreases. *V2B*'s control grid becomes less negative with respect to its cathode and its plate current increases. This increases the voltage drop across *R6* and *V2B*'s plate voltage becomes less positive, decreasing the positive grid voltage on *V2A*. *V2A*'s resistance now increases and the voltage supplied to the load drops.

Capacitor *C2* serves a very important purpose. Any ripple voltage appearing at the output terminals is coupled by *C2* to the control grid of *V2B*. Since the action of the regulator is just about instantaneous, it sees the ripple voltage as a change in output voltage, and responds accordingly. The effect of this is the elimination of bulky filter components for equivalent filtering.

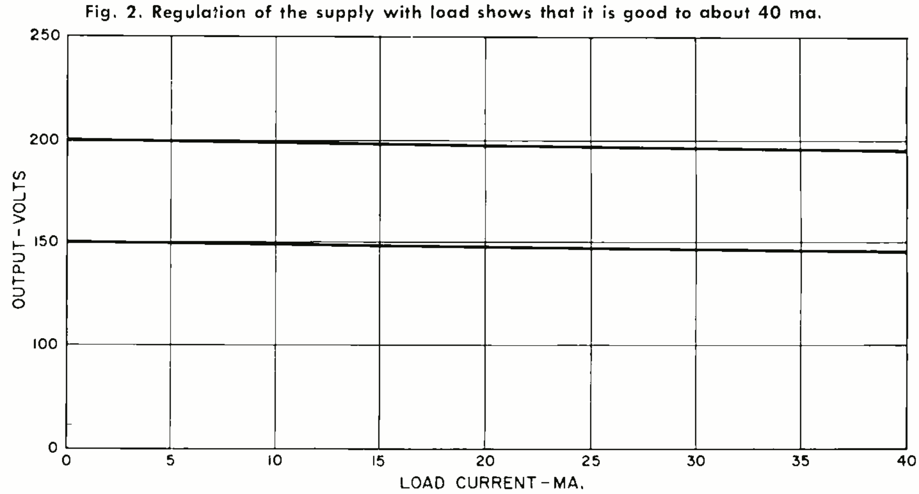
Fig. 2 shows regulation performance of the supply. The output voltage will vary less than 5 volts from no load to a



R1—250 ohm, 5 w. wirewound res.
R2—39,000 ohm, ½ w. res.
R3—100,000 ohm, linear-taper pot
R4—33,000 ohm, ½ w. res.
R5—150,000 ohm, ½ w. res.
R6—270,000 ohm, ½ w. res.
C1—20 μf., 350 v. elec. capacitor
C2—.1 μf., 600 v. paper capacitor
PL1—NE-2 neon lamp
T1—Power trans. 240-0-240 v. @ 60 ma., 6.3 v. @ 2.75 a. (Stancor P-6348 or equiv.)
S1—S.p.s.t. toggle switch
V1—6X4 tube
V2—ECL-82 tube

Fig. 1. Schematic and parts list. Dotted capacitor is for optional extra filter.

Fig. 2. Regulation of the supply with load shows that it is good to about 40 ma.



load of 35 ma. at 200 volts output. At 40 ma., the output voltage is down just 5 volts from its no-load level.

Between zero and 30 ma. output current, the supply will deliver an output voltage anywhere from 110 to 250 v. depending on the setting of *R*3.

The output ripple voltage is less than 3 mv. for load currents less than 5 ma. Ripple increases to 5 mv. at 20 ma. This increase in ripple could be reduced at higher current levels by using an additional filter capacitor as indicated by the dotted lines in the schematic. Capacitance should be the same as *C*1.

The 6.3-v. heater winding is brought out to terminals on the 4-screw terminal strip. Neither side of this winding is internally grounded as some applications require a floating heater supply.

When the unit is completed, check the wiring to make sure that all is in order. Set the voltage control *R*3 to the "minimum voltage" position (towards *R*2), and connect the line cord to a source of 117-v.a.c. Switch the supply on. After about 30 seconds, the NE-2 should light, indicating that *V*2*B* is drawing current. Connect a d.c. voltmeter (250 v.) across the output terminals. With the voltage control in the minimum position, the meter should read approximately 110 v. There may be a slight variation due to tolerance variations of the components. As the voltage control is rotated, the output voltage should now increase. If your unit operates in accordance with the above checks, you can assume that all is in order.

The supply will tend to drop out of regulation under certain conditions of high-voltage and high-current output. The panel-mounted reference tube *PL*1 is a handy indicator for this, as it will go out as soon as the supply drops out of regulation. ▲

MORE CB-ERS IN TROUBLE

THE FCC has announced the apparent liability for forfeiture of $100 each on 15 CB class D station licenses and one ship station license.

Those involved in the latest crackdown include: Herbert M. Harris, Grantsboro, N.C.; David L. Morgan, Los Angeles; Thomas J. Zimmerman, Mays Landing, N.J.; Leroy Quillman, Milpitas, Calif.; J. M. Middlebrooks, Lithia Springs, Ga.; Nash Carlisle, Baltimore; Roger P. Grider, Long Beach, Calif.; Johnny Tuggle, Atlanta, Ga.; Junior Lee Bowling, Rome, Ga.; John H. Thorpe, Buena Park, Calif.; James P. Bryant, Lynchburg, Va.; Bruno F. Sangtinette, Jr., Metairie, La.; Paul Schmal, Atlantic City, N.J.; Earnest C. Fortenberry, Cleveland, Tenn.; and John F. Orvis, Pacific Palisades, Calif. for Ship Station WL-5149.

All except Tuggle, who was cited for communicating with other CB stations contrary to the rules of Sect. 19.61 (a), have failed to respond to official notices and are subject to the monetary forfeitures. ▲

Transistor Power Amplifier

(Continued from page 35)

4 to 16 ohms (see Fig. 4). Above 16 ohms the supply voltage of the amplifier acts as a gate, imposing a limit on the maximum peak-to-peak signal at the output terminals. On the other hand, below 4 ohms the maximum current supply of the amplifier is restricted by the saturation resistance of the output transistors and the capabilities of the power supply. This is done deliberately to improve the amplifier's ability to withstand an accidentally shorted speaker load.

Figs. 5 and 6 show the distortion characteristics of the amplifier. They are not materially different from those of vacuum-tube amplifiers and therefore do not explain the superior tone quality of the instrument. This improvement, however, can be explained by Fig. 7 showing the damping factor and Fig. 8 showing the amplifier's square-wave response at 20 and 20 kc. The low tilt of the 20-cps square wave and the sharp and clean rise of the 20-kc. square wave indicate exceptional phase linearity. Together with the high damping factor at the extremes of the audio spectrum, these characteristics, not matched by commercial vacuum-tube amplifiers, explain the tight and transparent sound capabilities.

Service Hints

When servicing a transistor amplifier, it is urged that a number of simple practices be observed. The accidental shorting of a voltage point to ground by a probe or a screwdriver may cause damage to a transistor. Rule 1, therefore, is to make all meter connections while the amplifier power is turned off.

When troubleshooting, it is advantageous to disconnect the bases of the output transistors. After the difficulty has been corrected, the output transistors can be reconnected. This may save costly replacements.

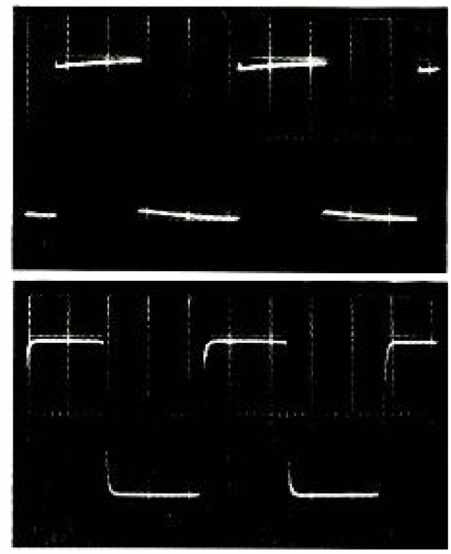


Fig. 8. The square-wave response at 20 cps (above) and 20 kc. (below) into 8-ohm load.

When checking the amplifier for proper operation, it is important to keep in mind that a transistor is inherently a current-amplifying device. Therefore, the best way of checking the correct operation of a transistor is by measuring its emitter current. This can be done by checking the voltage across the emitter resistor. The proper emitter currents are indicated on all our schematics.

Listening tests indicate a substantial improvement in the listening quality of both high- and low-efficiency speaker systems. Since the sound quality of a speaker system is prone to be one of subjective judgment, it is best to leave the selection of an appropriate speaker to the prospective listener. It should be kept in mind, however, that only a high-quality reproducing system will be able to develop the full potential of a transistorized amplifier. ▲

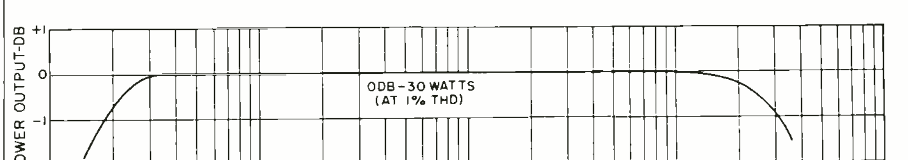
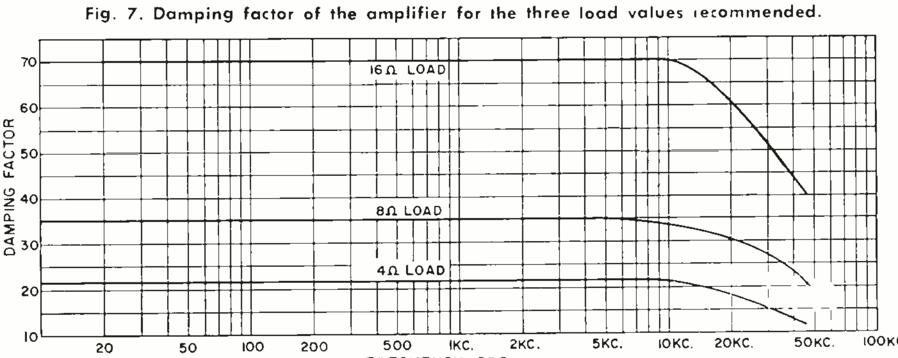


Fig. 6. Power response of the amplifier at 1 percent total harmonic distortion.

Fig. 7. Damping factor of the amplifier for the three load values recommended.



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INEXPENSIVE D.C.-VARIABLE INDUCTOR

By RUFUS P. TURNER

A pair of miniature transistor driver transformers may be connected together to form saturable reactor.

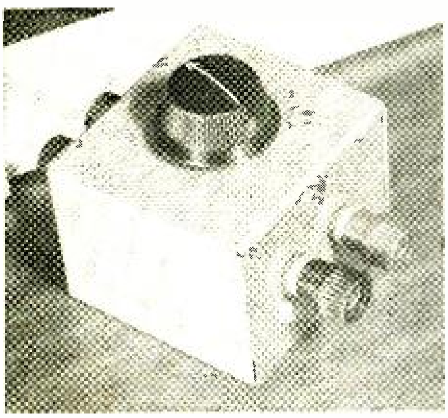
TWO miniature transistor driver transformers may be connected to provide an inexpensive saturable reactor and with low d.c. input the inductance may be varied from 2.8 to 20 henrys. The d.c. resistance is 800 ohms. Fig. 1A shows the arrangement in which the 20,000-ohm primary windings are connected in such a way that any a.c. induced in the two 1000-ohm windings is cancelled and does not appear in the battery circuit. The transformers are *Lafayette* No. AR-104, although the same principles could be applied to other transformers.

A 3-volt battery (two size D flashlight cells in series) supplies adjustable d.c. to the secondaries as the control winding through a 10,000-ohm, 5-watt TV-type rheostat. Fig. 1B shows variation of inductance from 2.8 to 20 hy. as current is varied from zero- to 20-ma.

The parts are conveniently mounted in a 2" x 2¾" x 1⅝" aluminum utility box. Any convenient shield can also be used.

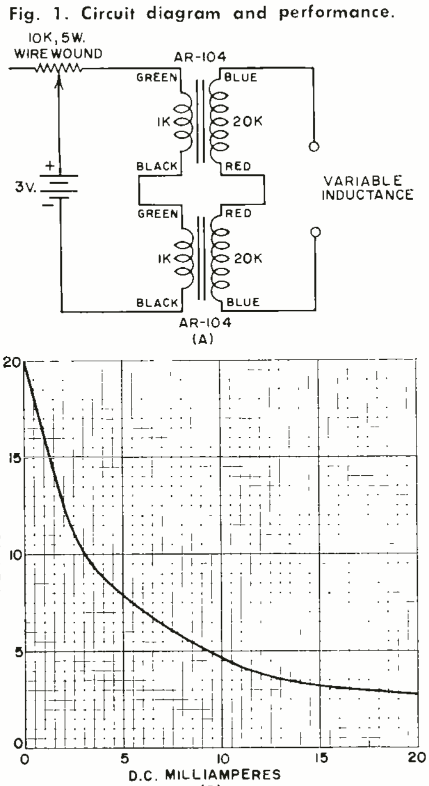
There are many obvious uses for a small variable inductor of this sort having the high inductance and better than 7:1 range it provides. One of these is the audio-frequency *LC* circuit tuned by varying *L*. Fig. 2A shows such a circuit used to peak the response of an a.c. v.t.v.m. or oscilloscope as a bridge null detector. The 0.003-μf. mica capacitor allows the circuit to be peaked to 1000 cps with 5-ma. control current. As shown in Fig. 2B, the 0-ma. peak is 640 cps and the 10-ma. peak, 1500 cps.

The same circuit has been employed as a d.c.-tuned audio-frequency meter with the rheostat dial calibrated in cps and various capacitances switched in to change bands into the 20-15,000-cps range. The variable inductor has also been used in a bridged-T network in a feedback-type bandpass amplifier. ▲



Parts are mounted in small utility box.

Fig. 1. Circuit diagram and performance.



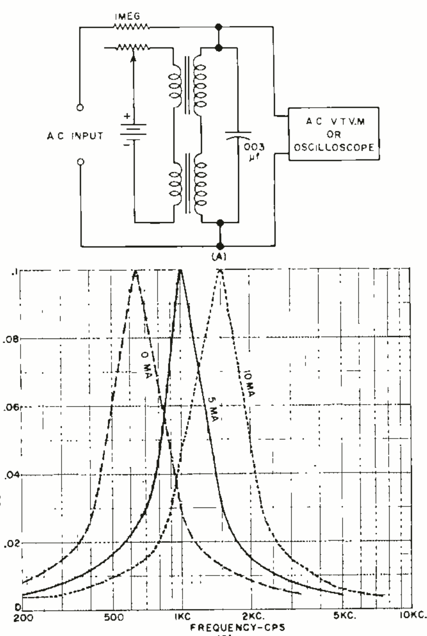


Fig. 2. Null-detector circuit application.

Transistors vs Tubes

(*Continued from page 36*)

waves are not reproducible in even the most professional audio equipment much less audible to the human ear. It should be noted that, although square-wave tests with resistive loads are useful for initial evaluation, actual loudspeaker loads may adversely affect the performance and alter the square-waves.

Important Qualities

It is extremely important in any given bandwidth that everything remain distortion-free and linear throughout this range whether sine waves, square waves, or transients are being reproduced. First, the amplifier should satisfy the most basic requirements of the classical tests of total harmonic distortion and, especially, intermodulation distortion. The lower the distortion percentages, the better. This test should also be made at low volume levels and under dynamic speaker loading. Second, square-wave response should be carefully evaluated for peaking and disturbances rather than merely for rise time or tilt. This should also be checked with speaker loads.

Third, the overload characteristic or recovery time of the amplifier, although very difficult to measure, should be checked. What happens to the amplifier after the drum beat or the crescendo? Will the amplifier still be linear immediately afterwards, or will it take a few fractions of a second to recover its initial bias setting? Direct-coupling helps minimize this recovery time and so does good power-supply regulation. Fourth, damping factor is extremely important especially at the peaks in the frequency response of the loudspeaker where it has a tendency to resonate. We have found by careful listening that improvement results from increasing the damping factor to 50 from a damping factor of 10—a figure usually considered to be good. Although the difference was barely perceptible in some loudspeakers, it was quite apparent in others and tone-burst tests, along with oscilloscope pictures, confirmed our listening judgment. This type of testing under speaker loading is what we consider to be the real test of transient response and distortion.

Power and Rating

There have been several problems associated with transistor power amplifier design as well as in its specification with regard to load impedance and output power. In high-efficiency circuits, where class B and AB operation are used, little or no power is drawn or dissipated in the transistors at no-signal conditions because the transistors in the output stages are at or near cut-off. As signal is applied, one transistor and then the other will take over the job of producing the signal. The crossover point is generally non-linear and will normally produce distortion at low power levels. It is therefore important to check distortion at low levels as well as at high levels in this type of circuitry. Large amounts of feedback at all frequencies in the audio band will reduce such distortion.

The output transistors normally used for high-power outputs (on the order of 50 watts per channel) are also capable of being used as switches in other types of circuit, handling power on the order of 1000 watts. It is therefore possible to obtain from most transistor amplifiers double the power output simply by halving the load impedance. An amplifier rated at 25 watts at 16 ohms, for example, would produce 50 watts at 8 ohms, 100 watts at 4 ohms, and so on.

However, the audio amplifier is not a switch but the controller of a power source supplying more or less power and at frequencies dependent on the input program material. At best the transistor amplifier is about 50% efficient, dissipating as much power in the output transistors themselves as power delivered to the load. It is therefore understandable that this cannot go on indefinitely and some limitation must be set as to what minimum impedances may be used. In addition, some form of protective device should be used to protect the transistor in the event of misuse or accidental shorts.

There are two major causes of transistor failure. Both are based on excessive power dissipation. The first is more gradual and is caused by overrating or by misuse due to loading the amplifier with lower impedances than recommended. Our protection circuit was designed with this in mind, reducing the power abruptly when loaded with impedances less than 8 ohms. The second type of failure occurs when excessive current is passed through the transistor at high voltage levels. Very intense localized heating takes place, fusing the junctions within the transistor. This type of failure, known as "secondary breakdown," can occur within a few microseconds and generally produces a totally short-circuited transistor. The reason this is a more serious problem is that this type of failure can be triggered by overloading inputs—as occurs when accidentally dropping a needle on a record. The rapidity of such failures requires us to use an all-electronic circuit in order to prevent such failures.

Our opinion of the transistor components currently available is much the same as our opinion of any other component. There are good ones and there are bad ones. A specification sheet never tells the whole story, nor does an advertisement. It is only through deliberate and careful evaluation that the customer can obtain what he is seeking. ▲

MINIATURE VOLTAGE REGULATORS

By HOWARD F. BURGESS

Simple regulator circuits for low-current applications take less space than a VR tube and associated resistors.

ELECTRONIC equipment is seldom free from the problems of varying supply voltage or changing load conditions. When such equipment is used on boats, aircraft, motor vehicles, or just plain portable power plants, these variations in voltage can become even more of a problem.

While most portable equipment is designed so that little actual damage will result from the usual voltage variations, some circuits may become very unstable. What might have been a well-designed receiver or converter can have its operation ruined by small variations in the oscillator plate voltage.

It is fortunate, however, that in many cases a larger percentage of the trouble can be cured by regulating just a few milliamperes of the total current required. If stabilized voltage is used on only the oscillator in h.f. and v.h.f. receivers, much of the drift can be eliminated. The same applies to various kinds of electronic control circuits and test instruments.

The gas-type regulator tubes are a satisfactory answer to many regulated low-current needs. However, for some uses they have several unfavorable characteristics. There is little choice of the fixed values of voltages that are available from VR tubes and they require high-wattage dropping resistors that sometimes create heat and mounting problems. Not the least important is the bleeder current of approximately 10 ma. that is lost in the tube itself. Even though this is a small amount of current, it can be very important in an already overloaded mobile power supply or in a piece of test equipment.

One approach to the problem is the use of simple electronic regulators of the "series tube" type of circuit. Although we think of these as rather complex circuits, a complete regulator can be built in less space than is required by a single VR tube and its dropping resistor. Even though the very simple circuits do not give perfect control, they are quite adequate for most needs. They have the advantage that the output voltage can be made either adjustable or fixed, they require only about 1 ma. of leakage current, and no large series resistor is needed.

There are a number of these simple circuits. Some will regulate only if the supply voltage varies, while others will regulate only if the load varies. The circuit shown in Fig. 1A will regulate under either condition. As shown in the diagram, this circuit is reduced to the bare essentials, consisting of three ½-w. resistors, a dual triode, and a neon tube.

The regulated output of the circuit shown is about 100 volts with the values given. To vary the voltage from the supply, the two resistors across the output are replaced by a variable resistor as shown in Fig. 1B. In this manner the output voltage can be set at any value between 75 and 150 volts. Of course, higher values of regulated voltage can be obtained if input voltage to the regulator is increased.

Several types of dual triodes can be used with varying results. Of the more common tubes, the 12AU7 is recommended for general use. When the 12AU7 is used, about 18-ma. output current is possible without overloading the circuit.

The curve of Fig. 2 shows the regulating ability of this little unit when the input voltage is varied. For these tests, the regulator was delivering about 10 ma. through the working range of the curve. The output regulation was about 1% for a 50-v. variation of the input voltage.

The curve of Fig. 3 shows the regulation capabilities under

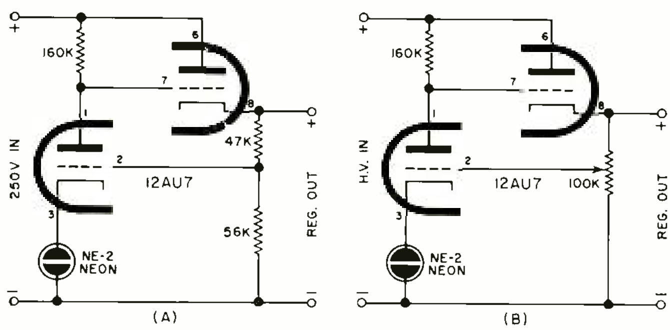


Fig. 1. (A) One tube, three resistors, and a neon tube will compensate for changes in either load or supply. (B) Output voltage can be made variable by changing to a potentiometer.

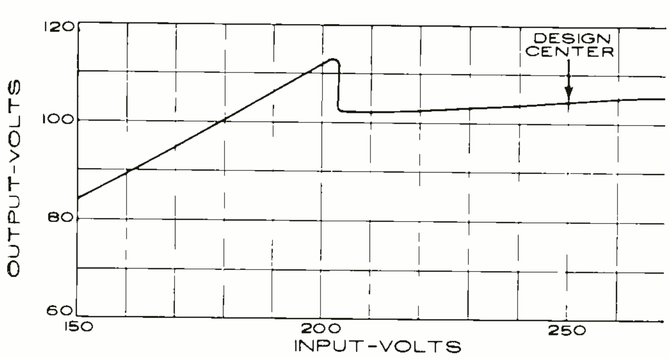


Fig. 2. Voltage curve of a regulator operating with 250 v. input. The peculiar bend is where the regulator takes control.

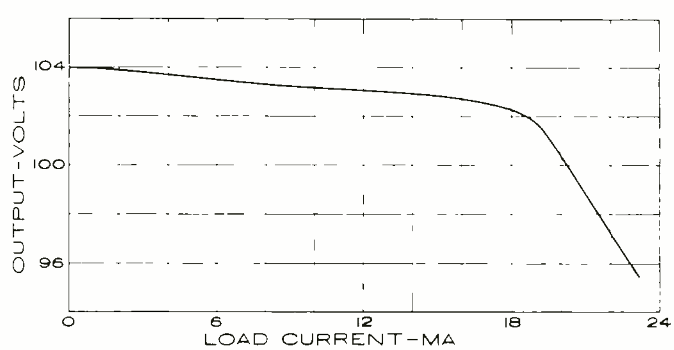
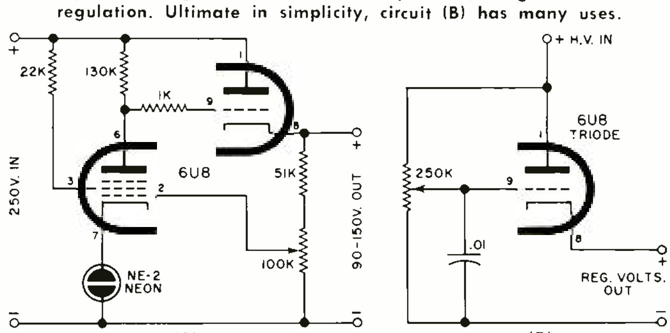


Fig. 3. The output voltage is relatively constant until it breaks at the overload point of regulator tube being used.

Fig. 4. Although somewhat more complicated, (A) gives better regulation. Ultimate in simplicity, circuit (B) has many uses.



changing load conditions. The curve shows the breaking point to be about 19 ma. When the output of the regulator is made variable, the maximum current available and the percentage of regulation will suffer slightly at the extreme ends of the range.

Variations of the circuit are simple to make if special output voltages are wanted. If changes are to be made, at least 100 volts drop should be allowed for the series tube. This will set the maximum voltage that can be expected from the regulator, depending upon the input voltage available. The lower limit of voltage is determined by the striking voltage of the NE-2 neon tube. With the usual striking voltage of about 55 to 60 v., the minimum output from the circuit will be about 75 volts. The regulating ability of the circuit will depend, to a great extent, upon the neon tube. As it is used to set the reference level, it will be found that some neons are more stable than others.

Shown in Fig. 4A is a variation of the same circuit that gives somewhat better control with just two additional resistors. A 6U8 tube is used with the pentode section as the control tube. This gives a bit more sensitive action than the triode.

For those who like the extreme in simplicity, the circuit of Fig. 4B should be of interest. However, this circuit should be used only to hold a constant voltage under varying load conditions. It is of little value for the regulation of supply voltage fluctuations. The values shown are for the triode section of a 6U8. This circuit will maintain a regulation of about 1% with a load varying between 3 and 10 ma.

Although the circuits shown have current capabilities of 18 ma. or less, this will be sufficient in most cases for local oscillators in receivers and converters or for the voltage-sensitive portions of test equipment. The circuits have been trimmed to the minimum to limit size and parts. Improved regulation can be realized with more complex circuits but this would defeat the purpose of this tiny regulator. ▲

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Which Channel Is It?

(*Continued from page* 40)

The AM communications receiver is used to measure the frequency of the beat signal produced by beating of the unknown transmitter signal with the known signal of the FM receiver's local oscillator.

If the FM receiver is equipped with a crystal for receiving on 157.56 mc., and the receiver i.f. is 10.7 mc., the local oscillator operates at 146.86 mc. to produce the 10.7-mc. i.f. signal. When a strong signal at some other frequency gets through the receiver front end to the mixer, an i.f. signal at some other frequency will be produced.

While this signal will not get through the i.f. amplifier, it is nevertheless present at the output of the mixer. It can be picked up and tuned in with the AM communications receiver, and its frequency determined.

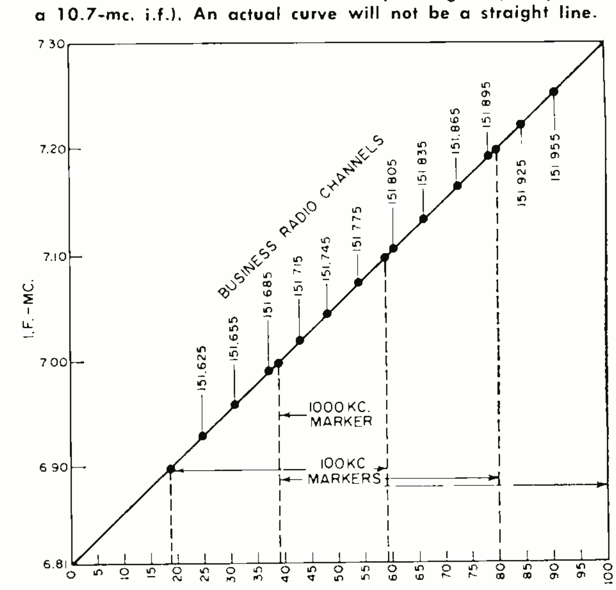
Should the transmitter be operating at 152.36 mc., the i.f. beat will be at 5.5 mc. since 152.36 minus 146.86 equals 5.5 When the AM receiver is tuned past 5.5 mc., its "S" meter will deflect. If the transmitter is on 154.54 mc., the beat signal will be found at 7.68 mc. Any channel in the 150-174 mc. band can be found in this manner with a receiver tunable through the 3-30 mc. range.

The general vicinity of the unknown i.f. signal can be found by using the main tuning dial of the AM receiver. Then, the bandspread dial can be used to pin point the channel. This is done by re-setting the main tuning dial to the nearest 100-kc. calibration signal, noting the locations of the 100-kc. marker points on the scale of the bandspread dial and making a calibration curve like the one shown in Fig. 4. The unknown i.f. signal is then tuned in with the bandspread dial reading noted.

In the vicinity of 7 mc. for example, the typical receiver's bandspread dial covers a range of about 500 kc. Thus, the 150-174 mc. band channels, spaced 30-kc. apart, would be separated by 4 dial divisions, and u.h.f. band channels, spaced 50-kc. apart, would be separated by 10 dial divisions.

Obviously, the AM communications receiver must be checked for calibration each time it is used. Tuning in WWV is a good place to start. Using these techniques, you can identify channels, but a good frequency meter is needed to determine if the transmitter is within the channel's frequency tolerance, and for setting it exactly on frequency as closely as your frequency meter permits. ▲

Fig. 4. Example of a calibration curve with FM receiver local oscillator at 144.7 mc. (155.4 mc. operating frequency and a 10.7-mc. i.f.). An actual curve will not be a straight line.



Level Clippers and Limiters

(*Continued from page 54*)

signal level. Adjustments may then be made to lengthen the attack time of the expander, which permits further pause before bringing up background noise. A further refinement holds the amplifier gain constant in the absence of signals above threshold for 10 seconds' pause.

Circuit function is diagrammed in Fig. 14. The main channel is a compressor, V3 is the controlled stage, and V4 the output. Output sampling is fed to two rectifiers: "Rect. 1" drives the 10-second "Memory," while "Rect. 2" feeds the "Comparator." "Rect. 1" governs platform or steady-state gain; "Rect. 2" limits instantaneous peaks. "Memory" and "Comparator" outputs combine in the "Recovery *and* Circuit," where bias is developed for V3. Meanwhile, V1 receives the input signal through "Threshold Level" control, and, through V2, drives "Rect. 3." If the audio input drops below the threshold, "Rect. 3," through the "Input Reference" circuit, inhibits signal expansion until the input exceeds threshold. After 10 seconds, the "Comparator" is released. The "Input Reference" circuit also inhibits the *and* gate, and during a lapse, the *and* is held at cut-off for 10 seconds, following which slow gain recovery takes place. However, gain returns only to zero, not maximum. The "Input Reference" also drives the "10-Sec. Time Delay" circuit and an *or* gate. If the audio lapses for more than 10 seconds and gain is *greater* than zero, the *or* gate causes a return to zero. Thus, the standby condition of the amplifier is always at zero gain.

Dynamic equalization. In film and broadcast work, when music fades behind an announcer, it usually sounds thin. Also, some commercials sound louder than music or other programming. These phenomena result from the disparity between *volume* and *loudness*. The former is derived from electrical values; the latter, from auditory-nerve stimulation, a combination of volume and frequency distribution.

A new device to boost highs and lows when program material drops below a preset threshold is being used. The action is automatic and listeners receive balanced audio even during low-level passages. As a result, there is no deterioration in listening quality (as opposed to what a vu meter reads) under compression or limiting.

Volume compression has often been applied in broadcasting stations in order to boost the average power being transmitted without actually increasing the station's allowable r.f. power.

This has enabled many stations to "reach out" to a greater distance for a given transmitter power. ▲

HUM FROM CROSSED CONNECTIONS

By JOSEPH A. RISSE / Asst. Dir., School of Electrical Comm., ICS

Hum may come from many sources, but one of the most elusive causes is a badly bungled "repair" job, leaving false clues.

WITH a soldering iron in nearly every household these days, it is not too unlikely that you may run into a similar case of trouble that an associate of the author encountered recently. He surrendered his radio to a well-meaning neighbor, a self-styled amateur repairman, who had offered to fix it up. After a delay of a couple of weeks, the radio was returned with its severe case of hum still present. In fact, according to the puzzled set owner, the hum was even worse than before.

The radio was a table-model superhet with push-pull audio output. The essential portion of the audio circuit is shown in Fig. 1. The triode V1A is RC-coupled to the grid of V2, one of the 50L6's. The grid resistor of this 50L6 is also a voltage divider consisting of R2 and R3, used for feeding back a portion of the output of V1A to the V1B grid. V1B is the phase inverter and, of course, is RC-coupled to V3, the other 50L6 output tube. The circuit is a standard one and is widely used.

New capacitors were substituted for the filter capacitors. The hum remained. Output tubes tested good, with no shorts. New output tubes were tried without luck. The phase-inverter tube proved OK too. A scope check showed hum present on both sides of the V2 coupling capacitor, but none on either side of the V3 coupling capacitor. Shorting the V2 grid to chassis removed the hum, but shorting the V3 grid removed program audio completely with the hum remaining. Normally, shorting either of these grids should only reduce the volume moderately—it shouldn't kill the sound completely.

In checking the circuit with the manufacturer's schematic, everything seemed normal. There was a minor discrepancy as to which triode fed which push-pull output tube and, theoretically, it makes no difference but, taking no chances, a schematic was drawn of the circuit as it was actually wired (Fig. 2). Suddenly the cause of the trouble became apparent. The grid ends of each of the coupling capacitors, C1 and C2, had somehow been switched. C1 was actually connected to the grid of V3 and C2 was connected to the grid of V2. The grid resistors of the output tubes were connected to their proper grids—only the capacitors were changed.

Analyzing Fig. 2 shows that the audio to the grid of V1A is amplified by it and coupled by C1 to the grid of V3. But the grid of V1B connects back to the tap between R2 and R3 and its input should be whatever signal is across R3. However, the output of V1B is itself coupled through C2 to the top of R2 and the grid of V2. V1B then receives no audio input to its grid. What apparently happens is that whatever hum is picked up by V1B is amplified by V1B and is then fed back to its own grid. Shorting out the grid of V2 would, of course, remove the hum—thus explaining the previous observation. Equally obvious is that shorting out the grid of V3 would remove whatever program was getting to the speaker, since V3 was the only output tube being driven.

The grid capacitors were switched back and the set worked fine. The filter capacitor appeared to be newly installed and probably was all that was needed to cure the original trouble. Apparently every capacitor in sight was disconnected during the troubleshooting procedure and when reconnected the coupling capacitors were interchanged. ▲

Fig. 1

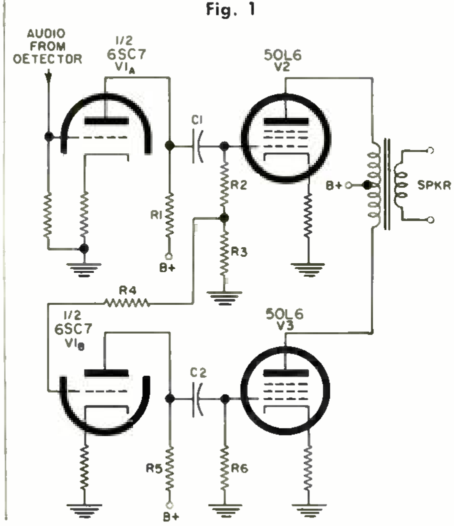
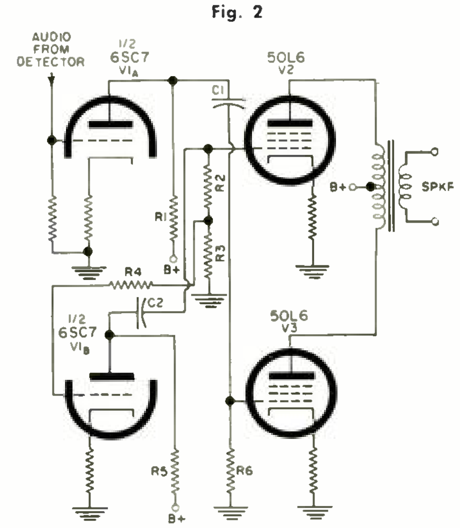


Fig. 2



MEASUREMENT UNIT QUIZ

By DAVID STEIN

WHO isn't familiar with many of the measurements encountered daily, such as the pound, inch, gallon, or even the kilowatt? Test yourself on the following twenty-one more technical measurements by matching the unit with the definition. A perfect score is 105 and the passing mark is 70. Check your answers to this measurement unit quiz on page 104.

(*a*) Angstrom unit	(*k*) Joule
(*b*) B.T.U.	(*l*) Lambert
(*c*) Calorie	(*m*) Lumen
(*d*) Candle	(*n*) Maxwell
(*e*) Curie	(*o*) Oersted
(*f*) Dyne	(*p*) Phot
(*g*) Erg	(*q*) Poundal
(*h*) Gamma	(*r*) Quantum
(*i*) Gauss	(*s*) Roentgen
(*j*) Gilbert	(*t*) Weber

(*u*) X-unit

1. Unit of force in the centimeter-gram-second (c.g.s.) system.
2. Electromagnetic unit of magnetic induction in the c.g.s. system.
3. Unit of illumination equal to 1 lumen per square centimeter when the centimeter is taken as the unit of length.
4. Unit of wavelength equal to 0.001 angstrom unit, or 10^{-11} centimeter, used for specifying wavelengths of x-rays and other highly penetrating radiations.
5. Definite elemental unit of energy associated with changes among electrons and with corresponding radiation.
6. Unit of energy or work.
7. Quantity of heat required to raise temperature of one pound of water 1°F.
8. Unit quantity of radium emanation of radon.
9. Unit of brightness equal to $1/\pi$ candle per square centimeter.
10. Unit of magnetic intensity equal to 10^{-5} oersted.
11. International unit of quantity of x-rays.
12. Absolute English unit of force.
13. Practical unit of magnetic flux, equal to 10^8 maxwells.
14. Unit of luminous flux.
15. Unit of magnetic flux in c.g.s. system.
16. Absolute unit of energy or work in c.g.s. system.
17. Unit of measurement of wavelength of light and other radiation, equal to one ten-millionth millimeter.
18. Unit of heat energy in metric system: amount of heat required to raise temperature of 1 gram of water from 15°C to 16°C.
19. Unit of luminous intensity.
20. Unit of magnetomotive force in the c.g.s. system.
21. Unit of magnetic intensity (magnetizing force) in the c.g.s. system. ▲

R.F. Response Measurement

(Continued from page 37)

coupled to the i.f. amplifier. The output lead of the generator can be placed under the chassis in the vicinity of the i.f. amplifier, or just clipping the generator output cable to the insulation of a grid or plate lead of the i.f. amplifier will give adequate coupling.

After the a.v.c. voltage is fixed, the equipment is set up as shown. The speaker is disconnected and a resistor equal to the speaker impedance is connected across the output-transformer secondary. An a.c. voltmeter is connected across this resistor. The indications of the meter will be used for the vertical plot of the graph.

Signal generator No. 2 is turned off, and signal generator No. 1 is tuned to the appropriate frequency at which the over-all r.f. response measurement is to be made. The modulation is turned on and the generator frequency is retouched for maximum output on the meter. Record this reading as the center frequency. (Remember not to overdrive the receiver.) All measurements will be made with respect to this frequency so be sure you keep track of the reading.

Turn off the modulation of generator No. 1 and turn on generator No. 2. Adjust its frequency to the receiver's i.f. frequency until a zero beat is noted in the output. This will be indicated as a null on the a.c. meter. The frequency of generator No. 2 will not be changed for the remainder of the test. In case a b.f.o. is used, it should not be changed after this preliminary setting.

Let us assume that we want to plot the response in 1-kc. steps. Set the audio generator frequency to exactly 1000 cps and adjust the level for a suitable horizontal line on the scope. Both ends of this line should be visible on the scope screen. Turn generator No. 2 on and adjust the frequency of generator No. 1 until a circle or diagonal line is obtained on the scope screen. This indicates a 1:1 frequency ratio. It will be necessary to adjust the vertical amplifier of the scope for this first setting so that the vertical deflection is about equal to the horizontal deflection on the scope screen. It is not important to have the line or circle stationary, just so it is reasonably stable. If the circle collapses or seems to revolve slowly, this means that generator No. 1 is slightly off frequency. But this will only be by a cycle or so, which is much better than we actually need. In the middle of the broadcast band, for example, this would mean that we have moved the frequency of generator No. 1 about one part in a million.

After the frequency of generator No. 1 is set to obtain the line or circle on the scope, generator No. 2 is either disconnected or its plate supply is turned off. It is suggested that the filaments be left on. Then the modulation of generator No. 1 is turned on and a second voltage reading is taken and recorded on the graph.

The procedure is then repeated with the audio oscillator set at 2000 cps, 3000 cps, 4000 cps, 5000 cps, or as far away from the center frequency as desired.

After one side of the curve is plotted, it is necessary to repeat the procedure with the frequency of generator No. 1 tuned to the other side of the original center frequency.

The alternate output meter shown in Fig. 1, can also be used and results will be slightly sharper. If the alternate meter is used, it is not necessary to modulate generator No. 1, and the sidebands are eliminated from the measurement. In this case, note that the response of the audio amplifiers are not taken into account. ▲

Modulation Circuits for CB

(*Continued from page 30*)

can be performed separately at low power with a signal generator. Thereafter, the transmitter can be connected to the matched antenna without further adjustments.

Other Transmitter Applications

These same modulation principles can be used for other transmitters, including amateur rigs. Their chief value lies in their low cost, low power consumption, and small weight and volume. Thus, these circuits are ideal for all types of portable equipment and are of greatest use in high-power transmitters. Without circuitry of this type, even 5-watt portable equipment is impractical and more so for ham transmitters in the 10- to 20-watt range. The excellent performance and low distortion obtained match or exceed that achieved by conventional "brute-force" collector modulation. ▲

(Note: The various power ratings given in the figure legends and in Table 1 should be considered as approximate only. They were included merely to give an indication of battery drain. The comparative performance of the various transmitter circuits is best expressed by the amount of demodulated audio voltage for a given degree of distortion.)

REFERENCES

1. Rheinfelder, W.A.: "Modulation Techniques for Transistorized AM Transmitters," Electronic Equipment Engineering, July 1963.
2. Rheinfelder, W.A.: "Design of Transistorized CB Transmitters," Electronics World, February 1962.
3. Rheinfelder, W.A.: "Modulation of Driver Stage to Increase Output of AM Transmitters," Semiconductor Products, March 1962.

EW Lab Tested

(Continued from page 22)

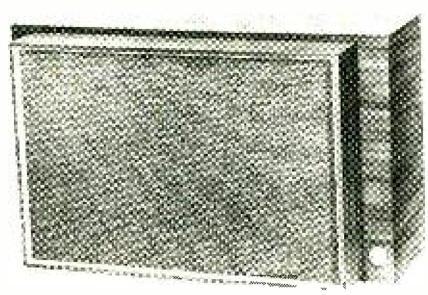
oratory microphone. Both microphones were mounted in the same position relative to a loudspeaker which supplied the test signals. After correction for the known response of the reference microphone, the response of the Model 664 was uniform within ±5 db from 60 cps to 9000 cps, falling another 5 db in the 40-50 cps region.

It is apparent from our test results, and from the manufacturer's specifications, that the Model 664 is well above the average p.a. microphone in performance. In use tests, we found its quality to be excellent, with crisp highs and a full bass. In close talking there was no sign of "blasting," but voice sibilants were quite noticeable. The cardioid polar response was very effective in reducing pickup from the rear, to the point where the interfering noise had to be much stronger than the speaker's voice to have any disturbing effect. The manufacturer's specifications show a front-to-back ratio of better than 20 db, and this was consistent with our observations.

The *Electro-Voice* Model 664 microphone sells for $50.00. ▲

Audio Dynamics ADC-16 Speaker System

For copy of manufacturer's brochure circle No. 47 on coupon (page 15).



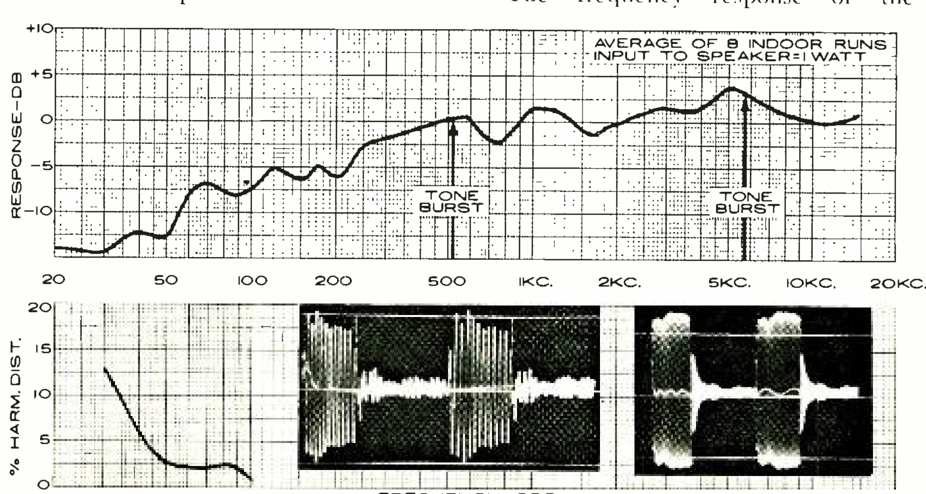
THE *Audio Dynamics Corporation* Model ADC-16 speaker system is a compact, two-way floor-mounted system employing the unique British-made *KEF* woofer. This low-frequency driver has a solid, rectangular styrene foam radiator, measuring approximately 12" x 16". Its flat front surface is covered with aluminum foil and is suspended directly from the baffle board by a highly compliant cloth surround.

The woofer has a fairly conventional voice coil and a nine-pound ceramic-magnet assembly. The low mass and high rigidity of the radiator give relative freedom from breakup effects throughout the useful range of the woofer. The effective radiating area of the low-frequency driver is equivalent to that of two 12" cone speakers.

The enclosure, distinctively styled and finished in oiled walnut, is of the ported type, using a number of 1-inch diameter holes on the rear panel as the port area. The port is damped by a high acoustic resistance, due to the effect of a number of small holes and to the acoustic absorbing material which covers them inside the cabinet. This damping eliminates the effects of low-frequency cone and cabinet resonance. The interior of the cabinet is also extensively padded with absorbing material.

High frequencies are propagated by a dome radiator, whose 1½" Mylar diaphragm is driven by a voice coil of the same diameter. This speaker has very wide dispersion and excellent transient response because of its husky magnetic system. The crossover network is built into the cabinet. Two slide switches on the rear panel allow some variation of over-all response characteristics. One switch reduces high-frequency output while the other boosts the mid-range response.

Although the speaker system can be operated either horizontally or vertically, by itself or on accessory legs, its dimensions of 17" wide x 27½" high x 12½" deep will dictate floor mounting in most cases. It is finished on all four sides. The frequency response of the



ADC-16 was measured indoors. Eight automatic response plots with different microphone positions were averaged to obtain a single composite response curve. The speaker's response was very smooth, with no significant peaks or holes throughout its range. There was a gradual downward slope of the response below 250 cps, which would probably be affected by the room characteristics and speaker position. It could also be substantially corrected by adjustment of amplifier tone controls. Harmonic distortion was low down to about 40 cps. Between 250 cps and 15,000 cps, the frequency response was flat within ± 2.5 db.

Tone-burst tests clearly indicated the excellent transient response of the system. There was little tendency toward ringing or the generation of spurious frequencies.

In listening tests, the ADC-16 had a full, well-balanced sound. In other listening rooms there was no evidence of any low-frequency loss. The highs were sweet and natural and so well dispersed that speaker orientation had little or no effect on the over-all sound. We found the "normal" settings of the speaker response switches to be most pleasing, although some bright listening rooms might require a reduction of highs.

The ADC-16 speaker system sells for $220, including a floor stand. ▲

SILICON RECTIFIER STANDARDS

PUBLICATION of the first set of comprehensive standards of silicon-rectifier diodes and stacks has been announced by the Power Semiconductor Component Section of NEMA. Purpose of the standards is to clear up the confusion which has existed in manufacturing and specifying diodes and stacks because of wide variations in testing and rating methods.

The 65-page book, known officially as "NEMA-EIA Standards for Silicon Rectifier Diodes and Stacks," sells for $5 per copy, and can be obtained by requesting SK 60-1963 from the National Electrical Manufacturers Association, 155 East 44th St., New York, N. Y. 10017. ▲

ENROLLMENT UP

COOPERATION between industrial firms and educational institutions has paid off in Southern California by producing an 11.1 percent increase in freshmen enrollment in engineering as against a 2.3 percent decline registered on a national scale, according to Charles F. Horne, president of EIA.

Instrumental in the increase in student interest in engineering was the Southern California Industry-Education Council, established in 1957 with the immediate aim of encouraging growth in science and mathematics and the long-range objective of making all industry resources available to schools in every subject.

Mr. Horne urged EIA members in other areas to give serious thought to setting up a similar program. ▲

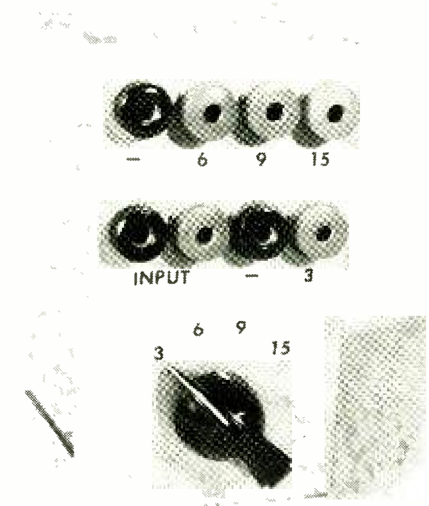
MULTI-OUTPUT ZENER VOLTAGE REGULATOR

By HAROLD REED

Two zener diodes, three resistors, and a switch produce four regulated voltages commonly used in semiconductor work. Simple power source is used.

FOR experimental semiconductor work, there is nothing like a regulated power source capable of furnishing most-needed supply voltages. Unlike batteries, there is only the initial cost and the inconvenience caused by run-down batteries in the middle of the experiment is thus eliminated.

This simple voltage regulator will provide regulated outputs at most commonly used values for semiconductor circuits—nominally 3, 6, 9 and 15 volts.



Zener voltage regulator front-panel view.

By using a special switching arrangement, only two low-cost zener diodes and three resistors are required. Any suitable d.c. source adjusted to 17 volts may be used for the input. If a d.c. supply is not on hand, the constructor can build an a.c. rectifier especially for the regulator. Good regulation is obtained even with a simple half-wave diode supply.

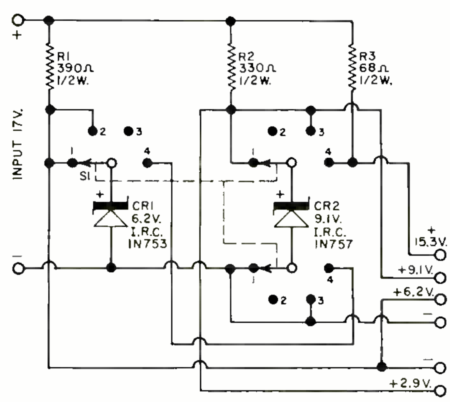
The schematic shows that two zener diodes (*CR1* and *CR2*, 6.2- and 9.1-volt units respectively) are switched into four different circuit configurations.

With the switch in the first position, both diodes are used. The regulated output is the difference potential of the diodes, which is 2.9 volts. The second switch step provides a 6.2-volt regulated output. Here, only *CR1* is used. On the third switch step, only *CR2* is used and 9.1-volt regulated output is available. The fourth position connects the two diodes in series giving 15.3 volts regulated output. The 17-volt input was chosen so that operation would be definitely in the zener region with diodes in series.

The voltage regulator diodes are rated at 400 milliwatts and cost about $2.60. These diodes are also available with ratings from 250 milliwatts up to 10 watts at various voltages. Thus, a regulator of this type may be constructed to handle considerably larger currents and with many different combinations of regulated outputs.

The device is housed in a 4x2¼x2¼ inch aluminum box with identifying decals on the front panel. Parts placement and internal wiring are not critical. Using a slightly larger box, a completely self-contained unit may be made by incorporating a power supply using germanium or silicon diodes.

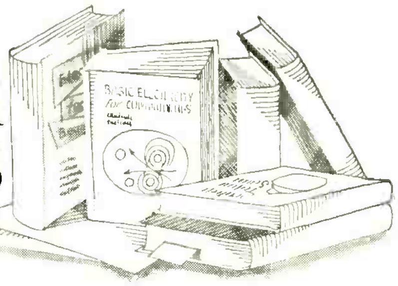
The regulator was tested with one of the simplest types of power supplies consisting of a half-wave rectifier and a capacitor-resistor filter. With a regulated output of 6.2 volts, starting with zero load current the output remained steady as the load current was increased. When load current reached 24 milliamperes,



Multiple outputs are available from this small regulator. Note that the 2.9-volt circuit has a separate negative terminal.

the output dropped 0.3 volt. The 9.1-volt output held steady from zero load current up to 20 ma. when it also went down only 0.3 volt. Output from the 15.3-volt terminal dropped 0.5 volt between zero and 22 ma. load current. Likewise, the 2.9-volt output held steady and went down only 0.2 volt when the load current reached 10 ma. In these tests, zero load current represented no load at all connected across the output terminals. ▲

BOOK REVIEWS



"RCA RECEIVING TUBE MANUAL" compiled and published by *Radio Corporation of America*, Harrison, N.J. 545 pages. Price $1.25.

This most recent edition of the *RCA* tube manual offers a wide variety of useful information for engineers, service technicians, experimenters, radio amateurs, hobbyists, students, and others who work or experiment with home-entertainment-type electron tubes and circuits.

The material has been revised and expanded to include the most recent advances in the electronics field. There are fourteen sections to the manual covering electrons, electrodes, and electron tubes; electron tube characteristics; electron tube applications; electron tube installation; interpretation of tube data; application guide for *RCA* receiving tubes; technical data for *RCA* tube types; picture-tube characteristics chart; electron tube testing; resistance-coupled amplifiers; outlines; circuits; an index; and a suggested reading list.

° ° °

"THEORY OF NETWORKS AND LINES" by James L. Potter & Sylvan J. Fich. Published by *Prentice-Hall, Inc.* 430 pages. Price $16.00.

This volume is designed for junior or senior courses in engineering and assumes that the student has had basic courses in circuits or networks and the usual preparation in mathematics as well as a familiarity with determinants.

The text first treats the development of the parameters of two-terminal pair networks and the derivations and application of the bisection theorem. The rest of the book covers the design of resistance attenuators, the synthesis of lossless networks from a specification of their poles and zeroes, the design of conventional filters, synthesis of networks with losses, an introduction to matrix algebra, small-signal equivalent circuits of tubes and transistors, and the circuit theory of transmission lines. A brief introduction to the transient analysis of networks and lines concludes the book.

° ° °

"SEMICONDUCTOR FUNDAMENTALS: DEVICES AND CIRCUITS" by A. H. Seidman & S. L. Marshall. Published by *John Wiley & Sons, Inc.* 271 pages. Price $6.50.

This is a basic and introductory text for those interested in the operation of diodes and transistors, their technology, and their application. Prerequisite is a familiarity with elementary physics and vacuum-tube electronics. Approximately half of the book is devoted to transistor physics, technology, manufacture, and construction.

The other seven chapters deal with transistor applications as well as the electrical measurement of diodes and transistors. Test questions at the end of each chapter can be checked by the answers to selected numerical problems carried in an appendix. Thus this volume can be used either for classroom instruction or home study.

° ° °

"LINEAR PROGRAMMING & EXTENSIONS" by George B. Dantzig. Published by *Princeton University Press.* 610 pages. Price $11.50.

Written by a mathematician for *The Rand Corporation*, this volume deals with the concepts, origins, and formulation of linear programs and the simplex method of solution. The balance of the text deals with price concept, matrix games, transportation problems, and additional applications to "real environment" situations.

Mathematical and computer background is assumed and innumerable examples are included in the text. An extensive 20-page bibliography is included for those wishing additional reference material.

* * *

"ELECTRONIC DEVICES & NETWORKS" and **"ELECTRONIC CIRCUIT TECHNIQUES"** edited by E.E. Zepler & S.W. Punnett. Published by *D. Van Nostrand Company, Inc.* $6.50 each.

These companion volumes have been written by a team of contributors from the Department of Electronics, University of Southampton in England—each contributor dealing with his particular specialty.

The level of writing in both volumes is for the research engineer but can be used by the engineering student at the college level. The first volume deals with the fundamental principles of active and passive components and explains in detail the components which make up the various single and multistage units covered in the second volume.

Because of the interlocking of the text material in the two volumes, these books should be treated as volumes 1 and 2 and should be used in conjunction with each other.

* * *

"ELEMENTS OF TELEVISION SERVICING" by Abraham Marcus & Samuel E. Gendler. Published by *Prentice-Hall, Inc.* 520 pages. Price $9.50. Second Edition.

When the first edition of this text appeared in 1955, it received a warm welcome from radio technicians and students at radio and TV schools for its practical approach to television servicing. We feel this second edition will acquire a whole new generation of adherents.

Since the authors have prepared this text on the assumption that readers will have a thorough working knowledge of radio circuitry, no attempt is made to cover this segment.

Basically, the book comprises four sections dealing with basic theories of TV transmission and reception, field servicing in the customer's home, the theory and practice of bench servicing, and color television. The text material is amplified by an extensive assortment of line drawings, schematics, patterns, photos of commercial equipment and receiver sections.

Those who have worked with the authors' First Edition will find this volume equally rewarding, while newcomers will welcome this well-planned and detailed exposition of the scope, responsibilities, and rewards of TV service work. ▲

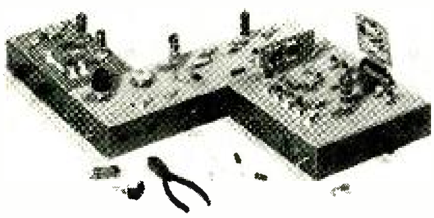
NEW PRODUCTS

Additional information on the items covered in this section is available from the manufacturers. Each item is identified by a code number. To obtain further details, simply fill in the coupon appearing on page 15.

COMPONENTS • TOOLS • TEST EQUIPMENT • HI-FI • AUDIO • CB • HAM • COMMUNICATIONS

BREADBOARD KITS

1 **Alan Kits, Inc.** is now offering a new line of breadboard kits which features a unique aluminum base and the ability to gang together any of the several size kits offered by the firm.



The matching hole patterns in the metal base allow the bolting together and the wiring to pass on the underside from chassis to chassis.

Mounting of components is accomplished by using special feedthrough terminals on the phenolic deck. Details on available kits will be supplied by the company on request.

ALL-CHANNEL YAGIS

2 **Clear Beam Antenna Corp.** has recently introduced three new all-channel yagi antennas as its "San Franciscan" series.

All three models feature the company's "Dura-Gold" finish and all are designed with separate yagi sections for low and high v.h.f. bands. The Model DG620 is peaked for extra gain on the low band. The Model DG700 has an additional director element for higher gain and greater directivity on all v.h.f. channels.

AUTO IGNITION SYSTEM

3 **Kapner, Inc.** is now offering a transistorized ignition system, Model K-70, which the company claims can be installed without disturbing either the old ignition ballast resistor or bypass. This feature is made possible by the inclusion of a specially designed ignition relay.

The system is designed for use with any car, truck, or marine engine whether 4, 6, or 8 cylinders. Since the system can be installed easily and removed at will, the unit can be transferred to another car in the event of sale or trade-in.

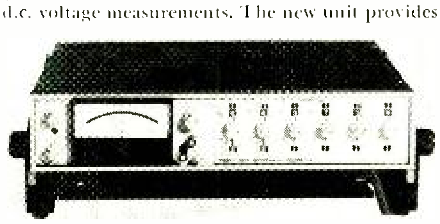
PENLIGHT FUSE TESTER

4 **Federal Pacific Electric Company** is now offering the "Econolite," a penlight device which may be used to test continuity in any kind of cartridge or plug fuse. Equipped with a pocket clip type of switch, the unit may be carried easily by plant maintenance personnel.

Fuses must be removed from live circuits for testing. Positive indication of fuse continuity also results from testing fuses out of live circuits since false readings of fuse continuity caused by feedback are avoided.

DIFFERENTIAL VOLTMETER

5 **Systems Research Corp.** is offering the Model 5501 differential voltmeter for 0 to 500 volt d.c. voltage measurements. The new unit provides



accuracy of 0.01% of the input maximum error or 20 μv., whichever is greater. Incorporating compact, all-transistorized circuitry, the Model 5501 requires only 3½" of rack space. Units can also be furnished with adjustable bench mountings.

Over-all stability of the unit is 0.01% per year. Voltmeter scales include 0.5, 5, 50, and 500 volts d.c. Null sensitivity ranges are 100, 10, 1, 0.1, 0.01, 0.001, and 0.0001 volts.

MINIATURE SELENIUM RECTIFIER

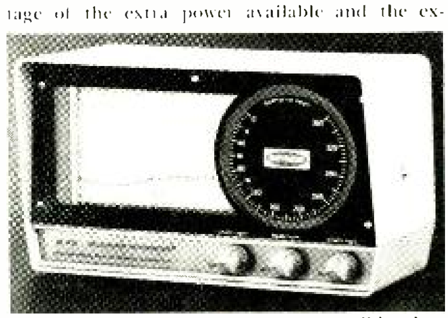
6 **International Rectifier Corporation** has announced a new miniature all-purpose selenium rectifier, measuring only 1³⁄₃₂" x ⁵⁄₁₆", capable of delivering the same power as conventional open-fin type assemblies (65 ma. @ 130 volts r.m.s.) in one-half the space.

The new device may be mounted either by printed-circuit terminals or by a mounting tab and is designed for radio, hi-fi, phono, and similar applications. The Type 1065U is rated for 380 volts peak reverse voltage and a maximum operating temperature of 85 degrees C.

RECORDING DEPTH SOUNDER

7 **Raytheon Company** is now offering a combination recording and indicating "Fathometer" depth sounder for record-keeping and detection of depths.

The recorder section is scaled to 240 feet. The flashing light indicator has a normal scale of 120 feet but is calibrated to 360 feet to take advantage of the extra power available and the ex-



tended readings that are frequently possible when a boat is operating over a hard bottom that acts as a good reflector of the ultrasonic pulses. The new depth sounder is controlled by a single knob that serves as an "off-on" switch and an intensity control.

SOLID-STATE LIGHT CONTROLLER

8 **Ward Leonard Electric Co.** has developed a new solid-state lighting control system packaged in a single enclosure for use in small theaters, schools, TV studios, and similar applications.

Known as the "Solitrol Controlette," the new unit is miniaturized, portable, and entirely self-contained. The system handles 36 kw. in a compact package measuring only 50" high x 26" deep x 22" wide. It contains six modern 6-kw. SCR dimmers. The solid-state dimmers feature square-law characteristics, silent operation, instantaneous response, and highly filtered output to prevent lamp noise.

H.V. EPITAXIAL SCR

9 **International Rectifier Corporation** has developed a high-voltage, high-current SCR which makes practical the replacement of bulky motor-generator sets, rotating frequency changers, induction voltage regulators, and thyratrons and ignitron tubes by a compact solid-state device.

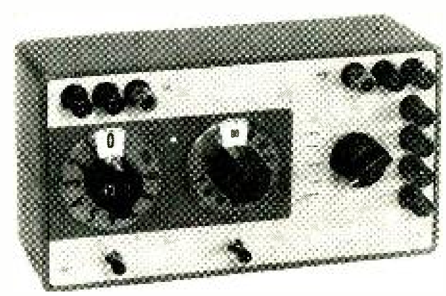
The new units may be applied to a.c. and d.c. motor drives in steel rolling and wire mills, paper mills, printing presses, or wherever variable speed drives are required.

Rated at 235 amps with bulk avalanche capabilities up to 1300 volts, the new SCR's eliminate the design problems encountered when lower voltage devices are operated in series.

Complete specifications on this new line, designated Types 150RE80 through 150RE130, are available from the manufacturer.

LOW-RESISTANCE BRIDGE

10 **Electro Scientific Industries** is now offering the Model 209, a portable Kelvin low-resistance bridge which measures switch contact and



connector resistances in the area of one milliohm and detects variations of resistance on the order of one microhm. Coverage is 0 to 11 ohms in five ranges. Rated accuracy at bridge current of one ampere is ±0.2% +one dial division +10 microhms.

Readings are presented in a straight line with a permanent decimal point located between the dials. A multiplier switch to the right of the interpolating dial selects five multiplier ranges of 1000, 100, 10, 1 and 0.1, permitting rapid readout and calibration by multiplying the readout by the range setting.

IGNITION SHIELDING KIT

11 **E. F. Johnson Company** is now marketing a universal-type automotive ignition shielding kit designed to control both conducted and radiated interference.

Known as "Eliminoise," the new kit is designed to increase two-way radio communications range and prevent the de-sensitization of both AM and FM auto receivers. The kit comes with detailed, illustrated, easy-to-follow instructions; chrome-plated sparkplug shields; distributor cap shield and coil shield with integral filter capacitor; sparkplug cable shielding; and all necessary hardware. The shielding is designed to be installed with readily available handtools and can be transferred from one vehicle to another as required.

PRECISION TEMPERATURE BRIDGE

12 **Winsco Instruments & Controls Co.** has added the Model 4103 precision temperature bridge to its line of temperature measuring and control equipment.

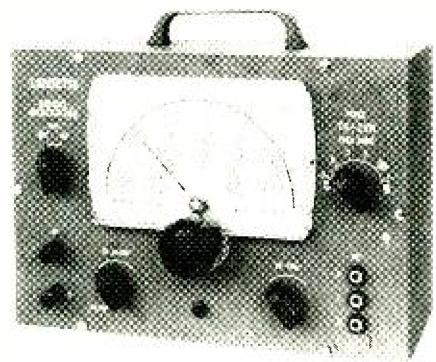
The solid-state unit utilizes the precision input of a platinum RTD and the accuracy of a high-precision galvanometer to measure and display media temperature to an accuracy of 0.1 degree F.

Available for single- or multi-channel operation, the self-contained, battery-powered instrument is designed for a wide variety of industrial and laboratory temperature measurements and applications. A choice of temperature ranges across the span of −320 to +1100 degrees F is available with up to ten channels.

R.F. SIGNAL GENERATOR

13 **Lafayette Radio Electronics Corporation** is marketing a new low-cost wired test instrument, the TE-20A r.f. signal generator.

Six overlapping ranges generate signals of 120-320 kc., 320-1000 kc., 1-3.2 mc., 3.2-11 mc., 11-38 mc., and 37-130 mc., all on fundamentals with calibrated harmonics from 120-380 mc.



The instrument which measures 7½"x 10¾" x 4½" is suitable for i.f.-r.f. alignment, audio signal tracing, TV linearity checks, and other service applications.

U.H.F. ANTENNA LINE

14 **Antennacraft Company** is marketing a new line of u.h.f. antennas which features new diamond-phased continuous aluminum-wire driven elements and a multi-resonant, colinear reflector system.

The antennas, which are shipped completely factory preassembled, are offered in either "Dura-Gold" or sapphire blue anodized finishes. The Model G-1483 is designed to cover all u.h.f. channels 14 to 83 while the Model G-7083 is peaked for channels 70 to 83. The blue anodized models are SA-1483 and SA-7083 respectively.

FIELD-STRENGTH METER

15 **Ferris Instrument Company** has added the Model 32E, a portable field-strength meter, to its line of radio noise and field-strength instruments.

The new unit offers five ranges covering the r.f. spectrum from 150 to 350 kc. and 550 kc. to 16 mc., performing as a radio noise meter in accordance with the latest proposed ASA standards, with time-constant weightings including average and quasi-peak. Peak readings may also be obtained by means of an accessory slideback.

The Model 32E is furnished with a rod antenna for field-strength measurements in free space while individual loop antennas for each of the five frequency bands are offered as accessories.

SOLID-STATE SCOPE

16 **Tektronix, Inc.** has developed a compact, ruggedized oscilloscope, Type 647, featuring a d.c. to 50 mc. passband with solid-state amplifier, Type 10A2, and time-base, Type 11B2, plug-in units.

Measuring 14½" high x 10" wide x 23" deep, and environmentalized to withstand wide operating and storage conditions, the new model can be used aloft (15,000 feet maximum) and can withstand 20G shock.

Total power consumption is 18 watts. A rectangular ceramic CRT with a parallel-ground faceplate, 14-kv. accelerating potential, and parallax-free internal graticule is also featured.

FLEXIBLE COAX CABLE

17 **Columbia Wire and Supply Company** is offering a new line of "Superflex" coaxial cables which features a minimum service life of 10 years and a potential life of 20 years under some conditions.

The new line comes in black, white, silver, and beige or can be produced in any color on special order. The cable features non-contaminating jackets, super flexibility, and low-loss foam polyethylene primary insulation for better performance and improved resistance to rigidity in cold weather.

SOLDERING PISTOL

18 **Wen Products, Inc.** is now offering the Model 75, a soldering pistol which is 9" long (including the 3" tapered tip) by 4½" high. It will produce at its tip the heat of a 100-watt device from a peak surge rating of only 50 watts and a normal draw of only 30 watts. All of the heat is concentrated at the pistol's tip.

The pistol, which is housed in shock-resistant molded red plastic, has a six-foot long connecting cord and molded plug. A built-in spotlight on the case illuminates the work area.

MARKING SET

19 **The Datak Corporation** is now offering a new component identification marking system for prototype and pilot production runs. "Instant Lettering" requires no water, solvents, tapes, or screens and does a professional-looking job with no setup or special equipment required. The letters adhere to almost any surface. Each set contains 12 sheets of letters as well as 10 sheets of consecutive numbers from 1 to over 200.

PRECISION DECADE BOXES

20 **Ultronix, Inc.** is now offering six models of "Ultrodec," a precision decade resistance box. The new five-dial units are available with nominal ±.01% accuracy (Series A) or nominal ±0.1% accuracy (Series B). A factory calibration chart is provided with each instrument. Resist-

ance ranges are 0.1 to 11,111 ohms for the Model 504, 1.0 to 111,11 ohms for the 505, and 10.0 to 1,111,100 ohms for the 506. All models are available in either bench-top style in aluminum cases or in rack-mount configuration.

IGNITION SYSTEM

21 **The Ignitioneering Company** is on the market with a transistorized ignition system which the manufacturer claims requires no engine or vehicle wiring modifications and only the simplest of handtools to install.

The system is being offered in two models: for 6- and 12-volt negative-ground cars and for 6- and 12-volt positive-ground cars.

NUMERICAL READOUT TUBES

22 **National Electronics, Inc.** has announced a line of numerical readout tubes whose characters are formed by neon glow.

The NL-8421/5092 and NL-6844A with .610" high characters, have ratings and characteristics typical of various types available: maximum ionization voltage 170 volts d.c.; minimum supply voltage, 170 volts d.c.; average cathode current 1.5 to 3 ma.; and viewing distance up to 30 feet.

HI-FI — AUDIO PRODUCTS

MODULAR MUSIC SYSTEM

23 **General Electric Company** is currently introducing a "modular" music system consisting of a stereo tape recorder, a fully transistorized 100-watt peak-power AM-FM-FM-stereo tuner/amplifier, four-speed automatic record changer, and a choice of speaker arrays.

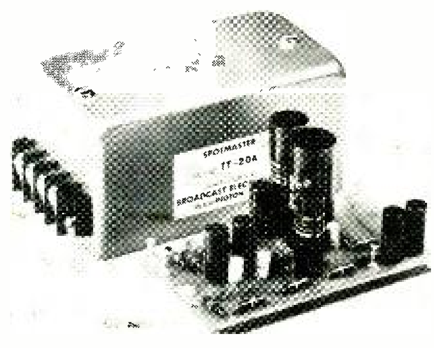
The modules are pre-matched in both style and performance. The individual units have been electronically coordinated for use as a system that can be grown building-block fashion. All connecting leads are color-coded. Plugs are mechanically matched to specific outlets. The controls are simple, and no ganged multi-function knobs are used.

All units are housed in identical hardwood oil-walnut veneer cabinets measuring 16½" wide x 10⅛" deep x 16½" or 8¼" high.

EQUALIZED TURNTABLE PREAMP

24 **Broadcast Electronics, Inc.** has announced an equalized turntable preamplifier which reduces residual noise level to better than 65 db below rated output and can be dry-cell battery powered to eliminate all residual hum.

Designated the "Spotmaster" Model TT-20A, the new unit is a compact, low distortion, low



noise, transistorized amplifier with built-in NAB equalization. No coils or inductors are employed. The TA-20A can be operated from any well-filtered d.c. supply providing 6 to 15 volts.

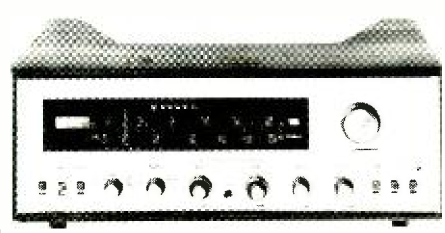
Housed in a metal case measuring 2¼"x2¼"x 5", the unit is designed for mounting in or near the turntable cabinet.

70-WATT TUNER/AMP

25 **H. H. Scott, Inc.** has just released the Model 380, a single compact AM-FM stereo tuner-amplifier rated at 70 watts.

Circuit features include slide-rule tuning, front-panel low-level output for private listening, and "Auto-Sensor" for automatic switching of operation mode.

In addition, there is a bandwidth selector for



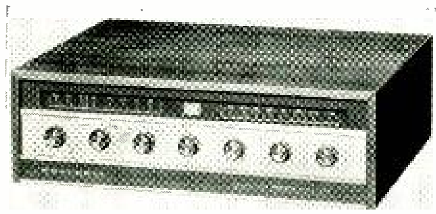
best reception of local and distant AM stations, illuminated d'Arsonval meter, and silver-plated circuitry. It is housed in a decorator-styled cabinet.

TRANSISTOR STEREO RECEIVER

26 **Heath Company** is now marketing the AR-13 all-transistor, all-mode stereo receiver in kit form. This compact unit includes two 20-watt power amplifiers, two separate preamplifiers, plus a wide-band AM, FM, and FM-stereo tuner.

Advanced features include automatic switching to stereo plus a stereo broadcast indicator light; two filtered tape recorder outputs for direct stereo recording; magnetic phono and two auxiliary inputs; dual-tandem controls; high-gain r.f. stage and high-"Q" rod antenna; a.f.c.; flywheel tuning; local-distance switch; external antenna terminals; plus concealed secondary controls to prevent accidental system settings.

The IHF music power output rating is 33 watts into an 8-ohm load, 18 watts into a 16-ohm load, and 16 watts into a 4-ohm load at 0.7%



THD, 1 kc. Power response is 15-30,000 cps ± 1 db at rated output. Channel separation is 40 db at 20,000 cps. FM tuner sensitivity is 2.5 μv. for 20 db of quieting and 3.5 μv. for 30 db of quieting.

The instrument measures 17" long x 5⅜" high x 11¾" deep in its low-silhouette walnut cabinet.

UNITARY HI-FI SPEAKERS

27 **Jensen Manufacturing Company** is currently introducing the "Sigma" series of unitary high-fidelity loudspeakers—a group consisting of seven completely new 8" and 12" models.

Among the features of these new speakers are: heavy-duty die-cast alloy housings for permanent alignment of all critical parts; high-energy "Syntox-6" magnets; carefully formulated cones for excellent coupling to air; the company's "Flexair" suspension system design; low-crossover tweeters; and separate remote high-frequency control to permit the custom balancing of treble response after cabinet installation.

"L-PAD" LINE

28 **Robins Industries Corp.** is marketing a new series of "L-Pad" volume and constant-impedance controls for adjusting volume of speakers without creating mismatch.

Available in 8- and 16-ohm impedances, these units feature a variety of mounting types. They are available in wall plate, panel, or surface mounts and come complete with hardware and instructions.

P.A. AMPLIFIER LINE

29 **Lafayette Radio Electronics Corporation** is now offering a complete line of public-address amplifiers as the Models PA-420 to PA-421.

New in styling and engineering features, the series consists of five models from 11 to 100 watts. Four units have a frequency response of 30-20,000 cps; hum and noise better than 65 db below rated output; 4-, 8-, and 16-ohm speaker impedances; and 25- and 70-volt lines. Some models feature separate bass and treble controls; individual volume controls for microphone and phono mixing; magnetic phono inputs; and plug-in output sockets. One model is an all-transistor design for 12-volt mobile operation.

ULTRA-THIN SPEAKER SYSTEM

30 **University Loudspeakers** is now offering its ultra-thin "Tri-Planar," a three-way speaker system which measures only 1¾" deep.

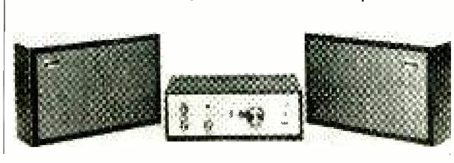
Sound radiates from both sides of the system and provides 264 square inches of woofer area. Frequency response is 45-18,000 cps with a power rating of 20 watts of integrated program material.

The system, which measures 23" wide x 15" high x 1¾" deep, is housed in an oiled walnut enclosure with modern cane grille.

TUNER/AMP/SPEAKER SYSTEM

31 **Eico Electronic Instrument Co. Inc.** is now offering an FM-stereo tuner/amp and speaker system as the Model 2510.

The tuner section provides 3 μv. sensitivity for 30 db quieting and a signal-to-noise ratio of 55 db. Harmonic distortion is 0.6% and channel separation is 30 db. The amplifier provides 10 watts IHF music power with a frequency re-



sponse 20-40,000 cps ± 1 db. Damping factor is 20 and the unit has 8-ohm speaker outputs. Inputs are provided for ceramic/crystal phono, tape, and auxiliary.

The speakers each have a 6½" woofer-midrange and 2" cone tweeter. Crossover is at approximately 4000 cps. Rated impedance is 8 ohms and frequency response is 60-15,000 cps ± 6 db.

FLEXIBLE P.A. AMPLIFIERS

32 **Fanon Electronic Industries, Inc.** has announced a new line of high-power public-address amplifiers which currently includes 100-, 65-, and 35-watt models.

In the 100- and 65-watt models where voltage variation is a factor, a specially engineered voltage regulation circuit has been incorporated to protect the screen grids of the output tubes.

In addition, all three units in the "Power-Flex" line will accommodate the company's "Add-On" circuits such as a two-microphone preamp, a transformer which provides 600-ohm balanced line operation for background music, a low-impedance microphone transformer, a special area selector control, and a priority paging control.

POCKET PAGING SYSTEM

33 **Executone, Inc.** has recently introduced a new pocket paging system designed especially for business and industrial firms, hospitals, hotels, restaurants, and other types of institutional facilities.

The 5½-ounce receiver alerts by means of a discreet sound signal. The person paged then goes to the nearest telephone or intercom station and replies. A unique feature of the new system

is the ability to make page calls either from one central point or from many locations through intercom stations or internal telephones. In a multiple call system, the man who does not answer his intercom or internal phone call may be paged directly without going through the switchboard.

EXPANDER-COMPRESSOR

34 **Allied Radio Corporation** is marketing the Model KN-777, a stereo expander-compressor which automatically increases the dynamic range of program material compressed by record and tape manufacturers. There is no change in frequency response. Low and average-level passages are not altered.

The unit is designed to be connected between the program source and the amplifier. It works with any amplifier with 4-16 ohm output. No power supply is required.

The expander-compressor is housed in a cabinet measuring 7⅝" wide x 2½" high x 6" deep.

CONSOLE SPEAKER SYSTEM

35 **Neshaminy Electronic Corporation** has recently introduced the Z-600, a wide-range console loudspeaker system using a pair of "JansZen" electrostatic radiators for the treble and a specially designed dynamic woofer for the bass.

The heavily weighted, high compliance cone of the woofer is capable of ⅜" excursions without breakup or doubling. Sealed in the 2.1 cubic-foot fiberglass-filled enclosure with the electrostatics, the entire system provides linear, low-distortion response from 30 to beyond 30,000 cps.

A built-in power supply and high-pass filter furnish power for the two push-pull electrostatic radiators and eliminate the need for external crossover networks or attenuators. The cabinet measures 26⅝" high x 20" wide x 13" deep and comes in either lacquered or oil-walnut finish.

MINIATURE TAPE RECORDER

36 **Craig-Panorama** is now offering a pocket-size transistorized tape recorder which has been tradenamed "Electronic Notebook" and is designed for a wide range of dictating applications.

Measuring 5½"x3 9/16"x2 1/16", the Model TR-408 offers double-track recording, variable tape speeds, and an ultra-sensitive microphone. Power is obtained from four 1.5-volt penlight cells which slide out, at the push of a button, in a single package for replacement.

The unit comes complete with remote control microphone, earphone, batteries, four full and one empty reel of tape, cowhide carrying case, and telephone pickup. The entire instrument weighs less than 2½ pounds complete.

CB-HAM-COMMUNICATIONS

BUSINESS RADIO UNITS

37 The **Hallicrafters Co.** has just released the first two models in its new "Command Line" of FM two-way radio units for business and industrial use.

Both units are narrow-band for operation in the 148-174 mc. frequency range. The Model CSB-30-2 is a desk-top v.h.f. base station designed for local or extended local control. It is available either with control head and transmitter/receiver chassis in a single package or with separate control head, cable, and chassis.

The Model CSM-30-2 is a v.h.f. mobile unit available as a single package for mounting under an auto dash, as a multi-component package providing for trunk mounting of the chassis, or as a multi-component package permitting trunk mounting of the chassis but with separate speaker and miniature-size control head.

Each unit has an r.f. power output of 30 watts.

ALL-BAND NUVISTOR PREAMP

38 **Ameco Equipment Corp.** is in production on an all-band nuvistor preamp which provides coverage from 6 through 160 meters. Two nuvistors in cascode give a noise figure of 1.5 to 3.5 db depending on the band. Over-all gain is in excess of 20 db.

Housed in a 3"x5"x3" cabinet, the panel contains the bandswitch, tuning capacitor, and a three-position switch which puts the unit into "Off," "Standby," or "On" operation and transfers the antenna directly to the receiver or through the preamp. Power requirements are 120 volts at 7 ma. and 6.3 volts at .27 amp.

The Model PCL comes completely wired and factory tested.

FM COMMUNICATIONS RECEIVERS

39 **Lafayette Radio Electronics Corporation** has put two new 8-tube FM communications receivers on the market: the HB-75 which tunes 30-50 mc. and the HB-76 which tunes 152-174 mc.

Useful for monitoring emergency, commercial, or industrial communications, each set offers 7-tube performance with a 3-gang tuned r.f. stage. Sensitivity is 4 μv. or less for 20 db quieting. There is a built-in, all-electronic adjustable squelch circuit and built-in 5" PM speaker, 7¼" illuminated slide-rule tuning dial, and transformer-type power supply.

The receivers are housed in 12" wide x 6¼" high x 6½" deep metal cabinets.

AIRCRAFT MONITOR RECEIVER

40 **Regency Electronics, Inc.** is now offering a deluxe v.h.f.-band aircraft receiver which has been tradenamed "Flight Monitoradio."

This new unit covers the 108-136 mc. band which includes all civil transport and private

aircraft v.h.f. navigation and communications frequencies. Sensitivity is 1 μv. for 10 db signal-to-noise ratio at 30% modulation. An adjustable squelch covers .5 to 100 μv. Audio output is 1 watt and the unit is powered by a transformer-type power supply which draws 36 watts at 105-125 volts, 60 cps.

Features of the receiver include a nuvistor r.f. amplifier for high sensitivity, illuminated slide-rule dial, fully tuned second r.f. stage, vinyl-clad steel cabinet, built-in noise limiter, and a 5" built-in speaker. Provision is made for an external speaker if desired. A v.h.f. antenna for use with this receiver is available as an accessory.

INDUSTRIAL RADIOTELEPHONE

41 **General Radiotelephone Company** is now in production on a new industrial radiotelephone, the Model VS-2.

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The new unit features such circuit innovations as electronic switching to eliminate relay problems, transistorized power supply with automatic short-circuit protection, and operation from either 117 volts a.c. or 12 volts d.c.

Because of its vibration service rating, the VS-2 will meet most outdoor requirements including operation in Jeeps, tractors, fork lifts, boats, or any type of equipment operated under unfavorable service conditions.

SELECTIVE-CALLING SYSTEM

42 **Reach Electronics, Inc.** is now offering a new encoder and decoder selective-calling system which is being marketed as the "Hush Selector."

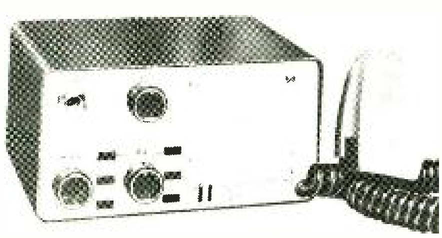
Operation is entirely automatic. Tone signaling is fast with the receiver being actuated in less than 1/4 second after the transmission begins. The actuating tone code is not heard at either the receiver or transmitter.

Several thousand ton codes are available which makes practical the individual calling of mobile units.

The compact, miniature semiconductor construction permits ease of installation. Transmitter and receiver are each approximately 1 3/8" x 2 3/4" x 1 3/4". No relays or other moving parts are used.

MARINE RADIOTELEPHONE

43 **Astromarine Products Corporation** has announced the availability of a new, improved version of the M-100 radiotelephone. It employs transistors instead of tubes in the transmitter



circuit. Using a unique broadband circuit design the M-100 has no adjustments and can be installed without the normal checkout by a licensed technician.

The new unit is FCC type accepted, is rated a 30 watts, and measures 4" w. x 7 3/4" h. x 6" d. It weighs 5 pounds.

The manufacturer can supply full details on this unit to those requesting such data.

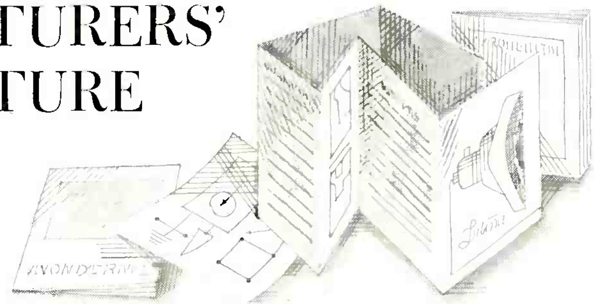
MOBILE DECODER

44 **Secode Corporation** is now offering a completely solid-state mobile decoder for selective signaling in two-way radio communications systems.

The Model SD-30 combines a digital decoder with a call-light indicator in a compact unit designed for under-dash mounting. The call light remains on, indicating a call has been received while the vehicle is unattended. Accessories allow for horn-blowing or other exterior alerting devices. The unit will respond to any one of more than 700 digital code combinations.

The pulse counting and memory function are processed electronically. The tone generator at the base station is keyed by an ordinary telephone dial for individual signaling without alerting other vehicles in the two-way communications system. ▲

MANUFACTURERS' LITERATURE



"COMPONENT SELECTOR"

51 **Cornell-Dubilier Electronics** has published an 144-page "Component Selector" designed to meet the needs of engineers, management, and purchasing personnel in commercial, industrial, and military electronics.

The catalogue covers the firm's industrial-military component line including capacitors, RFI filters and testing services, wave filters, pulse-forming networks, delay lines, relays, vibrators, power supplies, and test instruments.

Over 25 pages of the catalogue are devoted to reference material in the form of charts. All of the application and selection charts previously published by the company have been revised and up-dated and included, along with charts never before published.

H.F. VARIABLE TRANSFORMERS

52 **The Superior Electric Company** is offering copies of its Bulletin P463H, a concise, illustrated 28-page catalogue which features ratings and complete technical data on "Powerstat" variable transformers for high-frequency applications.

Full information is provided on manually operated and motor-driven types for 28, 120, 240, and 480-volt, single- and three-phase service in ratings from .056 to 8.7 kva.

SPEAKERS AND KITS

53 **Jensen Manufacturing Company** has published a new 24-page, two-color catalogue (No. 165-J) which illustrates and describes the newest items in the firm's line of stereo and mono high-fidelity speakers, headphones, private stereo listening, speaker components, and speaker-system kits for custom applications. Complete acoustical and dimensional specifications and prices are given.

INDUSTRIAL CRT HANDBOOK

54 **Sylvania Electric Products Inc.'s** Electronic Tube Division is offering a new handbook on industrial and military cathode-ray tubes.

Designed for the systems engineer, the brochure outlines design considerations important to optimum results in the display portion of a system and shows how cathode-ray tube performance is affected by various system factors.

It also offers tube application notes and detailed electrical and mechanical specifications on a variety of multi-gun, high-resolution, and double-deflection CRT's.

TURNTABLES AND TONEARMS

55 **Rek-O-Kut Co., Inc.** will supply copies of its new turntables and tonearms brochure on request. The four-page publication features technical specifications and illustrations on the company's assembled and kit turntables, various types of tonearms, and accessories to be used with the tonearms and turntables.

TEMPERATURE MEASUREMENT

56 **H. V. Hardman Company, Inc.** has published a 16-page, full-color brochure which describes the newest techniques for measuring critical temperatures and indicating isothermal patterns on small and large objects without instrumentation.

These techniques, utilizing the company's temperature sensitive "Thermochrom" crayons and "Detectotemp" paints, cover every major industrial application where accurate temperature information is essential to product quality and cost reduction.

MAGNETIC DRUM HEAD DATA

57 **Pickering and Company, Inc.'s** Industrial Products Division has published an engineering bulletin on its new Model 4047 magnetic drum head. Of special interest to R & D and system engineers, the bulletin fully describes this miniature magnetic read/record head, with specifications and technical information for its use with magnetic memory or storage drums in computer and acquisition systems.

U.H.F. CONVERTERS

58 **Jerrold Electronics Corporation** has issued a two-color illustrated catalogue sheet which describes and pictures three new top-of-the-set u.h.f. converters.

The data sheet covers two all-channel converters ("Super Vista" and "Vista") and one translator and MPATI converter ("Ultra Vista").

PRODUCT CATALOGUE

59 **Littelfuse, Inc.** has issued a 36-page multi-color product catalogue which pictures and describes an extensive line of indicating fuses, mountings for cartridge-type silicon rectifiers, subminiature microfuse holders as well as the

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firm's standard lines of high- and low-voltage fuses and circuit breakers.

A special 6-page "Fuseology" section is devoted to an informative presentation of basic fuse principles and operations, including plotted time versus current blowing charts for quick reference use.

INDUSTRIAL PRODUCT CATALOGUE

60 **Edmund Scientific Company** is now offering copies of the 1964 edition of its catalogue which lists hard-to-find industrial products, optical and electronic components, scientific and reference books, and instruments of all types.

The compact 8¼"x5¾" catalogue contains 148 pages of information and illustrations.

LOW-VOLTAGE VARISTORS

61 **The Carbone Corporation** is now offering a four-page brochure which describes a full line of voltage-dependent resistors in which resistance decreases as applied voltage increases. The variation is also reversible.

Complete engineering data is presented, including curves to help in the proper specification of type, series, and class to meet application requirements.

TRANSFORMER CATALOGUE

62 **Ferranti Electric, Inc.** has announced publication of a two-color, four-page brochure which contains complete listings on the firm's basic line of 60- and 400-cycle units for military, industrial, and commercial applications.

Engineering data is provided on filament, filament/plate, and plate transformers as well as on power supply filter reactors, military standard audio, and pulse/toroidal transformers and reactors.

ANTENNA SYSTEMS

63 **General Electric Company's** Ordnance Department has issued a two-color, 20-page illustrated brochure (GED-4923) which describes the firm's antenna design, development, and manufacturing capabilities and facilities.

Included is information on antennas for precision tracking, communications and detection, as well as antenna sub-systems.

SCOPES AND CAMERAS

64 **Fairchild Du Mont Laboratories** has issued a short-form catalogue, No. 129, covering its line of oscilloscopes and cameras. Complete specifications, prices, and performance data are provided on a wide range of instruments for laboratory and production line applications. Oscilloscope cameras and accessories are also covered, along with a selection of accessories designed to be used with the scopes.

ENGINEERING DESIGN MANUAL

65 **TA Mfg. Corp.** is offering 70 pages of design data, material specifications, and complete prints on standard hardware items in its engineering design manual, No. 212G.

Included are many labor- and cost-saving installation techniques for all types of electronic, hydraulic, and mechanical harnessing problems. Complete information on standard extreme high- and low-temperature insulating materials plus data on chemical resistance is supplied as an aid for all designers.

L.F. V.H.F.-RECEIVER DATA

66 **Interstate Electronics Corporation** has issued a four-page technical brochure on its Model LF-610 low frequency timing receiver. The unit receives the one per second time ticks now being broadcast 24 hours a day by NBS's WWVB.

The brochure includes a general description of the receiver, details of operation, a block diagram, and complete specifications.

ELECTROSTATIC AIR CLEANING

67 **Radex Corporation** has published three booklets covering its line of electrostatic air cleaning units and their applications. One booklet, entitled "Easier Living—Easier Breathing" describes both custom and single-room units while the other two booklets deal with the health aspect of electrostatic air cleaning: "Dust, the Germ Carrier" and "Helpful Hints to Allergy Sufferers."

GSA-APPROVED RECORDER LIST

68 **Ampex Corporation** announces publication of a new 12-page catalogue and government price list covering its line of audio tape recorders and associated equipment approved by General Services Administration under Contract No. GS-OOS-46680.

Catalogue No. 1817 has been compiled as an aid for government procurement agencies.

ANTENNAS & ACCESSORIES

69 **Jerrold Electronics Corporation's** Distributor Sales Division has issued a 16-page, 2-color brochure describing the firm's complete line of antennas for both black-and-white and color TV markets, FM-stereo models for master antenna systems, plus an extensive line of accessories used with the various antennas.

Catalogue DS-C-502 will be supplied without charge on request.

FREE-LOAN FILM

The 3M Company, 2501 Hudson Road, St. Paul 19, Minn. has issued a 25-minute, 16-mm. sound film entitled "Magnetic Memory" which is being offered on a free-loan basis for showings to clubs and other organizations.

This professionally produced film is built around the theme that magnetic tape has added a "new dimension" to the memory of man by providing a new method for recording and preserving his knowledge, skills, and creative efforts.

SATELLITE PHYSICS

Bell Telephone Laboratories has published a book "Satellite Communications Physics" as an aid to high school science education. The 88-page illustrated book covers some of the reasons for communicating by means of man-made satellites, the progress made in space communications, and some of the problems that had to be solved, plus six case histories about the problem-solving techniques involved in designing a communications satellite, keeping it working, and repairing it even after it has been placed in orbit.

Teachers and students may obtain copies of this book without charge from local **Bell Telephone** companies. ▲

Answers to Quiz

(Appearing on page 89)

(a) 17	(h) 10	(o) 21
(b) 7	(i) 2	(p) 3
(c) 18	(j) 20	(q) 12
(d) 19	(k) 6	(r) 5
(e) 8	(l) 9	(s) 11
(f) 1	(m) 14	(t) 13
(g) 16	(n) 15	(u) 4

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TRANSISTORIZED Products importers catalog. $1.00. Intercontinental. CPO 1717, Tokyo, Japan.

JUST starting in TV service? Write for free 32 page catalog of service order books, invoices, job tickets. phone message books. statements and file systems. Oelrich Publications, 6556 W. Higgins Rd. Chicago, Ill. 60656.

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5Y3	6C4	6SR7	12CA5
6A6	6C6	6U7	12SN7
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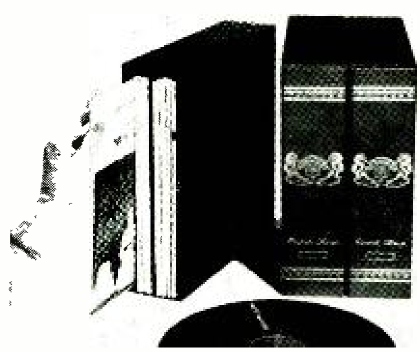
Here's the answer:



HI-FILE RECORD CASES

These handy record cases hold your albums safely and neatly on your bookshelf. They're the perfect answer to your record storage problems!

so attractive: rich library binding of simulated leather, tooled in 16K gold.

no chance of warping or breakage: albums are held in a vertical position, thus preventing damage.

albums stay clean and neat: each case is dustproof, holds twenty of your 12" LP's in their original jackets, with a divider for separating records by artist or category.

handy size: 13" high, 12½" wide and 3½" deep.

albums are easily accessible: open back enables you to read titles on the spine of albums for fast selection.

easily identified: comes with gold foil so you can emboss each album with proper designation.

Jesse Jones Box Corp., Dept. EW
Box 5120, Philadelphia 41, Pa.

Please send me ____ Hi-File record cases, at $3.50 each, 3 for $10. Color choice, check box.

☐ black ☐ brown ☐ maroon
☐ red ☐ blue ☐ green

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Name ______________

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City ____ Zone ____ State ____

Shipped prepaid Fully guaranteed

GREGORY ELECTRONICS

Reconditioned 2-Way Radio Savings

THIS IS A PARTIAL LIST
WRITE FOR NEW '64 CATALOG

LINK 6000 NW SERIES
25-50mc 20F3 Emmission—Fully narrow banded (Tx and Rx), 12 volt, 50 watt. Complete with all accessories, less crystals and antenna. **$168**
Add $40 for crystals, tuning and brand new antenna—ready to go on your frequency.

30-50mc MOBILES—GE 2-Piece Unit —6 volt or 12 volt
4ER6—4ET5 30w 30-40mc .... **$ 98**
40-50mc ....
4ER6—4ET6 60w 30-40mc **$108**
40-50mc ....
Complete with all accessories except antenna and crystals. Equipment can be crystalled and tuned to any frequency in the 30-50mc band.
GE 2-Piece Unit—6 volt or 12 volt
4ER6—4ET5 30w 30-50mc **$198**
4ER6—4ET6 60w 30-50mc **$208**
Complete with all accessories including antenna and crystals. Fully narrow banded (Tx & Rx) and tuned to your frequency within the 30-50mc range.

MOTOROLA 30-50mc T-51GGD or T-51AGD
6/12v 50-60 watts—Fully narrow banded (TX and RX). Complete with all accessories, less crystals and antenna....... **$228**
Same unit tuned to your frequency including brand new antenna, ready to be installed. **$268**
(This unit may also be bought without accessories for $198.)

RCA 25-54 mc CMF40
6/12v 40 watts—Vibrator power Supply. Fully narrow banded. Complete with all accessories, less crystals and antenna... **$178**
Same unit tuned to your frequency including brand new antenna, ready for installation. **$218**
(Same unit without accessories, $165.)

RCA 148 to 172 mc
CMC30 (Vibrator Power Supply)—6/12 volt, 30 watt. Complete with all accessories less crystals and antenna. Wide band **$158**
Fully narrow banded (transmitter and receiver) **$188**
Add $35.00 for crystals, tuning and antenna. Ready for installation.

GE 150-170 LOW POWER INDUSTRIAL
4ES20A2—6/12 volt, 1 watt, complete with all accessories. WIDE BAND ...... **$ 78**
Add $15.00 for crystals and tuning of the receiver only, thus making it a compact and highly sensitive monitor receiver. Weatherproof cases for these units are also available for $15.00.

We Buy Late Model Equipment for Cash—Write; Wire or Phone!

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CIRCLE NO. 121 ON READER SERVICE PAGE

TEKTRONIX 'SCOPE—Record. No. 512A—Gtd.—225.00
BALLANTINE 300VTM—Record. Gtd.—69.95
SYLVANIA 30KV PROBE—New. Worth 15.00—1.95
G.E. SCOPE Xformer—1350V—5MA—Small—1.49
813 TUBE—New. Boxed—8.95
4X 250B 19.50; **4-65A** 6.95; **4-125A** 19.50; **4X 150A** 9.00

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750 Ma. SILICON EPOXY DIODES
200 piv 10¢. 400 piv 20¢. 600 piv 25¢.
SILICON POWER TRANSISTORS
2N1039 50¢, 2N1041 $1.50, 2N511A 75¢
2N456 35¢, 2N1046 95¢, 2N1046A $2.00
$2.00 min. order. Cash, check or money order. Write for catalog of complete line of Diodes, transistors, tubes, relays, transformers resistors etc. Enclose 10¢ for mailing.
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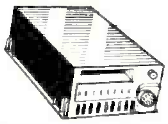
Money Back Guarantee

ARC-3 RECEIVER!



Complete with All Tubes Exc. Used **$21.50**
Like NEW $33.50
Crystal-controlled 17-tube superhet, tunes from 100 to 156 MC., AM., on any 8 preselected channels. 28-volt DC power input. Tubes: 1-9002, 6-6AK5, 1-12SH7, 3-12SG7, 1-9001, 1-12H6, 2-12SN7, 1-12SL7, 1-12A6.
110 V A.C. Power Supply Kit for above 15.00
Factory Wired and Tested 19.95

ARC-3 TRANSMITTER

Companion unit for above tunes 100 to 156 MC on any 8 pre-selected channels. 9 tubes, crystal controlled, provides tone and voice modulation. 28V DC Power input. Complete with all Tubes: 3-6V6, 2-832A, 1-12SH7, 1-6J5, 2-6L6. Exc. Used . . . . Only **$18.95**
Like new condition $28.50
ARC-3 PUSHBUTTON CONTROL BOX $5.95

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SPECIAL BUY! This excellent frequency standard is equipped with original calibration charts, and has ranges from 125 Kc to 20,000 Kc with crystal check points in all ranges. Excel. Used with original Calibration Book, Crystal, and all tables. CHECKED OUT!
Unmodulated **$79.50** Modulated . . . . . P.U.R.
BC-221 1000 Kc Crystal Brand New **$8.95**

LM FREQUENCY METER

Crystal calibrated modulated. Heterodyne. 125 Kc to 20,000 Kc With Calibration book Complete. Like New **$69.50**

LORAN APN-4

FINE QUALITY NAVIGATIONAL EQUIPMENT

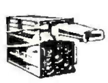
Determine exact geographic position of your boat or plane. Indicator and receiver complete with all tubes and crystal.
INDICATOR ID-6B/APN-4, and RECEIVER R-9B/APN-4, complete with tubes, Exc. Used **$69.50**

NEW! APN-4A Receiver-Indicator as above, changed to operate same as APN4-B for improved performance . . . . NEW $88.50
Shock Mount for above $2.95

INVERTER POWER SUPPLY for above APN-4. INPUT: 24 V DC. OUTPUT: 115 V AC, 800 cycles. Like New $22.50

12-Volt Inverter Power Supply for above APN-4. Like New . . . . P.U.R.
We carry a complete line of replacement parts and accessories for above.

LORAN R-65/APN-9 RECEIVER & INDICATOR

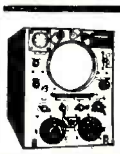


Used in ships and aircraft. Determines position by radio signals from known xmitters. Accurate to within 1% of distance. Complete with tubes and crystal. IN LIKE NEW Condition $79.50
Used, with all parts, less tubes, crystal and visor . . . . Special **$29.50**

INVERTER POWER SUPPLY for above APN-9. INPUT: 24 V DC. OUTPUT: 115 V AC. 800 cy. Like New $22.50

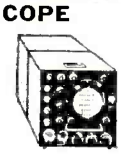
12-V. Power Supply for APN-9, like New P.U.R.
Shock Mount for above $2.95
Circuit diagram and connecting plugs available.
We carry a complete line of replacement parts and accessories for above.

LORAN APN/4 OSCILLOSCOPE



Easily converted for use on radio-TV service bench. LIKE NEW! Supplied with 5" Scope, type 5CPI only. **$14.95**

APN-12 3-INCH SCOPE



Has vertical and horizontal sweep with focus and intensity controls, coaxial antenna changeover motor. Complete with 11 tubes and 3JP1 CR Tube. For 115 V. 400 cycle AC and 24 V DC. Circuit diagram included. LIKE NEW. **$14.95**

TS-100AP 'SCOPE

EXC. USED (worth $750)
OUR LOW PRICE **$39.50**
Brand New $69.50
Can be used with linear sweep or general purpose test scope. Cables included. Also used with circular sweep as precision range calibrator. Self-contained in metal case 8" x 12½" x 16" deep. For 110 V 50 to 1200 cycles AC. Excellent used, like new, with all tubes including crystals and C.R. Tube.

BC-906 FREQ. METER—SPECIAL

Cavity type 145 to 235 Mc. Complete with antenna. Manual and original calibration charts included. BRAND NEW. OUR LOW PRICE **$12.88**

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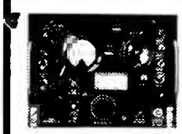
Hot Special! 2000 to 6000 Kc AM Receiver, 2-band, complete with all tubes, 200 Kc Xtal Calibrators, and 12 V Dynamotor. Fine for 80-meter Ham band, Marine, etc. Provides for CW, MVC, AVC, Speaker Jack and two Headphone Jacks. Shpg. Wt. 50 lbs. Brand New, only **$39.50**

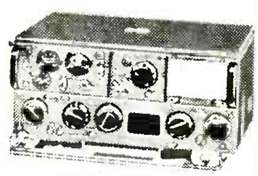
T-179/ART-26 TRANSMITTER



Airborne Radar Video Transmitter, 465 to 515 Mc. Power Output 15 Watts. Complete with 15 tubes, BRAND NEW **$69.50**
PP-104/APT-5 RECTIFIER POWER UNIT for above. Complete with 4 tubes, BRAND NEW $29.50

AN/ART-13 100-WATT XMTR

11 CHANNELS
200-1500 Kc
2 to 18.1 Mc



$79.50 EXC. USED
complete with Tubes

Famous Collins Autotune Aircraft Transmitter, AM CW, MCW. Quick change to any of ten preset channels or manual tuning. Speech amplifier/clipper uses carbon or magnetic mike. Highly stable, highly accurate VFO. Built in Xtal controlled calibrator. PPS11s modulate 813 in final up to 90% class "B." A Real "HOT" Ham buy at our low price!
AN/ART-13 XMTR. as above. In LIKE NEW condition, with all tubes and crystal **$89.50**

0-16 Low Freq. Osc. Coil for ART-13 . . . . . 7.95
24V Dynamotor for ART-13 . . . . 11.95
We carry a complete line of spare parts for above.

SCR-274 COMMAND EQUIPMENT

ALL COMPLETE WITH TUBES

Type	Description	Used	Like NEW
BC-453	Receiver 190-550 KC	$12.95	$14.95
BC-454	Receiver 3-6 MC	12.45	17.95
BC-455	Receiver 6-9 MC	11.50	13.95
1.5 to 3 MC. Receiver Brand New			$17.95

110 Volt AC Power Supply Kit for all 274-N and ARC-5 Receivers. Complete with metal case. Instructions **$8.95**
Factory wired, tested, ready to operate $12.50
SPLINED TUNING KNOB for 274-N and ARC-5 RECEIVERS. Fits BC-453, BC-454 and others. Only . . . . **49¢**

2.1 to 3 Mc Transmitter, Brand New $12.95
BC-457 TRANSMITTER—4-5.3 Mc. complete with all tubes and crystal, BRAND NEW **$9.75**
Like New $7.95
BC-458 TRANSMITTER—5.3 to 7 Mc. Complete with all tubes and crystal.
BRAND NEW **$10.95**
Like New $7.95
BC-696 TRANSMITTER 3-4 Mc Complete with All Tubes & Crystal. Like New **$11.95**
BC-456 Modulator . . . . USED 3.45 NEW 5.95
ALL ACCESSORIES AVAILABLE FOR ABOVE

SCHEMATIC DIAGRAMS

For most equipment on this page, each **65¢**

Please include 25% Deposit with order—Balance C.O.D., or Remittance in Full. 50c Handling Charges on all orders under $5.00. All shipments F.O.B. Our Warehouse, N.Y.C. All Merchandise subject to Prior Sale and Price Change.

G & G RADIO SUPPLY CO.

Telephone: CO 7-4605
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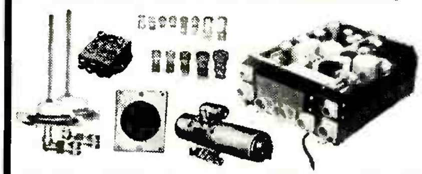
FAMOUS BC-645 TRANSCEIVER



BRAND NEW! 15 Tubes 435 to 500 MC
Can be modified for 2-way communication, voice or code, on ham band 420-450 mc, citizens radio 460-470 mc, fixed and mobile 450-460 mc, television experimental 470-500 mc. 15 tubes (tubes alone worth more than sale price!): 4—7F7, 4—7H7, 2—7E6, 2—6F6, 2—955 and 1—WE-316A. Now covers 460 to 490 mc. Brand new BC-645 with tubes, less power supply in factory carton.
Shipping weight 25 lbs. SPECIAL! . . . **$19.50**

PE-101C Dynamotor, 12/24V input $7.95
UHF Antenna Assembly 2.45
Complete Set of 10 Plugs 5.50
Control Box 2.25

SPECIAL "PACKAGE" OFFER

BC-645 Transceiver, Dynamotor and all accessories above. COMPLETE, BRAND NEW While Stocks Last **$29.50**

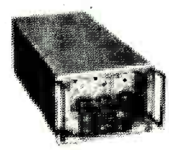
EE8 FIELD PHONES, Checked out, perfect working order. Complete with all parts. Excellent Cond. Each **$12.95**

BC-604 TRANSMITTER Companion unit to 21-27.9 Mc FM BC603 Receiver. Complete with all tubes. BRAND NEW **$10.95**

ARB/CRV 46151 NAVY AIRCRAFT RADIO RECEIVER 190 to 9050 Kc in four bands. 6-tube super communications receiver with local and remote tuning, band change. Complete with tubes and dynamotor. LIKE NEW **$39.50**

RA62 AC POWER SUPPLY FOR SCR522 Transceiver. Like New **$42.50**

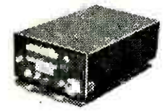
AN/ARC-1 TRANSMITTER-RECEIVER



100-156 Mc. radio telephone communication aircraft to ground. Complete with tubes and dynamotor, operates from 24 volts DC. Excellent condition. LIKE NEW.
AN/ARC-1 10-channel unit **$59.50**
AN-ARC-1 50-channel unit $99.50

BC-617 FM RECEIVER & Selector. Frequency range 30 to 40 Mc. 10 channels tone selector actuates relay circuits. Coaxial antenna input, squelch circuit, audio control output jack. Complete with 15 tubes and 24 Volt Dynamotor. Size 11"x8"x20". NEW **$24.50**

AN/ARN-7 RECEIVER



Frequency range 100 Kc to 1750 Kc in 4 bands. Aircraft navigational instrument comprising superhet receiver and additional radio compass circuits. Complete with tubes, exc. cond. **$29.50**
Accessories for above, available.

AN/APR-4 RECEIVER only. 38 to 4000 Mc in 5 tuning unit ranges. High precision lab instrument. Input 115 V60 cy. Like New $89.50
TN-16, TN-17, TN-18, TN-19 and TN-54 Tuning Units for above, in stock . . . . P.U.R.

SCR-625 MINE DETECTOR

Complete portable outfit in original packing, with all accessories. Brand New **$29.50**

DYNAMOTOR VALUES:

Type	Input	Output	Excellent Used	BRAND NEW
DM-32A	28V 1.1A	250V .05A	2.45	4.45
DM-33A	28V 5A	575V .16A		
	28V 7A	540V .25A	2.95	4.45
DM-34D	12V 2A	220V .080A	4.15	5.50
DM-36	28V 1.4A	220V .080A	1.95	2.95
DM-43	28V 23A	925V .220A		
		460V .185A	—	7.95
DM-53A	28V 1.4A	220V .080A	3.75	5.45
PE-73C	28V 20A	1000V .350A	8.95	14.95
PE-86	28V 1.25A	250V .050A	2.75	3.85

DM-37 DYNAMOTOR. Input 25.5 V DC @ 9.2 A. Output 625 V DC @ 225 Ma. BRAND NEW. Each $3.25

MICROPHONES Checked Out, Perfect

Model	Description	EXC. USED	BRAND NEW
T-17D	Carbon Hand Mike	$4.45	$7.95
RS-38	Navy Type Carbon Hand Mike	3.95	5.75

HEADPHONES Checked Out, Perfect

Model	Description	EXC. USED	BRAND NEW
HS-23	High Impedance	$2.79	$4.95
HS-33	Low Impedance	3.15	5.45
HS-30	Low Imp. (featherwt.)	.90	1.65
H-16/U	High Imp. (2 units)	3.75	7.95

TELEPHONICS—600 ohm Low Impedance HEADSETS. BRAND NEW. PER PAIR $3.95
CD-307A Cords, with PL55 plug and JK26 Jack .99
Earphone Cushions for above—pair 50

CIRCLE NO. 119 ON READER SERVICE PAGE

SAY YOU SAW IT IN

Electronics World

TAPE AND RECORDERS

TAPE Recorders, HI-FI Components. Sleep Learning Equipment, Tapes. Unusual Values. Free Catalog. Dressner, 1523 EW Jericho Turnpike, New Hyde Park 10, N.Y.

RENT Stereo Tapes—over 2,500 Different—all major labels—free brochure. Stereo-Parti, 1616—E. W. Terrace Way, Santa Rosa, California.

SELF-Hypnosis. New concept teaches you quickly by tape or LP-record. Free literature. McKinley Publishers, Dept. T6, Box 3038. San Bernardino. California.

SAVE 30-60% Stereo music on tape. Free bargain catalog blank tape/recorders/Norelco speakers. Saxitone, 1776 Columbia Road, Washington. D.C.

TAPE Recorder Sale. Latest models $10.00 above cost. Arkay Sales, 22-21 Riverside Avenue, Medford 55, Massachusetts.

AMERICAN Recorders. 4-track stereo play, mono record. Incredible Discount Price $89.50. Caravelle, 916 McLean, Yonkers, N.Y.

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DISGUSTED with "Hi" Hi-Fi Prices? Unusual Discounts On Your High Fidelity Requirements. Write. Key Electronics, 120 Liberty Street, New York 6, N. Y. DI6-4191.

WRITE for lowest quotations, components, recorders. No Catalogs Hi-Fidelity Supply, 2817-GC Third, New York City 55.

LOW, LOW quotes: all components and recorders. Hi-Fi, Ros'yn 9. Penna.

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LPs Like new Top labels $1.C0 for lists. Refunded first order. Records, Hillburn P.O., Hillburn, N.Y.

ATTACH adaptor to conventional Stereo Amplifier. Add two speaker cabinets. Witness natural sound reproduced with full incremental locations. Unit encapsulated. Guaranteed. $39.95 Prepaid USA. Stereosphere, Box 3009, Dept. EW, Huntsville. Alabama 35811.

HI-FI components, tape recorders, sleep learn equipment, tapes. Unusual Values. Free Catalog. Dressner, 1523 Jericho Turnpike, New Hyde Park 10, N.Y.

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1¼ AMP	5.50	7½ AMP	14.95
1¾ AMP	6.25	10 AMP	18.95
2 AMP	7.50	20 AMP	24.95
3 AMP	8.95	20 AMP (Cased)	29.95

SILICON CONTROLLED RECTIFIERS TESTED!

PRV	7 AMP	25 AMP	PRV	7 AMP	25 AMP
70	1.50	2.75	350	3.50	4.40
140	2.00	3.25	400	4.00	4.65
200	2.25	3.50	450	4.40	
250	2.75	3.75	500	4.75	
300	3.00	4.00	600	5.50	

NPN-Germanium MESA Transistors F max—250 Mc-BV-10V 10/4.00 100/35.00
MADT Transistors 4/1.00
Germanium Diodes .... Computer type—$8/1.00

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#1504-A New .... $1195.00 Pair

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1 Mfd. 12. 5K Volts OIL .... 13.95 ea.

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Guardian No. 16AC 115 VAC— 2 lb. pull ... 1.79 ea. 12 for 20.00

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Pri 115 V or 230 V Sec—3 x 6.3V8A. 230 V 450 Ma Epoxy Encapsulated .... $6.95 ea.
Pri 115 V Sec 12.6 VCT @ 4 A & 15 V @ 1 A .... 2.95 ea.
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115 V Pri Sec. 6.3 VCT @ 30 Amp .... 6.95 ea.
Plate tsfmr. 1100 VCT 250 Ma .... 6.49 ea.

PANEL METERS

1½" SQUARE
0-1 MA .... 3.25 ea.
0-2 MA .... 3.25 ea.
0-100 MV .... 3.25 ea.
0-500 MMA .... 3.25 ea.

2" ROUND
0-200 VAC .... 4.49 ea.
'S' Meter 0-9 .... 3.95 ea.
0-200 MADC .... 4.25 ea.
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0-100 MMA .... 5.25 ea.
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0-150 VAC .... 4.95 ea.
0-150 VDC Weston (Dual scale) .... 5.25 ea.
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0-20 MA DC .... 3.95 ea.
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200-0-200 V DC 3.95 ea.
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AC—VOLTS—0-2; 3; 5 10; 15; 25 or 50 .... 3.95 ea.
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AMPS— 0-1; 2 or 3 5.95 ea.
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AC—VOLTS— 0-50 .... 3.50 ea.
MA—0-150 .... 3.50 ea.
DC—VOLTS—0.25; 300 or 500 .... 3.50 ea.
0-50 VDC (4 scales—basic 0-1 MADC) 4½" RD .... 4.50 ea.

All Shipments FOB NYC

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79 Cortlandt St., New York 7, N.Y. RE 2-0270

CIRCLE NO. 101 ON READER SERVICE PAGE

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TELEFIXIT Alltime Bestseller Nontechnical TV Repair Book with Famous Troubleshooting Charts. 60¢ Postpaid 2 for $1.00. Telefixit, Box 714, Manhasset 4, N.Y.

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WOW! 110 All Different Germany 10¢! Zeppelins, Semi-Postals, Airmails, High values, etc. Giant Catalog, bargain lists included with beautiful approvals. Jamestown Stamp, Dept. A24EG, Jamestown, N.Y.

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