# Electronics World

JUNE, 1965
50 CENTS

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SEMICONDUCTOR SWEEPS FOR LARGE-SCREEN TV

ELECTRONIC INTRUSION ALARMS

LIQUID FLOW MEASUREMENT

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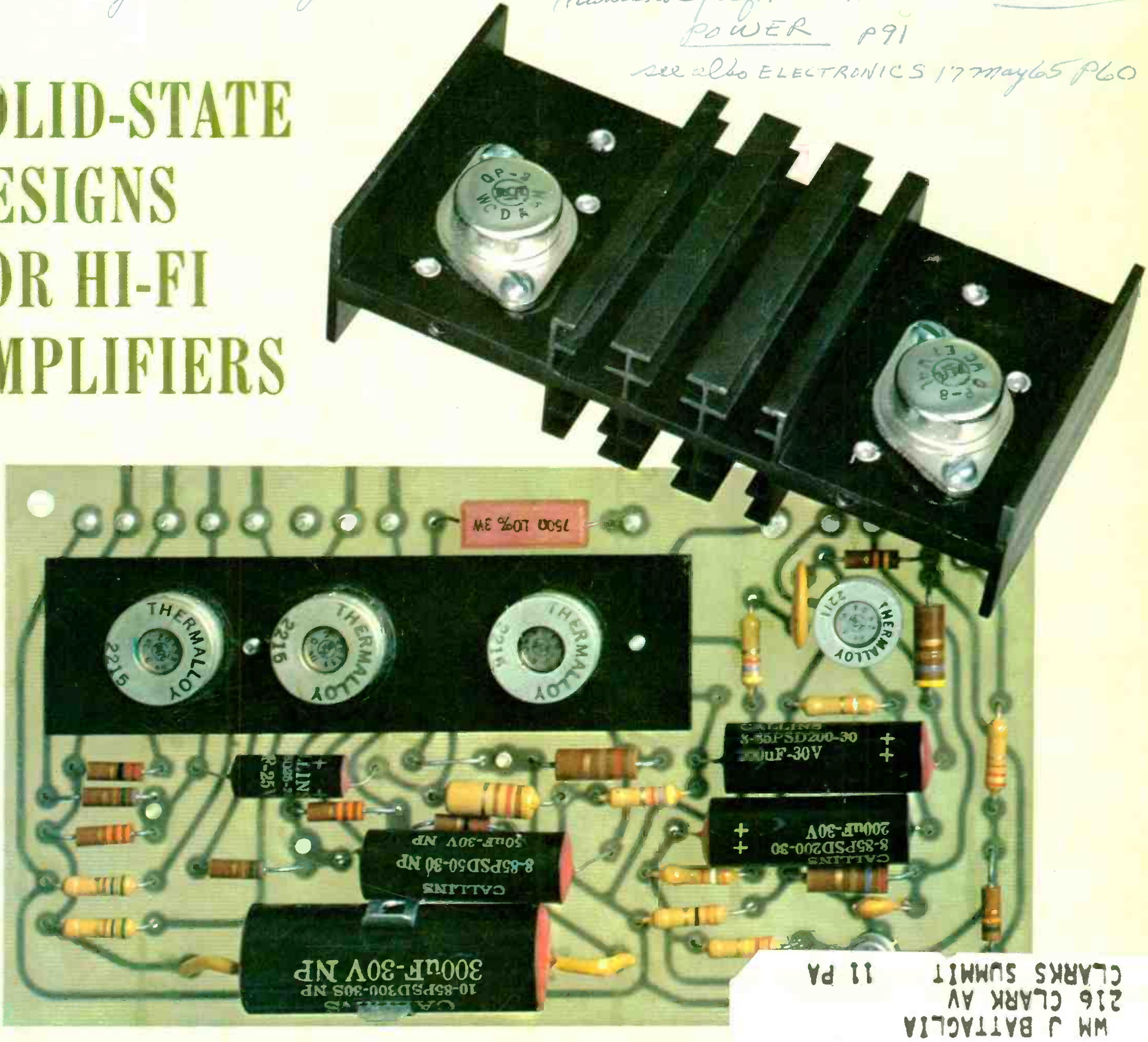
## SOLID-STATE DESIGNS FOR HI-FI AMPLIFIERS

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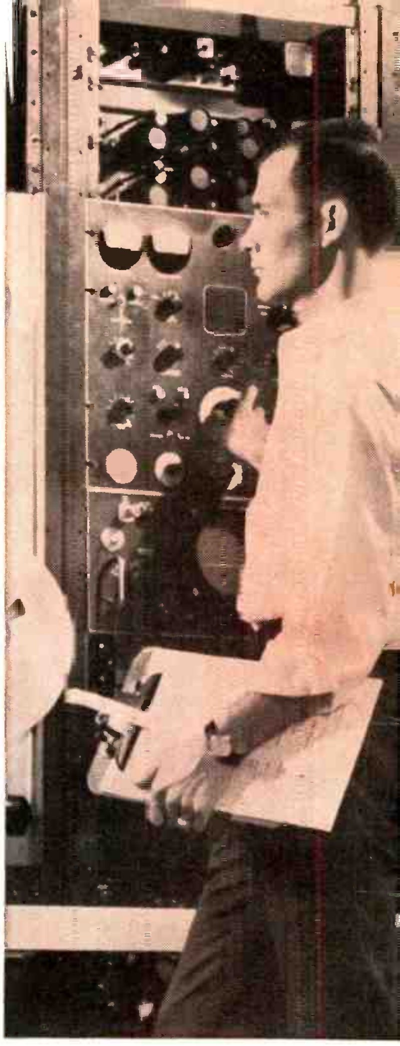

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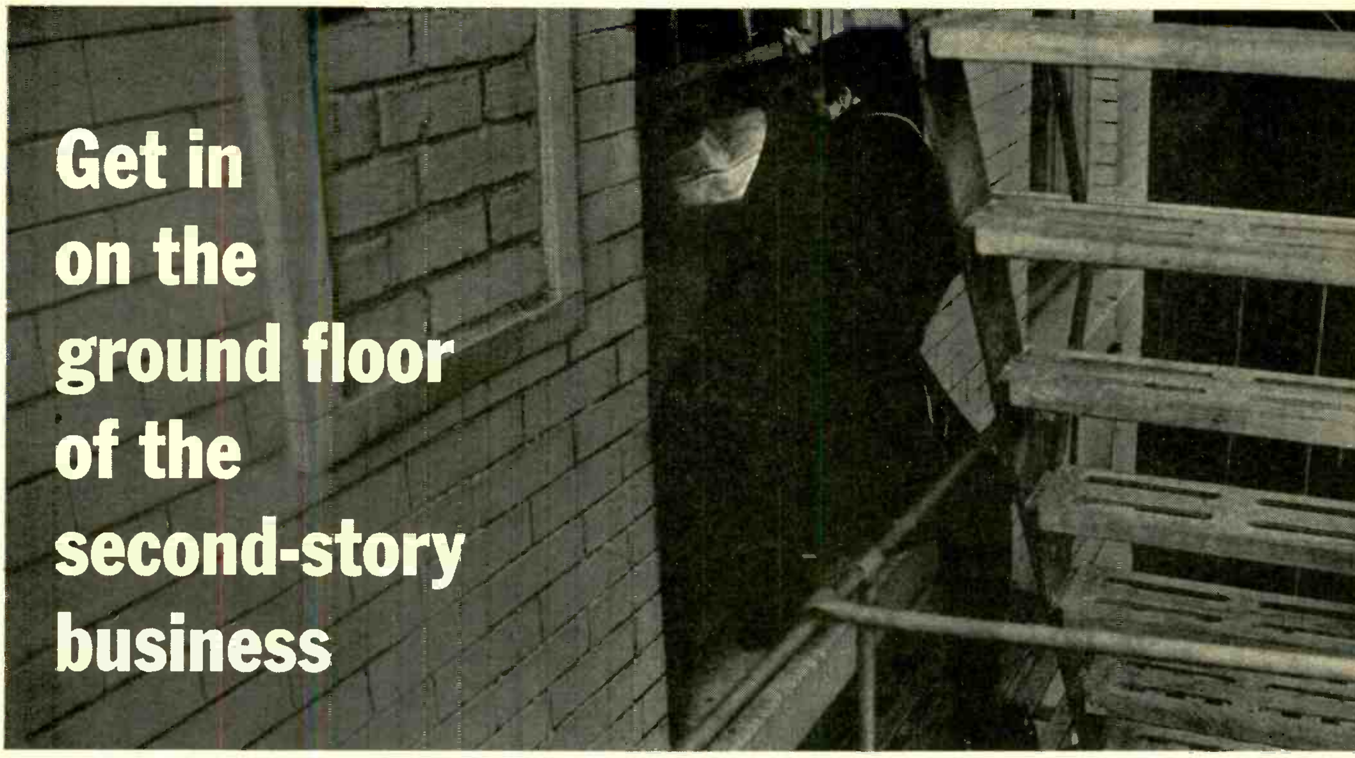


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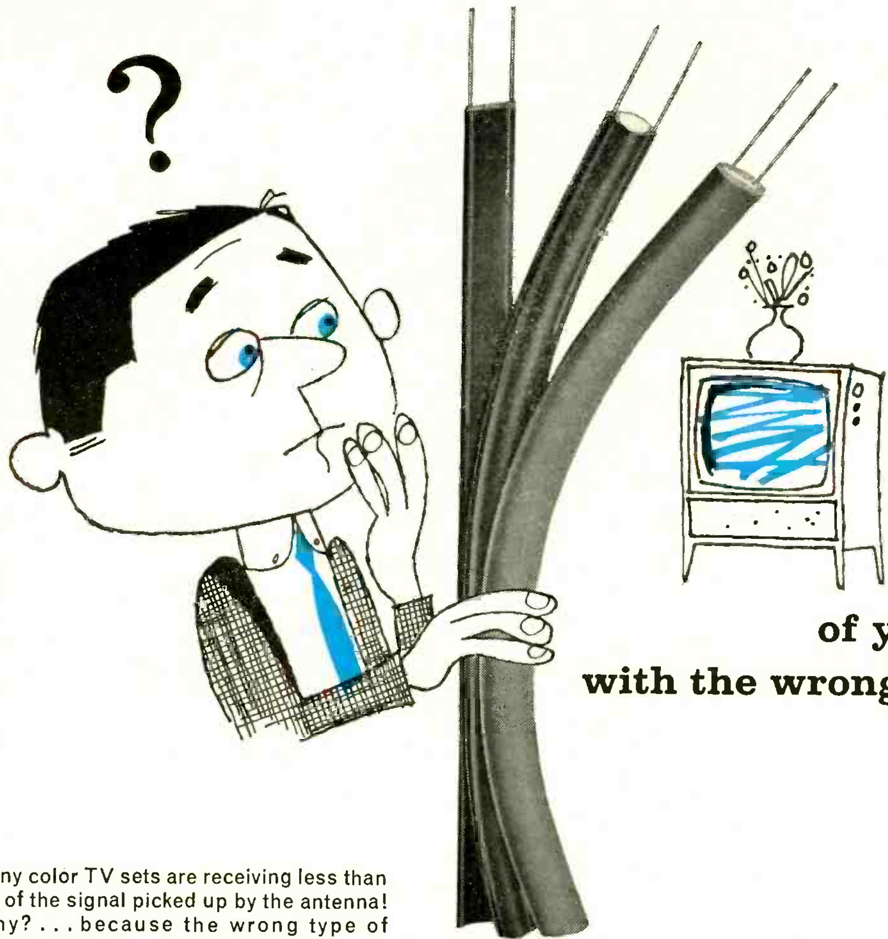


# You can lose 99% of your color TV signal with the wrong transmission line!

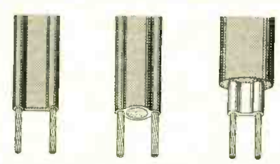
By Roland Miracle
Engineer, Electronics Division
Belden Manufacturing Company
Richmond, Indiana

Many color TV sets are receiving less than 1% of the signal picked up by the antenna! Why? . . . because the wrong type of transmission line is used. It is easy to forget that the *best* color TV receiver gives an image only as good as the signal it receives.

Because of the increasing volume of UHF and color TV installations, Roland Miracle, electronics engineer at Belden Manufacturing Company's Richmond, Indiana plant, answers questions on the various transmission lines available today.

**Q.** *Will most of the lead-in types now available perform adequately at UHF channels or in critical color TV applications?*

**A.** No! There are three basic types of lead-in on the market . . . flat ribbon . . . tubular . . . and encapsulated lead-in. Flat



Flat Ribbon    Tubular    Encapsulated

and tubular . . . perform well at UHF frequencies *only* when they are free from all traces of surface deposits. The minute these lines encounter dirt, rain, snow, salt, smog, fog or industrial deposits, problems arise. These deposits interfere with the critical signal area. Impedance drops abruptly. Attenuation losses soar. Ghost pictures result.

**Q.** *What about the encapsulated lead-in?*

**A.** This type of lead-in is made by Belden Manufacturing Company under the name, "Belden All-Weather Permohm* Lead-in" and is highly recommended for UHF and color TV installations. The encapsulated lead-in features a low loss cellular polyethylene protective jacket which surrounds the precisely spaced conductors, keeping all surface deposits out of the critical signal area . . . regardless of weather conditions.

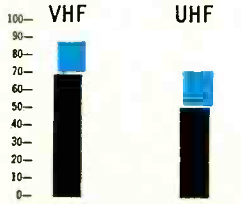
The illustrations show how the signals are *unprotected* by the flat and tubular lines, but *protected* by the Belden All-Weather lead-in.

Flat Lead-in    Tubular Lead-in    Belden All-Weather Lead-in

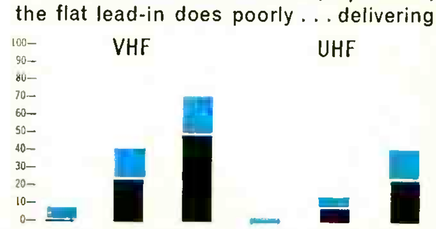
**Q.** *Is there really much difference in the three types?*

**A.** Let's look at the charts below which show how *all types* of lead-in operate at VHF and UHF frequencies when *weather conditions are good.*

At VHF frequencies, from 70% to 87% of the signal remains . . . at UHF frequencies, 52% to 70% remains. Under good weather conditions, there isn't much difference between the three lead-in types.




Now look at the relative performance when *weather conditions are bad.* The chart to the left shows that with *VHF frequencies,* the flat lead-in does poorly . . . delivering




from 2% to 8% of the signal. The tubular lead-in delivers from 25% to 42%. However, the Belden Permohm All-Weather Cable delivers from 50% to 70% of the signal.

The chart to the right shows performance *at UHF frequencies* . . . less than 1% for the flat lead-in . . . only 9% to 14% for the tubular lead-in . . . but from 25% to 42% for the Belden All-Weather Permohm lead-in. Obviously, a color TV receiver gives a better image with a stronger signal.

**Q.** *Does Belden Permohm lead-in cost more?*

**A.** Yes . . . but it's well worth it. Permohm helps you make sure the picture is right the first time around. You cut way down on those costly call-backs. Ask your distributor about Belden Permohm.

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Electronics World

# CONTENTS

JUNE 1965
VOL. 73, No. 6



## MONTHLY FEATURES






OUR COVER illustrates the use of transistors in hi-fi amplifiers. The subassembly at the top is one of two identical output stages of the Scott 260 stereo amplifier. A pair of matched power transistors is shown mounted on a heatsink. The printed-board subassembly at the bottom is the driver and pre-driver section of one channel of Harman-Kardon's "Citation B" power amplifier. Four of the five transistors shown employ individual heat sinks. For further details on these units and on other solid-state stereo amplifiers, see the article on page 49 of this issue . . . . (Photo: Jay Seymour, Burns Bros., N.Y.)

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# COMING NEXT MONTH


# SPECIAL ISSUE

**Fixed Capacitors**—A special 19-page section dealing with this important component. The various articles include information of vital importance to those responsible for specifying and purchasing capacitors at all industry levels. Walter C. Lamphier, Senior Product Specialist of Sprague provides pertinent data on **Plastic-Film Capacitors. Mica Capacitors**—foil, silvered, reconstituted, molded, and dipped—are discussed by E. M. Rothenstein, Executive Vice-President of Arco Electronics. William M. Robinson, Chief Engineer for Cornell-Dubilier covers the widely used **Paper Capacitor** with details on the various types of impregnants used, while the Engineering Department, Capacitor Products, Centralab tackles the subject of **Ceramic Capacitors.** In addition, N. Wayne Etter of Mallory, chairman of the EIA Fixed Capacitor Subsection of the Parts Division, discusses industry potentials. A directory of fixed capacitor sources completes this information-packed section. We also hope to present, space permitting, Harry Nieders' (Mallory Capacitor Co.) comprehensive and definitive article on aluminum and tantalum electrolytics—construction, applications, advantages.

**THE ART OF XEROGRAPHY**

*A laboratory curiosity when we first reported on the subject in 1944 has now become an industry giant. This article updates the original with special emphasis on new and broader electronics applications for such copying techniques.*

**EXPERIMENTS IN SPACE**

*The first of a new and exciting series of articles which will cover various facets of our scientific program for the exploration of space. In this article, Joseph H. Wujek, Jr. describes sounding rockets, scientific satellites, and deep space probes.*

**COAX VS TWINLEAD**

*A possible future trend for ghost-free color-TV reception is the installation of coaxial cable rather than twinlead between the antenna and the color set. Article by Lon Cantor of Jerrold Electronics Corp. points out the reasons for the superiority of coax.*

*All these and many more interesting and informative articles will be yours in the JULY issue of ELECTRONICS WORLD . . . on sale June 17th.*

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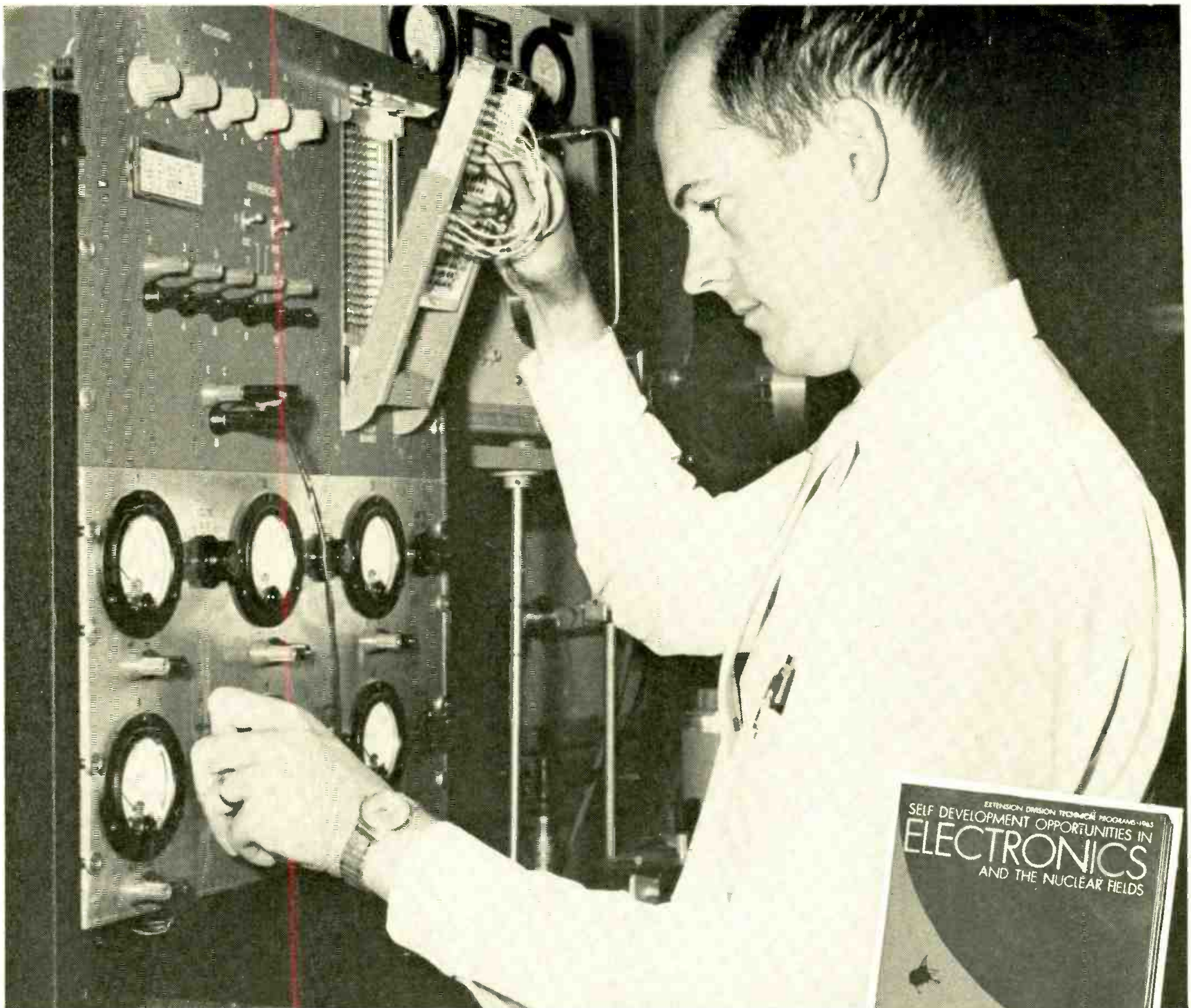


CREI GRAD ROY A. REICHERT *makes an adjustment on the prototype of a programmable power supply which he designed and built in his capacity as Senior Technical Aide, Bell Telephone Labs, Murray Hill, N. J.*

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# For the record

WM. A. STOCKLIN, EDITOR

## THE I.E.E.E. AND N.E.W. SHOWS

THE past few weeks have engendered more excitement than we have ever encountered before in a similar period. It seems we covered miles of exhibits at the IEEE convention in the Coliseum in New York City and at the National Electronics Week show (formerly called the Electronics Parts Distributors Show) at the N. Y. Hilton and Americana—with resulting sore muscles and tired feet. On top of this we saw on TV a Russian cosmonaut floating in space tethered to his spacecraft by a 16-foot line; the remarkable flight of our Ranger 9 to our neighboring satellite, the Moon; and most important, our own astronauts Grissom and Young in their Gemini 3 spacecraft, which they successfully maneuvered.

This year's Institute of Electrical and Electronics Engineers international convention marked a turning point in the industry—a bottoming-out of the economic problems seemed evident. The conversion of many companies from military and defense electronics to the less sophisticated civilian and industrial markets seems to have been successful resulting in a forecast of improved business in the future. This year's show was different in that top company executives—presidents, vice-presidents, and division heads—were in attendance and in many cases they were even manning the display booths. Instead of being interested solely in financial matters, as in the past, they were more actively participating in the show this year; studying the pulse of the industry, its problems, and their competition.

New products were in evidence throughout the show. One highlight was *Fairchild Semiconductor's* announcement of a cut in integrated-circuit prices. Within three months they will have on the market integrated circuits consisting of three or four transistors, with at least six resistors, at a price of 98 cents in 1000-unit lots. A cut of at least 50% in price on standard circuits is the trend, with other major manufacturers following suit.

Just over 59,000 engineers, scientists, and technicians attended the show, including representatives from 40 different countries. Russia's seven representatives included V. I. Siforov, President of the Popov Society, and several press conferences and special meetings were held in their honor. Siforov proved to be a very likable individual and his willingness to try to answer all questions as honestly as possible was commendable. As might be expected, many questions were asked about the Soviet space program and for obvious reasons replies were evasive and non-committal. However, we had the feeling that he didn't know the answers, since most of this work is government sponsored and does not involve the Popov Society, which seems to be the equivalent of our old IRE. They have a membership of 86,000, which is divided equally among communications, radio-TV, and industrial electronics fields.

In contrast to the IEEE convention, which is mainly a technical event, the NEW (National Electronics Week) show is market-oriented. Although many of the same companies participated in both events, which were held only a week apart, the NEW show involved only those manufacturers who sell through electronic parts distributors and commercial and hi-fi dealers.

This is the first time in more than a quarter of a century that this event has been held in New York City. The Show had been held annually in Chicago until this year.

This show was far smaller than the giant IEEE event, but there was no less interest and excitement.

Prior to the opening of the exhibits, which this year ran from Friday through Sunday, there was a two-day business forum attended by some 485 persons. This forum consisted of five sessions on the first day, held simultaneously, and five more on the second. Most heavily attended were the sessions that were strictly sales and management oriented. We spent some time at a most interesting debate on CATV and its effects on distributors and dealers. Although CATV is bound to have considerable effect on parts distributors' business, there seemed to be more interest in this session from equipment manufacturers and members of the press than from the distributors.

Attendance appeared to be down a little this year, particularly on late Saturday and Sunday. Quite a few people we talked to expressed the idea that the Show appeared to be getting quite regional in nature. Hence the move to New York will benefit New York area firms more than those from the Midwest.

The general feeling we got as we visited the various exhibits and exhibitors was of restrained optimism. The big words this year appear to be color-TV and communications equipment—with many of the companies pushing hard in these two fields.

All in all, we got the feeling that most who attended the Show found that it was definitely worthwhile and are looking forward to a similarly successful Show on the West Coast next year. ▲

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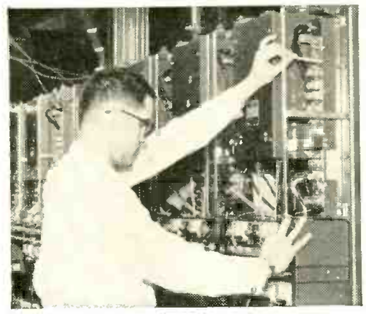

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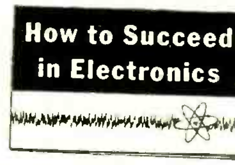


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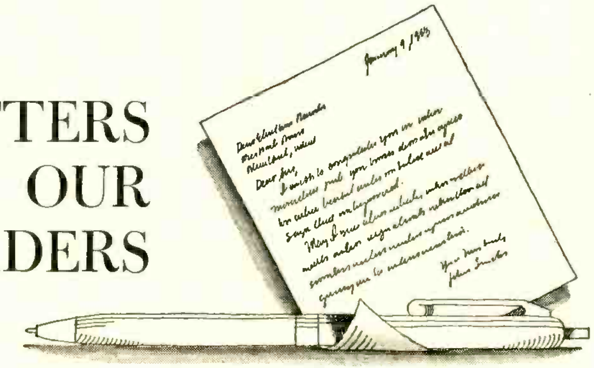
# LETTERS FROM OUR READERS



### "SHIELDED" NERVE FIBERS

To the Editors:

I have read your article entitled "Shielded Cables" in ELECTRONICS WORLD for November, 1964 and am reminded of the similarity of coaxial cable and myelinated (with fatty insulating tube) nerve fibers.

The axons of nerves conduct impulses by a wave of depolarization sweeping down the fibers at a rate of about 1 meter/second in unmyelinated fibers (no fatty insulating tube) and from 20 to 120 meters/second in axons surrounded by a myelin sheath.

Our research disclosed an annulus or ring of cytoplasm (cell protoplasm exclusive of nucleus) in a myelinated nerve between the axon and the myelin that may serve as an external conductor for nerve-impulse transmission. Since the volume of the cytoplasm of the external conducting annulus and the contents of the axon are about the same, it suggests an impedance-matched system for channeling the impulse with the insulating myelin layer serving to prevent loss of ionic current and thereby speeding the depolarization process.

Nerve-impulse transmission is of course not the same as conduction in a wire. However, can coaxial-cable theory be applied to this problem and if so, do you think that surrounding a slowly conducting nonmyelinated fiber with an insulating tube spaced so as to include an external circuit (of resistance equal to the internal circuit) within the tube would increase the speed of impulse transmission? Any comments would be appreciated.

WILLIAM G. ESMOND, M. D.
Univ. of Md. School of Medicine
29 S. Greene St.
Baltimore, Md. 21201

* * *

### MATH AND THE TECHNICIAN

To Mr. John Frye:
Dear John:

I feel that I can call you by your first name because after reading your article on "Math and the Technician" in the March issue, we could only be the closest of friends. You have made a point in this article that we have been trying to get across for years, albeit not so clear-cut and forceful as you.

We have been integrating mathematics into our home-study courses for years but unfortunately we have had to disguise it with catchy names so as not to scare the technician away. Obviously, the technician needs math, yet why does he, like so many persons, shy away from it? We try not to cram it down his throat but show him how it's to be used. A technician couldn't care less about the derivations of formulas, yet so many texts make an issue of this.

Your articles are most interesting and are, I hope, awakening technicians to the professional development they must seek just to keep pace with this fast-changing industry.

DR. ROBERT A. NOTTENBURG
Vice Pres., Education & Training
Cleveland Inst. of Electronics
Cleveland, Ohio

To the Editors:

As an electronics instructor in the Air Force, I wish to say "amen" to John Frye's article on "Math and the Technician." Today the lack of knowledge of basic mathematical principles of simple algebra and trigonometry is holding back the advancement of many bench technicians in the service because they are unable to pass their Skill Knowledge Tests for promotion in duty grade. Yet because of the lack of an adequate math training and their unwillingness to spend the time to learn these mathematical operations and methods, they have reached the top of their military careers prematurely.

There is no easy royal road to mathematical knowledge except working examples and problems. The military services' educational programs all offer training in the areas of algebra, geometry, trigonometry, and college-level higher math to those who are willing to spend the time and effort.

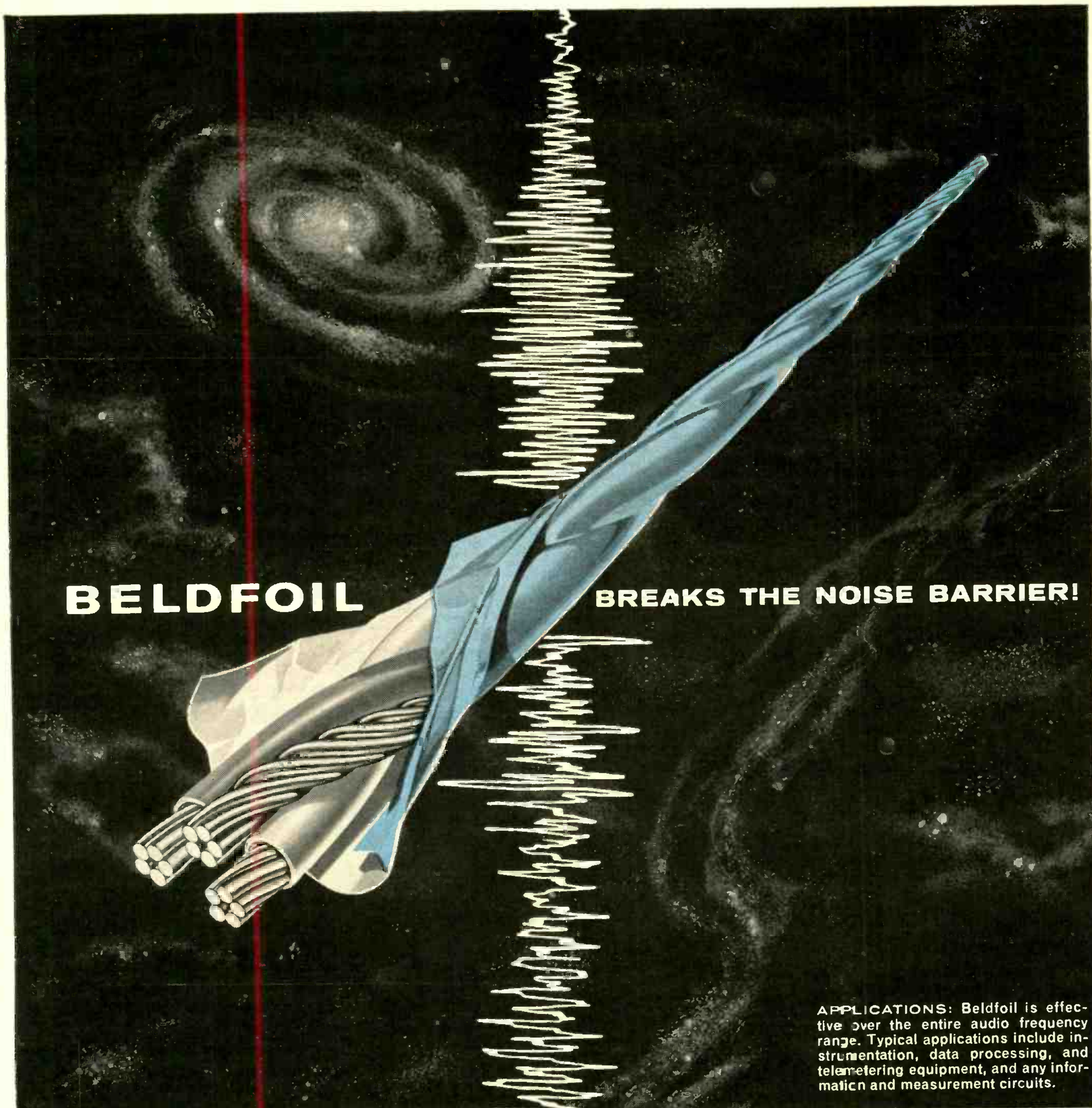
TSGT. GEORGE F. TYLER
Holloman AFB, N. M.

* * *

### CCTV CAMERAS

To the Editors:

Received your March, 1965 issue of ELECTRONICS WORLD and read with interest and great disappointment Mr. Wortman's article "Choosing a Closed-Circuit TV Camera." We here at *Dia-*

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8-1-3

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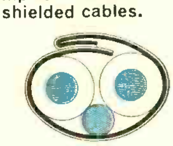

Typical cross section looks like this.

*Belden Trademark Reg. U.S. Patent Office
**du Pont Trademark ***U.S. Patent 3,032,604

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**CIRCLE NO. 100 ON READER SERVICE PAGE**

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J. W. ANDERSON
Applications Engr.
Diamond Electronics
Lancaster, Ohio

° ° °

### LINE-OF-SIGHT NOMOGRAM

To the Editors:

The nomogram in your March, 1965 issue bothers me since it appears to apply only to locations *at sea level,* not inland places like Chicago or Cleveland where sea-level elevations are all 500 feet or more.

I have drawn a line between a 500-foot-above-sea-level transmitting antenna height (*i.e.*, antenna on the ground) and a 500-foot-above-sea-level receiving location height (*i.e.*, antenna also on the ground), and I get a line-of-sight distance of 63 miles!

H. P. DAVIS
Cuyahoga Falls, Ohio

*Obviously, a line-of-sight distance of 63 miles for two ground-level antennas is quite impossible. All references to* sea level *in the nomogram, as a matter of fact, should be changed to* effective ground level. *The only time one would use the term "sea level" would be in the event of over-water transmissions.*

*The reason the term "sea level" was used in the nomogram was to avoid the fact that some readers might be tempted to use the height above an elevated ground level, such as a hill, in their calculations instead of the height of the antenna above smooth effective ground. —Editors.*

° ° °

### TRANSISTOR MV'S

To the Editors:

It appears that there is an error on page 54 of the February, 1965 issue ("Design of Transistor Multivibrators"). In Fig. 3, the ground connection for the two emitters has been omitted.

LARRY LOCKWOOD
McMinnville, Ore.

*Everyone who checked these pages read a ground into the circuit even though it wasn't shown. Of course, the emitters should be grounded. Also, just five lines above the diagram our printer substituted a "B" for a "β".—Editors.* ▲

  

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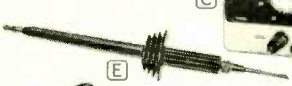
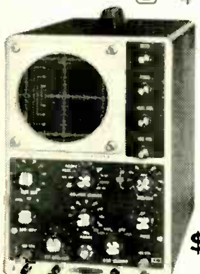


E

D



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B **Deluxe "Service Bench" VTVM, Kit IM-13...$32.95, Assembled IMW-13... $49.95** 7 AC/DC/Ohms ranges; measures AC volts (RMS), DC volts, resistance & db; separate 1.5 & 5 volt AC scales; gimbal mount for bench, shelf or wall; 6" 200 UA meter; single AC/Ohms/DC probe. 7 lbs.

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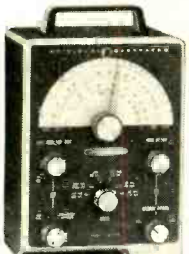

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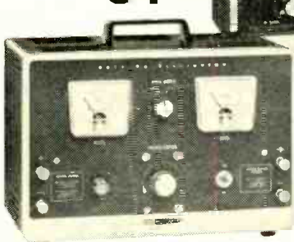

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[L] **"Solid-State" Regulated DC Power Supply, Kit IP-20...$72.95, Assembled IPW-20...$114.95** 50 MA, 150 MA, 500 MA & 1.5 A current ranges; 5, 15, 50 v. DC voltage ranges; filtered output for less than 150 uv ripple; adjustable current limiter, 30 to 100% on each range. 16 lbs.

[M] **Variable-Voltage Regulated Power Supply, Kit IP-32...$56.95, Assembled IPW-32...$84.95** Furnishes B+, bias & filament voltages; DC output variable from 0 to 400 volts; separate panel meters for voltage & current; output terminals isolated for safe AC/DC work. 17 lbs.

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| THE CARTRIDGE | ITS FUNCTION, ITS FEATURES... | IS YOUR BEST SELECTION |
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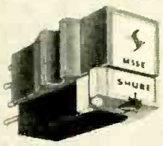
|  M55E | Designed to give professional performance! Elliptical diamond stylus and new 15° vertical tracking angle provide freedom from distortion. Low Mass. Scratch-proof. Similar to V-15, except that it is made under standard quality control conditions. | If you seek outstanding performance and your tonearm will track at forces of $\frac{3}{4}$ to $1\frac{1}{2}$ grams, the M55E will satisfy—beautifully. Will actually improve the sound from your high fidelity system! (Unless you're using the V-15, Shure's finest cartridge.) A special value at $35.50. |
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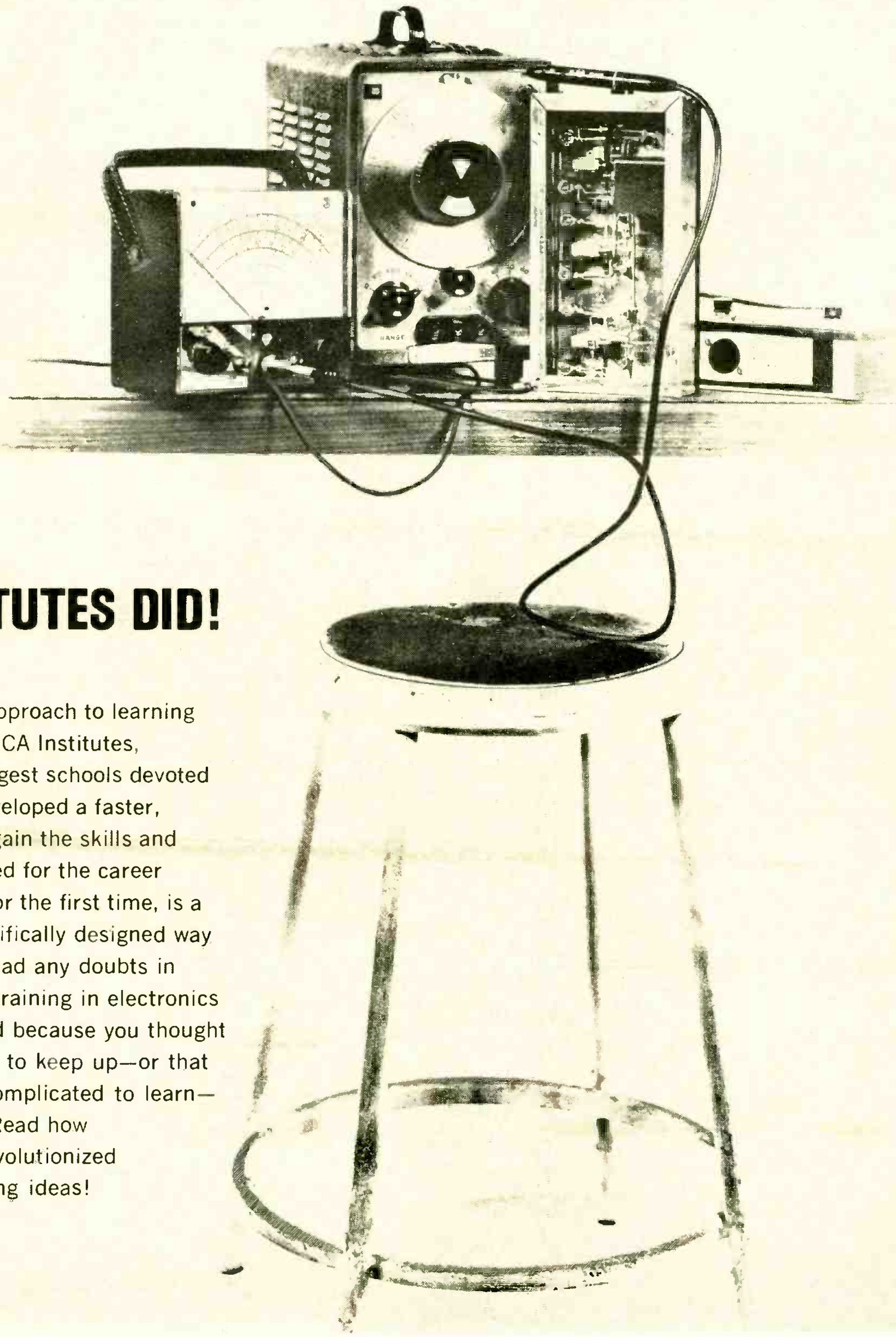

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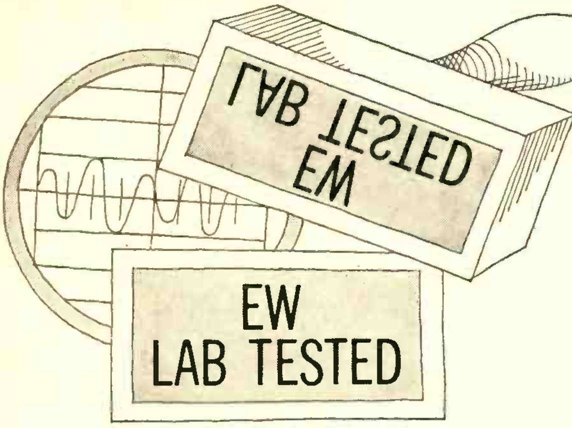



# HI-FI PRODUCT REPORT

*TESTED BY HIRSCH-HOUCK LABS*

**Concord 994 Tape Recorder**
**Goodmans "Maximus I" Speaker**

## Concord 994 Tape Recorder

*For a copy of manufacturer's brochure, circle No.* 55 *on coupon* (*page* 15).


THE *Concord* 994 is a three-speed portable tape recorder, featuring automatic tape reversal. A small piece of conductive tape (supplied with the recorder) may be affixed to the tape at any point. When set for automatic operation, the recorder reverses direction when the conductive tape passes a contact in the head assembly. Simultaneously, a second set of heads is switched in, allowing the uninterrupted playing of a full 7" reel of four-track stereo tape.

The reversing feature is effective on recording as well as on playback, since the switching affects both the combined record/playback head and the erase head. In the "Auto. Reverse" position of the "Function Selector" switch, the tape plays through completely and then shuts off. In the "Continuous" position, when a second piece of tape is attached near the beginning of the reel, the recording repeats over and over, without attention from the operator. This "Continuous" mode of operation is especially convenient for background-music applications. A recording can be made at 1⅞ ips, when highest quality is relatively unimportant, and a 2400-foot reel of 0.5-mil tape will play for 8 uninterrupted hours. Even at 7½ ips, the program will repeat only at 2-hour intervals, which is adequate for restaurant and similar background-music applications.

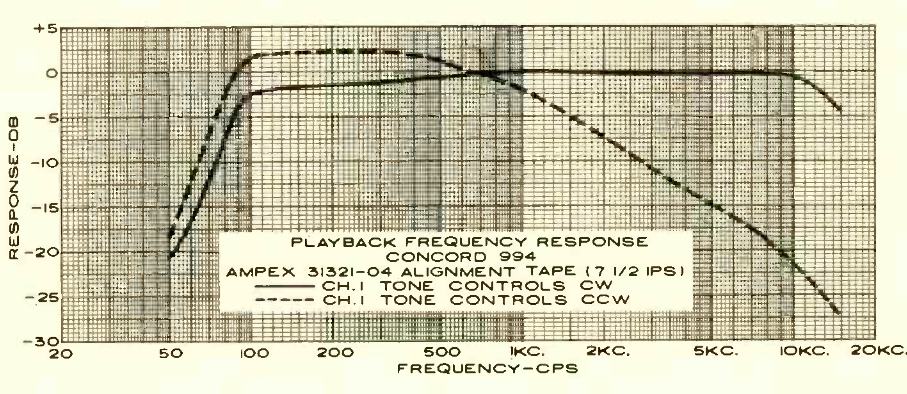
The transport is controlled by a group of push-buttons for "Fast Forward" and "Reverse," "Play," "Stop," and independent "Record" buttons for the two channels. One or both of these must be pressed simultaneously with the "Play" button to make a recording. They are released automatically when the "Stop" button is operated. A "Cue" button stops the tape and returns it to motion instantly when released, without declutching the "Record" buttons. In the "Continuous" mode of operation, the tape motion may be reversed manually by pressing either of two illuminated buttons which indicate the direction of tape travel.

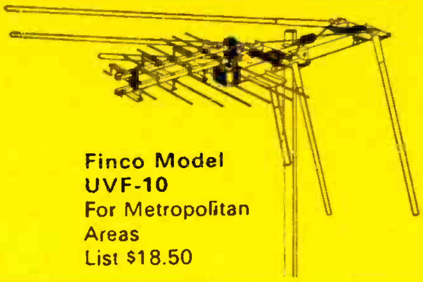
Each channel has line and microphone inputs, with a single gain control per channel. This control affects both recording and playback levels. When recording, two meters monitor program levels. Each channel also has a tone control, which attenuates high-frequency response during playback only. Turning one of the tone controls fully counterclockwise connects the incoming program to the speakers for monitoring while recording.

The inputs and outputs are located behind a hinged panel on the side of the recorder. In addition to the "Aux." and "Mic." inputs, there are line and speaker outputs, and a stereo headphone jack for monitoring. A slide switch parallels the two channels in playback, for mono listening. Another switch connects the playback output of Channel 1 to the recording input of Channel 2, and *vice versa.* By means of this switch, sound-on-sound recordings can be made without recourse to external cables or patch-cords.

The cover of the recorder consists of two sections. Each contains a 3" x 5" oval woofer and a 1½" cone tweeter, with integral cables and plugs. Also stored within the covers are input cables and microphones, which are supplied with the recorder.

The measured playback response of the unit, using the *Ampex* 31321-04 (7½ ips) alignment tape, was within ± 2.5 db from 100 to 13,000 cps, and was down only 4 db at 15,000 cps. The low frequency response fell off sharply below 100 cps, to about −20 db at 55 cps. The tone controls rolled off the highs at a 6 db/octave rate above 500 cps when set fully counterclockwise. The 7½-ips record/playback response was similar, within ± 2.5 db from 100 to 12,000 cps on one channel, using either the





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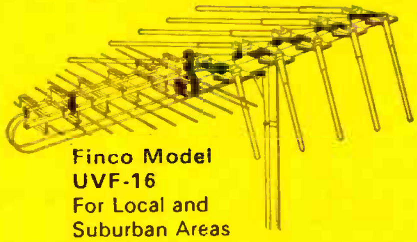

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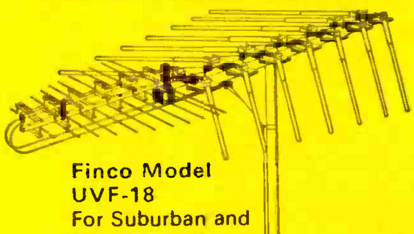

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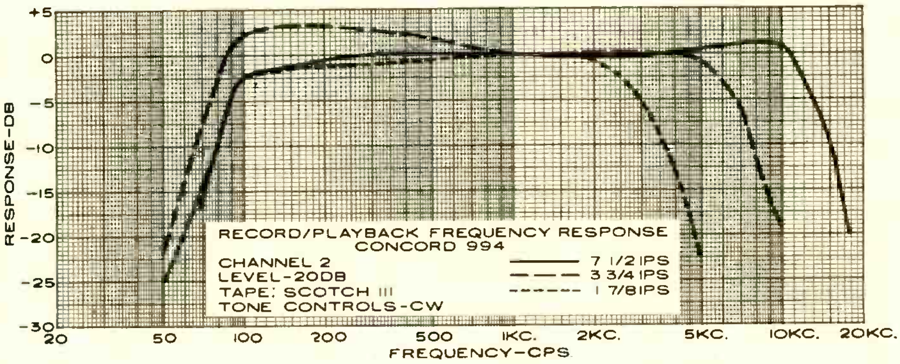


forward or reverse set of heads. One channel on the test sample showed a somewhat reduced high-frequency response (−8 db at 10 kc.), evidently due to a faulty component or improper adjustment of the recording equalization circuits. (Both recording and playback channels have such adjustments.) At 3¾ ips, the over-all response was ± 3 db from 80 to 6000 cps, and at 1⅞ ips it was ± 3 db from 90 to 3000 cps.

The wow and flutter were, respectively, 0.04% and 0.19% at 7½ ips, when playing the *Ampex* 31326-01 test tape. When recording and playing back a test tone, the combined wow and flutter were slightly higher, but were not noticeable except at 1⅞ ips. At this slow speed the flutter was 0.5% and was clearly audible.

The signal-to-noise ratio varied from 47 db at 7½ ips to about 43 db at 1⅞ ips. Stereo crosstalk was below the noise level. The operating speeds were very slightly fast. In fast-forward or rewind, 1200 feet of tape was handled in 3½ minutes.

The dynamic microphones were of satisfactory quality for most home recording purposes. The speakers sounded very good, especially in view of their small size. Some treble roll-off was needed to produce a pleasing balance between lows and highs. On most program material, the low-frequency response was adequate, even when playing through large external speakers. The over-all sound through the monitor speakers was quite musical and listenable. The built-in sound-on-sound facility worked well, but there was a noticeable high-frequency loss when transferring a program from one channel to the other.

All in all, the recorder appears to be a well-constructed, easy-to-operate machine which is well suited to home use, particularly when playback of recorded tapes is the chief mode of operation. The automatic reversal feature allows the user to turn on the unit and enjoy many hours of uninterrupted music, and the built-in monitor speakers have more than adequate quality for enjoyable listening. The recorder is delivered with an automatic-threading takeup reel.

The *Concord* 994 lists at $449.95. ▲

## Goodmans "Maximus I" Speaker

*For a copy of manufacturer's brochure, circle No. 56 on coupon (page 15).*

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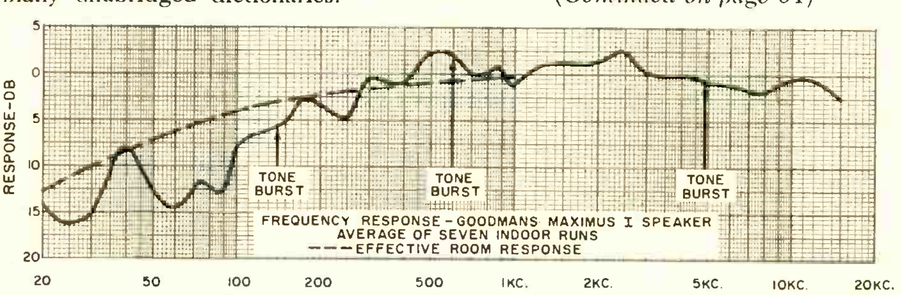
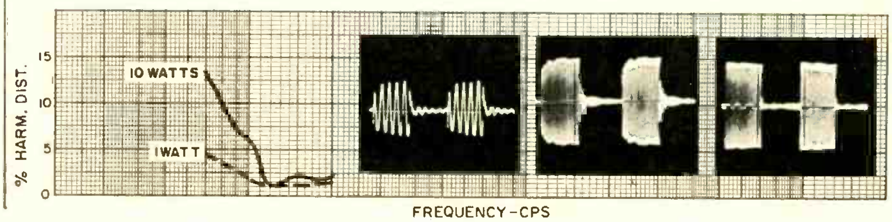
(*Continued on page* 64)



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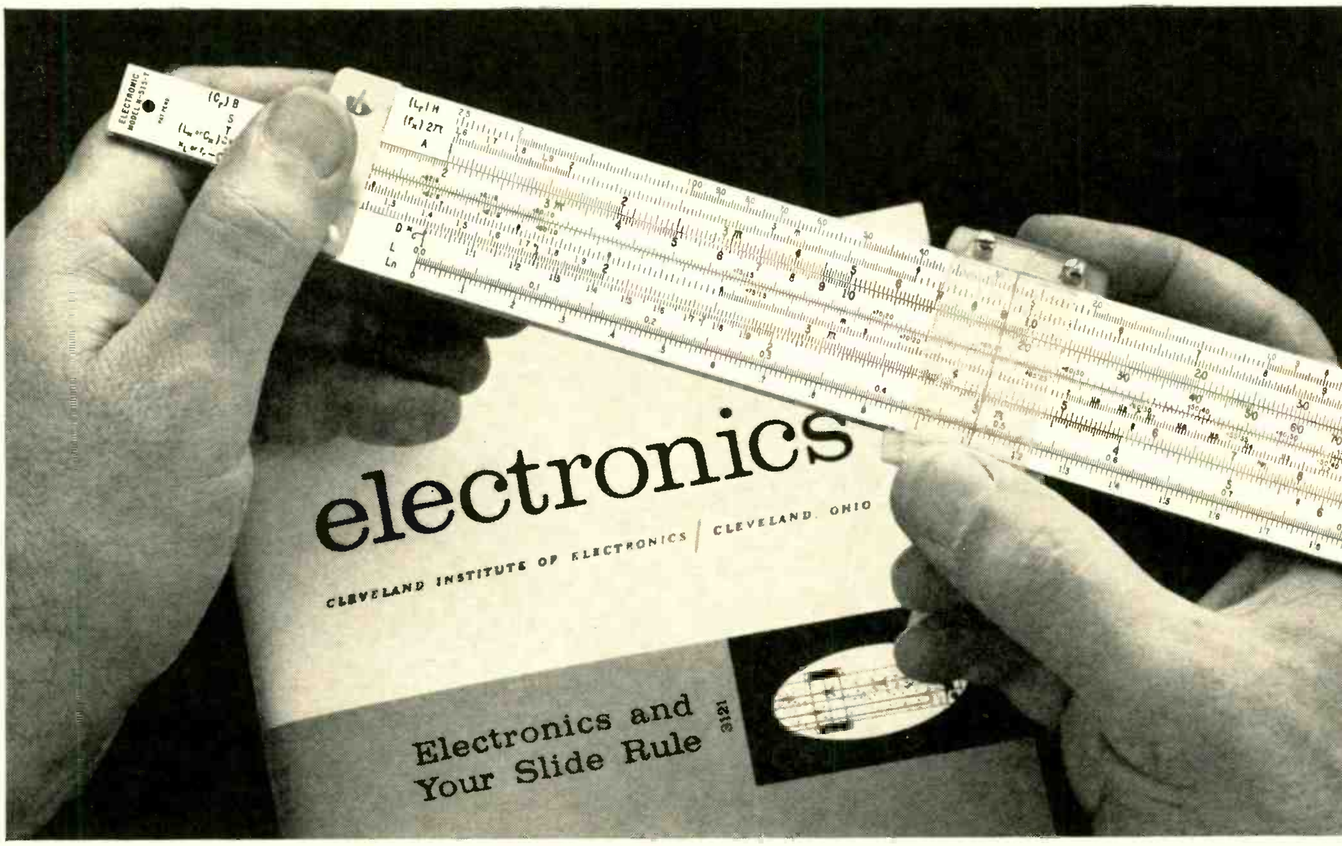


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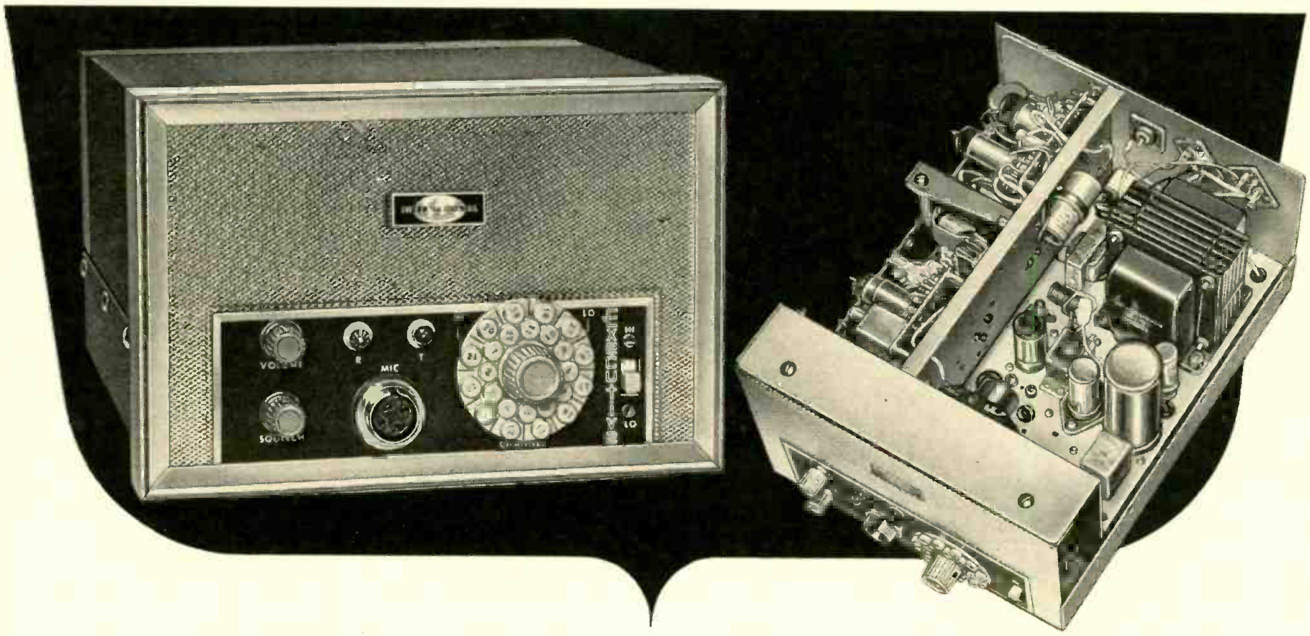

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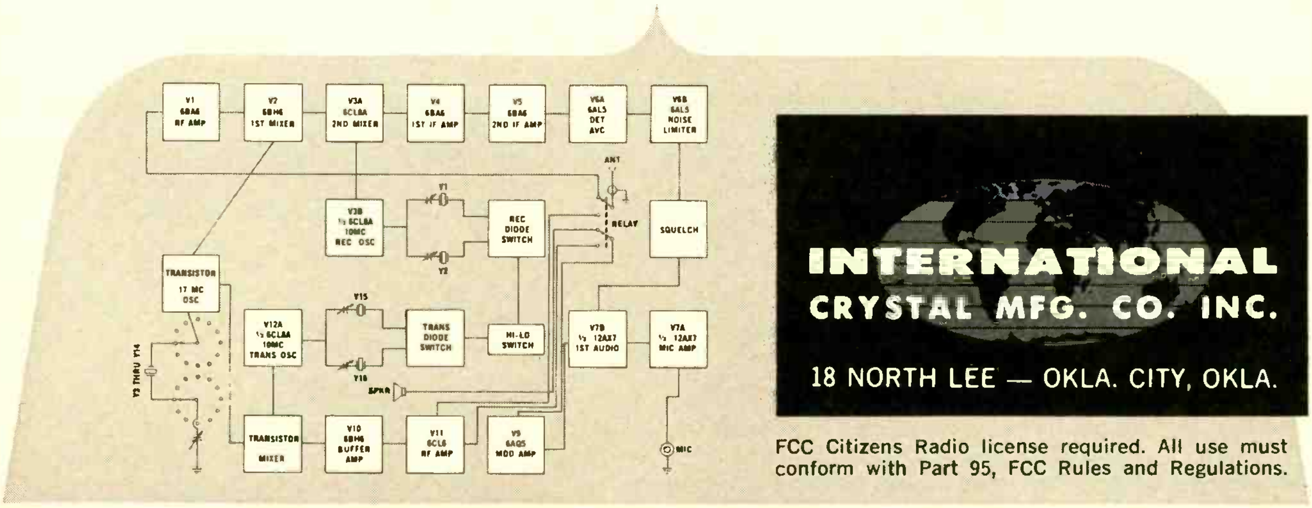


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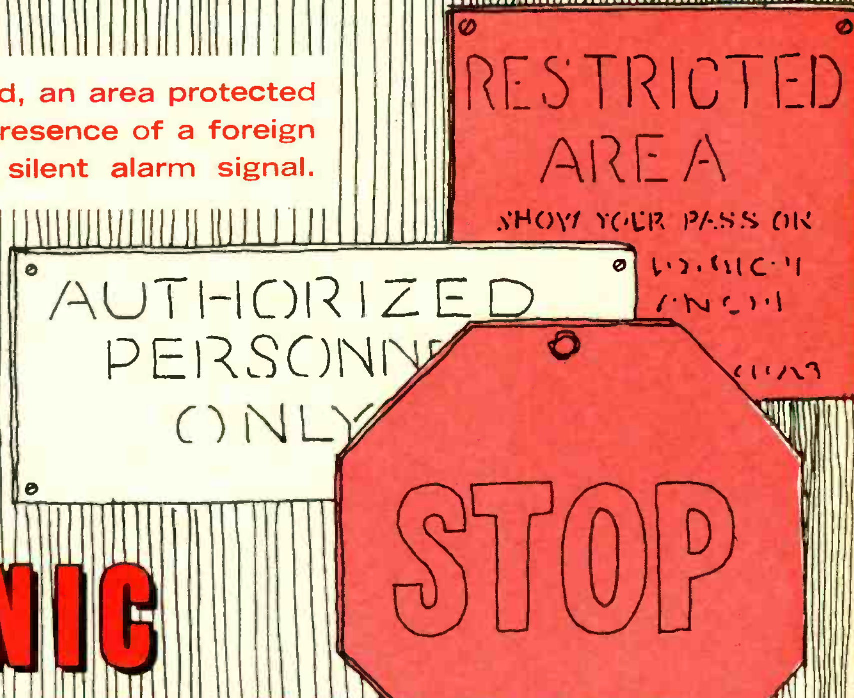



# ELECTRONIC INTRUSION ALARMS

By WALTER H. BUCHSBAUM / Contributing Editor

WHILE the daily newspapers headline such crimes as murder, rape, and the more spectacular robberies, the great increase in such unglamorous crimes as theft, burglary, shoplifting, and pilferage has presented a real challenge to the forces of law and order. The growing trend towards self-service stores, supermarkets, and large department stores has been responsible for a tremendous increase in shoplifting. As industrial facilities have become larger and more impersonal, workers have felt less compunction about pilfering their employer's goods. With so many homes now equipped with a host of expensive appliances, burglars often specialize in portable television sets and hi-fi equipment which can easily be converted into ready cash. The addition of more policemen, more guards, and more patrols is very costly and is not the complete answer. As in many other fields, electronic devices have been introduced that allow the police to be far more effcient, and that go a long way towards discouraging potential criminals.

Electric burglar and fire alarms and similar protective devices have been known for well over 50 years and are widely used in stores and industrial facilities. Unfortunately, all of these devices require a great deal of special wiring and installation and, with the increase in skill and knowledge of the criminals, can be easily circumvented. This article describes some examples of a new generation of electronic security devices which are either completely foolproof or extremely difficult to tamper with.

Elaborate intercommunication systems and closed-circuit TV systems are not included in this article.

Detailed circuitry of most of the new electronic devices is being kept under wraps because security people feel that circuit familiarity with these devices will reduce their effectiveness. It is known that the mere presence of an electronic protection device will prevent many crimes because non-technical people hold anything electronic in great awe. A typical example of this is the use of signs in many department stores which warn that closed-circuit TV is being employed to observe potential shoplifters. If one looks for the cameras there are usually quite a number to be seen. In actual practice, at least half of them are dummies, but experience has shown that the very presence of the camera is enough to discourage any but the most hardened shoplifters.

### Electronic Entry Alarm

Police statistics indicate that the vast majority of burglaries in apartments are committed by forced entry through doors. Skilled burglars can easily pick most conventional doorlocks and where chains are used they can be cut through. One typical electronic entry alarm made by *Dadco* can protect any door, regardless of lock, by a simple electronic circuit. The device (shown in Fig. 1) consists of a small metal box which is bolted to the inside of the door and a small permanent magnet which is mounted against the door jamb, adjacent to the metal box when the door is closed. With the door closed, the magnet is opposite a magnetic reed switch located inside the box which keeps this switch open. As soon as the door is opened the reed switch closes, an internal relay is energized, and an electronic timer is started. Any legitimate person entering will have a key which turns the entry alarm off. If the key has not turned the entry alarm off within approximately 15 seconds, an extremely loud and unpleasant alarm sounds. To permit a person to leave the apartment or to open the door from the inside, it is only necessary to set the mechanical timer to de-activate the system for a period up to 60 seconds. When that time is up, the alarm is again cocked and ready.

The circuit of the *Dadco* electronic entry alarm, shown in Fig. 7, illustrates the use of a six-volt battery and a two-transistor network to provide the 15-second silent delay. The magnetic reed-switch contacts (S1) are open as long as the door is closed. As the door is opened, the magnetic contacts automatically close, causing the relay to close and, even if


Fig. 1. Door protection device operates by moving the magnet away from the unit. See text.

the door is closed afterwards or the mechanical timer is opened, the relay remains closed because of the latching contact. This relay then furnishes power to the two-transistor network. Transistor $Q1$ is turned on as soon as the relay closes and is turned off by the gradually accumulating charge on the capacitor. Potentiometer $R1$ is used to set the delay approximately 15 seconds. Second stage $Q2$ is cut off until $Q1$ drives it into saturation. This energizes the reed relay coil, closing the relay and passing current to the two horns.

Only a screwdriver is required for installation of this alarm and no external wiring is necessary. Whenever the door is opened, the light located next to the key switch is illuminated, indicating to the owner that the battery is still operating correctly.

Another self-contained burglar alarm is the Model B-165 manufactured by *Fire Alarm Thermostat Corp.* in which a single battery powers three semiconductors. A power transistor drives the alarm horns, an SCR acts primarily as a latching device, and another SCR provides the time delay to permit the homeowner to enter and turn the device off before the alarm sounds. No exit timer, like in the *Dadco* unit, is required here. This unit is armed simply by turning the key switch on with the door open. Once the door is closed the "Fiatco" unit is automatically armed again. Another special feature is a night switch which disables the time delay so that the alarm goes off at once. Patent applications cover these particular electronic features of this burglar-alarm unit.

### Motion Detectors

To protect internal premises from prowlers, burglars, or other unauthorized persons, a variety of different devices is available. Ranging from audio to microwave, all of these devices essentially use the Doppler principle to detect motion.

The Doppler principle states that a signal reflected from a moving object changes its frequency according to the relative speed of motion. Police radar speed traps are based on this principle. The idea behind Doppler motion detectors in security systems is that any person on the premises will have to move in order to achieve his objectives. Motion of any kind, even slow, is detected and generates an alarm signal. The *Corbell* G-1 motion detector contains the essential features of all other motion detectors except that it uses the highest frequency of any microwave motion detector currently on the market, operating slightly above 10 gigacycles. The block diagram of Fig. 6 illustrates the major functional blocks, and the photograph of Fig. 2 shows the appearance of the complete unit. Note that the transmitting antenna is a horn-type antenna, providing a cone-shaped beam, while the receiving portion is a slot antenna, the circular opening shown next to the horn in the photograph of Fig. 2. At 10 gc., radio waves behave very much like light waves in that they are reflected from both metallic and non-metallic objects.

The r.f. detector compares the frequency of the received signal with a small portion of the signal taken from the transmitter. In this motion detector, the transmitter consists of a klystron tube but all other circuits are transistorized. Unless the received signal has been shifted in frequency due to reflection from a moving object, its frequency will be the same as that of the transmitter although the phase may be slightly different. The output of the r.f. detector is then essentially zero. As soon as motion occurs, and depending on the speed of the motion, the r.f. detector output becomes a low-frequency audio signal which is amplified until it is strong enough to actuate the audio-frequency detector and the alarm relay. Because fail-safe operation is required, the alarm relay is arranged so that it is normally energized, and is de-energized when an alarm occurs. This means that in the case of power failure the alarm relay will be de-energized. The block diagram of Fig. 6 also shows a supervisory circuit and supervisory relay. This supervisory circuit is an auxiliary detection and amplification circuit which holds another relay energized as long as the oscillator, r.f. detector, and amplifier stages are all working properly. An alarm signal, over the supervisory relay, is presented when a failure occurs. This type of additional circuitry is included in one form or another in most of the electronic security devices. It protects not only against component failure but also sounds the alarm when tampering with the equipment is attempted. In simpler equipment, Microswitches are activated when an unauthorized person without a key tries to open a control box.

Typical of other microwave motion detectors is the "Intrud-Alarm" made by *Bay State Electronics* and shown in Fig 3. In this device, the r.f. transceiver is mounted in a separate box and sends the Doppler audio signal to the remotely located control box. One of the special features is an adjustable delay period from two to ten seconds before an alarm is sounded. This eliminates false alarms caused by falling objects, momentary power failure, etc. Another microwave alarm system is the WJ-1000, manufactured by *Watkins-*

Fig. 2. In the microwave motion detector, the horn-shaped antenna is the transmitter, while the circular opening is the receiving antenna. Unit operates in the 10-gc. band.

Fig. 3. Small-size microwave motion detector transceiver sends Doppler signal to remotely located control console.

*Johnson Co.* and widely installed by the *William J. Burns International Detective Agency.* This unit features modular construction and uses separate units for the microwave radiator and for the alarm sensor. It is particularly useful in guarding large areas and can be arranged to have a number of transmitters and receivers (alarm sensors) installed in different places. Tamper-proof communication between the various modular units is one of the features of this system. Separate annunciator panel units, line supervisory units, and remote test units are also available to permit central control of the many different areas being protected by the system.

The frequency range of these systems is approximately 1 gc. and omnidirectional antennas are used. Fail-safe features and tamper-proof arrangements are similar in all of these alarm systems.

The "Radar Sentry Alarm" made by *Radar Devices Manufacturing Corp.*, is a u.h.f. Doppler system used to provide protection for areas up to 5000 square feet (10,000 square feet with remote detectors). Any human motion within the area causes a police-type siren to sound. Tampering with the equipment, or a power failure, also starts the siren.

Typical of the new electronic security systems is the Air Force 410-L program which is being installed to protect Titan II and Atlas missile sites. This system uses microwave motion-detection devices similar to those described here to

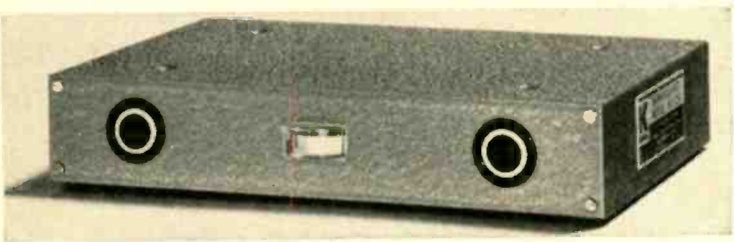


**Fig. 4. Ultrasonic Doppler-effect motion detector covers cone-shaped area approximately 12-ft. deep to the front.**

cover a series of areas, with alarms going to a central, underground command post. Because this equipment must guard outdoor areas, it is designed to operate at threshold levels which are set to distinguish between small animals and human beings. Standby circuitry, internal alarms, line-tampering alarms, and other special features make this system more reliable and versatile than the sentries it will replace.

In the ultrasonic frequency range, the *Walter Kidde Company* offers the "Mini-Guard Intrusion Alarm," which uses the same Doppler principle as microwave motion detectors but which is more dependent on phase shifts. Ultrasonic "sound" waves will detect any moving object, even hot- and cold-air boundaries. This can lead to false alarms when air-conditioning or heating systems go on at night. The *Kidde* "Mini-Guard" is a completely self-contained portable unit that can be placed on a bookshelf or table. For normal operation, the space covered is approximately 12 feet in a cone-shaped area in front of this device. The unit, shown in Fig. 4, is completely transistorized, operates from a 12-volt source, and contains a built-in, self-charged battery which will keep the unit in operation if the a.c. power is interrupted. The front-panel meter is used to test the system by walking through the protected zone and watching the meter change. The alarm signal generated by the internal relay can be connected to either a local bell or to a remote alarm system. It is also possible to use separate external transducers, and the sensitivity of the entire system can be adjusted.

As a motion detector in the audible range, the *Honeywell* "Sono-Sentry" is a particularly interesting device. Looking like a conventional public-address loudspeaker (Fig. 5), the transceiver is essentially both a loudspeaker and microphone for a 460-cps protective signal. This audible signal is beamed into the area to be protected and can be heard by the unauthorized intruder as well as by any guards patrolling nearby

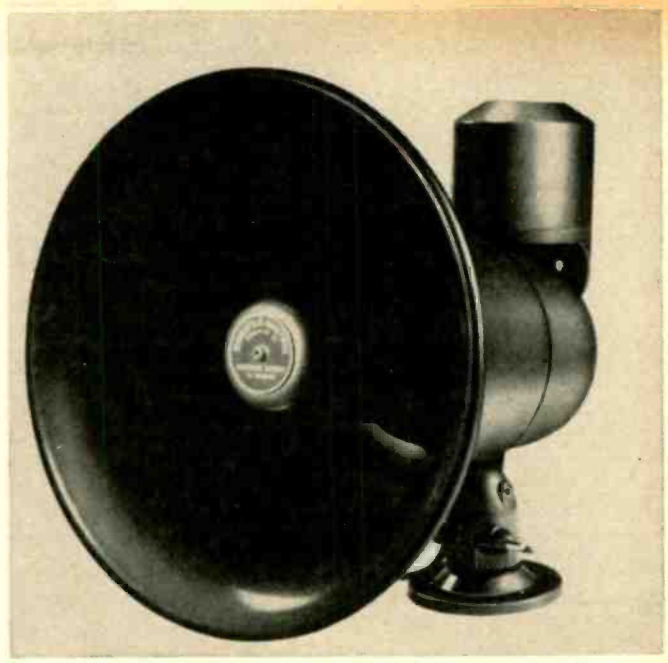


**Fig. 5. Looking like a public-address loudspeaker, this is a sonic motion detector working on the received phase shift.**

areas. The microphone portion of the transceiver picks up the 460-cps signal of both the transmitted phase and out-of-phase components due to reflections. At the control cabinet, the original oscillator signal is compared with the received signal and any change in the reflected phase pattern is detected. Such a change closes a relay which, in turn, operates the alarm signal. Because of the combined directivity of the

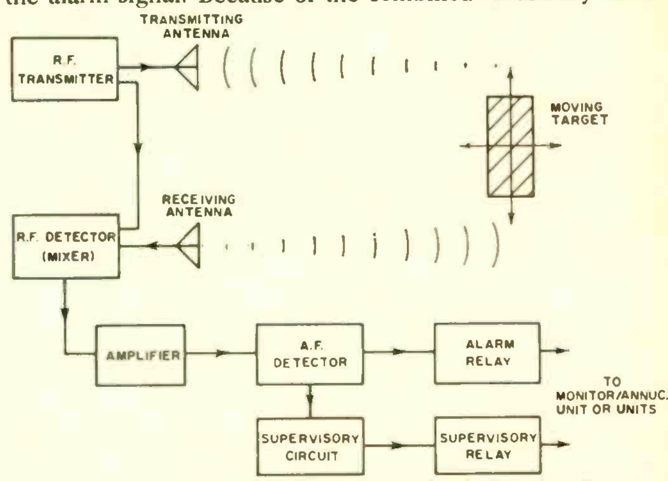
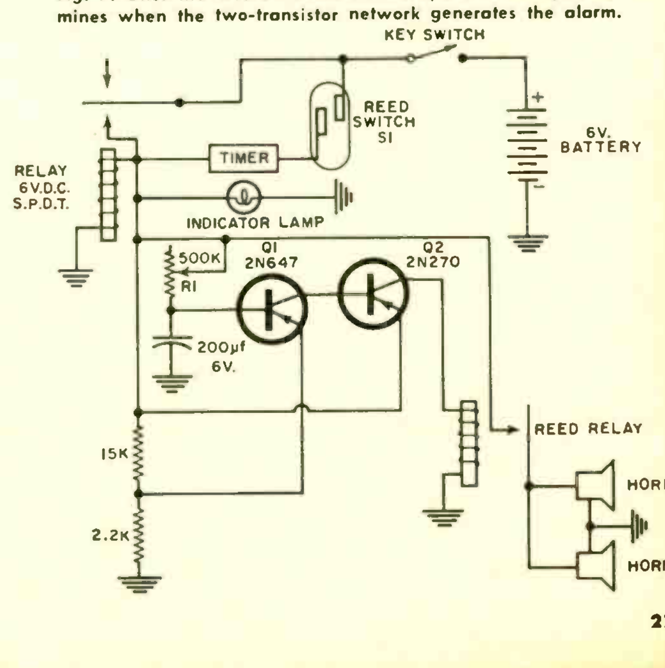



**Fig. 6. Microwave motion detector works by the Doppler effect.**

**Fig. 7. Once the reed switch is activated, a time delay determines when the two-transistor network generates the alarm.**



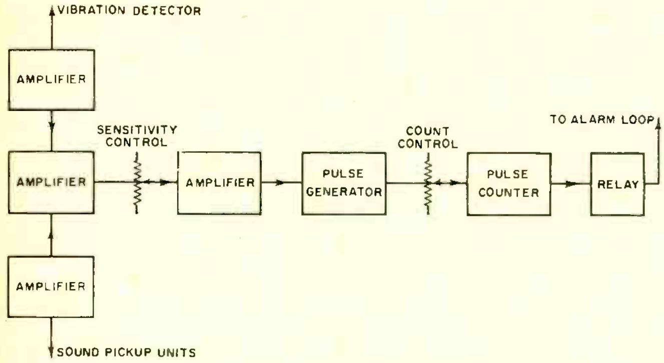



**Fig. 8. Sonic detector has both vibration and sound pickup. Each sound generates a pulse that is counted. When the predetermined number of pulses has been counted, alarm works.**

loudspeaker and microphone unit which form the transceiver, it is possible to cover a particular zone or a large area by suitable arrangement of transceivers. When the equipment is installed, the control circuitry must be adjusted for phase discrimination and sensitivity, a limiting circuit has to be set, and calibration of the alarm system is necessary. It is important that all the above adjustments made with such factors as thunder, truck backfires, and other possible noise sources taken into consideration.

## Audio Protection Systems

As previously mentioned, closed-circuit television can be used to monitor areas remotely. A less expensive method uses sound instead of sight, and most of the audio protection systems are essentially long-range hearing aids. Such systems are therefore useful only in areas that are normally quiet, such as warehouses, department stores, and factories (at night), or schools during non-school hours. The *Honeywell* W676A audio detector shown in Fig. 8 contains a transistor audio amplifier, pulse generator, and pulse counter. The pulse counter allows a number of noises to occur in a given period before the alarm is turned on to avoid false alarms every time a truck backfires in the vicinity, thunder occurs, or an airplane flies over. By including a reversing relay, the facility of two-way operation is also provided. It is possible for the guard, who is alerted by the audio alarm, to "talk" to the protected area to ask what has caused the noise. As audio-pickup sources, conventional intercom speakers are used and up to four speakers can be connected directly. The tamper-proof feature of this unit consists of a "Micro-Switch" whose arm contacts the front panel of the control unit. If the front panel is removed, the switch opens and indicates at a remote station that someone is tampering with the audio detector.

The *Honeywell* device can also be used with a vibration detector. Smaller than a pocket watch, this detector is glued or taped, in a concealed location, to the safe, glass case, file cabinet, or other object to be protected. The vibration detector is insensitive to audio frequencies but picks up higher frequencies and direct-contact vibrations. Anyone touching the protected object or case immediately activates the alarm.

A device somewhat similar to the vibration detector is the "Glas-Guard" made by *Wessco* and installed by the W. J. *Burns International Detective Agency*. It replaces the well-known metal-foil strips on glass panes that are used to protect store windows. A small piezoelectric transducer is glued to one inside corner of the window and connected to a sensitive audio amplifier. The combination of the transducer and audio amplifier is tuned to the higher audio frequencies that are generated when the glass is scratched or broken. As in the vibration detector, a number of transducers can drive a single amplifier and alarm signals can be sent to a central control panel.

An ingenious audio detection scheme is provided by the *Du Kane* "School Alarm" which protects all four schools in Redding, Ohio. Each of these four schools has a conventional p.a. system with a control console in the principal's office and loudspeakers along the hallways and in the classrooms. When the principal shuts the p.a. system off, all of the speakers are automatically connected as microphones which, with suitable amplification, are then connected to a central monitor board at the city's Police Department.

Ordinarily, each of the schools is connected to one intercom amplifier with the volume turned down. Each school is also connected to an alarm circuit which, when the noise reported over any one of its speakers reaches a certain level, turns on a light and sounds a buzzer. The desk sergeant then turns up the volume of the reporting school and listens to the sounds. Sometimes these sounds are nothing more than a basketball dribbling in a courtyard, a sonic boom from an aircraft, or other such noises. But if the desk sergeant hears a whispered conversation, the clink of a crowbar, or the breaking of glass he can immediately dispatch a patrol car. Since the system has been installed, there have been a number of alarms but not a single case of vandalism.

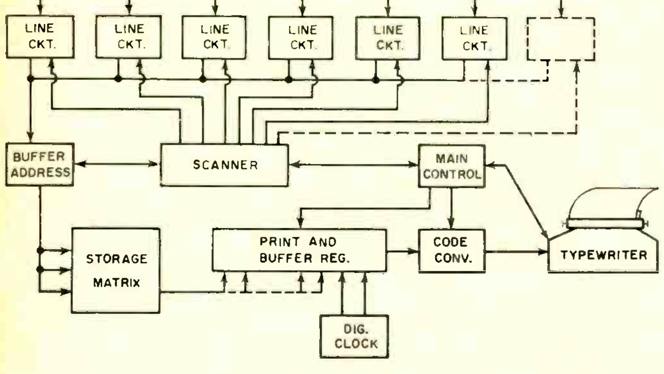
## Central Control Consoles

Most industrial alarm and protection systems send alarm signals to some central place, such as the guard room or the receptionist desk, where a guard is available to take action when an alarm occurs. Many companies offer central alarm consoles, but from a technical point of view, the *Notifier* "Cyber-Larm" is the most elaborate and elegant.

This system does much more than merely show a light or ring a buzzer. It is capable of measuring different quantities, recording time, type, and source of various alarms, and printing them on an electric typewriter. The block diagram of Fig. 9 shows that the "Cyber-Larm" is really a complete data processor. In addition to circuitry which monitors each individual line and detects any tampering or failure, the main portion of the system uses digital logic to accept simultaneous signals from many different lines, put them in temporary storage, and rearrange them, together with time and location data, for serial printout on an electric typewriter. Each alarm-signal line controls a light and a temporary signal storage such as a flip-flop. A scanner or electronic sequence switch continuously scans each of these flip-flops, and whenever it detects the presence of an alarm signal, it reads into the buffer register the location and type of signal present. In the storage matrix, information as to the source of the signal is converted by a prewired diode or magnetic-core arrangement into binary data sufficient for the printer to print out a word and numbers. The digital clock inserts the time of day and the date in binary code and the entire "word" is then converted into the eight-bit code used to drive the typewriter or a paper tape punch.

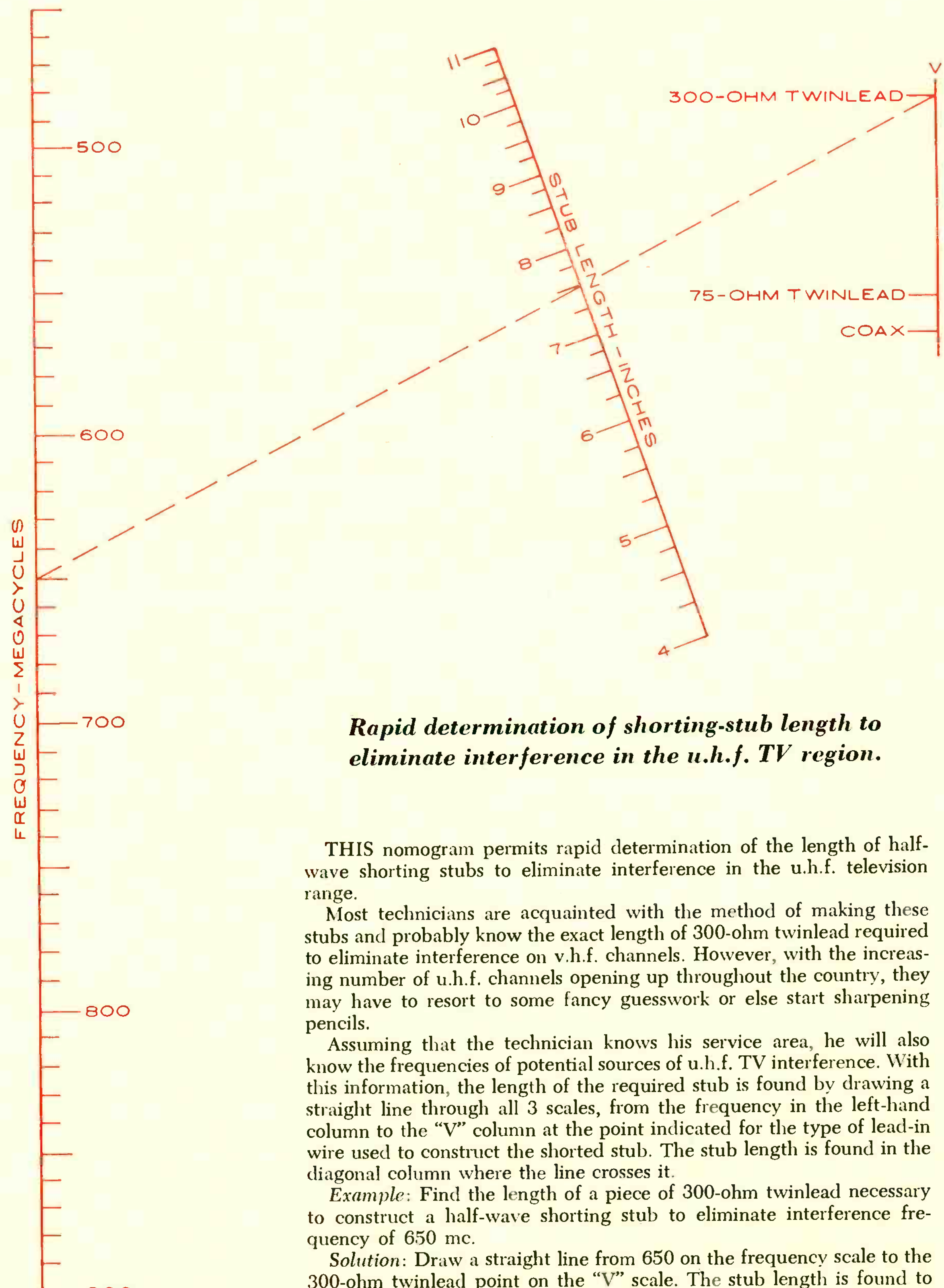
The *Notifier* "Cyber-Larm" is particularly suited for large industrial plants. ▲

**Fig. 9. Looking very much like a data processor, this alarm prints out the complete data on any detected station signal.**



# U.H.F.-TV HALF-WAVE SHORTING-STUB NOMOGRAM

By MAX H. APPLEBAUM / Warwick Electronics Inc., Pacific Mercury Div.




***Rapid determination of shorting-stub length to eliminate interference in the u.h.f. TV region.***

THIS nomogram permits rapid determination of the length of half-wave shorting stubs to eliminate interference in the u.h.f. television range.

Most technicians are acquainted with the method of making these stubs and probably know the exact length of 300-ohm twinlead required to eliminate interference on v.h.f. channels. However, with the increasing number of u.h.f. channels opening up throughout the country, they may have to resort to some fancy guesswork or else start sharpening pencils.

Assuming that the technician knows his service area, he will also know the frequencies of potential sources of u.h.f. TV interference. With this information, the length of the required stub is found by drawing a straight line through all 3 scales, from the frequency in the left-hand column to the "V" column at the point indicated for the type of lead-in wire used to construct the shorted stub. The stub length is found in the diagonal column where the line crosses it.

*Example*: Find the length of a piece of 300-ohm twinlead necessary to construct a half-wave shorting stub to eliminate interference frequency of 650 mc.

*Solution*: Draw a straight line from 650 on the frequency scale to the 300-ohm twinlead point on the "V" scale. The stub length is found to be 7.45″ where the line crosses the center scale. ▲

**Some entirely new approaches to sweep circuit design must be made before reasonably priced, large-screen transistor TV sets make their appearance. Here are the design details.**

# SEMICONDUCTOR SWEEPS FOR LARGE-SCREEN TV

By FRANK GROSS

THE fundamental limitation to an all-semiconductor 24- or 27-inch TV set has been the high cost of the transistors used in the sweep circuits, particularly the horizontal output stage. This last limitation to large-screen, solid-state television is about to be swept away, as indicated by the large number of recent technical articles dealing with this specific problem.

### Three Major Approaches

There are now three major new approaches to the semiconductor sweep problem, all of which are radically different and all of which promise to make the horizontal output stage a low-cost, high-efficiency, and highly reliable circuit. These three methods differ markedly in their approach to the problem and in the actual semiconductors used. One new approach uses a gate controlled switch (GCS) in a very high efficiency, straightforward circuit. The second method makes use of conventional transistor circuitry but uses transistors of new price and performance capability. The final method employs a silicon controlled rectifier (SCR) in an unusual circuit configuration that eliminates the need for a conventional horizontal oscillator and driver and combines the power and flyback transformers into one multiwinding transformer.

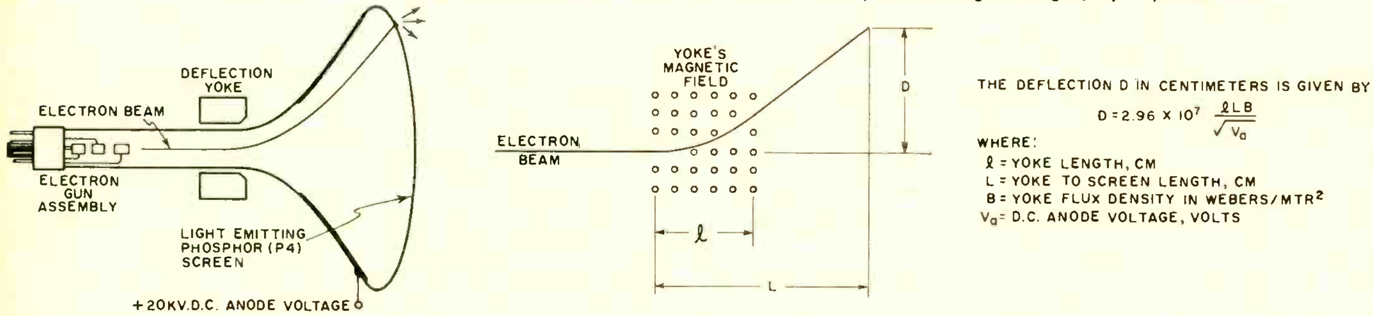
The advantages to be gained in an all-semiconductor TV are quite numerous. Today, the tube-type horizontal sweep circuits account for a major percentage of service problems and produce more heat than any other single circuit area. Further, because these circuits are the bulkiest and heaviest, they are in direct conflict with the set designer's ultimate goals of extreme portability and picture-on-the-wall, "two-dimensional" television sets. The tube-type sweep requires high-voltage supplies, in excess of that obtainable directly from the 117-volt line (without the use of doublers, etc.) or from 12-volt batteries compatible with portability. For these reasons, major design emphasis is being placed on this area by virtually every set manufacturer.

### Basic Principles

The geometry and mathematics involved in a magnetically deflected CRT is shown in Fig. 1. As the electron beam enters the strong yoke-produced magnetic field, a force is created which is both at right angles to the beam and the field. This force deflects the electrons, and the electron beam assumes a circular path over the field length. Upon leaving the magnetic field, the beam again has no forces acting upon it, except for the anode voltage, and so assumes a straight-line path toward the screen. The stronger the magnetic field, the more the beam will be deflected by the yoke. As the over-all screen size increases, the required magnetic field for full deflection also increases. The increase would be a linear one, except that the brightness goes down as the screen size goes up. (This is because the electron beam spends less time on any phosphor area.) When increasing screen size, the high voltage must also be upped to maintain constant brightness. As CRT anode voltage goes up, the deflection sensitivity goes down. This means that the amount of deflection current provided must disproportionately increase with increasing screen size. Doubling the screen size approximately triples the required current for deflection. (The energy stored in a deflection yoke at any time is given by $W = \frac{1}{2}LI^2$ where $W$ is stored energy in joules (watt-sec.), $L$ is yoke inductance in henrys, and $I$ is yoke current in amperes.)

Before we go into the exact mechanism of the horizontal deflection circuit, it is obvious that the energy stored in the yoke at maximum deflection must somehow be switched by the deflection circuit to collapse the field and return the

Fig. 1. The geometry involved in magnetically deflecting a cathode-ray tube. Both yoke and high voltage play important roles.



beam to its initial position. Doubling the screen size means three times the current, which in turn means *nine* times the stored energy! Here is why the deflection problem exists. To increase screen size slightly requires a radical increase in the deflection-circuit capabilities.

Small-screen TV's have been here for some time, using relatively low-cost transistors in circuits that are very much the same as conventional tube sweeps. But to date, as screen size has been increased, the switching and breakdown requirements of the output transistor have made it cost-prohibitive above a 15-inch, or at best, a 19-inch screen. Actually, transistors can handle any deflection problem with ease; it is done all the time in military CRT radar displays at about $85 per transistor.

A basic sweep circuit is shown in Fig. 2 and consists of a constant voltage source, an inductor, a switch, and a load resistor. The basic circuit behavior of an inductance states that $V=L(\Delta I/\Delta T)$ where $V$ is the voltage on the inductor terminals, $L$ is inductance in henrys, $\Delta I$ is the change in current in amperes, and $\Delta T$ is the change in time in seconds.

If we rearrange the equation by dividing by $L$, we get $V/L=\Delta I/\Delta T$ which says that if $V$ is constant and $L$ is constant, the change in current in any time interval must also be constant. This is a linear current ramp. In Fig. 2, when the current ramp reaches the desired maximum value, the switch is opened momentarily, and the energy stored in the inductor is rapidly dissipated in load resistor $R_L$. The linear current produces a linear magnetic field which produces a linear sweep from the center to an edge of the CRT. (Differences in curvature of the beam and the tube face are taken into account by varying the spacing of the individual yoke windings.) Closing the switch once again starts a linear current ramp. The timing of the switch determines the period of the saw-tooth waveform, while the voltage and the inductance determine the slope.

There are two serious shortcomings of this simple sweep; namely, the extreme dissipation required in the load resistor $R_L$ and the fact that the sweep is not symmetrical. Since no power is consumed by the inductance, it ought to be possible by a fancy switching scheme to *use the same energy over again* instead of "throwing it away" at the end of each cycle. Obviously we must make up system losses, but these would be trivial compared to the dissipation in $R_L$. It also ought to be possible to make the sweep symmetrical so that it can sweep from extreme left to extreme right when acting on a normally centered electron beam. A capacitor and a diode replace $R_L$ in the practical sweep of Fig. 3.

As before, when the switch is closed, the inductance is driven by a constant voltage ($V$), and a linear ramp of current is produced. At the end of the sweep (maximum current in the yoke), the switch is opened. The circuit now consists of a series *LC* circuit with a return path being provided by the constant voltage supply. This circuit is highly oscillatory and at this particular instant, maximum positive current is flowing in the inductor. A quarter cycle later, all the stored energy is in the capacitor, and the yoke current is zero. Another quarter cycle later, the maximum *negative* current is flowing in the inductance and the stored energy in the capacitor is zero. So far, the voltage at point "A" has always been positive and diode $D$ has always been back-biased. The negative current flowing in the inductor will try to force point "A" negative, which in turn *forward* biases damper diode $D$, effectively shorting out $C$. The oscillatory circuit no longer exists. All that remains is an inductor with negative current flowing in it connected to a positive constant voltage source. This produces a current ramp that subtracts from the maximum negative inductor current. This continues until the inductor current reaches zero. At this instant, switch $S$ is once again closed, and the cycle repeats. Diode $D$ disconnects as soon as point "A" begins to swing positive, and the sweep has gone through one complete cycle.

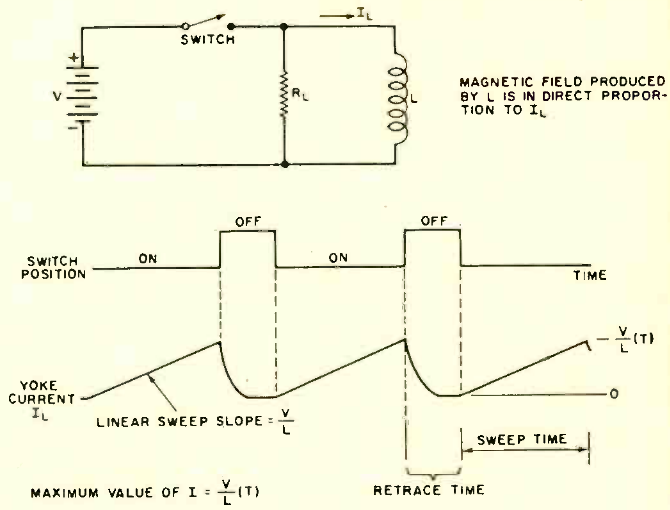


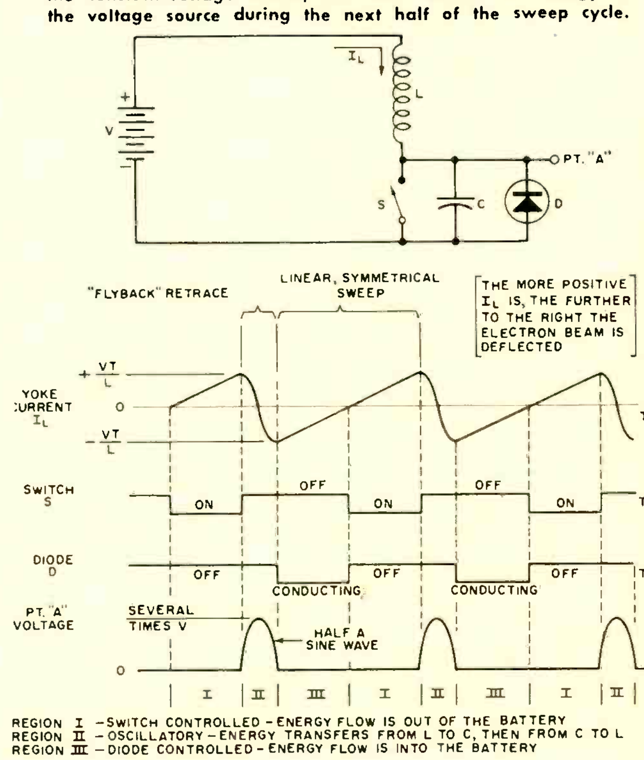

Fig. 2. Simple sweep circuit and the resulting basic waveforms.

At the time of switch closure, there is no current in the inductor, no magnetic field, and the electron beam is centered. As the switch is closed, the electron beam is deflected to the right until the switch is opened at maximum deflection. The electron beam now rapidly returns to the extreme left side of the tube, and as the damper diode turns on, begins a sweep from extreme left to center. Upon reaching center, the cycle begins anew. The beam is blanked during the retrace period.

From an energy standpoint, starting with zero deflection, energy is first removed from the supply and allowed to build up in a linear manner producing a linear magnetic field. When maximum deflection is reached, the energy is transferred to a capacitor and then returned "backwards" to the inductor. The energy is then returned to the supply in a linear manner. Fig. 3 also shows the waveforms involved.

In terms of actual horizontal requirements, there are 15,570 horizontal sweeps per second, giving a total sweep time of about 63 microseconds. Of this, about 11 microseconds are reserved for retrace ("flyback") time. The *LC* resonance must have a half-period of about 11 microseconds, which

Fig. 3. A lossless symmetrical sweep only borrows energy from the constant-voltage source, and then returns this energy to the voltage source during the next half of the sweep cycle.



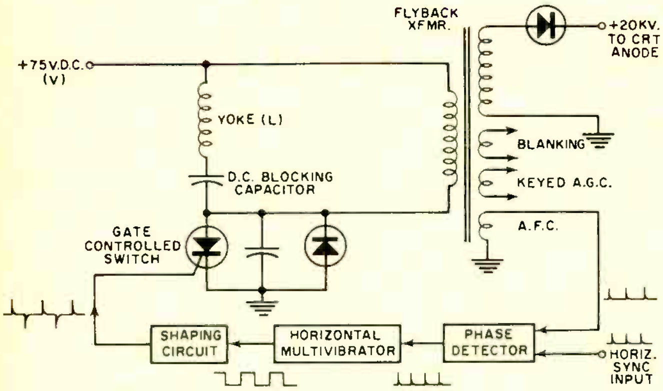



**Fig. 4. A gate-controlled switch horizontal sweep takes advantage of the high blocking voltage (600 v.) and low "on" forward drop (1.2 v.) of the gate-controlled switch (GCS).**

corresponds to a frequency of about 46 kilocycles. In actual circuits, there is an advantage to making the yoke-capacitor resonance exactly three times the sweep frequency.

The average deflection power drain of a 23-inch tube would be about 150 watts, were this energy not returned to the supply each cycle. The horizontal output stage must be capable of handling this power. In addition, the switching va. characteristics are much more severe since the circuit is highly reactive. A 1500-va. switching capability is required for a 19-inch tube deflection, and the requirement can go as high as 5 kva. on large-screen, large-deflection angle CRT's. The va. switching capability of a semiconductor is defined as the maximum blocking voltage multiplied by the maximum saturated current that the semiconductor switch can handle over a certain mode of turn-on.

## Gate Controlled Switch Circuit

The first of the new sweep techniques uses a gate controlled switch, a new semiconductor that operates similarly to an SCR but with the added feature that it can be very rapidly turned *off* as well as on by a gate pulse. Turn-off times of less than a microsecond are typical. The high-current capacity, rapid switching, and low drive levels make the GCS very attractive for this application. Even more attractive is the high blocking-voltage capability, typically 600 volts or more for this device. Fig. 4 shows a GCS controlled sweep that uses a 75-volt d.c. power supply. The circuit is essentially the same as the basic sweep of Fig. 3, the GCS replacing the mechanical switch. The d.c. blocking capacitor in series with the yoke does not interfere with normal sweep operation but does prevent any shift of the normally centered electron beam due to a d.c. offset in the yoke. The transformer (flyback) also does not interfere with normal operation but borrows some of the stored energy during the retrace time, steps it up, rectifies it, and uses it for the 20 kv. or so of CRT anode voltage. Additional windings on the flyback transformers are used for sync phase comparison, blanking, and a.g.c. Protection must be given the "B+" supply lest a drive failure occur that would leave the GCS in the *on* state. This consists of two capacitors and a resistor, omitted in Fig. 4 in the interest of simplicity.

## Transistor Circuits

A second approach to the sweep problem uses newly available power transistors in essentially the same circuit. Considerably lower supply voltages must be used because the breakdown characteristics of most transistors are substantially lower than the GCS, typically 100 or 120 volts. The high blocking capability is required during retrace, when the capacitor voltage (point "A," Fig. 3) can get up to three or four times the supply voltage due to series-resonant build-up. A higher current circuit results when providing the same energy control at lower voltages; consequently, the switching transistors must, of necessity, be of the high-current type.

The circuit is now possible because of the tremendous advances in power transistors. Silicon power transistors are now becoming reasonable enough in price to make their better temperature performance highly desirable. New means of constructing germanium transistors have substantially reduced leakage and improved thermal properties. New technologies have also raised the maximum frequency response and the minimum switching time considerably. (*Editor's Note: In addition, recently announced silicon transistors are available with breakdown voltages around 400 volts. These should make possible more conventional circuit designs.*)

The most significant parameter in a switching power transistor is its "safe area." This is the region on the transistor $V_c$-$I_c$ characteristics where switching can reliably take place without any fear of latch-up or thermal runaway. The normal safe area of these transistors is quite small when compared to the entire $V_c$-$I_c$ plot. The new technologies have considerably fattened the safe area; in some transistors, it is possible to switch over any load-line path within the total $V_c$-$I_c$ curve. This means smaller, more economical transistors can be used. It also reduces the required amount of circuit protection.

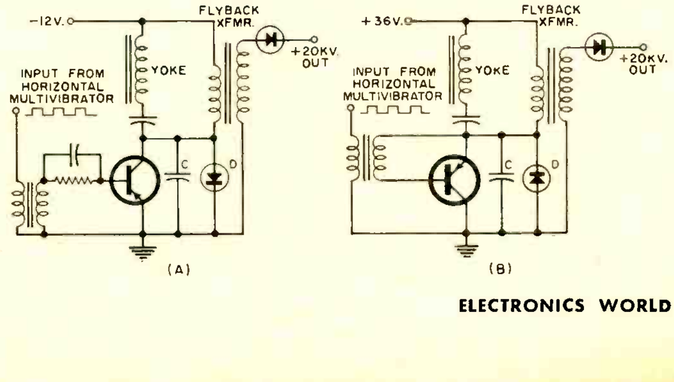
Two circuits that use power transistors are shown in Fig. 5. One uses a −12 volt supply, suitable for battery operation. The second uses a high-voltage *p-n-p* transistor upside down and operating from a +36 volt supply.

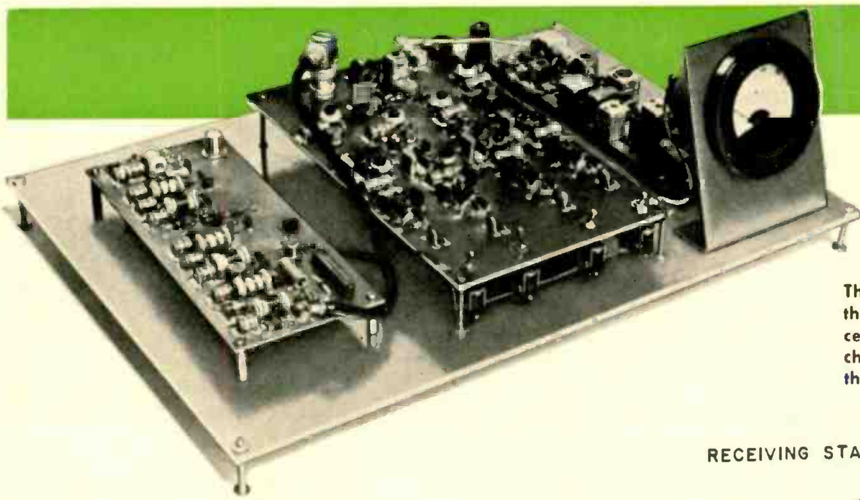
## SCR Switching Circuits

The final new approach to the sweep problem is extremely interesting. A conventional high-speed SCR is used to produce the horizontal switching, operating directly from the rectified power line. An unusual feature of this circuit is the combination of the flyback transformer and power transformer into a single high-frequency, multiwinding transformer. Since the transformer is a high-frequency one, little iron is required, and only small amounts of filtering are needed for the rectified d.c. power. In addition, the conventional horizontal oscillator and driver are not required and are replaced by simpler circuitry. The amount of set-cost and weight reduction this circuit could provide is considerable. The circuit has been successfully used on a 23-inch, 114-degree, 19-kilovolt tube and shows high promise of being quite economical for any screen size or deflection angle.

The circuit is the exact opposite of all previously used TV sweeps. The sweep *starts* with the retrace and then produces a linear ramp. Sync pulses are delayed to get video and sweep back together. All the energy required for the sweep cycle is supplied to the cricuit *during* retrace; the circuit then produces a linear sweep while returning the energy. The returned energy is used to power the rest of the set, and the circuit is automatically self-timing. Only a sweep start pulse must be provided the SCR, as it turns itself off later in the cycle. This eliminates the requirement for a horizontal multivibrator or other oscillator. Less linearity correction is required because the sweep is one continuous trace, unlike the crossover produced in the center-screen portion of normal sweeps. (*Continued on page* 74)

**Fig. 5. (A) Conventional transistor sweep using 12-v. and a high-current transistor. (B) Using a special high-voltage transistor in upside-down circuit allows use of 36-v. supply.**





The receiver was built on three circuit boards. The board at the left is for wideband, low-noise r.f. preamplifier. The center board is for the first mixer and the four separate l.o. channels. The remainder of the circuit is on the board at the right. The meter is for monitoring the amount of a.g.c.

# RECEIVER REQUIREMENTS FOR MONITORING GEMINI

By JESS C. WRIGHT & WILLIAM L. BLAIR
Cubic Corporation

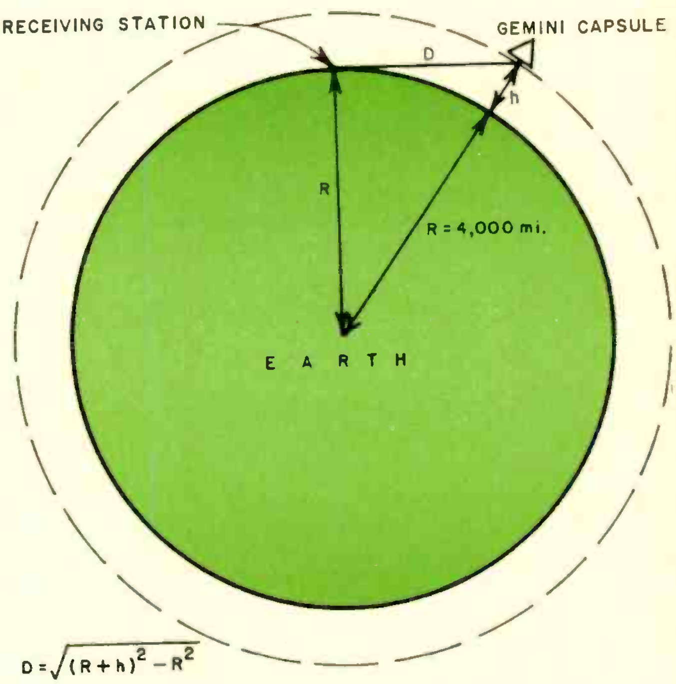



Fig. 1. Maximum distance to space vehicle at the horizon.

**Design of a four-channel transistorized receiver that permits voice reception from our astronauts. Calculations of orbital distance, space attenuation, and Doppler shift are covered.**

SINCE the Russian Sputnik went into orbit in October 1957, launching of new satellites has become almost routine. Thousands, the world over, tuned in on the beeping signal from the very first satellite, since it fell within the tuning range of most communications receivers. However, later U.S. satellites broadcast signals in the 108-mc. band and at such low power levels that not many enthusiasts continued to track them.

Today, almost eight years later, the challenge is still there and the thrill is just as great the first time one hears the characteristic signals from a man-made object hundreds to thousands of miles above the earth. Of particular interest to the authors is the possibility of receiving voice communications from the two-man space capsule Gemini, the first one of which made a successful 3-orbit flight on March 23 of this year. (*A total of ten or more Gemini flights, each of longer duration that the first, is expected to be made this year and next year.—Editor.*)

The experimenter has two advantages which simplify the task of monitoring transmissions from this series of manned orbiting vehicles. First, the operating frequencies are known to be the same as those of the earlier Mercury flights. Obviously this information is important since without it it would be almost impossible to find the signal during the 10 to 15 minutes per orbit that the vehicle will be above the radio horizon.

The second advantage lies in the fact that the capsule uses moderately high-power transmitters for voice transmission. Consequently, relatively unsophisticated receiving equipment may be employed with good results.

The astronauts will have available a choice of four different operating frequencies at the upper portion of the v.h.f. band. Therefore, the receiver should have at least four-channel capability so that the probability of intercepting signals as soon as the radio horizon is passed is maximized. A rather unique scheme for receiving all four frequencies simultaneously has been tried and found to be very satisfactory.

Before proceeding to a description of the receiver design, it might be instructive to calculate the signal level to be ex-

Table 1. The operating frequencies employed for Gemini.

| Gemini Channel | Function | L.O. Crystal Frequencies |
|---|---|---|
| 296.8 mc. | Voice | 95.3667 mc. |
| 259.7 mc. | Telemetry | 83.0000 mc. |
| 243.0 mc. | International Emergency | 77.4333 mc. |
| 226.2 mc. | Telemetry | 71.8333 mc. |

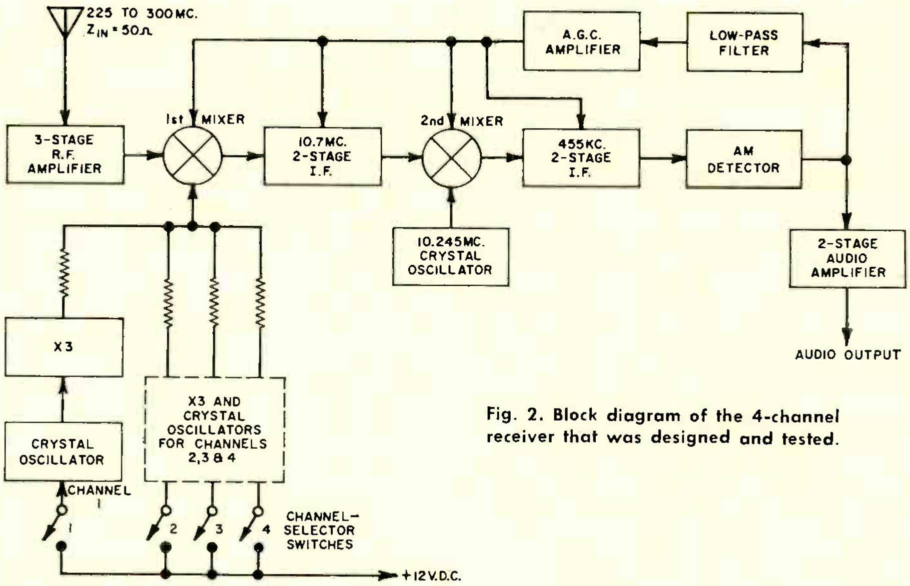



Fig. 2. Block diagram of the 4-channel receiver that was designed and tested.

pected at the ground as the Gemini capsule passes overhead. Given the output power of the transmitter as 3 watts and the frequency band of operation as about 300 mc., the space attenuation ($\alpha$) may be computed with only one additional piece of information: the distance between satellite and ground receiver.

If the anticipated orbit is achieved, the height of the vehicle above the earth ($h$) will be between 90 and 150 miles. Fig. 1 shows how the Pythagorian equation can be used to calculate the maximum distance ($D$) to the capsule when it is at the horizon. $R$ is the radius of the earth and $h$ is chosen as 125 miles for the purposes of the calculations. $D=\sqrt{(R+h)^2-R^2}=1000$ miles.

The space attenuation (in db) is then: $\alpha=37+20 \log D_{mi.}+20 \log f_{mc.}=37+60+50=147$ db.

The received signal strength is equal to the transmitter power output plus the vehicle and ground antenna gains and minus the space attenuation. Since the vehicle antenna must be omnidirectional, its gain is assumed to be 0 db. It is also desirable that the ground antenna be simple to construct and omnidirectional. Therefore, a gain of 0 db is again assigned.

Thus, 3w.$=+5$ dbw$=+35$ dbm (db re 1 mw.); the ground antenna gain is $+0$; the vehicle antenna gain is $+0$, space attenuation is $-147$ db; and received signal (s) is $-112$ dbm. This is 0.55 $\mu$v., modulated 100%, across 50 ohms.

### Receiver Noise Level

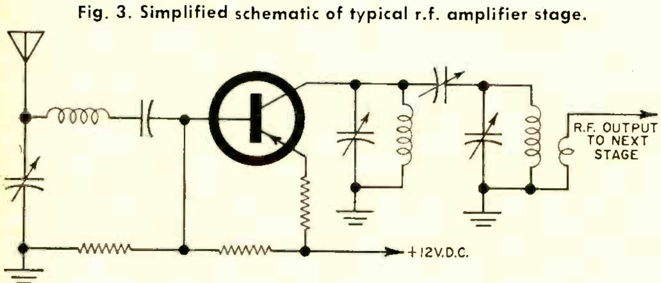
In order to determine the receiver's ability to detect a signal at this level, it is necessary to compare it to the equivalent noise input at the receiver. The noise power is calculated from the expression: $N=KTBF$ where $K=1.38\times10^{-23}$ (Boltzmann's constant); $T=290°K$ (absolute temperature in degrees Kelvin); $B=25$ kc. (receiver i.f. bandwidth); and $F=2.5$ (receiver noise factor). Using these values in the equation, receiver input noise level becomes: $N=1.38\times10^{-23}\times2.9\times10^{2}\times2.5\times10^{4}\times2.5=2.5\times10^{-16}=-156$ dbw. which is equal to $-126$ dbm.

As will be seen shortly, the r.f. preamplifier used is very wideband in order to receive all four frequencies simultaneously. Consequently the noise present at the image frequency is also present at the input to the receiver, and increases the total noise in the i.f. stages by a factor of 2 (3 db) to $-123$ dbm.

In the audio amplifier, following the AM detector, a low-pass filter rolls off the audio response at 3 kc. Considering that noise frequencies in the i.f. stages, both 3 kc. above and 3 kc. below the carrier, contribute to noise in the audio, the equivalent noise bandwidth in the output is 6 kc. This reduces the noise level in the audio by 10 log (25/6)$=6$ db to $-129$ dbm.

At last the quality of the received signal may be seen by comparing its level of $-112$ dbm to the noise level just computed. The signal-to-noise ratio out of the receiver at maximum satellite range is therefore: $S/N=-112-(-129)=+17$ db.

Fig. 3. Simplified schematic of typical r.f. amplifier stage.




This represents an excellent safety margin, allowing for nulls in antenna patterns, elliptical orbits resulting in greater ranges, and even a considerably poorer receiver noise figure before intelligibility is lost.

### Doppler Shift

In the calculation of receiver noise, an i.f. bandwidth of 25 kc. was used. Normally, an i.f. bandwidth equal to twice the audio bandwidth ($2\times3000=6000$ cps) is all that is required. However, in receiving communications from an orbiting satellite certain additional considerations apply. Both the vehicle transmitters and the ground receiver usually employ crystal-controlled oscillators. These have certain frequency stabilities (typically $\pm0.001\%$) which could cause a received signal to drift outside the frequency to which the receiver was tuned. If the transmitter drifted to its maximum upper limit and the receiver to its maximum lower limit, they could be separated by as much as 6 kc. at 300 mc.

A second source of frequency error is Doppler shift. It occurs because of the relative velocity between the satellite and the receiving station. When the satellite first comes over the horizon, it approaches the receiver with almost full orbital velocity ($V$). The shift ($\Delta f$) from nominal frequency ($f_o$) is maximum at this time. However, as the satellite reaches the point of closest approach, the received frequency is equal to $f_o$.

The maximum number of cycles of apparent frequency shift away from the nominal transmitted frequency is given by the expression: $\Delta f \approx f_o V/C$, where C is the speed of light, equal to $9.8\times10^{8}$ ft. per second. In order to compute $\Delta f$, the velocity of the satellite must be known. At an altitude of 125 miles, orbital velocity is approximately $2.65\times10^{4}$ ft. per second. Substituting this value into the previous equation, the maximum Doppler shift is found to be 8100 cps at 300 mc.

It can be seen that a fixed-tuned receiver must be sufficiently wideband to insure accommodation to the most adverse combination of oscillator drift and Doppler shift without excessive distortion of the signal. Selection of a 25-kc. i.f. bandwidth minimizes difficulties without introducing excessive noise and reducing receiver sensitivity.

### Approach to Receiver Design

With the dynamics of the receiving task in mind, the receiver shown in the photo was designed and tested. A wideband, low-noise preamplifier determines the over-all receiver noise figure and r.f. bandpass. These circuits are on the

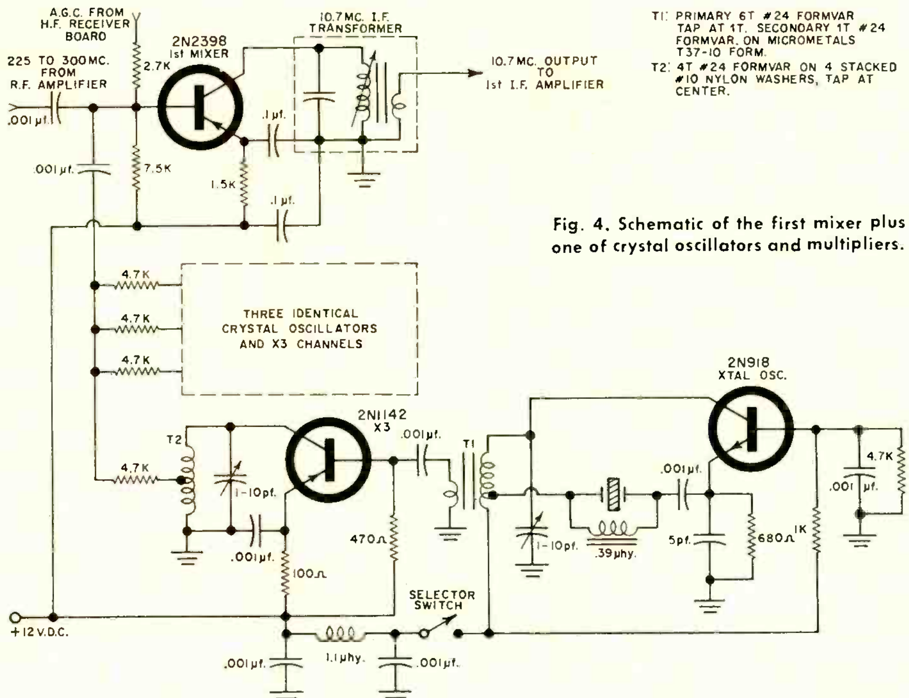



Fig. 4. Schematic of the first mixer plus one of crystal oscillators and multipliers.

printed-circuit board to the left in the photograph. All four Gemini frequencies are within the passband of the input circuitry.

Four independent crystal-controlled local-oscillator channels and the first mixer are located on the center circuit board. A separate toggle switch controls d.c. power to each local oscillator so that any or all may be on simultaneously. They are added resistively at the mixer. Since one is not sure which channel might be in use on a particular pass, operational procedure would be to turn on all local oscillators until an intercept is made. Since each l.o. adds a new frequency band of noise to the receiver, the noise figure is degraded by 6 db when all are operating. When the signal is heard, oscillators are turned off until the channel being used is determined.

The first i.f. amplifiers, second local oscillator, second mixer, second i.f. amplifier, AM detector, a.g.c. circuit, and audio amplifier are located on the board shown to the right in the photograph. An a.g.c. meter has been added and calibrated against the received signal level in order to compare actual with predicted signal strengths. A 12-volt d.c. supply completes the receiver. Table 1 lists the Gemini channels, channel function, and crystal-oscillator frequencies.

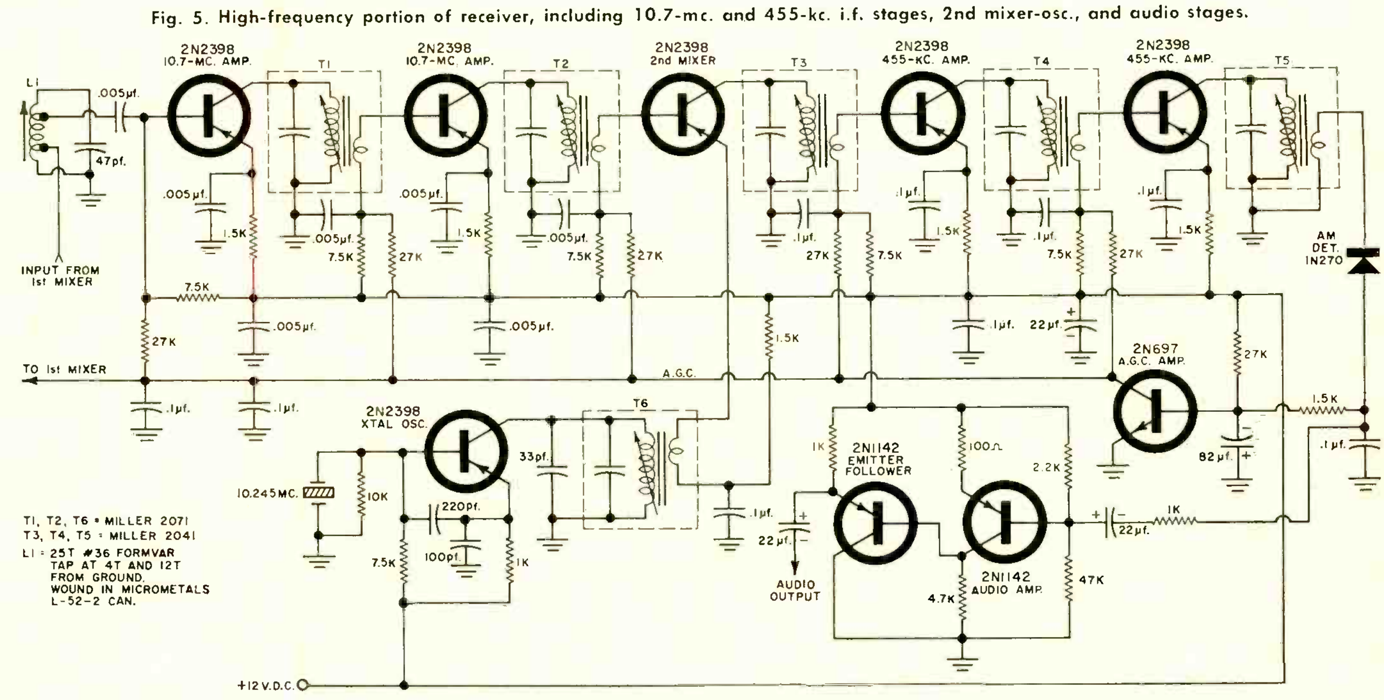
## Receiver Circuitry

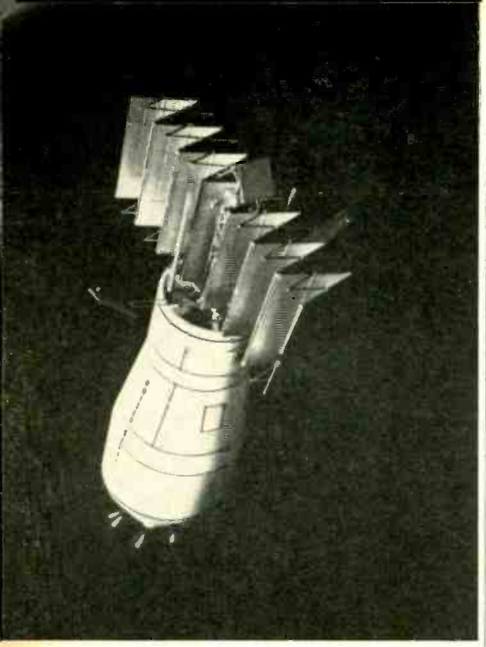
Fig. 2 is the block diagram of the receiver. The input signal is fed to a low-noise r.f. preamplifier which has three double-tuned stages to achieve a bandpass of 225 to 300 mc. ±3 db with 20-db gain. The noise figure of this amplifier is less than 3.5 db over the entire passband which accounts for the excellent threshold performance of the receiver. Fig. 3 shows a typical double-tuned stage of the r.f. amplifier.

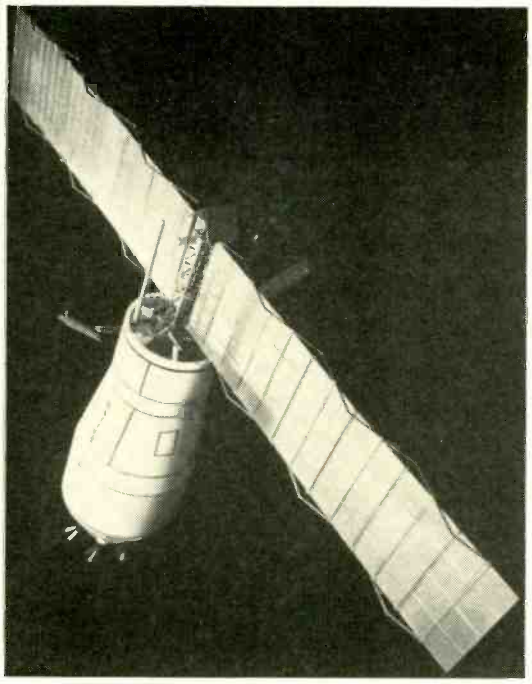
The output of the r.f. amplifier is connected to the first mixer by an RG-58A/U cable. The mixer is fed by four local-oscillator channels (see Fig. 4). Any or all of these oscillators can be operating at one time by switching the d.c. power to the oscillator. A 2N918 is used as the oscillator transistor in a series crystal circuit. The crystal tap in the transformer is one turn from the cold end; this assures low drive power to the crystal for more stable operation. Crystal case capacitance is neutralized by the shunting choke to prevent non-crystal-controlled oscillation. The oscillator is coupled by a one-turn link to a 2N1142 tripler. The 2N1142 is biased in class-C, with the 470-ohm bias resistor chosen to give optimum multiplier efficiency. A center tap on the multiplier tank circuit feeds a 4.7k isolating resistor; this resistor injects the local oscillator signal into the mixer base.

The mixer is a 2N2398. Its collector tank is tuned to 10.7 mc. Thus signals both 10.7 mc. above and 10.7 mc. below the local oscillator frequency will be received equally well. While it is normally not desirable to have zero image rejection, in this particular application it does not prove to be a problem because there are few signals in this band. To achieve any useful image rejection would require an i.f. of 45 mc. or higher. An i.f. below 30 mc. is (*Continued on page* 60)

Fig. 5. High-frequency portion of receiver, including 10.7-mc. and 455-kc. i.f. stages, 2nd mixer-osc., and audio stages.





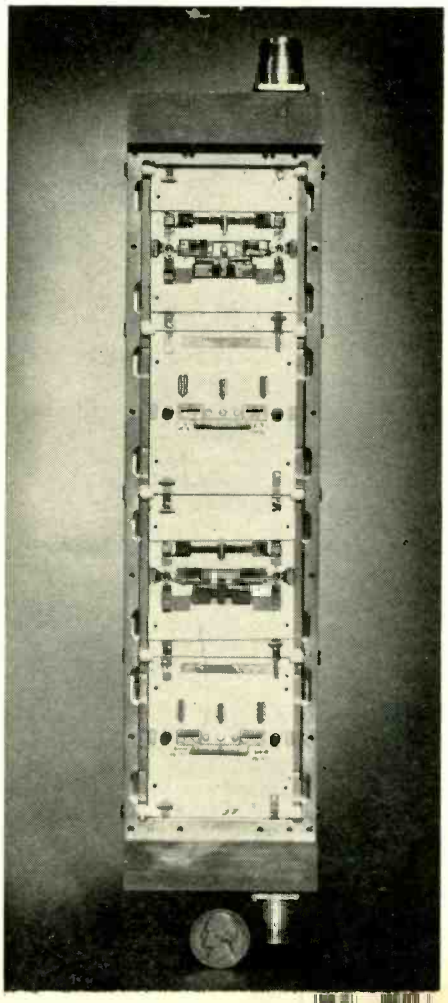


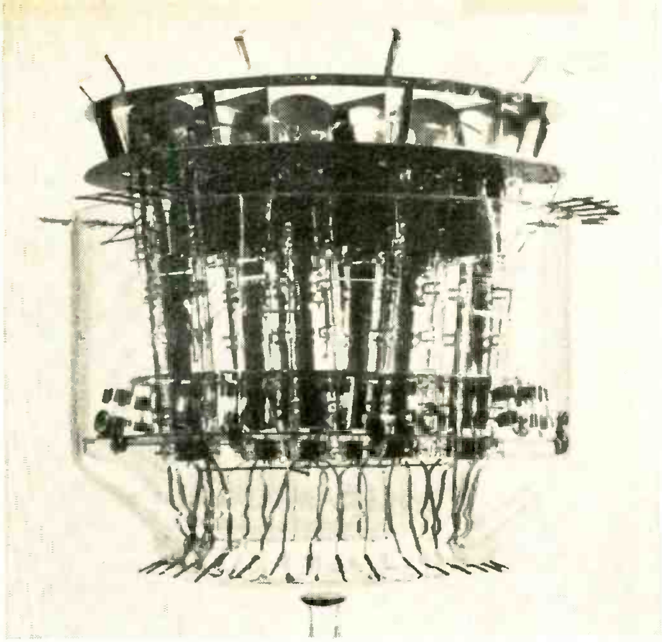
**Pegasus Meteoroid-Detection Satellite.** (Left) Second only in size to our Echo balloon satellites is Pegasus with its 96 feet long and 14 feet high wing panels. During launch the panels are completely folded, but as the vehicle continues its flight the wings are unfolded to their entire length. The wings are not used for flying the satellite but are used as targets for meteoroids flying through space. Each of the over 200 rectangular openings is covered with aluminum foil, backed by a copper-coated plastic film, and wired to an electronic package that records and radios to earth each meteoroid hit and the impact force. An infrared sensing system on the satellite that indicates which part of the satellite is facing earth permits scientists to determine the direction of meteoroid travel. At the time of this writing, the satellite—named after mythology's great flying horse—can be seen by nocturnal sky watchers as it orbits the earth high overhead.

# RECENT DEVELOPMENTS in ELECTRONICS

**First Integrated-Circuit Microwave Amplifier.** (Right) An amplifier that operates at the highest frequency and with the widest bandwidth ever achieved with integrated circuits has been developed at Bell Telephone Laboratories. The new amplifier operates at frequencies from 500 mc. to 3000 mc. with a bandwidth of 1000 mc. This electrical performance is twice the frequency and bandwidth of the best previous transistor circuits and equals or surpasses the performance of most traveling-wave tubes in this frequency range. The amplifier employs advances in circuit design, improved microwave transistors, and thin-film techniques. Unit has potential use in radio relay and other microwave systems.

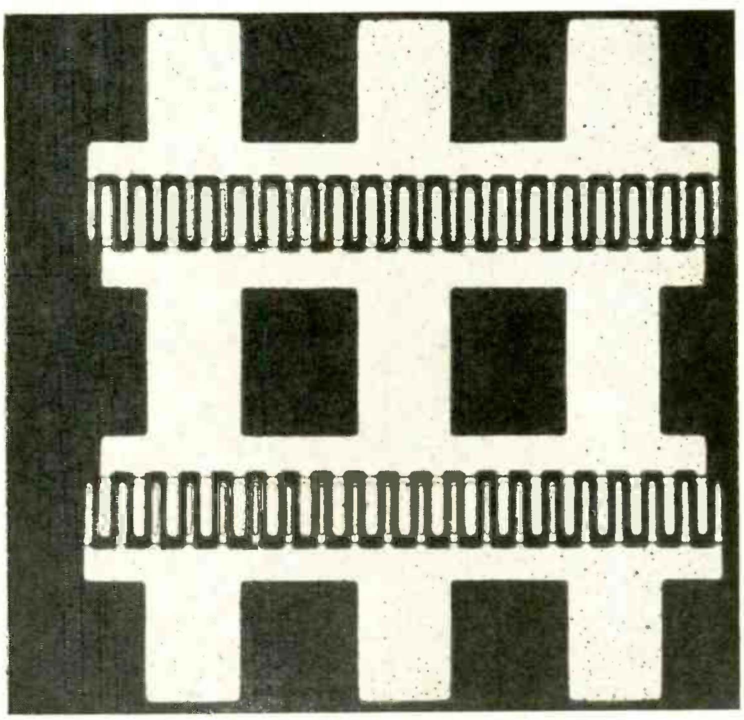
**Experimental Millimeter-Wave Link.** (Left) For more than a year an experimental radio system has been operating under severe weather conditions across Long Island Sound (N.Y.) at one of the highest frequencies to be used for communications. The system operates at 90,000 mc., in the millimeter range. The antenna is located on the roof of the GT&E Laboratories physics building. The radio beam is directed almost 1¼ miles across the Sound to Fort Schuyler near Throgs Neck Bridge. All-solid-state components developed by the Laboratories are employed in the system.





**Six-Gun Cathode-Ray Tube.** (Left) This six-in-one gun assembly is part of a cathode-ray tube developed for use in airborne countermeasures equipment. The use of multi-guns makes possible simultaneous displays on one 10 by 12 inch rectangular tube faceplate. The complete tube, made by Sylvania, features monoaccelerator design for excellent pattern linearity and employs electrostatic deflection and focus. The six-gun mount shown is approximately 7 inches high. The entire tube is 21 inches long and utilizes an encapsulated shield of Mumetal.

**Oceanographic Research Computer.** (Right) An electronic computer is lending a helping hand to sailors and scientists aboard a research ship sailing on a 10-month voyage to the Indian Ocean. The vessel is the Atlantis II, operated by the Woods Hole Oceanographic Institution. The seagoing computer, made by Digital Equipment Corp., will not only collect a huge store of oceanographic data, but will also navigate the ship via a new navigational system that makes use of the signals emitted by orbiting earth satellites. The technician in the photo is examining the transmitter of one of the ship's dozens of neutral buoyancy devices which detect hidden currents in the ocean.



**New Microwave Transistor.** (Left) A new transistor that will deliver a full watt of output at 1000 mc. at an efficiency of 40 percent is now available. The photomicrograph here shows the multiple interdigitated geometry that enables the new Fairchild planar epitaxial transistor to achieve these sample fundamental frequency power levels at even higher frequencies: 350 mw. at 1500 mc., 200 mw. at 2000 mc., and 10 mw. at 3000 mc. The new transistor is available at $250 in under-100 quantities.

**All-Purpose Display Console.** (Right) A highly versatile display console has been demonstrated recently that will work with any kind of radar, sonar, or computer. Until now, with the exception of very rudimentary installations, every new radar, sonar, or computer system has required a custom-designed console. The display, which uses plug-in "building-block" components made of microcircuits, tiny wafers that contain entire circuits within their molecular structure, can be used for purposes as different as shipboard sonar and air traffic control radar. Or it can display a line by line message at a rate of over 250,000 characters per second, outpacing most computers. The new all-purpose display console was developed by the Sperry Rand Corp.

# LIQUID FLOW MEASUREMENT

By JOHN R. COLLINS

Liquids can have different electrical properties, different viscosities or masses, or they can be corrosive, boiling, or cryogenic. To make flow measurements, each property must be taken into account for best results.

PRACTICALLY all industries utilize liquids in one way or another, and whether the product is petroleum, paper, chemicals, or beer, it is essential to measure and record the rate of fluid flow under varying conditions of temperature and pressure, both for quality control and cost analysis. To meet this need, a surprisingly large number of different kinds of flow meters have been devised, many purely mechanical in nature. Differential pressure types, for example, derive rate of flow from the pressure difference on either side of an obstruction or narrow place in the pipe. Displacement meters have rotating chambers that permit a fixed amount of liquid to pass with each rotation—not unlike a turnstile.

New problems, such as monitoring the flow of cryogenic liquids, often cannot be met with conventional flow meters, so the search for new types of instruments has continued. Data in electrical form is easy to telemeter and record, hence most recently developed flow meters utilize electronic principles and give an electrical output.

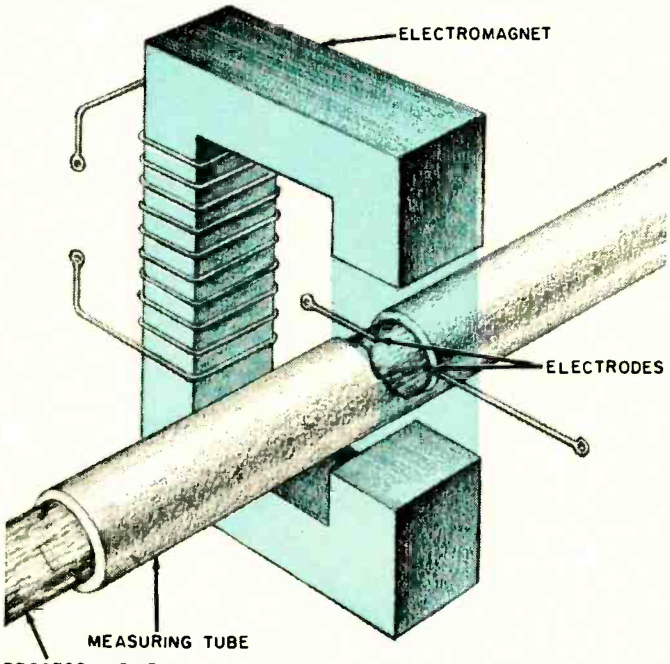
### Magnetic Flow Meter

In just a few years, the magnetic flow meter has moved from a laboratory curiosity to become one of the most important industrial meters, with many advantages to recommend it. It works on the familiar rule for electrical generators—that a voltage is induced when a moving conductor cuts a magnetic field. This principle is expressed by the formula $E = Blv$, where $E$ is the induced voltage, $B$ the magnetic field, $l$ the length of the conductor, and $v$ the velocity. If $B$ and $l$ are constant, $E$ obviously is determined only by the velocity $v$ of the conductor.

The elements of a magnetic flow meter are shown in Fig. 1. The fluid is itself the moving conductor, and fluid size is constant, being determined by the inside diameter of the pipe. A uniform magnetic field is provided by a magnet. A voltage is thus induced across the fluid which varies directly and exclusively with variations in flow velocity. Since it is strictly a function of flow velocity, the output voltage can in no way be influenced by such factors as temperature, viscosity, turbulence, or degree of conductivity. Output is detected by flush-mounted electrodes.

An actual magnetic flow meter is shown in Fig. 2. The pipe is of stainless steel and is lined with a plastic material, such as Teflon or neoprene, to prevent short-circuiting of the generated voltage. A glass liner is sometimes used, and

Fig. 1. The magnetic flow meter uses liquid as a conductor.



the pipe is then made of Inconel which matches the temperature expansion of glass. A fiberglass tube may replace the metal pipe and therefore a liner is not needed. A uniform magnetic field is supplied by an electromagnet having two saddle-shaped coils of insulated copper wire. A core of laminated iron focuses the field perpendicular to the flowing liquid.

The voltage generated by the cutting of the magnetic field by the flowing conductive liquid is detected by electrodes mounted on each side of the pipe. They are usually made of stainless steel, but platinum, titanium, nickel, or other materials may be used for exceptionally corrosive solutions.

Unlike differential-pressure or displacement instruments, the magnetic flow meter introduces no obstruction into the stream to inhibit flow. This is especially advantageous when metering thick liquids, sewage, and slurries. The meter is fitted directly into the process line like a section of pipe, is unaffected by mounting position regardless of angle, and needs no recalibration when the same process line is used for different liquids.

Most installations involve two- or three-inch meters, but there is no essential limitation on size. For example, a magnetic flow meter having a six-foot pipe diameter was supplied to the city of Pittsburgh by the *Foxboro Company* for use in the main discharge tunnel of the city's sewage system.

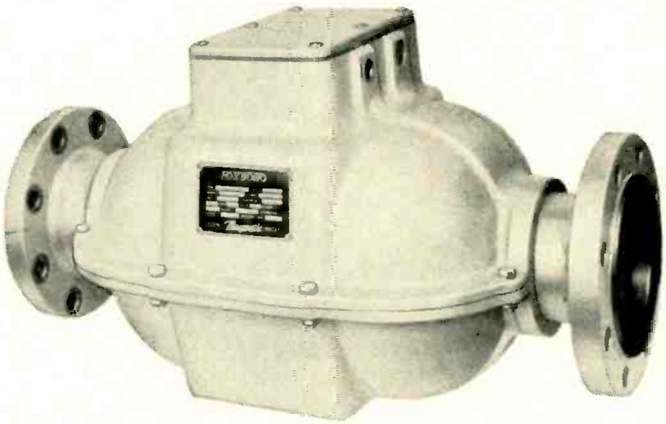


**Fig. 2. An actual magnetic flow meter is made of stainless steel lined with non-conducting plastic to prevent shorts.**

### Turbine Flow Meter

Unlike the magnetic flow meter, a turbine flow meter can be used for either conductive or non-conductive fluids. It is based on the principle that flow rate can be inferred from the velocity of a rotating vane immersed in the process stream, and its elements, as shown in Fig. 3, are simple. A multi-bladed rotor is suspended in a housing having end-fittings to match the pipe in which the meter will be installed. A pickup coil containing an Alnico magnet is mounted externally to the fluid passage. When fluid flows through the pipe, the rotor spins at a speed determined by the fluid velocity and the angle of the rotor blades. As each rotor blade moves past the coil and magnet, a change occurs in the reluctance of the magnetic circuit and the total flux through the coil. One cycle of a.c. voltage is thereby induced. The frequency of the pulses thus generated is proportional to the flow rate, and the total flow can be determined by adding up the total number of pulses with a conventional integrating counter.

The permanent magnet in some turbine flow meters is sealed inside the rotor itself. This provides a moving magnetic field which induces a pulse in the coil at each rotation. Mounting the magnet externally, however, results in a lightweight rotor which can withstand extreme environmental conditions and shock.

A turbine meter is inherently linear over most of its range, though some non-linearity may be encountered at minimum flow rates which are insufficient to overcome the drag on the rotor. Even in these instances, the meter shows a remarkable degree of repeatability. Although turbine meters can be installed in any position, linearity over the widest range is achieved by horizontal mounting. Since the rotor spins freely, it responds rapidly to flow variations and will indicate a transient change within the time needed for the rotor to make one revolution.

Where digital telemetering or recording systems are employed, the output signal can be used without further processing. Analog recorders require a d.c. signal, however, and when these are used, the output is rectified and amplified by a special frequency-to-d.c. converter.

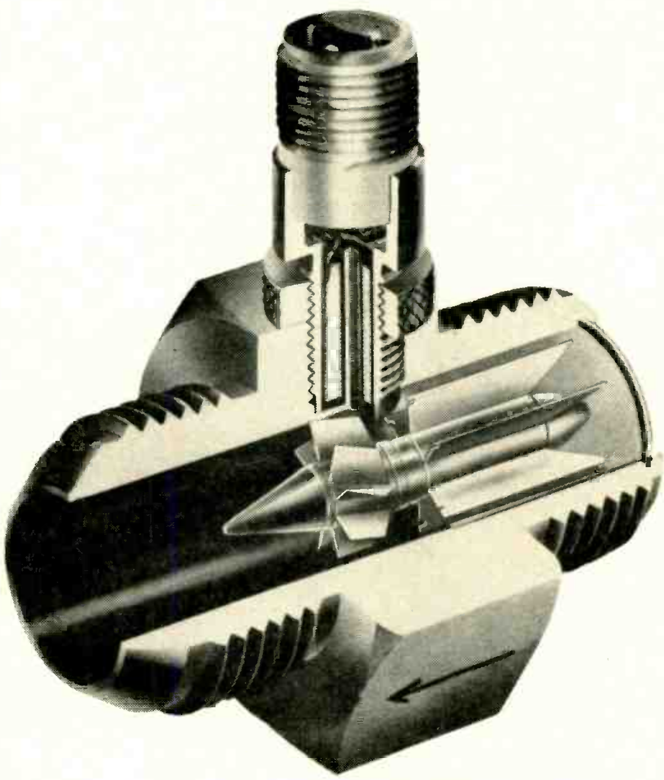
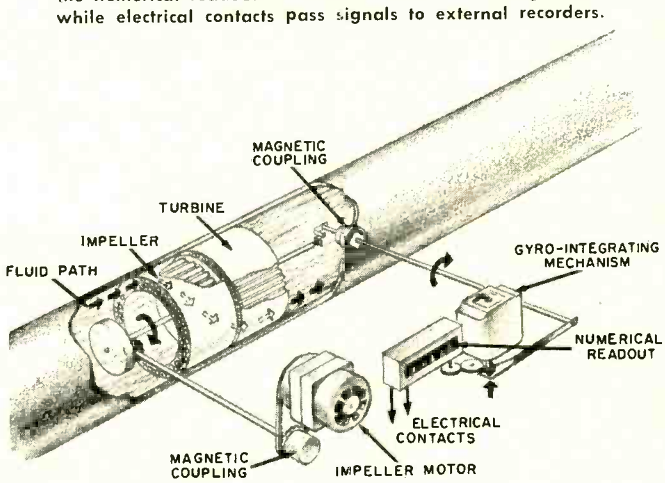


**Fig. 3. The turbine fluid flow meter generates a pulse of current each time the blade passes the electrical pickup.**

### Mass Flow Measurement

Anyone who has had the tank of his car overflow while it was parked in the sun on a hot day is aware of the fact that gasoline, like many other volatile liquids, changes in

**Fig. 4. The mass flow meter changes the direction of fluid flow, then measures the energy required to redirect flow. An integrating gyro senses the degree of the fluid torque, the numerical readout indicates the mass of flowing liquid, while electrical contacts pass signals to external recorders.**



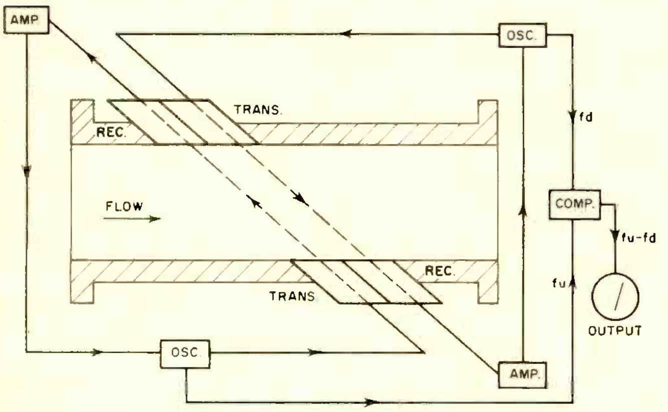



Fig. 5. An acoustic flow meter measures the time required for a signal to pass both ways across the moving stream by measuring the generated beat-frequency between two oscillators.

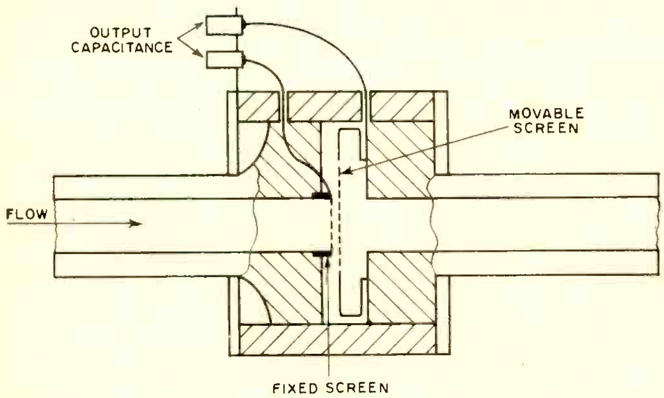
volume with temperature. Volume is also affected by pressure. The actual fuel value, however, is dependent on the precise number of molecules or atoms contained rather than volume. For this reason, a flow meter that simply measures volume flow must be corrected for temperature and pressure if it is to provide an accurate measure of fuel content. A more direct solution is to use a mass flow meter which needs no compensation since its output signal is proportional to the weight or mass of the liquid which, in turn, is proportional to the actual number of atoms or molecules contained.

One method to determine mass flow rate is to superimpose a known velocity in a direction perpendicular to that of fluid flow and to measure the force required to restrain the movement of the stream in that direction. That force will be proportional to the mass rate of flow. The data thus obtained is substantially independent of fluid properties such as viscosity, density, temperature, or flow patterns.

An interesting mass flow meter, made by *Black, Sivalls & Bryson*, is illustrated in Fig. 4. Fuel entering the meter passes through an impeller which has many parallel channels for passage of the liquid and which is driven at a constant speed by a synchronous motor. A known angular velocity is thus imparted to the fluid. Immediately behind the impeller is a second element, called the turbine, which is nearly identical to the impeller and is mounted independently on the same axis. Fluid leaving the impeller enters the turbine channels, and the angular velocity imparted by the impeller tends to move the turbine. However, the turbine is restrained and does not rotate. It thus removes the angular momentum of the stream, and the torque needed to restrain the turbine is directly proportional to the mass flow rate.

Through a system of mechanical linkages and a magnetic coupling, the torque exerted on the turbine is applied to the minor axis of a gyro-integrator. This causes the gyro to precess or rotate about its major axis at a rate proportional to the torque. Since the torque is proportional to the mass flow, the rotation of the gyro about its major axis is also proportional to mass flow. The gyro rotation is transmitted to a register and the mass flow is recorded in pounds.

Fig. 6. Cryogenic flow meter uses the dielectric constant of the liquified gas to produce a capacitance change. The change produces a frequency variation in a calibrated oscillator.




### Acoustic Flow Meter

An interesting type of flow meter is based on the time required for a signal (either in the sonic or ultrasonic region) to travel a certain distance upstream, as compared with the time needed for a similar signal to travel the same distance downstream. The flow will impede the propagation of the signal upstream and accelerate the downstream signal, so that the difference between the two periods will be proportional to rate of fluid flow.

Fig. 5 shows the essentials of an acoustic flow meter. It consists of a section of pipe in which are flush-mounted two sets of piezoelectric crystals, each set consisting of a transmitting and a receiving crystal. An oscillator is placed at the transmitting end of each set, and an amplifier at the receiving end. The amplifiers are coupled to the corresponding oscillators to form two complete loops.

In operation, each oscillator emits a single, discrete signal consisting of a radio-frequency wave packet which strikes each transmitter crystal and causes a signal to be propagated across the fluid stream. The signals are picked up by the corresponding receiver crystals, amplified, and conducted back to the generators. There they retrigger the oscillators, causing the generation of another wave train. The repetition frequency of each oscillator is thus determined by the time it takes the signal to cross the process stream and complete the loop.

The upstream repetition frequency is $f_u=(v+V\cos\theta)/2d$, and the downstream repetition frequency, $f_d=(v-V\cos\theta)/2d$, where $v$ is the rate at which the signal travels through the stream (called *acoustic velocity*), $V$ is the velocity of the stream, $\theta$ is the angle between the direction of the stream and the direction of the signal, and $d$ is the distance from the transmitter to the receiver. The two frequencies are combined in the comparator, and a beat frequency such that $f_u-f_d=V\cos\theta/d$ results. This beat frequency is proportional to fluid velocity but is independent of acoustic velocity.

The acoustic flow meter gives a measure of volumetric flow only, and where mass flow is important it is necessary to add a densitometer. The output of both instruments may be channeled into a computer which then calculates the mass rate of flow.

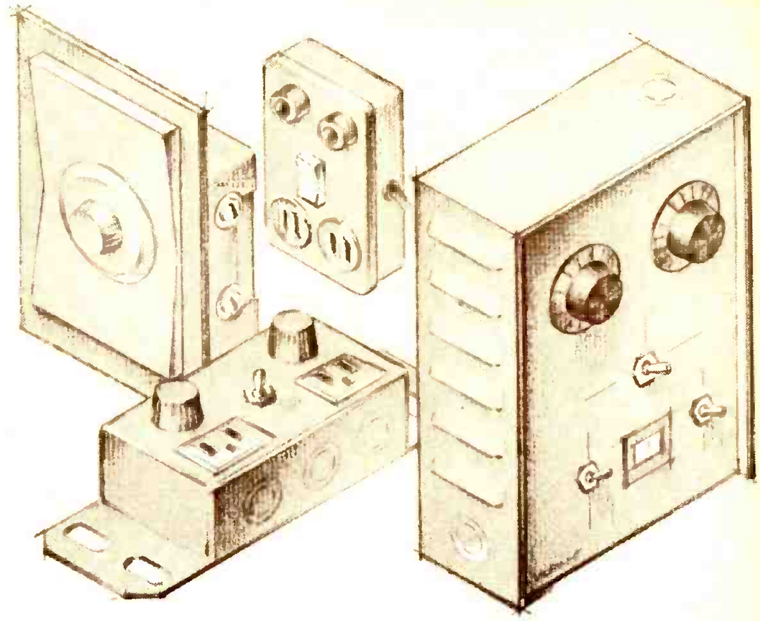
Acoustic flow meters are capable of measuring a very wide range of flow rates and, since they introduce no obstructions into the line, of handling a variety of fluids. However, it is important that there be no bubbles in the stream comparable in size to the wavelength of the acoustic signal. The electronics of the system are relatively complex, and this is a limitation for some applications.

### Cryogenic Flow Meter

Current interest in cryogenic fluids, especially because of the use of liquid hydrogen and oxygen as fuels for missiles and satellite launch vehicles, has spurred research into light, rugged flow meters able to operate at temperatures near absolute zero. The physical conditions found at extremely low temperatures rule out most ordinary flow meters. Because of the difficulty of lubricating bearings in cryogenic fluids, meters with rotating elements are not practical. Because cryogenic fluids are non-conductive, magnetic flow meters cannot be used.

The volume of a liquefied gas is subject to change with both temperature and pressure, and under practical conditions a tank may include some fuel in gaseous as well as liquid form. Since the useful fuel content depends on the actual number of atoms, a (*Continued on page* 80)

# Solid-State Dimmers & Power Controls



By DONALD LANCASTER

*Part 2. Specific circuits and their characteristics. Included is operation of circuits for fluorescent lamps, tool controls that use feedback for constant torque, and special controls for light, d.c., and audio input.*

LAST month we looked at solid-state power controls from a user's standpoint; considering what they are, their basic operating principles, the loads they can and cannot handle, and the various available packages with their individual advantages and disadvantages. This month, we will look at these controls from a different angle, considering how they work, and then going into specific circuits. There are many approaches to these new power controls, differing primarily in economy and utility.

All solid-state power controls make use of the a.c. phase-control principle to chop up the a.c. line into bursts of energy fed the load. The greater the fraction of each cycle that reaches the load, the greater the average load power. The load smoothes the "off-on-off-on" sequence into a uniform average value of load power with its inertia, be it thermal or mechanical. There are two basic switching schemes: the symmetric and the asymmetric. The asymmetric controls, although lower in cost, invariably produce a d.c. term in the output waveform which prevents their use on fluorescents, soldering guns, and any transformer-operated loads.

### Common Control Circuits

Fig. 1 shows a family of dimmer and tool control circuits which illustrate the common control schemes in use today. Each control consists of two parts—the power control itself and the turn-on circuitry. Although we have shown complete circuits, look at them initially only from their power-control aspects.

Fig. 1A is the simplest control and consists of a three-position switch and a single silicon rectifier. In the "Off" position, no power reaches the load. In the "Dim" position, only the negative half cycles reach the load since the diode blocks the positive halves. In the "Bright" position, the diode is removed and both cycle halves reach the load. The circuit is asymmetric and has no continuous adjustment. It is suitable only for incandescent lamps and two-speed electric drills. Its main features are economy and simplicity. The maximum load current is twice the diode rating, since the diode is "on" only half the time. An ordinary 750-ma., 200 p.i.v. diode is good to 1500 ma. or almost 200 watts of load. A diode with a somewhat higher current rating can be used for loads of 600 watts or more.

The next simplest configuration is that of Fig. 1B. Here the silicon rectifier is replaced by a silicon controlled rectifier (SCR). The turn-on of the SCR is delayed each half cycle until it receives a turn-on pulse from the control circuit. Varying the 10,000-ohm pot varies the time of the turn-on pulse, and the SCR gives continuous adjustment from "off" to half power. Note that the range of this control is restricted and that, once again, the waveform is asymmetric. A silicon controlled rectifier, just like an ordinary diode, works only one way and conducts current only when forward biased. The SCR is turned "on" by a gate pulse and "off" by the first a.c. zero.

By combining the circuits of Figs. 1A and 1B, a full-range asymmetic circuit results (Fig. 1C). If the switch is open, the SCR controls from "off" to half power, since the negative cycle halves aren't passed. With the switch closed, the diode passes the negative half cycles and control of half power to full "on" is achieved. Usually the switch is combined with the delay pot in the turn-on circuit, so that two turns of the pot are required to go from full "off" to full "on." This circuit is commonly used in the dimmer and tool controls now being offered by distributors and hardware stores, but the newer symmetrical circuits will soon match it in parts cost. The disadvantages of this circuit are two-fold: an asymmetric output waveform and the two-turn control. Power rating is determined solely by the current ratings of the SCR and shunt diode.

The only thing that can be said for asymmetric circuits is their economy, for they are capable of handling only a limited number of useful loads and plugging in the wrong load can cause permanent damage to both control and load. This economy will shortly be matched by the newer circuits, and this form of circuit will ultimately disappear.

### Symmetrical Controls

There are two approaches to symmetrical control, either using unilateral (one current direction only) components in pairs, or using bilateral components only. The bilateral components are quite new, while the unilateral SCR circuits have been around for some time.

An SCR is unilateral. It works in one current direction only. So why not use two SCR's, one going in each direction? This is the approach of the circuit of Fig. 1D. The SCR's each operates in its own forward direction and provides full-range symmetric control. The diodes in the control circuitry do not handle the load current and can be quite small. The turn-on circuit for this configuration must be bilateral, as it must provide a turn-on pulse of the proper polarity each half cycle, properly routed to the right SCR.

But a unilateral turn-on circuit may be preferable, particularly when using the special circuits that require input signals. The shorted bridge configuration of Fig. 1E allows symmetric power control with a unilateral turn-on circuit. This requires two SCR's and two power diodes. The current flow is always in the forward direction of one of the SCR's and the opposite diode. This circuit has recently become quite attractive due to the availability of reverse-polarity SCR's and diodes. By a proper combination, one uninsulated heatsink may be used as the common connection for all four components.

The circuit of Fig. 1F uses a full-wave bridge rectifier and a single SCR. This might be preferable if you were using one of the new insulated full-wave bridge assemblies, either molded or stud mount. Also, the SCR never has reverse voltage applied to it. This is a protective advantage, important on older type SCR's.

There is an interesting variant of this circuit. If the load is brought inside the bridge circuit, the same bridge may be used on a multiple SCR arrangement. Of course, this puts a strong d.c. component in the output waveform, but this doesn't matter with incandescent bulbs. Each SCR may be independently controlled. This is quite useful for theater lighting, color organs, and variable color advertising displays. Fig. 1G shows this extension. Its advantage is that only a single bridge assembly is needed for *all* the SCR's and control circuits.

There must be an easier way. Why not a single bilateral semiconductor directly in series with the load and a simple bilateral turn-on circuit? *Transitron* and *General Electric* have very recently come up with *bilateral* power-switching devices, *e.g.*, ones that operate equally well in either direction. Typical ratings of these semiconductors are 600 watts, 1 kw., and 5 kw. They can provide complete symmetrical control with either four or five components. These devices are so new that they are not priced competitively with the SCR systems. There is another disadvantage to these new devices, which may be important in some applications. The circuits *must* be driven by a bilateral turn-on circuit. In cases where control is to be by d.c. or other external signal, the available turn-on circuitry is quite limited. This limitation will almost certainly be overcome in the near future, but at present it limits the use of the new bilaterals in external-signal controls.

The *G-E* bilateral, called the "Triac," is similar to an SCR except that either polarity gate pulse may be used to turn on the device. (One particular combination of gate pulse and load current at present requires excessive current. Because of this, forward gate polarity with respect to the main current is almost always used.) A "Triac" power control is shown in Fig. 1H. Operation is just like the circuit of Fig. 1B, except that turn-on occurs each half cycle, giving symmetrical, full-range control.

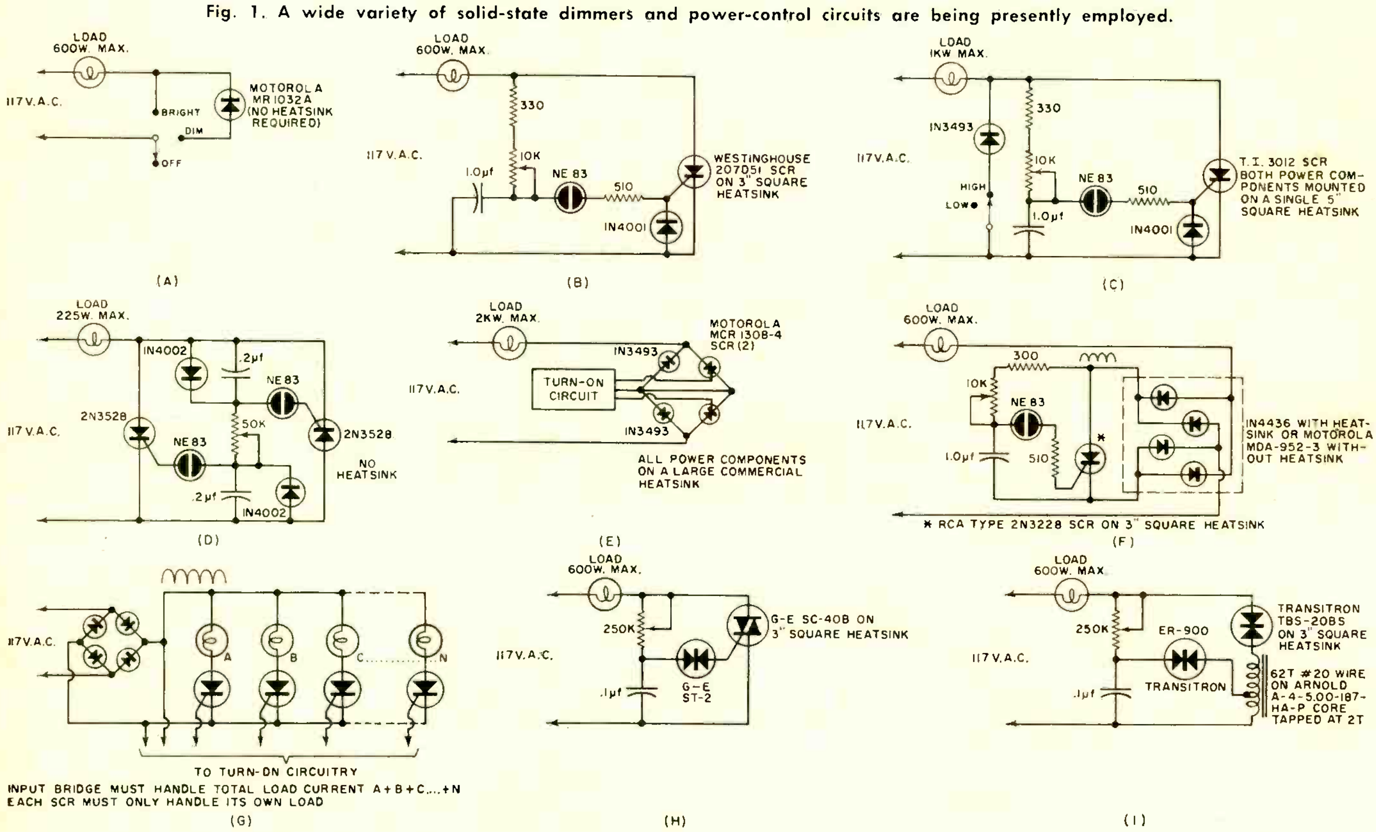
The *Transitron* bilateral, called a "Biswitch," has no gate. It is turned on by exceeding the forward breakover voltage and avalanching the five-layer silicon structure into conduction. To do this, a small transformer steps up the turn-on pulse to a 400-volt spike which breaks down the "Biswitch." This transformer has a very low 60-cycle reactance and does not affect the main current flow. The circuit of Fig. 1I is similar in operation to the "Triac" circuit with the transformer replacing the gate connection. The "Biswitch" has a lower unit price than the "Triac" but the need for a transformer largely offsets this price advantage.

Ultimately, the circuits of Figs. 1H and 1I, because they require fewer parts and are easier to manufacture, may replace the rest as the price of bilateral switching devices drop and the external control problem is solved.

### Turn-On Circuitry

Fig. 2A shows a circuit consisting of a resistor and a capacitor connected to the gate of an SCR. This is a phase-shifting circuit in which the current leads the voltage. As an a.c. zero

**Fig. 1. A wide variety of solid-state dimmers and power-control circuits are being presently employed.**



comes up, *R* will start to charge *C*. When *C* gets up to the forward turn-on voltage of the SCR (about 0.6 volt), the SCR turns "on," discharges *C*, and removes the source of charging current for *R* by shorting out the *RC* network. A large value of *C* is needed and the turn-on is temperature-dependent, due to the changing turn-on level of the SCR. This can cause a time drift in the control settings which can be quite severe. This circuit is not used in any but the lowest priced controls. It is bilateral and is shown because it is the basis for the more practical circuits that follow.

The main objections to the *RC* turn-on circuit are the loading of the SCR gate on capacitor *C* and the absence of a discrete turn-on pulse. Both these objections are overcome by adding a neon lamp to the circuit, as shown in Fig. 2B. *R* charges *C* until the breakdown level of the neon is reached. At this instant, the neon ionizes and briefly conducts a turn-on pulse into the SCR gate. The precision of the turn-on is determined entirely by the neon characteristics and not by the SCR. In practice, a high-current neon, typically a low-cost NE-83, is used to provide sufficient current to guarantee SCR turn-on. The circuit is bilateral and operates equally well unilaterally.

There are several limitations to this improved circuit. The first is the intrinsic "orneriness" of neon lamps with regard to their firing levels and pulse capabilities. This is largely overcome by painting the neon black, using a fixed, short geometry, and by using only neons that have radioactive tracers added to stabilize their operating points. A second, and major, disadvantage is that a neon will not turn on at less than about 80 volts. This means that no matter how small *R* is, the circuit cannot turn on the SCR *until the a.c. line has reached at least 80 volts,* and cannot provide turn-on any later than after the a.c. line has dropped below 80 volts. This results in a reduced control range. Starting with "off," no control can be obtained until a jump to a low brilliance is achieved at 80 volts. From there, smooth control exists up to the setting at which the first 80 volts occurs. *There can never be full power applied to the load.*

What is needed is a neon lamp that breaks down at 20 or 30 volts. There is very little power in the "corners" of half a sine wave, since power is proportional to voltage squared. The missing parts of the control range would be quite small and of no consequence. Gaseous discharges at such low potentials simply do not occur, and no neon or argon device will break down at these low potentials. But any small-signal transistor has an avalanche breakdown voltage. The breakdown characteristic of a transistor may be used to provide the turn-on pulse.

This is the circuit of Fig. 2C. The turn-on pulse is produced by the voltage on *C* exceeding the avalanche voltage of transistor *Q*. *Q* avalanches at this point and produces a turn-on pulse. The SCR then resets the circuit by discharging *C* through *Q* and shorting out the source of current for *R*. This is a quite practical circuit. Transistor *Q* is a special inexpensive one, optimized for safe avalanche breakdown very near 25 volts. This circuit is unilateral and will not drive the bilateral controls unless a double configuration is used. The circuit smoothly controls output power between 3 and 97 percent of maximum available power from the line. This corresponds to very nearly "off" and very nearly full brightness.

Instead of using a transistor, any avalanche diode may be used, such as a four-layer diode or a *p-n-p* avalanche diode. These are shown in Fig. 2D and are simply alternates to Fig. 2C.

By going to a *five*-layer *p-n-p-n-p* trigger diode, as in Fig. 2E, bilateral operation may be obtained over the same range as the circuits of Figs. 2C and 2D. This is a very good circuit and, except for critical applications, is well suited to all home-power-control needs.

There is a minor annoyance in connection with this circuit that is corrected by the addition of a phase-shift network,

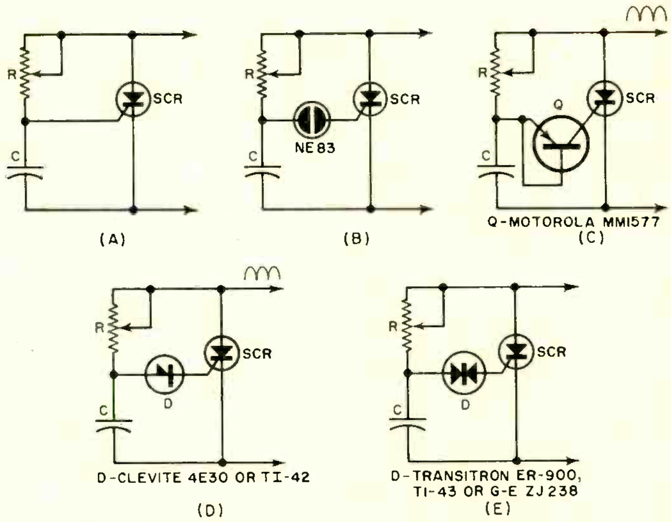



**Fig. 2. Turn-on circuits arranged in order of increasing cost.**

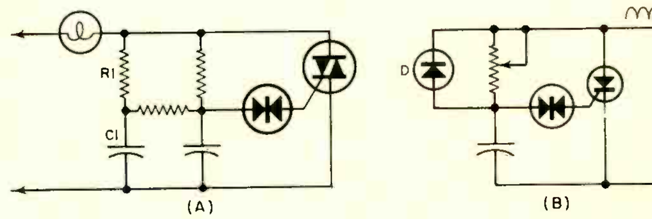



**Fig. 3. Circuits employed to eliminate "jump-start" effect.**

consisting of a fixed resistor and capacitor. In bringing the bilateral control up from zero, a sudden jump occurs to about one-quarter brightness or speed. From this point, the control may be smoothly varied, either up or down in intensity. The jump is caused by capacitor *C* failing to discharge through *R* fast enough for settings so low that *C* never reaches 30 volts, SCR turn-on never happens, and at each zero, *C* must begin charging, not from zero but from some reverse bias. As soon as initial turn-on is achieved, *C* always starts charging from zero bias, which shifts the settings so that a full control range may be realized. The new resistor and capacitor provide enough additional phase shift at extremely low brightness (or speed) settings to minimize this effect. Fig. 3A shows the circuit.

In unilateral turn-on circuits, the addition of a diode and a resistor across the line may be used to eliminate this effect. This is detailed in Fig. 3B. Diode *D* is always reversed biased *except* when the charge on *C* exceeds the line voltage. This insures zero capacitor charge at the beginning of each half cycle, whether or not the SCR has turned on during that cycle. This effect is called the "jump-start" effect and is of importance only in critical light-dimming applications.

All of the firing circuits shown are somewhat line-voltage dependent. If it is necessary to precisely control the load power totally independent of line variations, a regulated charging supply for the timing capacitor must be used. This usually takes the form of a zener diode. A very old combination is to use a zener and a unijunction transistor as the avalanche device. This circuit is quite expensive when compared to the others, but provides stable operation despite varying line voltage, a feat that the other circuit cannot match. The unijunction circuit is shown in Fig. 4. It is strictly unilateral and must be driven from an inverted (positive-going half cycles only) a.c. source. A pulse transformer may be added to provide gate signals for two or more SCR's. The circuit finds little use in home and shop applications due to its expense and the large number of parts, but is widely used in precision regulators and servos.

There is much confusion over the use of solid-state power controls on fluorescent lights. Any symmetrical control will

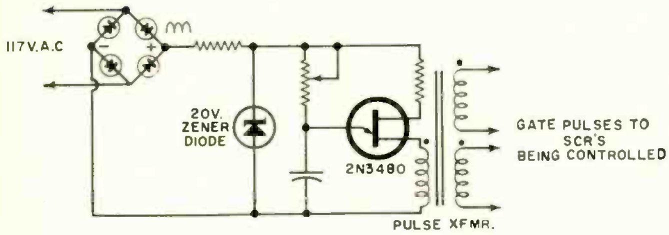


Fig. 4. Unijunction turn-on circuit is stable under varying line voltage but is more complex and is much more expensive.

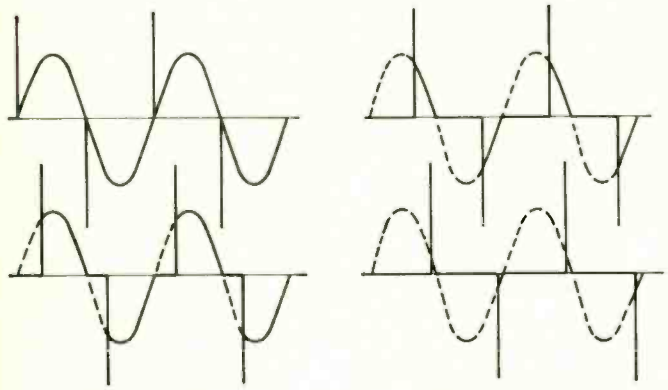


Fig. 5. Typical waveforms for fluorescent-lamp dimmers.

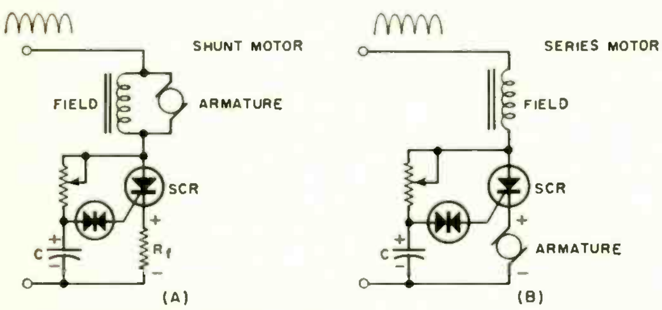


Fig. 6. Techniques using feedback for constant motor speed.

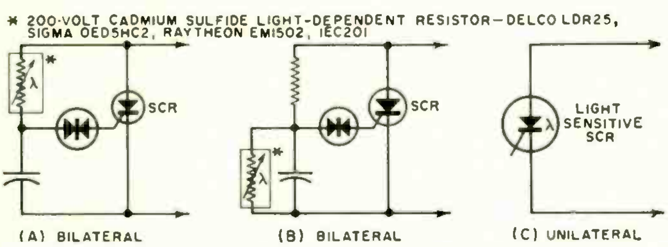


Fig. 7. Light-sensitive turn-on circuits. Thermistors may be used in (A) and (B) to produce temperature-sensitive controls.

provide a reasonable control range, provided the fluorescent is turned "on" initially at full brilliance and not at a dim setting. *Asymmetrical controls will permanently damage the ballast in a fluorescent lamp.* For total, linear, full-range operation, a special fluorescent dimming circuit has to be used. It is a problem, at very low brightness levels, to maintain enough ionization in the tube to prevent flickering of the light level and to prevent the bulb from extinguishing completely. There are a number of dimmer circuits that overcome this, by use of waveform distortion. A *spike* is always applied to the fluorescent just as SCR turn-on would normally occur. This "restrikes" the discharge in the tube every time, insuring enough ionization to maintain a uniform low brilliance. Typical waveforms are shown in Fig. 5. The actual circuits employed vary with the size and types of lamps in use.

It has been assumed all along that these circuits are to operate on 60-cycle a.c. To the SCR, the operating frequency does not matter, as long as the a.c. zeros are available. But the delay circuit must be changed each time to "fit" the time length of each half cycle of the particular supply frequency in use. Time constants must be lengthened for 50-cps operation and shortened for the 400-cps aircraft lines. If d.c.-only operation is attempted with the controls shown, they will simply lock at full brilliance very soon after power is applied and stay "on" until the power is disconnected, hence, these circuits are totally unsuitable for d.c. operation. Similar control functions may be provided on d.c. by using a gate controlled switch (an SCR that can be turned *off* as well as on by a gate pulse). Another alternative is the use of pairs of SCR's in various capacitor commutation schemes.

## Constant-Speed Arrangements

The controls shown provide constant power to a load. If the load is a motor or a tool (electric drill, etc.), it would be preferable to provide constant *speed* in light of a varying mechanical load. A mechanical load reflects itself as an increase or decrease in motor current. Feedback is used to advance or retard the turn-on time of the control as the load increases or decreases. This is done by sensing the output current or using the induced back-e.m.f. of the motor to alter the biasing of the turn-on circuit. As motor current increases (corresponding to a heavier load that would try to decrease speed), a feedback signal is produced that shifts the turn-on earlier in the half cycle (corresponding to more power that tries to increase speed).

Two typical circuits are those of Fig. 6. (A) shows a resistor $R_f$ in series with the SCR whose voltage drop adds to the normal 30 volts to which the timing capacitor $C$ must charge. As the load varies, the drop across $R_f$ follows, producing a feedback voltage according to Ohm's Law. $R_f$ must be a high wattage unit since the total load power flows through it. Fig. 6B replaces resistor $R_f$ with the armature of the motor. This is only applicable to series motors. The $IR$ drop of the armature is directly proportional to motor current which, in turn, is directly proportional to the mechanical load. This $IR$ drop forms the correction voltage which is again used to shift the turn-on time to maintain constant speed. There are considerably more elegant schemes for providing constant torque or constant speed, but these two simple methods are indicative of the general principles behind all controls of this type. These circuits are usually unilateral.

## Light-Sensitive Controls

Light-sensitive power controls involve one of the three methods shown in Fig. 7. A photoresistor, usually cadmium sulfide or selenide with a 200-volt rating, is added to shunt the timing capacitor or to replace the timing resistor. If the capacitor is shunted, as in Fig. 7B, *increasing* light causes *decreasing* load power. Or, as in Fig. 7A, if the photoresistor is used as the timing resistor, increasing the light decreases the photoresistance, which increases the load power. The latter method is considerably more linear. Both circuits are bilateral. There are also available SCR's which are directly light sensitive. Here the presence of light simply turns the SCR on, resulting only in "on-off" and *not* proportional control.

A final large group of these controls makes use of external control signals, whether d.c., low-voltage 60 cps, or audio. These are useful for temperature controls, feedback and logic systems, color organs, displays, and other audio-driven devices. An important advantage of this type of operation is that low-voltage "doorbell" circuits may be used instead of the conduit runs that are normally required for direct 117-volt proportional control circuitry.

## D. C. and Audio Controls

A new and rather obvious means of d.c. control consists of placing a light bulb (incandescent or neon) in front of the photoresistors in either light control circuit (Figs. 8A and 8B). Commercial optical links (*Continued on page* 75)

# PORTABLE ATOMIC FREQUENCY STANDARD

**Having a short-term frequency stability of better than one part in ten billion, this rubidium-vapor atomic clock can be battery powered for use in remote, isolated areas.**

A RUBIDIUM-vapor frequency standard developed by the National Bureau of Standards (U.S. Department of Commerce) combines the accuracy and stability of atomic standards with easy portability and independence of power lines. Based on a transition frequency of the rubidium atom (6834.68 mc.), the device uses a rubidium lamp which stimulates rubidium vapor to undergo the required transition.

The rubidium vapor standard has a short-term stability better than 1 part in $10^{10}$, recommending it for use both as a clock and as a frequency standard. Lightweight and requiring approximately 23 watts of power, it is useful for synchronizing clocks in isolated areas to which it can be transported. Normally it operates from conventional a.c. power. When power is removed, it switches automatically to self-contained batteries for approximately 8 hours of operation at room temperature.

Stable frequencies determined by atomic structures have recently come into increased use as frequency standards. A cesium-beam clock, for example, establishes the frequencies of standard transmissions of NBS radio stations WWV, WWVH, WWVB, and WWVL.

Atomic frequency standards operate by one of two means; by determining the frequency corresponding to dipole inversion in a beam of atoms, or by determining the frequency corresponding to a transition between the energy levels of atoms in a fixed sample. The transition method is used in the rubidium frequency standard. Here, rubidium vapor in a cell is stimulated by a beam of light, causing two kinds of energy transitions to occur in the cell. The stimulating light is scattered most when the populations of the two different ground states are equal. Conversely, more stimulating light passes straight through the cell when the population difference is greatest, producing maximum response of a photoelectric cell placed in the path of the emerging beam. The operation of the rubidium standard uses the fact that the transmitted light intensity is decreased in the presence of an oscillating magnetic field at a frequency known as the rubidium hyperfine frequency. The samples in the rubidium standards have been selected so that population difference is low, and photocell indication least, when a microwave field at a frequency of 6,834,683,405 cps is applied to the cell.

Like most atomic clocks, the rubidium clock operates in an indirect way to sense the frequency of the atomic reference. The applied microwave field is frequency-modulated at an audio rate, the frequency of the atomic transition is sensed, and the average frequency of the field is modified by servo circuits to center the transition frequency in the sweep. The sweep center frequency is then the transition frequency sought.

### Physical Basis

When construction of the portable frequency standard was undertaken in 1959, NBS physicists decided to use an atomic transition as a reference because transition standards do not consume any reference material and do not require great length for stability. The development efforts were directed primarily toward a device having low power consumption and good long-term stability, with secondary emphasis on compactness and short-term stability.

The circuitry of the rubidium standard produces the magnetic field, within which the transitions take place, in a cylindrical microwave cavity having dimensions chosen so that it is resonant at 6.83 gc. in a mode permitting large openings at both ends. Rubidium vapor at a pressure of about $10^{-6}$ torr (pressure of 1 mm. mercury at 0°C and standard gravity) and a nitrogen and methane buffer mixture at a pressure of about 39.6 torr, are contained in a quartz cell which fits into the microwave cavity. The transparent cell and the open ends of the cavity permit the beam of pumping, or stimulating, light to shine in one end, and the light passing out the other end to be focused on a silicon photovoltaic cell.

The source of stimulation is a discharge lamp containing rubidium vapor and krypton gas. Before entering the quartz cell (see Fig. 1), the light passes (*Continued on page* 62)

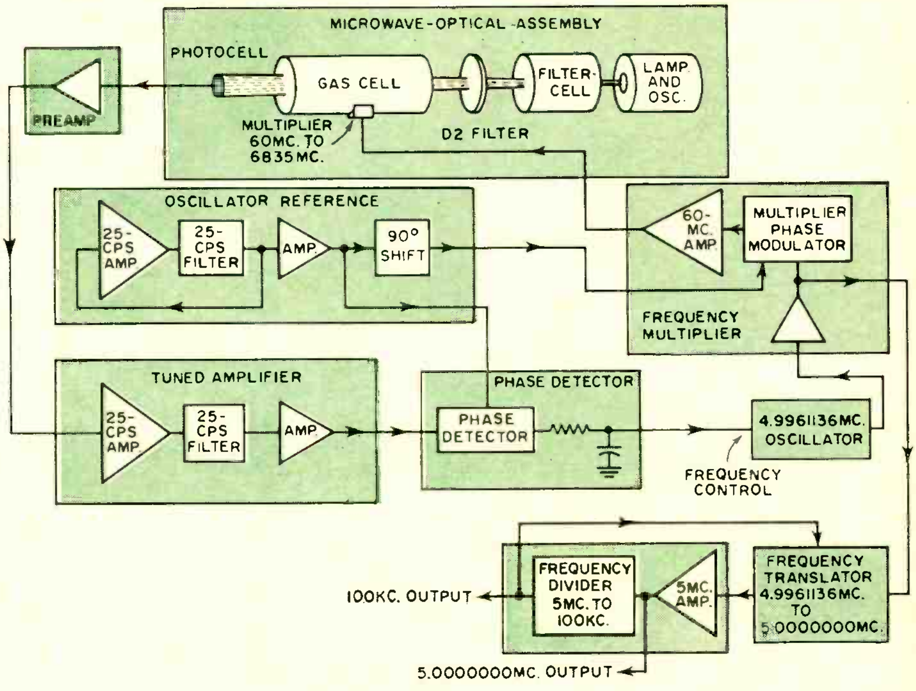
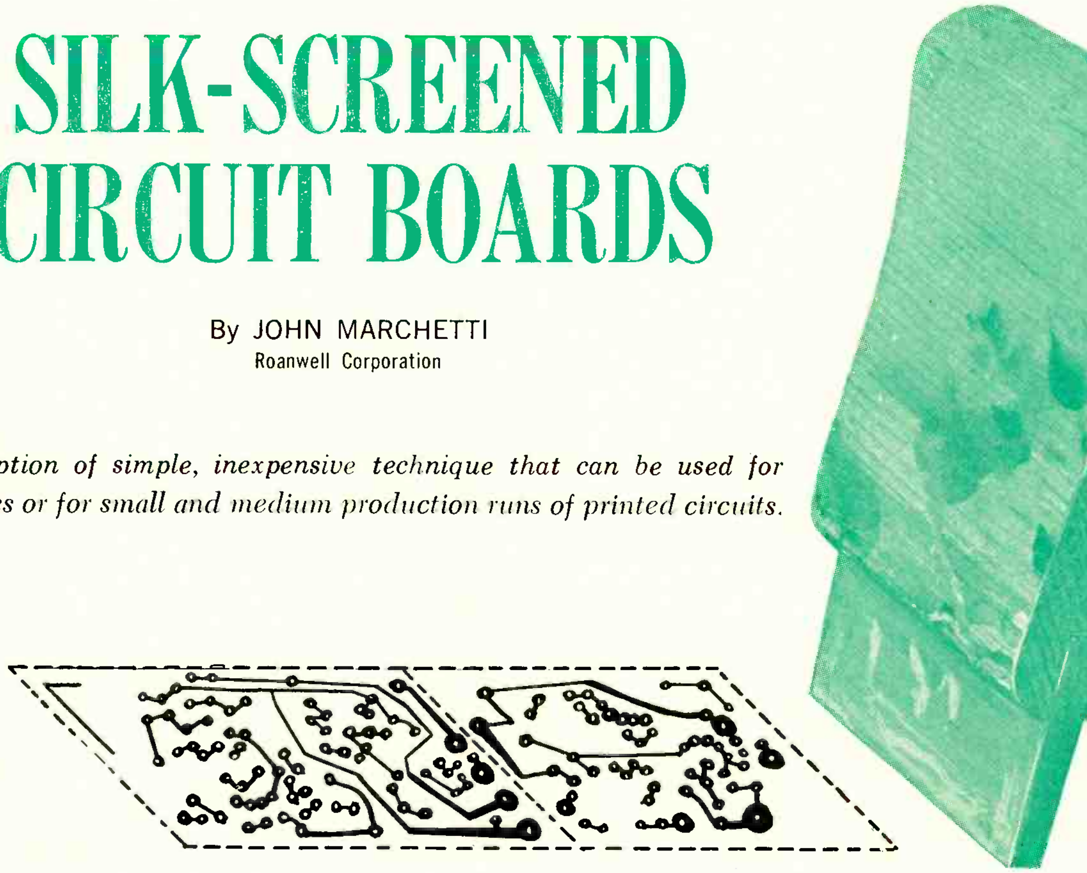


Fig. 1. Block diagram of the rubidium-vapor frequency standard developed by NBS.

# SILK-SCREENED CIRCUIT BOARDS

By JOHN MARCHETTI
Roanwell Corporation

*Description of simple, inexpensive technique that can be used for samples or for small and medium production runs of printed circuits.*



THE fabrication of printed circuits using the silk-screen process has become quite popular throughout the electronics industry. The process is economical for making circuit-board samples and can easily be adapted for medium-run production. The screen for a particular circuit, if properly handled, can be used many times, stored and used again at some future date. The author has had occasion to use single pattern screens similar to the one in this article as many as 200 times without difficulty and larger, multiple pattern screens in production runs of a 1000 quantity. The screen in this technique is used as a means of depositing an acid-resistant paint on a copper-clad phenolic board prior to etching; however, it can also be used for labeling equipment front panels and chassis, or even with silver conducting paint to deposit a circuit on any smooth insulator, thereby eliminating etching. Since the silver paint is expensive, this process is restricted to very small circuitry.

### Method & Materials

The screen process consists of preparing a hand-drawn or photographic positive of the circuit. The positive is transferred to a wooden frame covered with fine-mesh silk. The transfer is similar to a photographic process but much less complicated, since the positive is only black or clear and the transfer can be performed in subdued light with a minimum of chemicals. The paint is then forced through the openings in the screen with a rubber squeegee onto the copper-clad surface, producing the pattern. After drying, the paint acts as a resist for etching.

The materials used are simple to obtain, moderately priced in small quantity, and readily available from any large art or paint store or from a silk-screen supplier (Item 1 in Table 1). Ten to fifteen dollars is adequate to purchase a sheet of film, silk, one pint of paint, and enough dichromate sensitizer to do small trial exposures and several small circuits. Any sturdy wooden frame can be used, the dimensions are determined by the circuit size. A thick piece of rubber wider than the circuit can be used as a squeegee. A one-half inch camel-hair brush is used to apply the sensitizer, a standard #2 photoflood (Item 2) is used for exposure, and hot water is used to develop the film. Turpentine or benzine is used for cleaning the screen; and the silk can be soaked, cleaned, and re-used if desired. Standard copper-clad phenolic can be used for the circuit board. The procedure is as follows.

### The Procedure

The method described here is a modification of the commercial process; however, with a little care, good technique,

Table 1. Suppliers of materials employed by the author.

| | |
|---|---|
| Items #1 & 4 | Silk Screen Supplies Inc.<br>33 Lafayette Avenue<br>Brooklyn 17, New York |
| | Ace Clearprint Products Inc.<br>44 East 21st Street<br>New York, N.Y. 10010 |
| Item #2 | Sylvania Superflood R34 |
| Item #3 | Higgins Black Acetate Ink |
| | Prepared Acetate<br>The Bee-Ko Co. Inc.<br>155 East 44th Street<br>New York, New York |
| Item #5 | Scrink Screen Process Ink<br>#475 (white)<br>The Craftint Mfg. Co. |
| Item #6 | Printed Circuit Black #211<br>Silk Screen Supplies Inc. |
| Item #7 | Oakite, Ajax, floor & wall cleaners |

and practice exposures, equivalent results can be easily obtained and repeated.

The first step is the construction of the screen. The silk is purchased according to weave; a grade of 14XX, 138 mesh is adequate for smaller circuit work. A coarser grade such as 10XX would be used for large lettered printing. The minimum screen size should be approximately 4 inches longer and 4 inches wider than the circuit to be made. As an example, the two circuits fabricated here were placed end to end measuring 1½"x 5". The screen size was 6"x 9" to give a two-inch border around the pattern. This permits working the paint with the squeegee while screening. The wooden frame was constructed of ¾-inch stock with 6"x 9" inner dimensions and the silk was cut to give a 1½" border in excess of the frame outer dimensions. This border acts as a grip when stretching the silk and is doubled when tacking.

In Fig. 1, the silk on one of two adjacent sides of the screen is doubled over and tacked in place, the tacks placed every half inch. The closer the tacks are spaced, the fewer the ripples in the silk. A staple gun was tried and it was necessary to place masking tape over the doubled silk to prevent the wire staples from pulling through the silk. If small carpet tacks are used, there will be less tendency for the silk to tear when stretched, and the head size will increase the allowable spacing between tacks.

Next, the opposite side is pulled as tight as possible, doubled and tacked in place. The same procedure is used for opposite ends. Boiling water is then poured over the silk and the screen is allowed to dry.

If the silk has been stretched correctly, it will resound like a drum when tapped while wet and be free from ripples when dry. If ripples are visible, additional stretching and closer tacking is necessary.

The circuit pattern necessary to prepare the screen is a 1:1 (actual size) positive prepared either by photographic means, by drawing with black ink on a clear acetate material, or black tape pressed on clear celluloid. The positive of the printed circuit will be black where copper is to appear on the circuit board and clear where the copper is to be etched away. In Fig. 2 the author used black acetate ink on a prepared clear acetate (Item 3). The prepared acetate is available in art stores and will accept ink drawings whereas the normal clear celluloid will only take tape.

The acetate is placed over the circuit and the pattern traced with ink. Circles are drawn with an ink compass or an ink-drop bow. Three types of pens are illustrated, each of which is adequate for drawing with ink. The least expensive is the common wooden pen holder. Points in a variety of line widths are available for the holder at art stores. The finished drawing is inspected by holding it up to a light on top of a piece of thin white paper. No light should penetrate the black lines or circles. The darker the lines, the better the screen.

The drawing is now transferred to the screen using a standard unsensitized screen photo process film which is available in sheets at graphic arts dealers (Item 4). It is a gelatin coating on a flexible plastic backing. The gelatin side at this stage is soluble in water; therefore it should be rolled and stored in a cool, dry place. Once wrinkled or creased, the film becomes useless.

The next step is sensitizing the film. This step is performed with only the light of a 15-watt bulb, at a distance of 20 feet from the film. After sensitizing, the film should not be handled in brighter light. The sensitizer used is a solution of 3 ounces of water to ½ teaspoon of either potassium dichromate or ammonium bichromate powder. These chemicals are poisonous and flammable and care should be taken when handling and storing them. The author hasn't experienced any skin irritation from contact with these chemicals but others may be sensitive to them.

Cut a piece of the film larger than the circuit pattern to permit handling; then tape the film, emulsion side up, on a

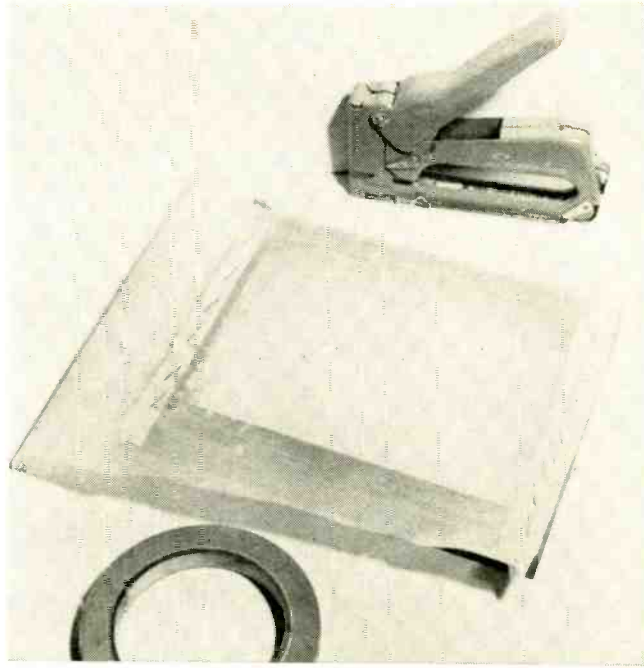
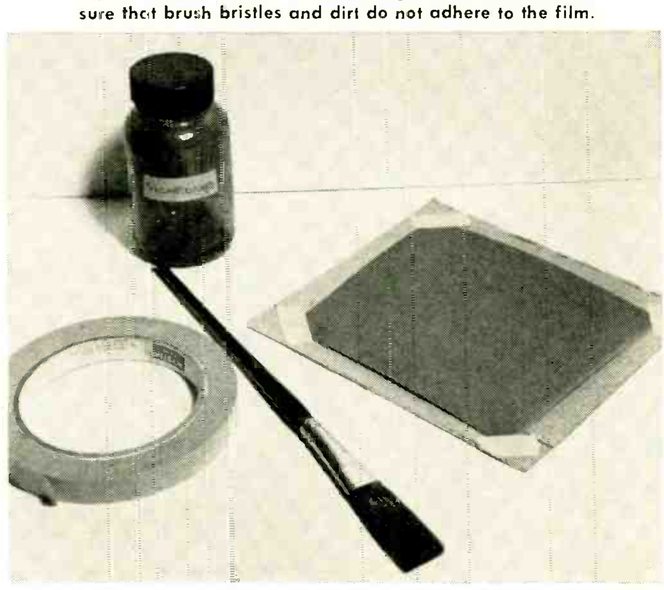


Fig. 1. First step is constructing the silk screen. The silk is doubled over and tacked or stapled into place. Masking tape is used in order to prevent screen tears.

Fig. 2. The finished positive is drawn on special acetate. The author has employed black acetate ink for line work.

Fig. 3. Preparing film for sensitizing with dichromate. Be sure that brush bristles and dirt do not adhere to the film.



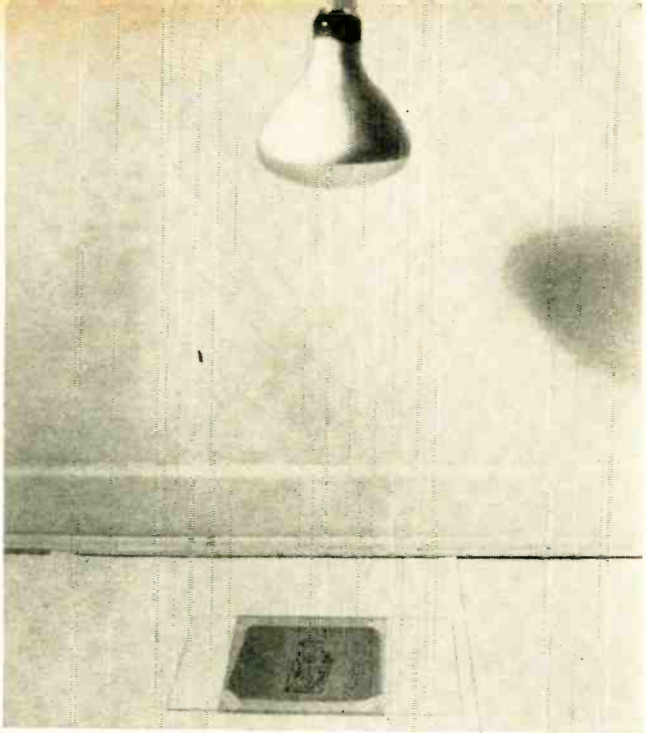


Fig. 4. Exposing the sensitized film with photoflood lamp.

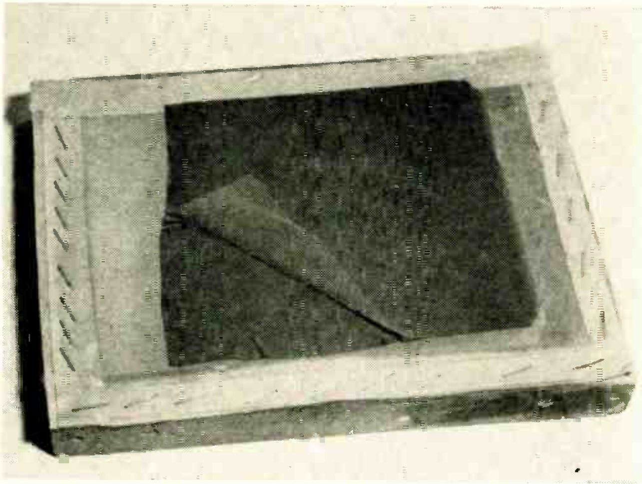


Fig. 5. Peeling the plastic backing from the dried film.

Fig. 6. The finished screen, squeegee, and printed board. Note the use of masking paper around the printed-circuit layout which keeps ink away from borders of layout used.

piece of cardboard, Fig. 3. The sensitizer is painted lightly on to the emulsion, first with cross strokes in one direction until covered and then another light coat in the opposite direction. Finally a third coat is given the film in the original direction to insure uniform soaking of the emulsion without wet spots (puddles). Reflections on the film can be used to check your job. Care should be used to prevent dirt and bristles from adhering to the tacky film. The camel hair brush must be washed thoroughly after use. Since the film must dry completely it is best sensitized on a cool, dry day and placed in a dark corner facing away from the light until dry. On a rainy or humid day it is almost impossible to dry the film. Heating the film may irreparably harm it.

### Exposing the Film

The dry film is now ready for exposure. The film is placed emulsion side down on a hard smooth surface covered with dull black paper. The positive hand drawing (tape or photo positive) is placed with the inked pattern side face down on the plastic side of the film and a piece of glass placed over these two. The weight of the glass will be sufficient to hold the positive and film tightly in contact, Fig. 4. Looking through the glass, the circuit pattern should appear backwards.

A #2 photoflood lamp in a reflector is suspended approximately 24 inches above the glass and the film is given a 10- to 15-minute exposure without disturbing the positive and the film. The length of exposure may vary due to the extent of sensitizing. If possible several small trial exposures should be made to determine the best time. Weak room lighting will not affect the exposure. Care should be taken to avoid heating the glass or film. On a very warm day, intermittent exposures amounting to 10 minutes can be given the film without disturbing the positive contact, or a fan can be played on the glass during exposure. Heating or over exposure will prevent the circuit pattern from washing out when developed; and under exposure will cause the solid portions to wash away.

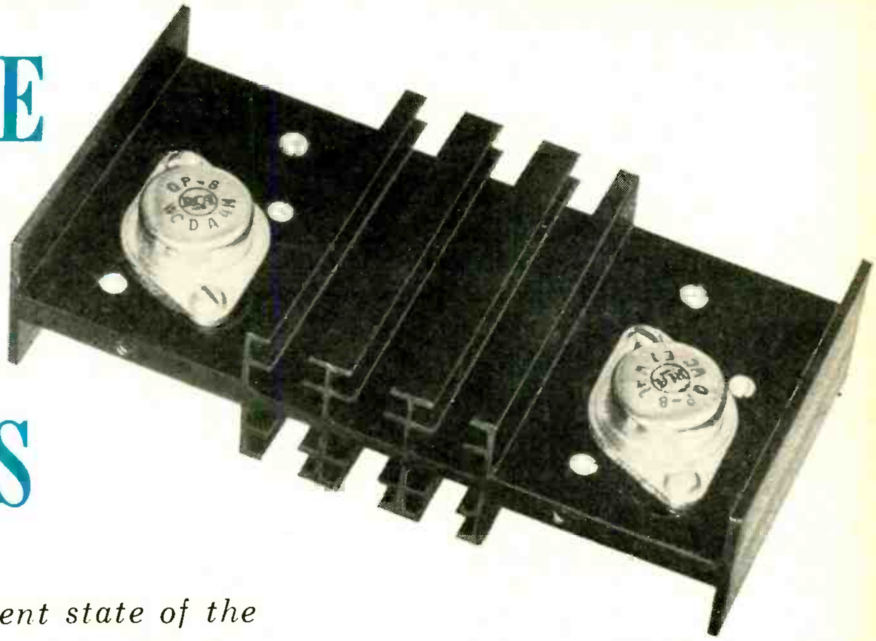
After exposure the film is removed from beneath the glass. A faint pattern will be visible, depending on the color of the emulsion and the length of exposure. The film is now submerged in hot water at approximately 110°F, preferably running water. The developing can be performed under normal room lighting. Be sure to agitate the film while it is soaking. Lift it out of the water periodically, let it drain, and examine it. The lines of the circuit pattern will begin to swell and wash out of the film. After five to ten minutes the lines will be extremely sharp, completely washed out down to the plastic backing and only that portion of the film that was clear in the positive will remain. At this point the film is rinsed in cool water and placed emulsion side down on the outside bottom of the damped silk screen.

The screen is now placed with the outer plastic side of the film face down on newspaper and the inside is blotted firmly (not rubbed) with lintless blotting paper, paper towel, or rags until all water is removed. The emulsion with its plastic backing will adhere to the screen. The screen and film are now allowed to dry naturally or with a fan some distance away directed on the silk.

As the film emulsion dries, the natural tendency of the plastic backing will be to peel away leaving the hardened dry emulsion adhered to the silk screen (Fig. 5). If the emulsion is known to be dry and the plastic doesn't peel, a corner can be lifted and rolled back gently from the emulsion. If the emulsion is the slightest bit damp, it will be rubbery and peel away from the silk. Only when the emulsion is completely dry should you attempt to peel off the backing.

The finished screen can now be examined for flaws by holding it with the bottom emulsion side towards a light; the inner silk and frame side toward the viewer. All parts of the circuit pattern should be clear to permit the paint to flow through the silk. All background will (*Continued on page* 83)

# SOLID-STATE DESIGNS FOR HI-FI AMPLIFIERS



By PAUL MARCUS and LARRY ZIDE

*An investigation into the current state of the design art and a roundup of circuits now being employed by a number of component manufacturers.*

EVEN a quick glance at the current high-fidelity market place will leave no doubt that solid-state has arrived. True, there are still a few cautious hold-outs, but virtually every manufacturer of note has units of all- or hybrid-transistor design.

With this wealth of data on hand, we decided to investigate the current state of the art to see if manufacturers were taking full advantage of the latest advances in transistor work and to determine if they were remaining true to their basic design philosophies. For purposes of this report it was decided to limit our research to amplifier/preamplifier circuits, omitting r.f. altogether.

Considering the short time that transistors have been in use, when compared to vacuum tubes, and acknowledging that commercial realities limit manufacturers of component hi-fi, we rather expected to find every amplifier exactly like every other, at least as far as power output stages were concerned. Surprisingly, this was not the case.

We are glad to report that most manufacturers have done considerable research in the audio applications of transistors. And, many have come up with original ideas. In the course of our investigations, we interviewed a number of engineers. Without exception, we found that they had done their homework well. Their units were far from being copies of circuits in the *G-E* or *RCA* transistor manuals—a characteristic of the earliest designs

Every manufacturer of note apparently has a basic design philosophy to which he attempts to adhere. Of course, advertising copy notwithstanding, all components are designed to a price and the price may determine just how much of a compromise the company must make with its ideals.

No one argues with the basic goals of low distortion, flat frequency response, and the like. But there are differences on how to achieve these objectives. That old controversy about amplifier frequency bandwidth has carried over from tubes to transistors. The same arguments are put forth by both sides. The 1-cycle to 1-megacycle group, the "wide-banders," contend that the proof of this system's superiority is in the listening—a wide-band amplifier sounds better than a restricted one. The 20-cps to 20-kc. group, the "narrow-banders," say you can hardly hear this bandwidth anyway, and besides, outside of this band all you are amplifying is rumble and r.f. So, they use filters to remove the frequencies they are not interested in.

There is a conciliatory compromise movement afoot. Several manufacturers are advocating extension of the high end somewhat; several others push out both ends, although cautiously.

We examined products from eight manufacturers. They were *Acoustech, Allied Radio, Fisher, Harman-Kardon, Heath, McIntosh, H.H. Scott,* and *Sherwood*. There are others, of course. Their omission is simply our failing; there was just so much time and space.

In preamplifiers we looked for adequate dynamic range and input overload characteristics. Phono cartridges have a wide variety of output-voltage characteristics; driven from a steady-state 5 cm./sec., 1-kc. frequency recording, a cartridge may put out anywhere from 2 to 15 mv. Under peak conditions 70- to 80-mv. output may be produced by maximum output cartridges. On the other hand, very low output cartridges may provide as little as 2-3 mv. under steady-state conditions. A well-designed preamplifier input must be able to cover this range without distortion. Because transistors used in preamps have relatively poor overload characteristics compared to tubes, we checked to see how the manufacturers solved this problem.

The other major area of investigation was power output device protection. Given the right set of conditions, a power

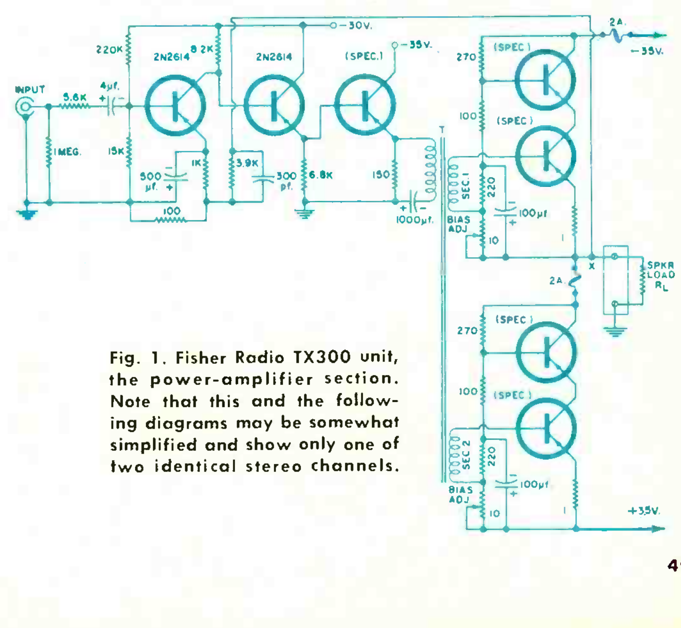



**Fig. 1. Fisher Radio TX300 unit, the power-amplifier section. Note that this and the following diagrams may be somewhat simplified and show only one of two identical stereo channels.**

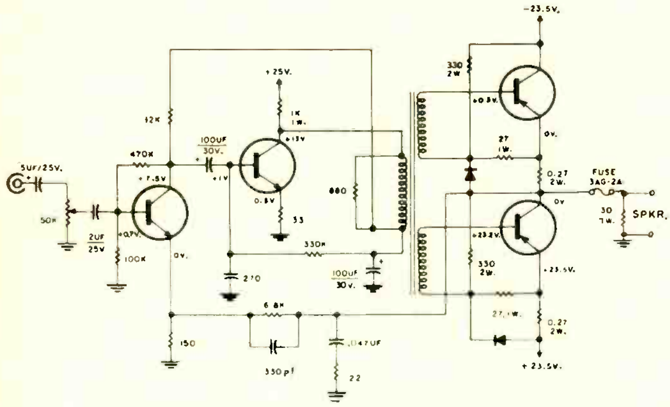


Fig. 2. Harman-Kardon SR-900 receiver, power-amplifier portion.

transistor will burn itself out, and a short across the output terminals can be the "right condition." Also, a floating output ground going through a customer's speaker selector switch using a common ground may prove disastrous. Manufacturers have come up with all sorts of schemes to prevent costly transistor burnout.

*Fisher* has long championed the design philosophy of medium-wide bandwidth. Its TX-300 integrated amplifier is built to these standards. Low frequencies are cut off fairly sharply at 20 cps but the high end is extended to well beyond 20 kc. The TX-300 uses a two-stage, direct-coupled preamplifier. Phono equalization is provided in the preamp feedback circuits. Because silicon transistors are used, the problem of d.c. stabilization is greatly simplified.

Four transistors are used in the interstage section, which then applies signal through a volume control to the power-amplifier section (Fig. 1). After one stage of gain, the signal is direct-coupled to a pair of transistors connected in a Darlington configuration. This feeds the driver transformer. The result is very low source impedance to the transformer thus minimizing phase distortion due to the transformer's distributed capacitance.

Four *RCA* 2N2147 germanium transistors in a "totem-pole" circuit drive the speaker. Among its advantages, the "totem-pole" circuit provides push-pull operation with its low distortion along with single-ended output for direct transformerless coupling to a speaker. The amplifier provides 50 watts of power per channel. Using four transistors rather than two provides a safety margin against secondary breakdown at these high power levels because of less peak inverse voltage across each transistor. Feedback is taken directly from the speaker load to the input stage.

*Harman-Kardon* is firmly in the wide-band camp. Its basic approach is to achieve the widest possible frequency response consistent with the product at hand. This is the only major manufacturer to have cast its lot entirely with transistors. For the purposes of this article, however, we are to consider two units only, the A-1000T integrated amplifier and the SR-900 receiver. The former uses silicon output devices in a driver-transformerless design. The more recently designed SR-900, interestingly enough, uses transformer-driven germanium transistors.

This latter unit's amplifier section uses a two-stage, capacitance-coupled preamp. Extensive feedback, on the order of 25-30 db, provides bandwidth to 60 kc. and the necessary equalization. From the preamp, the signal goes to the loudness control, high- and low-cut filters, and tone controls. Tone controls are Baxandall feedback designs with a tone-control defeat switch for flattest frequency response at lowest distortion. Next comes a grounded-emitter gain stage that is, in turn, fed into the balance control. From this pot, signal flows through a capacitor into another grounded-emitter stage which is capacitance-coupled to the transformer driver transistor (Fig. 2). The transformer itself drives two *RCA* 2N2147's or equivalents, directly coupled to the speaker. Both d.c. and a.c. feedback are obtained from the speaker line and back to the emitter of the pre-driver.

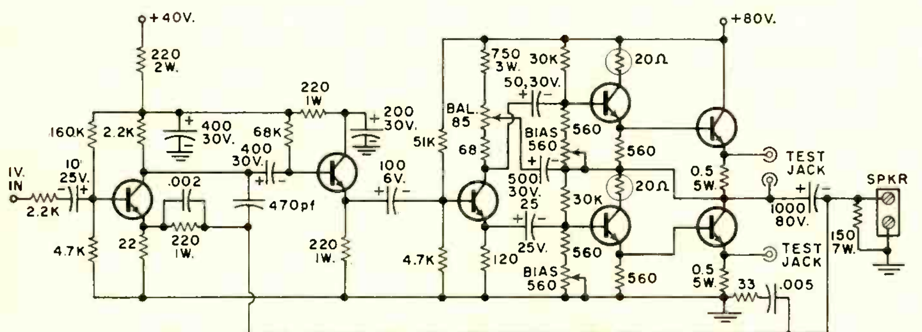
The A-1000T (Fig. 3) uses a pair of driver transistors directly coupled to two silicon output transistors. Two 20-ohm thermistors connect the driver collectors to the output collectors. Single-ended push-pull operation occurs and the signal is applied through a 1000-µf. capacitor.

*H. H. Scott's* Model 260 integrated amplifier starts off with a silicon transistor. This is direct-coupled to a second stage functioning as an emitter-follower to drive a *p-n-p* output stage. Feedback equalization is used, providing very good d.c. stabilization. The output of the preamp is fed into a loudness control.

The interstage section consists of two transistors direct-coupled, providing the feedback for tone controls. This feeds, through a capacitor, into the base of the first amplifier (Fig. 4). The output of this transistor is split into two lines, one to a *p-n-p*, the other to an *n-p-n* transistor—thus achieving phase inversion. The two signals now alternately feed an emitter-follower to power transistor, or flow through two stages to the power transistor. Both silicon power transistors are coupled to the speaker by a 2000-µf. capacitor. Feedback from the speaker side of the capacitor is returned to the base of the first amplifier transistor.

## Some Comparisons

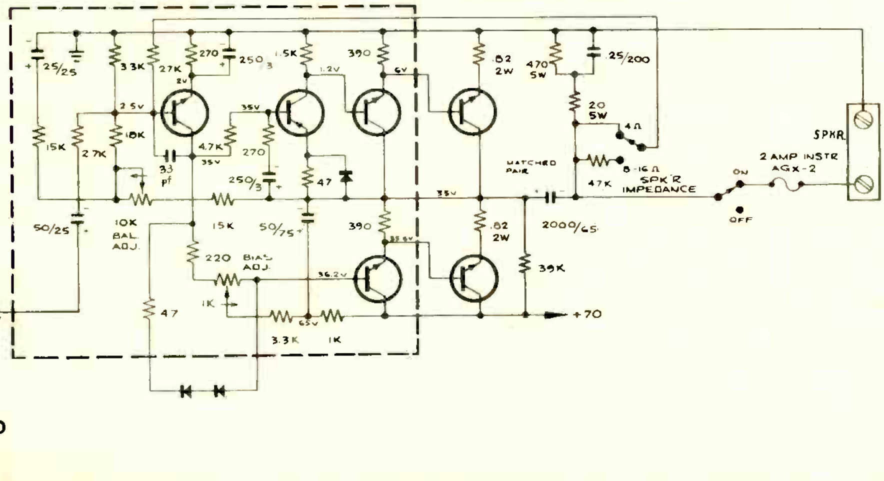
Before analyzing another amplifier we must invite comparison between the circuit of the *Scott* and the *Harman-Kardon* units, at least in the output stages. It is




CAPACITORS IN µF. UNLESS OTHERWISE SPECIFIED

Fig. 3. Harman-Kardon A-1000T is completely transformerless.

Fig. 4. The H.H. Scott Model 260 integrated audio amplifier.



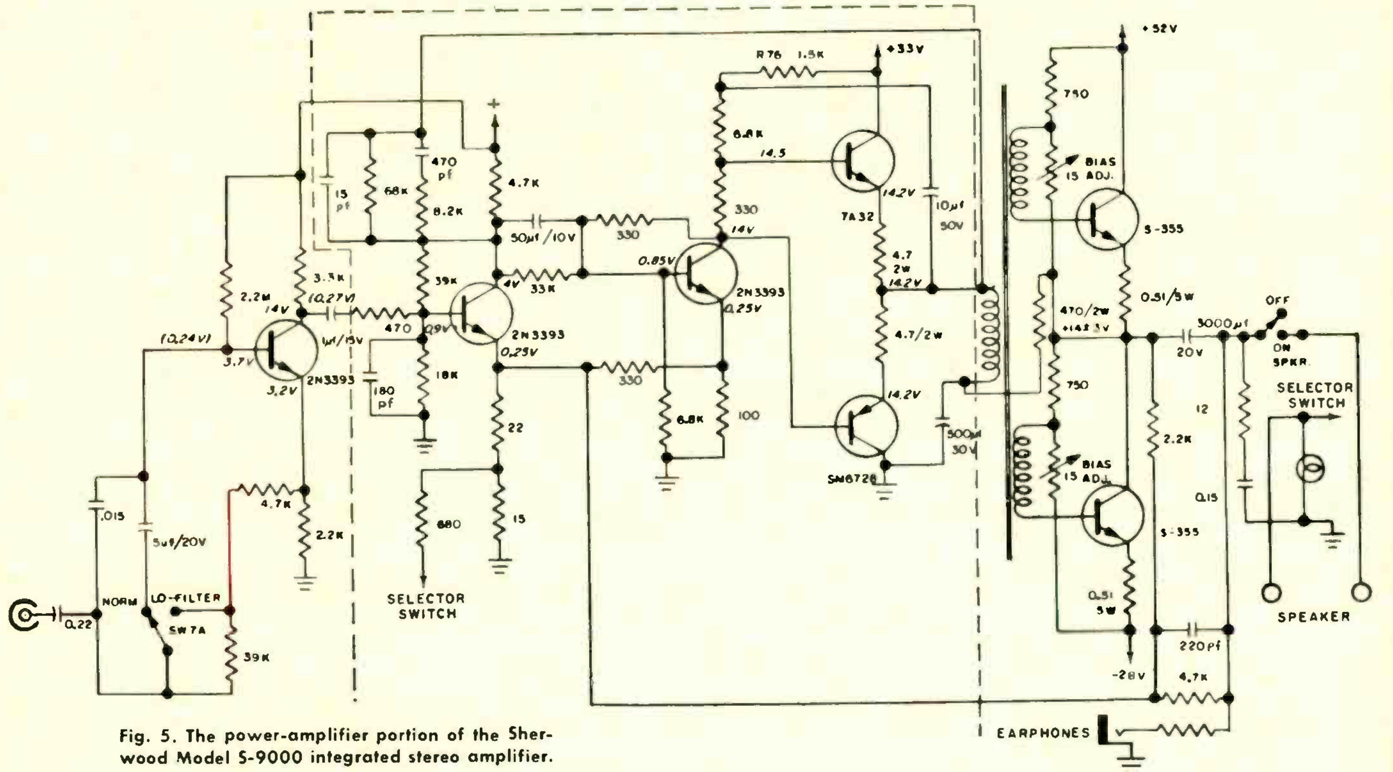



Fig. 5. The power-amplifier portion of the Sherwood Model S-9000 integrated stereo amplifier.

interesting to note that while *Scott* has moved toward driver-transformerless "totem-pole" designs, *Harman-Kardon* which has featured this design for some time is now using a driver transformer in the SR-900.

*Fisher* believes in driver transformers and states the following reasons for its view: 1. Phase inversion is better than two emitter-follower d.c.-coupled drivers; 2. Equal voltage amplitudes are provided for the positive and negative portions of the signal; 3. Equal source impedance is provided for both signal alternations; and 4. The secondary of a transformer can have a lower d.c. resistance than an emitter-follower output stage. Using germanium transistors, in particular, this will improve d.c. stabilization characteristics.

Arguments against the use of the transformer include its more limited frequency response and the possibility of phase distortion.

So we leave the argument for the use or non-use of transformers right there. There is obvious validity to both arguments. We do note, however, that it requires considerably more careful design in order to achieve the same results with a transformerless design as with a transformer circuit.

*Sherwood* has an integrated amplifier designated as the S-9000, which uses silicon transistors throughout, including the output stages. The preamp is a two-stage, *RC*-coupled circuit, quite similar to the configuration used in the *Harman-Kardon* SR-900. However, collector voltage is only 4 volts so that medium- or low-level cartridges should be employed.

A grounded-emitter gain stage is followed by cascaded tone controls. A second grounded-emitter completes the tone-amplification section which also includes the loudness control. From the arm of the pot the signal is capacitance-coupled into the base of the first driver stage (Fig. 5). After going through two additional stages, signal is applied to a complementary-symmetry single-ended push-pull driver that feeds the interstage transformer. Note the use of the *n-p-n* and *p-n-p* transistor in this stage. There is also 100% voltage feedback from this stage.

On the secondary side of the transformer are the two out-

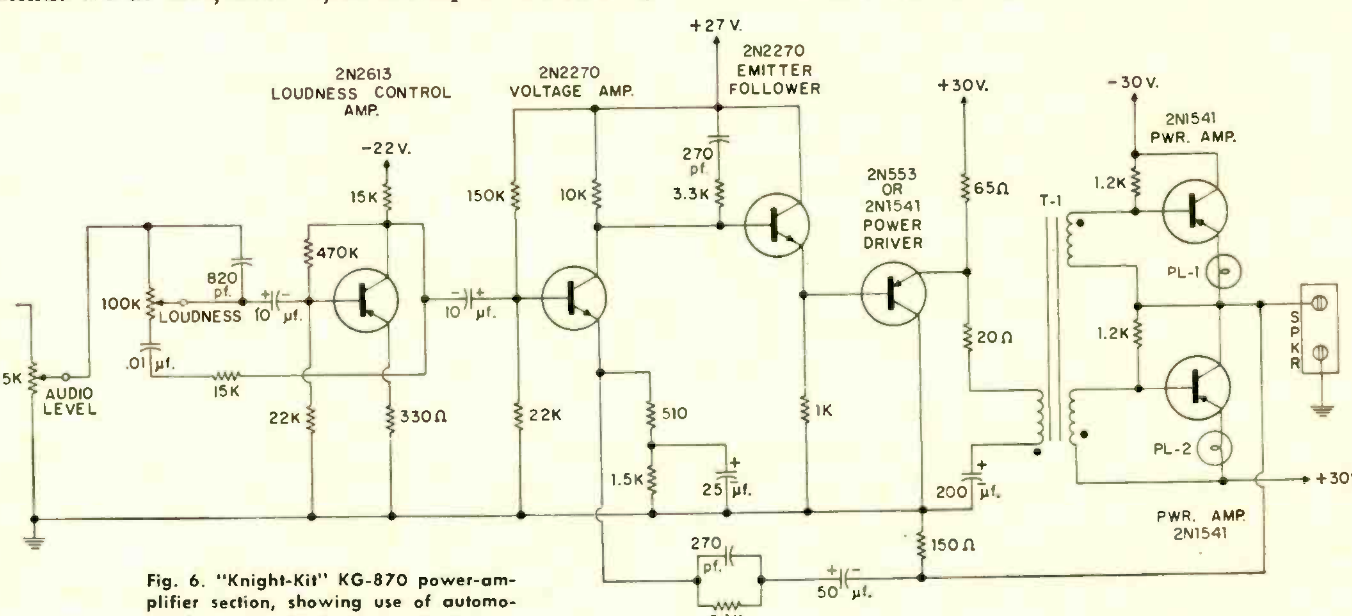



Fig. 6. "Knight-Kit" KG-870 power-amplifier section, showing use of automotive-type protective lamps in output stage.

put transistors. These are coupled to the speaker through a 3000-μf. capacitor. Note the extensive use of feedback in the circuit. In order to obtain 50 watts per channel, the circuit employs +52 volts on the collector of one output transistor and −28 volts on the other output transistor.

### Two Amplifier Kits

The next two integrated amplifiers—from *Allied Radio* and *Heath* respectively—are both offered to the consumer in kit form. These units have not been circuit-compromised for the sake of constructional simplicity.

*Allied Radio's* "Knight-Kit" KG-870 has several unique features. The preamplifier is straightforward enough. The amplifier (Fig. 6) features a loudness-control amplifier, capacitance-coupled to the base of a voltage amplifier. This is direct-coupled to an emitter-follower which is itself directly connected to the power driver. This transistor drives the transformer. On the other side we find a conventional enough half-bridge circuit, using germanium transistors but with an interesting variation. The emitter resistors are replaced by 6-volt automotive-type incandescent lamps. The manufacturer claims that the tungsten-filament lamps combine a positive temperature coefficient for d.c. stabilization, circuit balance, and runaway protection. The lamps also function as fast fuses because of their sensitivity to overvoltage caused by shorted speaker leads.

The transistors are direct-coupled to the speakers. Feedback is taken from this feed and returned to the emitter of the voltage amplifier.

The *Heath* AA-21C uses three stages in the preamp including feedback equalization. The remainder of the amplifier up to the output stages is fairly standard and in keeping with industry requirements (Fig. 7). There are two predrivers, the first of which uses a diode from emitter to ground for biasing. This is direct-coupled to the next transistor which functions as an emitter-follower to feed the driver itself, which is, in turn, connected to a driver transformer. Four output transistors serve as a single-ended, series-arranged push-pull power amplifier. They are direct-coupled to the speaker. Voltage feedback is taken from the speaker lead and returned to the emitter of the driver. The return speaker lead is above ground by 0.18 ohm to provide current feedback.

### Other Circuits

We have saved the "super" components for last. Our investigation of these components showed not so much circuit innovation as circuit sophistication. The "Citation B" power amplifier is very much like the A-1000T in *Harman-Kardon's* regular line, except more so. We have not discussed power supplies; suffice it to say that in every case these premium components had higher power capabilities, improved filtering, and better regulation, *via* zeners, and the like.

The "Citation A" is an elaborate preamplifier using plug-in type circuit boards. It contains many gain stages to offset passive stages of equalization and tone controls. Tone controls are by switch rather than pot, with a neutral position bypassing the controls.

A view of the circuits used by *McIntosh* displays the characteristic conservatism that has distinguished this company's products. All areas are well served in the simplest possible way. This company makes an integrated amplifier of hybrid design as well as a separate preamp (Model 24). The preamp and interstage sections are solid-state but the power section uses vacuum tubes.

*Acoustech's* amplifier designs (Fig. 8) are conservative and, superficially, similar to those used by *Scott* and *Harman-Kardon* in its "Citation." What is distinguished is the quality of components and layout. The same may be said of the firm's two preamplifiers. The company also offers an integrated amplifier, the Model V. This is a combination of the separate units with simplification and less versatility.

In looking through the power-supply diagrams of the various amplifiers, we found some simple circuits and other circuits that were not so simple. All used full-wave solid-state rectifier circuits. None of the supplies deliver regulated voltage to the output stages of the amplifier but quite a few of them employed extensive regulation for the preamplifier and driver portions of the amplifiers. Zener diodes were employed as were some transistor regulators and capacitance-multiplier circuits. A high degree of filtering was common and large size electrolytics were utilized.

As we said earlier, we undertook to investigate very carefully two areas. One of these had to do with the phono-input provisions; the other, the output device protection. We found differences among the various components in these two areas. It doesn't much matter that a component is otherwise perfect in operation and design if it distorts and overloads when an input signal is applied to it or burns itself out on switching transients of loudspeaker short circuits.

### Input Signal Handling

For most purposes, the phono preamp should be able to

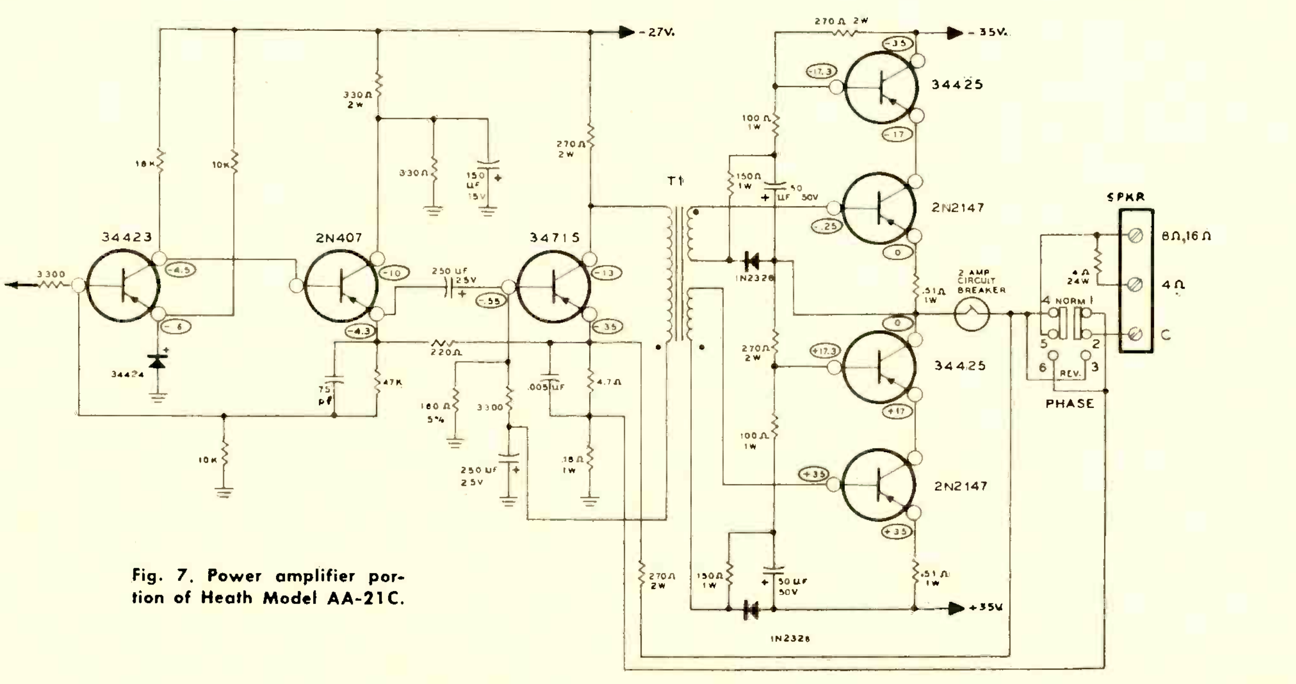



**Fig. 7. Power amplifier portion of Heath Model AA-21C.**

handle a signal range of 3 mv. to 80 mv. We feel it unnecessary to pursue sensitivities for full output below 3 mv. However, the more we can get before clipping at the maximum end, the better. And, when clipping does occur, it should be symmetrical.

The *Scott* 260 solves the problem of input signal handling with a three-position sensitivity switch at the preamp input. And it does this by feedback change; input impedance and noise characteristics remain constant. It is incumbent upon the user to select the correct position for his cartridge, but this system covers the requirements of dynamic bandwidth *vs* noise and impedance match.

*Fisher* and *Harman-Kardon* make no provision for input reduction, relying instead on the use of silicon planar transistors, careful design, and high collector voltages to provide a 75- to 80-mv. swing. (*Fisher* does attenuate the *output* of the preamp section but this seems to be primarily for level balance, although it also helps to prevent possible overload of the first high-level stages by the high sensitivity preamp.)

*Sherwood* provides no attenuation, has a 1.5-mv. sensitivity, and uses fairly low collector voltage. Hence, medium- and low-output level cartridges should be employed with this particular unit.

*Acoustech* uses fixed resistors in series with input jacks for attenuation while *Heath* uses a pot across the input to ground. The center arm feeds the preamp input. Both systems alter the input source impedance and this must have some effect on noise and frequency response, although it is true that the worst noise conditions will be with the highest output cartridges where it is likely to be least objectionable.

"Citation" and *McIntosh* rely on high collector currents to solve the signal-handling problem. "Citation" has 22.5 volts on the second transistor (where most overload problems would otherwise occur); and *McIntosh* uses a hefty 45 volts.

The problem of overload and noise is one where we expect to see still further improvement. Much of this will come by way of transistors with better dynamic characteristics and higher breakdown voltage ratings.

### Output Device Protection

Two basic approaches are possible. The first is to find a device that is itself highly resistant to breakdown under shorted or severe transient conditions. The second approach is to devise special circuits that will take over or cut the current load under overload conditions. A variation, of course, is to use bigger and more transistors than necessary for the power required. This works, of course, but is expensive.

Four transistors instead of the normally used two in a "totem-pole" arrangement illustrate this last method. *Fisher* and *Heath* do this with germanium transistors. *Fisher* also fuses the collector voltage supply while *Heath* fuses the supply and the speaker leads.

*Harman-Kardon*, in the SR-900, uses the same germanium transistors (*RCA* 2N2147's), but only two are used. Protection is achieved by relying on the driver to limit current. In the event of a short, the source impedance is increased to approximately 150 ohms.

The *Acoustech*, the *Harman-Kardon* A-1000T, and the *Scott* 260 use silicon output devices. Silicons offer some protection themselves as compared to the more temperature-sensitive germanium types. *Scott* uses instrument-type fast-blow fuses in the speaker leads. *Harman-Kardon* uses driver collector thermistors and a fused collector supply. *Acoustech* uses fast-blow fuses in the collector supply and provides fused speaker leads "Knight-Kit" uses the tungsten-filament lamps in order to protect a pair of germanium power transistors.

### High-Quality Components

Schematics tell little about the quality of components put into a set. We visited one manufacturer who goes to the trouble of buying high-side and low-side resistors and capacitors and then balances them during assembly in an effort to maintain specifications. Schematics also don't show the kind of heat sinks used. They do not show component layout, and they certainly do not indicate the manufacturer's production quality control.

Our investigation led us to believe that, from the point of view of circuit analysis, the transistor is being wisely used in home-entertainment component equipment. We have found intelligent use of a number of basic circuits, all of which have been adapted to the specific needs of the individual manufacturers. ▲

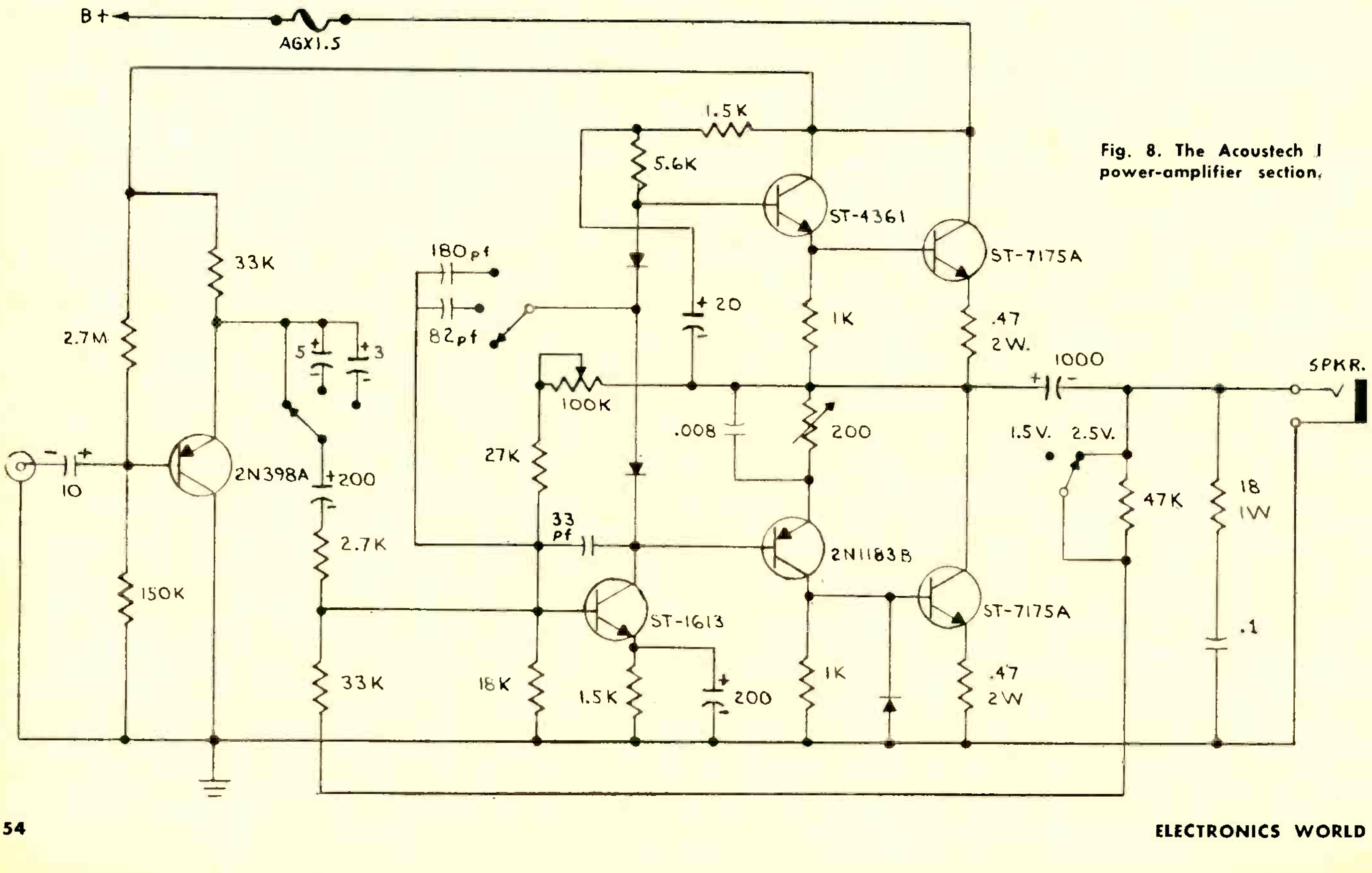



Fig. 8. The Acoustech I power-amplifier section.

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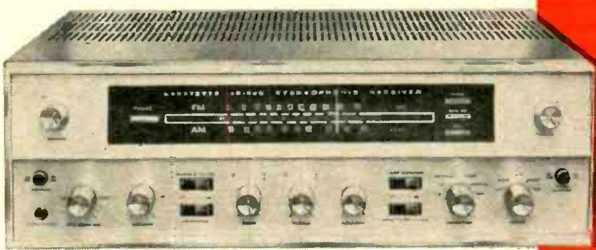

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# TRANSOCEANIC STEREO

*International stereo standard will be chosen in near future.*

TRANSOCEANIC stereophonic broadcasting *via* orbiting satellite may not be too far in the future. Recent tests conducted at NASA's Goddard Space Flight Center communication ground station located at Goldstone Dry Lake, used the Relay II satellite to prove the capability of the satellite to accept a conventional stereo signal and re-transmit it back to the earth station.

Actually, the test's purpose was to gather proof that the American method of stereo broadcasting should be adopted as the world-wide standard. The American method, known as the "pilot-tone" system was adopted as the national standard by the FCC in 1961.

Results of this test will be presented at a meeting of Study Group X of the Commission Consultatif International de Radio (CCIR) in Vienna, Austria. The CCIR is composed of representatives of the world's major countries. Group X is concerned with broadcasting.

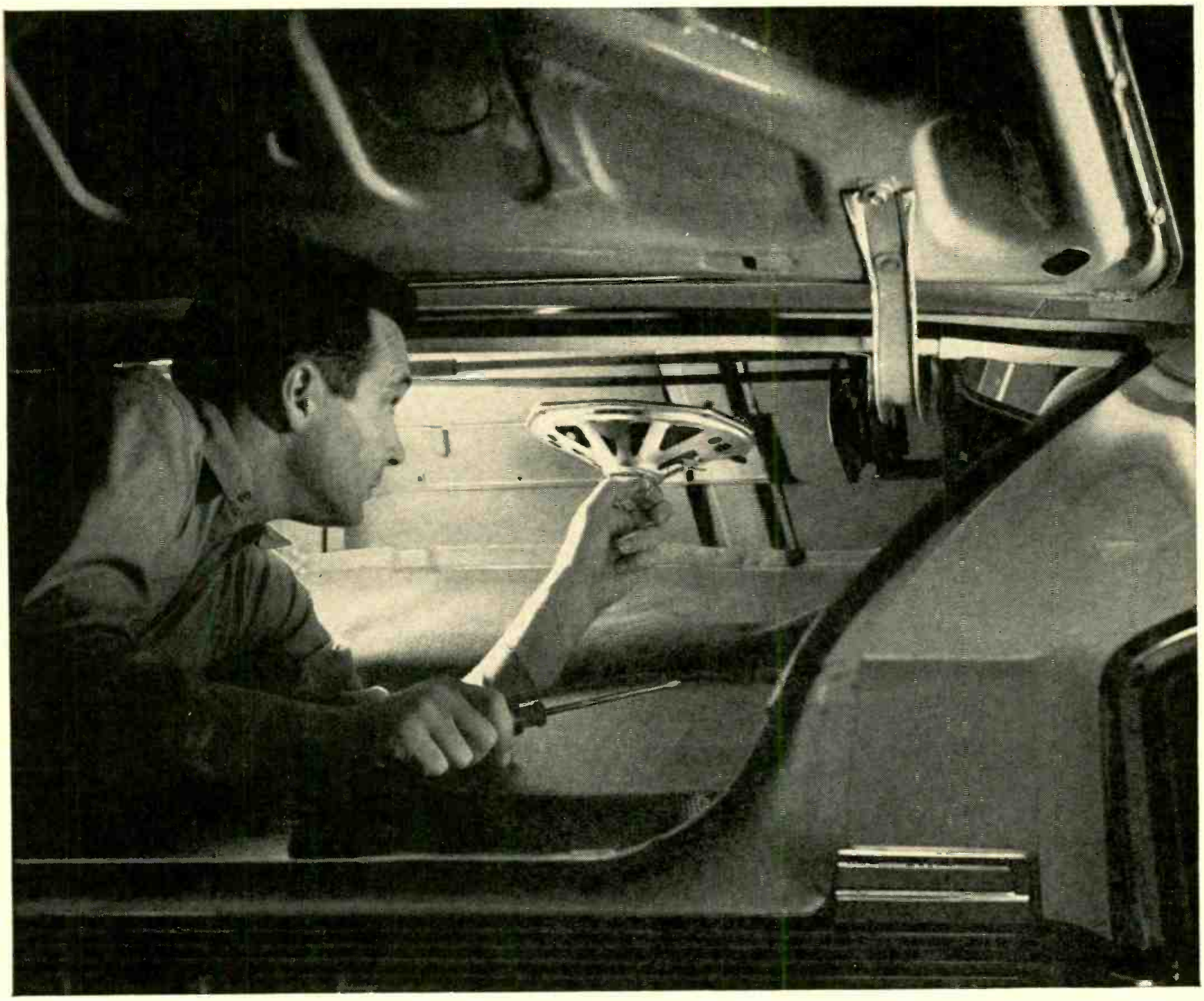
This study group is slated to consider making recommendations for the international standardization of stereo broadcasting with the recommendation presented to a plenary session of the CCIR in 1966 for adoption.

Study Group X is faced with recommending either the American "pilot-tone" method, or the Russian "polar-modulation" method of stereo broadcasting. Success of the satellite tests should greatly assist the American system. This method is also greatly reinforced by the fact that it has already been adopted by the European Broadcasting Union, and many countries in Europe and in other parts of the world are now using it.

During the actual satellite test, a stereo recording of voice, music, and tones (for measurements), were fed into a *Collins* 786-1 stereo generator. This provided a single, composite signal that was used to modulate the NASA satellite communications transmitter. The signal was beamed to Relay II, then re-transmitted back to the earth station.

Back on the ground, the received signal was decoded into right and left channels and tape recorded.

Both recordings—the original stereo signal that was transmitted, and the decoded received signal—will be played at the Vienna meeting to illustrate that the pilot-tone method of stereo transmission can maintain its quality when transmitted through a satellite relay station. ▲



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CIRCLE NO. 123 ON READER SERVICE PAGE

# JOHN FRYE

*Before a service shop undertakes the repair of Citizens Band equipment, all factors should be carefully weighed.*

# CB SERVICING: PRO AND CON

ON this first really hot day of early summer, Mac and his two employees, Barney and Matilda, were enjoying Cokes the latter had brought in from the corner drugstore. A warm breeze drifted in through the screen door of the service shop, rustling some papers on the counter.

"Barney, what do you think of our taking on CB service?" Mac asked his young technician.

"Not much!" Barney answered quickly.

"Why?"

"I'm convinced there are more headaches than money in it. Three different technicians who have dabbled in CB service gave me identical advice: stay out of it!"

"Aw, come on. Let's at least argue about it a bit," Mac suggested as he leaned back comfortably against the wall. "I'll take the 'pro' side; you keep on with the 'con'; Matilda can be our unbiased referee. Let me start by pointing out more than 700,000 CB licenses have been issued. Since every CB system is supposed to have at least two transceivers, we're being conservative if we estimate 1,500,000 sets are in use, with roughly half of these being mobile installations.

"Citizens Band equipment gets hard usage. Many CB'ers turn on their base station the first thing in the morning and turn it off the last thing at night, and the majority of their mobile sets come on with the car ignition. We both know mobile equipment takes an especially bad beating from extreme temperatures, vibration, dust, and varying input voltage. Now lots of units plus hard usage equals a big demand for service. Can you argue with this equation?"

"No, but do you know who is doing that service now?"

"After trying to find out, I've decided hardly anyone is doing it—at least the way it should be done. CB service is a waif no one wants. Most dealers in CB equipment make some effort to service what they sell, but that's as far as many of them go. This certainly does not help the CB'er who buys his equipment from a large mail-order house, as many do."

"Careful, you're starting to argue on my side," Barney warned. "If CB servicing were a good thing, more people would be after it. My ham receiver tunes the CB band, and I listen to those guys a lot. From this I know a lot of them try to fix their own sets without having the foggiest notion of what they are doing. This strikes me as odd. Hams have to know a lot more about electronics than CB'ers do to pass the ham examination; yet most hams keep their fingers out of their commercially made equipment. When something goes wrong with a receiver or transmitter, most hams return it to the factory or take it to an authorized dealer for service or turn it over to a really qualified service technician. But many CB'ers, without any test equipment at all, will blithely undertake to fix their transceivers or even attempt to 'peak them up.' I know what you think of anyone's attempting to re-align a receiver without a good signal generator and output meter."

"Let's not be too hard on them," Mac suggested soothingly. "It's the old story of fools rushing in where angels fear to tread. The more you know about a complicated mechanism the more reluctant you are to tinker with it. But what you say only underlines my contention that CB people have a deep need for really good servicing and maintenance."

"Sure, but will they pay for it? With most of them CB radio is a hobby, and any time you try to make a living dealing with hobbyists you're in trouble. CB'ers will spend money like water for new antennas, new mikes, new mike amplifiers, etc., but they begrudge every penny put out for service. That's why they try to do it themselves or, almost as bad, take it to a fellow CB'er who knows just a little bit about electronics. Every community has one of these who can pose as an 'expert' only because his customers are so poorly informed. It's like the proverb I learned in Spanish class: *En la tierra de los ciegos el tuerto es rey,* or 'In the land of the blind the one-eyed is king.'

"A friend of mine was telling me about his experience with CB service. He said they were always calling him on the air and asking him to give them a free frequency check of their crystals. They constantly pestered him for free advice. They brought in their sets to be 'checked out,' and they wanted to hang around the service department and watch him work. If he found nothing wrong, they felt he shouldn't charge more than a buck.

"And they were constantly bugging him to soup up their transmitters and to make their receivers hotter. They wanted him to make silk purses out of sows' ears. Every time they received a non-flattering report or failed to hear a mobile twenty miles away quite as well as did a neighbor, they rushed down to the shop for reassurance that nothing was wrong with their set—for free, of course. Still worse, after a set had been put in top working condition the owner would take it home and start messing around in it with his busy little screwdriver. When he had things completely fouled up, he would bring it back and say the service job was unsatisfactory—the set still wasn't working right!

"But the thing that really made my friend give up CB service was that he found it was interfering with his bread-and-butter radio and TV service. Did you ever see a gas station start catering to the hot-rodding car-customizing set? The first thing you know the drive is so cluttered with a bunch of weird-looking klunkers you can't get up to the pumps. A teen-age gang uses the lift, helps itself to the tools, and loafs in the office. Before long, regular customers are driven away by the unbusiness-like atmosphere of the station, and the owner wakes up to find there's not much of a living in the money the gang puts into the cold-drink machine and the small amount of gas they buy for their playthings.

"Exactly the same thing was happening to my friend. CB'ers are a very gregarious group, and they like to chew the fat in a suitable atmosphere. My friend's shop suited them just fine, and they made a real CB hangout of it. His radio and TV service began to slip badly. Money received from CB work did not begin to take up the slack. He dismantled his shop CB antenna, sold his specialized CB service equipment, and spread the word he no longer did CB service."

"I believe every word," Mac said, "and you've spotlighted some very real pitfalls in CB servicing. But now that we know the pitfalls are there, we should be able to avoid them.

What's more, I think we can educate CB'ers around here to appreciate and pay for really good service.

"First we'll get you a Second Class Commercial Phone ticket. With your ham background and the fine technical knowledge I've pumped into you, this should be no sweat. But I'll give you a couple of months in which to bone up on the rules, regulations, and theory you'll need to pass, and I'll even furnish manuals for your study."

"Gee, thanks!" Barney said sarcastically.

"Next we'll need some new equipment. We'll put up a 'typical' good CB antenna. We'll also need an accurate method of checking crystal frequencies on all twenty-three channels, a good dummy antenna and r. f. output indicator that will give accurate readings up to five watts, an s. w. r. meter and field-strength meter for checking out mobile installations, and a tube-type noise generator for measuring receiver sensitivity. Two or three of these instruments can be had in a single unit especially designed for CB service.

"That's about all the special equipment we'll need. We can check percentage of modulation with the scope and use our distortion analyzer for checking out speech circuits. We have the signal generators necessary to do an excellent job of alignment. Our studies in ignition-noise suppression will come in handy in taking the noise out of mobile installations."

"I *know* we can do a good job technically," Barney said; "it's the business aspect of CB service that bugs me."

"Okay, how about these precautions: first, we'll charge the same hourly rate for CB service we do for TV service. Those who don't want to pay it can take their business elsewhere. We won't tolerate CB'ers in the service department any more than we tolerate radio and TV customers. And I'm sure Matilda can discourage any loafing in the front office. We won't go in for the 'souping-up' type of circuit modifications. Every transceiver passing over the bench will have a record made of r. f. output, percentage of undistorted modulation possible together with the audio signal input necessary to produce this, receiver noise figure, and any peculiarities noted. These records will permit us to detect any falling-off in performance and, by comparing sets of the same model, give us some idea of normal performance for that model.

"We'll guarantee our work just as we do in radio and TV service, but before a set goes out we'll place seals over every adjustment screw. Breaking one of these seals automatically voids the guarantee and makes a re-alignment charge mandatory. Actually, I see no reason why we should not build up a good business in CB service if we insist on keeping it strictly on a business-like basis. The circuitry should not present any problems, especially after we acquire a good service library on CB transceivers. As a ham, you know all about modulation, transmitter r. f. circuits, "S"-meters, noise-blankers, etc. What say, are you willing to 'have a go at it,' as the British say?"

"How much choice do I have?" Barney answered with a grin. "I can see by the look on the face of our 'unbiased referee' that her vote goes for the debater who signs her pay checks. I guess all that's left for me to say is, 'That's a big 10-4!'" ▲

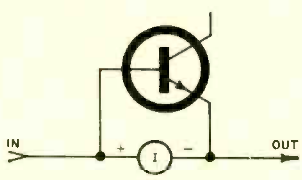
## USING ONE-DIODE TRANSISTORS

By RONALD M. MANN
Texas Instruments Inc.

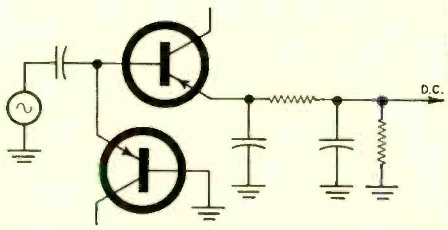
**WHEN transistors are inadvertently ruined, they are usually thrown away. Usually, no matter how catastrophic the failure, at least one of the diode sections (collector-base or emitter-base) is still good.**

**There are many uses to which these diodes can be put. An excellent use is shown at (A) where the diode offers overload protection for various types of meters. For voltage measurements, the diode can be placed across the meter and its associated scale-setting resistors, where it will start conducting at some voltage higher than the maximum for which the meter is calibrated (as shown in C).**

**High-frequency transistors have low-capacitance, fast-recovery diodes that can be used to rectify the output of a high-frequency amplifier as shown in (B). They can also be used in a.g.c. rectifier circuits.** ▲



(A)



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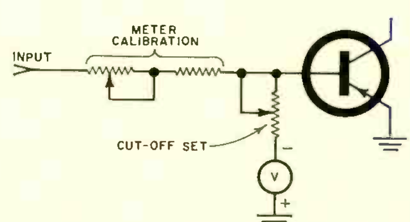


(C)

## Gemini Receiver

*(Continued from page 35)*

acceptable so the mixer output can feed a conventional h.f. communications receiver if desired. If an i.f. below 30 mc. is to be employed, it should be 10.7 mc. so standard i.f. transformers can be used.

The four crystal oscillators and ×3 multiplier circuits are identical except for frequency. Each drives the mixer through a 4.7k isolating resistor. By using large resistors the four circuits do not affect each other in operation.

First mixer output is cabled to the h.f. receiver board (Fig. 5). The 10.7-mc. i.f. signal is amplified in two conventional amplifier stages. This amplified signal is again converted in the second mixer to a standard 455-kc. i.f. The second local oscillator is also crystal-controlled and operates at 10.245 mc. This oscillator uses a standard 10.7-mc. i.f. transformer to tune the collector circuit; a small external padding capacitor is necessary to tune the stage properly.

Following the second mixer are two 455-kc. i.f. stages. These stages are designed exactly the same as the 10.7-mc. i.f. stages except for the transformers. The i.f. amplifier, mixer, and oscillator transistors on this board are 2N2398's. The output of the last i.f. is detected by a 1N270 diode.

Detector output is used in two ways. First, a portion is fed through a 1000-ohm isolating resistor to a 2N1142 audio amplifier. The 1000-ohm resistor plus the transistor-input impedance, along with the shunt 0.1-μf. capacitor, form a high-frequency roll-off that limits the audio response to 3 kc. The output of the 2N1142 voltage amplifier is direct-coupled to another 2N1142 connected as an emitter-follower. This stage provides a low-impedance output to drive a tape recorder or audio amplifier. Audio output is approximately 3 to 4 volts r.m.s.

Second, a portion of the detected output is fed through a 1.5k resistor to a shunt 82-μf. capacitor. This low-pass network gives a d.c. proportional to the received signal strength. This d.c. is used to operate the 2N697 a.g.c. amplifier. Both mixers and all four i.f. amplifier stages are a.g.c.-controlled. The result of controlling six stages is a constant output amplitude over an input range of 105 db. Useful dynamic range of this receiver is −115 dbm to −10 dbm.

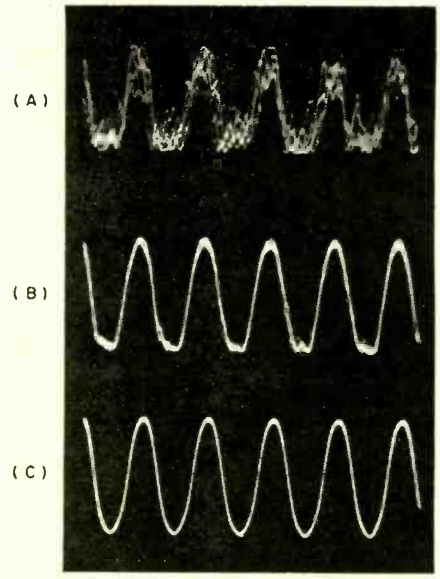


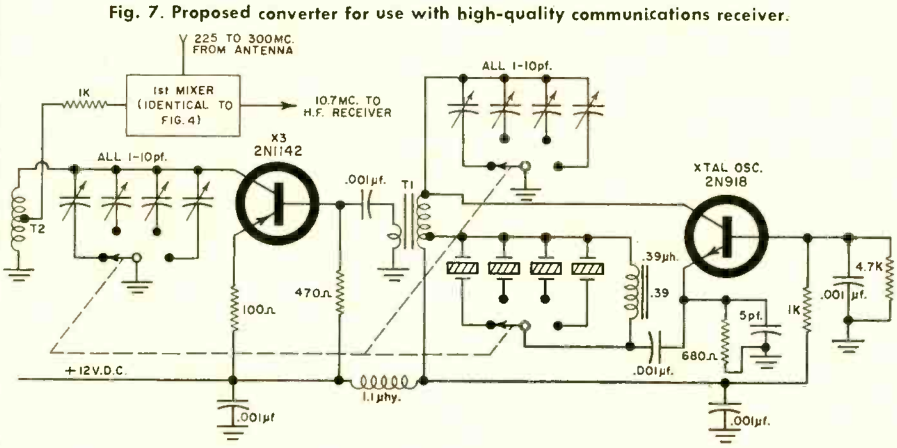

Fig. 6. Oscillograms of audio output vs input signal level at 80% modulation. (A) Input at 0.2 μv. (−121 dbm); S/N = 6 db. (B) Input at 1.5 μv. (−103 dbm), corresponding to a 300-mile range; S/N = 25 db. (C) Input increased to 2 mv. (−41 dbm).

The a.g.c. voltage is also fed to a voltmeter to indicate signal strength. The a.g.c. voltage varies from about 9 volts with no signal in, to 12 volts at −20 dbm. In order to make the a.g.c. meter read approximately 0 with no signal, a 9-volt zener is placed in series with the voltmeter input, thus the meter reads 0 for all voltages below 9 volts and is a linear voltmeter for all voltages above 9 volts. The meter is adjusted for 3 volts full-scale.

### Receiver Performance

As already stated, the receiver has a useful dynamic range for voice communications, of −115 dbm to −10 dbm. Fig. 6 is an oscillogram of the audio output *versus* signal level. The carrier is 80% modulated by a 1-kc. tone. This figure

Fig. 7. Proposed converter for use with high-quality communications receiver.

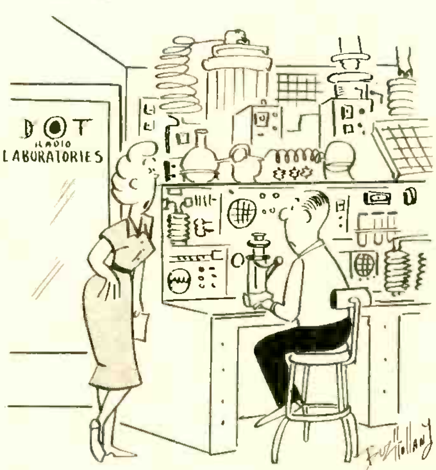


shows a 6-db signal + noise/noise ratio at −121 dbm (0.2 μv.). At this signal level the tone is clearly audible, but voice is difficult to understand. As the signal is increased to −112 dbm (0.5 μv.), the signal + noise/noise ratio is 15 db and voice signals are completely intelligible. A further increase to −103 dbm (1.5 μv.) results in a 25-db signal + noise/noise ratio. Fig. 6 shows oscillograms of the output.

### Construction

To the experimenter this receiver as it stands is too expensive and complex to build in the home workshop. However, a receiver can be built, for a more modest investment, that will meet the sensitivity requirements. The complex receiver design has a +17 db S/N at the maximum range. The first mixer of this receiver can be modified to serve as a converter to drive an h.f. communications receiver. The modified mixer has a 10 db S/N at maximum range. The converter is shown in Fig. 7. The mixer is identical to the first mixer in the 4-channel receiver except the isolation resistor is reduced to 1k. In place of the four oscillator-multiplier chains, a single chain is used with a switch to select the desired crystal and tuning capacitors. This does not permit simultaneous reception of all four channels, but it does permit rapid selection of any channel.

By connecting the output of the converter to a good-quality communications receiver, it is possible to achieve a high-performance, switch-selected, four-channel Gemini receiver. It is necessary to determine that the h.f. receiver is tuned to precisely 10.7 mc. This can be accomplished in several ways. The easiest way is to inject a 10.7-mc. signal into the receiver and tune for maximum signal. After this is completed, reconnect the converter and set the l.o. switch to voice channel. The receiver is now ready to receive the signals from the Gemini space capsule. ▲




"Can't knock on wood around here. Everything's plastic, silicon, selenium, or something."

## Atomic Frequency Standard

(*Continued from page* 45)

through a filter cell containing rubidium-85 mixed with argon or neon, and then through an interference filter which passes only the D-2 rubidium line at 780.0 nanometers (7800 angstroms).

The microwave field applied to the cavity is frequency-modulated about the atomic reference frequency of 6,834,-683,405 cps. This frequency is obtained by repeated multiplication of the output of a stable, high-frequency local oscillator. The oscillator is crystal-controlled for optimum short-term stability, but its output frequency, approximately 5 mc., is adjustable by means of voltage-controlled trimming capacitors. The oscillator output is used by both a frequency translator (which produces the standard's output) and a transistor frequency multiplier having an output at 60 mc. This signal is applied to a varactor diode, mounted directly on the side of the microwave cavity, which multiplies the frequency by a factor of 114. Sufficient energy is obtained at 6.8 gc. for observation of the transition phenomenon.

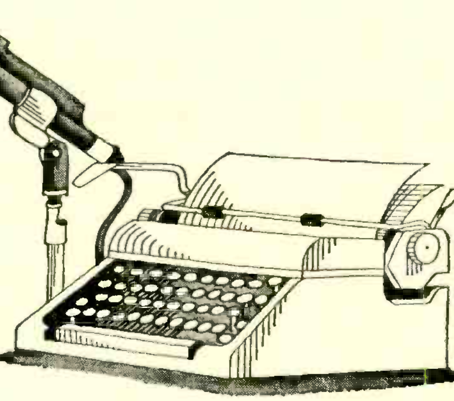
The oscillator output is frequency-modulated before multiplication so that the 6.8 gc. signal is sinusoidally phase-modulated at 25 cps to a deviation of approximately 100 cps. At instants when the signal is exactly at the transition frequency, the stimulating light is scattered most and the least light passes through the gas cell to the photocell, resulting in a minimum photocell output. The photocell error signal is passed through a preamplifier and then through an amplifier tuned to the modulation frequency.

The amplified error signal is compared with the modulating signal in a synchronous detector that responds to both amplitude and phase. The output of the detector is the correction signal to the voltage-controlled capacitor making fine adjustment of the crystal oscillator frequency. This feedback path operates to maintain the local oscillator frequency at 4.9961136 mc., 1/1368 of the rubidium transition frequency, with a stability approaching $10^{-11}$ for long periods of time.

The crystal- and capacitor-controlled oscillator drives not only the modulator-multiplier, but also frequency translator circuitry. The translator consists of frequency-dividing and heterodyning circuits translating 4.9961136 mc. to 5.0000000 mc., as well as to 100 kc.

The portable atomic standard was designed for the National Aeronautics and Space Administration (NASA) by a team of NBS scientists; Robert J. Carpenter, Sachio Saito, Robert O. Stone, Dr. Earl C. Beaty, and Dr. Peter L. Bender. ▲

# RADIO & TV NEWS



**P**ERFECT TV reception with a minimum of snow or multiple images could be relayed from outer space directly to homes and schools in any part of the world, however remote, within two to three years. This was prophesied by Dr. H. A. Rosen, Asst. Manager of *Hughes Aircraft Company's* Space Systems Div.

Dr. Rosen pointed out that a broadband satellite could be placed in a stationary orbit to relay color or monochrome TV images to any TV receiver capable of picking them up.

The receiving antenna could be a six-foot dish stamped out of aluminum and costing about $40 which would operate together with a microwave converter performing in the same fashion as a present u.h.f. converter. Total conversion cost for a receiver would be less than $100, according to Dr. Rosen.

Because the satellite would be stationary, ground transmitters could use relatively simple and cheap fixed antennas to beam their signals to the satellite.

A TV network could own and operate its own satellite with total cost, including launch, amortized by commercial broadcasts over the estimated five-year life of such a satellite.

Use of such a space system would permit reception anywhere in the world. However, some problems may arise because of the many monochrome standards now in use throughout the world. This situation would be further compounded with the transmission of color, as added complexity will be introduced because of the different color standards now being used.

### New Look For TV

A unique method of projecting an optical image that may result in a new concept of TV and other displays was recently unveiled by the Rome Air Development Center.

The device, discussed in a paper given by Edward J. Calucci, an electronic research scientist at the Center, is basically a solid-state light valve that has successfully projected TV images.

Objective of present studies is to determine the feasibility of using a crystalline element exhibiting the electron-optic effect as the control layer of a light-valve projection system. This system is basically similar to a film-projection system except that the film is replaced by an electro-optic element. By proper modulation and scanning of an electron beam, an electrostatic charge pattern is impressed on the surface of the electro-optic element, and this results in an optical image that can be projected.

The Center's scientists are presently working toward the ultimate in system perfection where electroluminescent boards can be plugged into computers for full-color portrayal of large-scale front-line or space situations.

### Coal-Powered TV

A group of engineers over at *Westinghouse Research Labs.* have been successful in operating a conventional monochrome TV set from a 100-w. fuel cell that converts gases from a handful of powdered coal directly into electricity with no intermediate step.

The power system consists of 400 thimble-sized fuel cells plus a chemical reactor for producing the volatile gases at 1800° F. Such a high temperature can be used with any natural carbonaceous fuel. The tiny cells are arranged in 20 stacks of 20 cells, each forming two parallel strings of 200 cells in series. In lab tests, the battery has achieved slightly over 100 volts at one ampere.

The gases extracted from the powdered coal by high temperatures are mainly hydrogen and carbon monoxide. This mixture is fed to the battery where it flows through the fuel-cell stack and makes contact with the cathode terminal. At the same time, heated air is passed around the outside surface of the cells where the anode is located. Electrons removed from the anode surface by the oxygen in the air attach themselves to these atoms to form negatively charged ions. The ions move through the solid electrolyte and collect at the cathode terminal. Here they combine with the atoms of fuel gases, freeing the electrons that were picked up at the anode terminal. Such an electron movement constitutes an electrical current. ▲





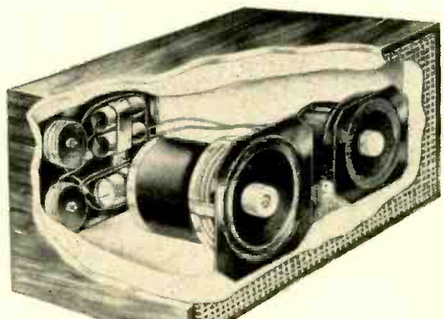
CIRCLE NO. 232 ON READER SERVICE PAGE →

## EW Lab Tested

(*Continued from page* 22)

The small size of the unit does not imply any sacrifice in performance. It is not expensive (at least when compared to any other speaker of similar capability) and delivers a true, high-fidelity sound of remarkable consistency. The unit has a woofer with an effective cone diameter of about 3½ inches, crossing over to a 2-inch cone tweeter at 1900 cps. The woofer has an extremely flexible surround which allows very large cone excursions (up to about ⅜ inch) without severe distortion or damage to the speaker. The tweeter level is fixed. The rated impedance of the system is 8 to 16 ohms. The efficiency is relatively low, but since it is normally played at comfortable listening levels, it can be driven by any good 15-watt amplifier. It will handle much larger amounts of program power without difficulty.

We measured the frequency response of the speaker system indoors, averaging seven sets of test data taken at different microphone positions to obtain a single curve. This test set-up has been in use for several years, during which time enough data has been accumulated so that we have been able to calibrate the low-frequency response of the test room. The room response, plotted as a dashed line on the curve, has a drooping characteristic. When the measured speaker response is compared to the reference curve, it can be seen that the speaker is flat within ±2.5 db from 110 to 15,000 cps, with exceptional smoothness and freedom from peaks or holes. The low-frequency response is down about 7 db in the 60 to 90 cps region, which is highly creditable performance for a 3½-inch cone. The peak at 40 cps is at least partially due to a room resonance.



The harmonic distortion at 1-watt input (based on an 8-ohm load impedance) is very low down to 100 cps, and rises to 4.5% at 70 cps. At a 10-watt level, the distortion increases rapidly below 110 cps. The outstanding smoothness and freedom from resonance over the entire range of this speaker is emphasized by its tone-burst transient response, which is as good as any we have measured from a cone speaker.

The sound of the system is decidedly musical, balanced, and free from distortion or coloration. It has an open, airy quality which is difficult to associate with such a small box. The extended high-frequency response makes the over-all sound rather "top-heavy," requiring some bass boost to balance it. When this is done, the speaker takes on a smooth, balanced quality without emphasis of any portion of the spectrum. Of course, the two lowest musical octaves are attenuated considerably, so that the sound lacks the "body" of most larger systems. Unless an A-B comparison is made against a larger speaker, the listener soon forgets he is hearing a miniature speaker system, and simply enjoys its sweet, effortless sound.

The *Goodmans* "Maximus I" is manufactured and distributed in this country by the *UTC Sound Division*. It sells for $59.50 and the unit is finished on all six sides. The same drivers are available in double and quadruple groupings (for double and four times the power-handling capabilities) and are known as the "Maximus 2" and "Maximus 3," selling for $109 and $169, respectively. ▲

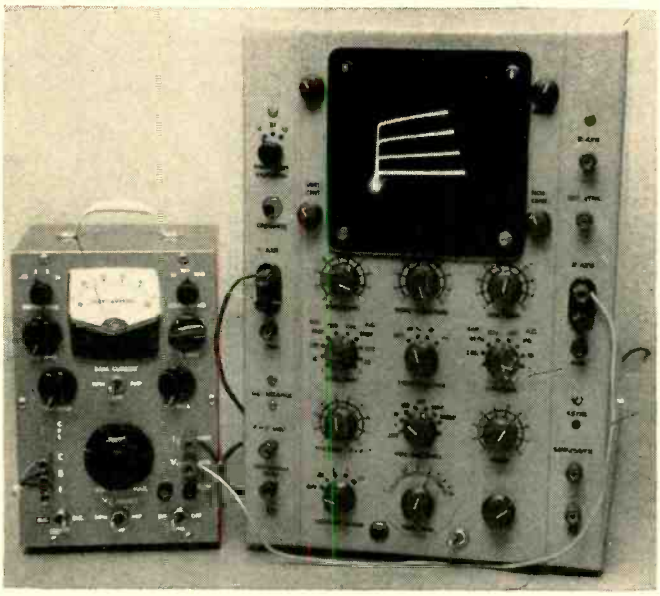


Fig. 1. This multiple-exposure photograph shows a family of transistor $V_c$-$I_c$ curves displayed on the oscilloscope screen.

# TRANSISTOR AND DIODE CURVE TRACER

By A. A. MANGIERI

*Complete family of characteristic curves can be displayed on scope. Component operation can be checked and faults can be found quickly. Transistor-matching and comparison tests can also be performed.*

TESTS which check a transistor at only one operating point may not uncover defects that can make the transistor inoperative in the actual circuit. With the instrument to be described, transistor-collector characteristics can be displayed on the screen of an oscilloscope, and by scanning the entire operating region of the transistor, defects such as localized instabilities, low collector breakdown voltage, high and erratic leakage currents, extreme non-linearity, and other faults are easily found. Transistor-matching and comparison tests are quickly performed on new, used, unlabeled, and bargain transistors, and a complete family of $V_c$-$I_c$ curves can be prepared on graph paper in a matter of a few minutes.

In addition, the instrument permits the display of the *V-I* curves of the smaller diode rectifiers. Diode forward and reverse characteristics may be displayed separately or simultaneously. An oscilloscope, preferably having d.c.-coupled amplifiers, is required for use with the analyzer although an a.c.-coupled scope, capable of passing a 60-cps square wave without a tilt, is satisfactory. Fig. 1, a multiple-exposure photograph, shows a typical family of transistor $V_c$-$I_c$ curves. The oscilloscope, however, shows only one trace at any given time. Low- and medium-power transistors are checked over their entire operating range while high-power transistors are checked over a portion of their operating range as limited by the collector and base power supplies. The instrument provides a peak collector voltage of 38 volts, a peak collector current of 1.5 amp., and base currents up to 50 ma.

### Circuit

As shown in the schematic (Fig. 2), variable autotransformer *T*1 adjusts the voltage applied to step-down isolation transformer *T*2. Diode *D*1, a low-leakage type, rectifies the secondary voltage of *T*2. The half-wave voltage appearing across *R*15 is applied to the collector and emitter of the transistor under test. Collector supply-reversing switch *S*1, with a center-off position, permits reversal of polarity to accommodate *n-p-n* or *p-n-p* transistors.

Either of three 1% resistors, *R*12, *R*13, or *R*14, is placed in series with the collector supply and the transistor as selected by load switch *S*6. Voltage developed across the selected resistor is proportional to collector current $I_c$ and is applied to the vertical input of the scope. These resistors also limit the peak collector current available from the collector supply. Adjustable wirewound power resistors, adjusted to value using an accurate ohmmeter, may be used in place of precision resistors. Four potentiometers, *R*1 through *R*4, permit adjustment of base current with ranges of .05, .5, 5, and 50 milliamperes. Resistors *R*5 through *R*8 are current-limiting resistors for each range.

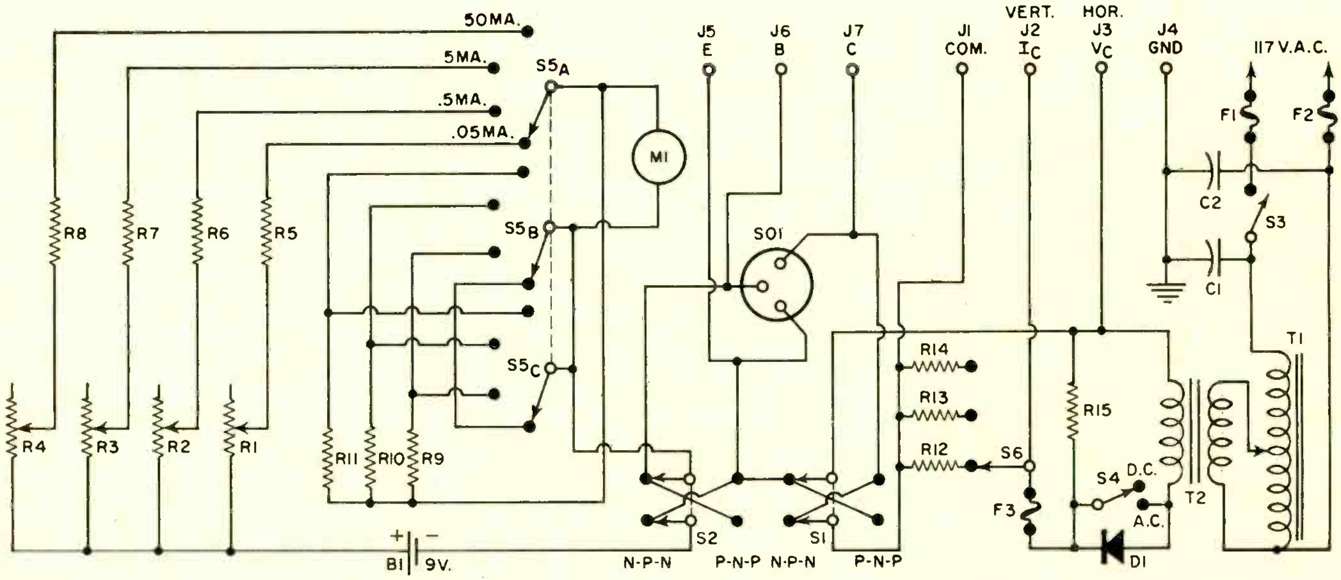
Switch *S*5, a three-pole, four-position shorting switch, selects each of the base-current bias pots and switches the appropriate meter shunt across meter *M*1. *S5B* and *S5C* are identical paralleled sections providing decreased switch resistance and added meter protection should either section fail. *R*9, *R*10, and *R*11 are meter shunts as required. Base-current-reversing switch *S*2, with a center-off position, allows reversal of the base supply to accommodate *n-p-n* or *p-n-p* transistors.

Switch *S*4, in parallel with diode *D*1, is closed to provide an a.c. sweep voltage and is opened to provide a varying d.c. sweep voltage. Fuse protection is afforded by a double-fused a.c. line-cord plug. In addition, fuse *F*3, which is in series with the collector supply, provides additional protection. Capacitors *C*1 and *C*2 are line-noise filters.

### Construction

Mount and wire all parts, with the exception of *T*2 and *B*1, on the front panel of the 9"x6"x5" *Bud* case as shown in Fig. 3. Install one or more transistor sockets on the front panel for use with clipped lead transistors. Mount three binding post terminals, "E," "B," and "C," for connections to long-lead transistors and for clip-lead connections to power transistors. Depending upon the diode used for *D*1, employ a heat sink if required.

Resistors *R*9, *R*10, and *R*11 are calculated for use with a meter having an internal resistance of 2500 ohms. If another meter is used, refer to any good handbook for details on measuring meter resistance and calculating shunts. Preferably




R1—2 megohm pot
R2—200,000 ohm pot
R3—20,000 ohm pot. wirewound, 4 w.
R4—1500 ohm pot, wirewound, 4 w.
R5—100,000 ohm, 1 w. res.
R6—10,000 ohm, 1 w. res.
R7—1000 ohm, 1 w. res.
R8—100 ohm, 1 w. res.
R9—278 ohm meter shunt (see text)
R10—26.3 ohm meter shunt (see text)
R11—2.5 ohm meter shunt (see text)
R12—20 ohm, wirewound, 25 w., 1% res.
R13—200 ohm, wirewound, 10 w., 1% res.
R14—2000 ohm, wirewound, 5 w., 1% res.
R15—1000 ohm, wirewound, 5 w., 1% res.
C1, C2—.05 μf., 600 v. capacitor
T1—Variable autotransformer, 1.75 a., (Superior 10B or equiv.)
T2—Transformer, pri: 117 v.; sec: 26.8 v., 1 a.
S1, S2—D.p.d.t. center-off switch
S3, S4—S.p.s.t. switch
S5—3 pole, 4 pos. shorting switch (Mallory 3134J)
S6—1 pole, 3 pos. shorting switch (Mallory 3115J or equiv.)
D1—1N550 diode
M1—Meter, 0.50 μa., d.c.
B1—Battery, 9 v. (Burgess 2N6 or equiv.)
F1, F2—Fuse, 3 amp., 3AG double-fused a.c. power plug
F3—Quick-action 1 amp. fuse
J1 through J7—Multi-purpose binding post
SO1—Transistor socket, subminiature, (Elco 3301 or equiv.)

Fig. 2. Schematic and parts list for the transistor and diode curve tracer.

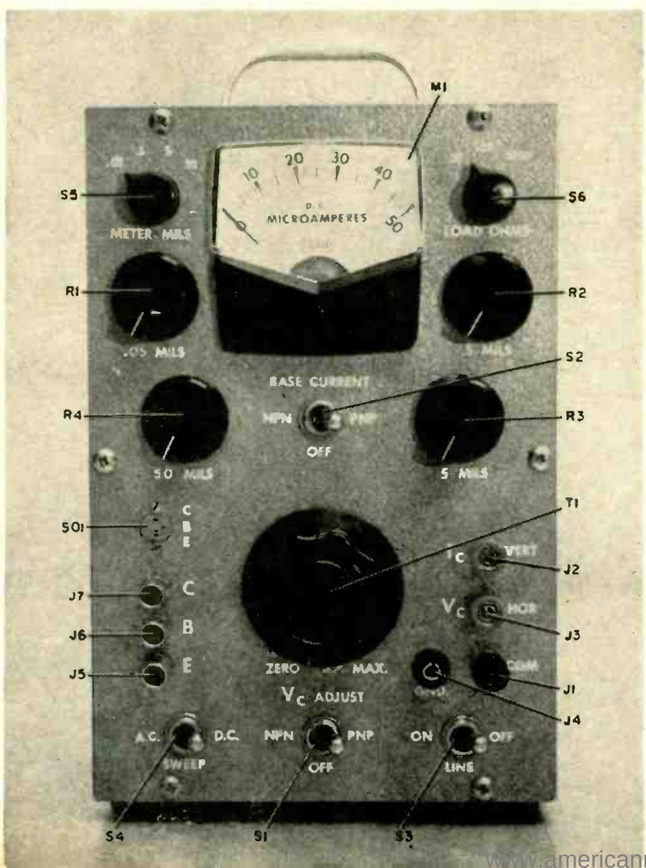
utilize selected wirewound resistors, paralleling two if necessary, to make up the shunts. Resistance wire, if available, may be used to make up a shunt.

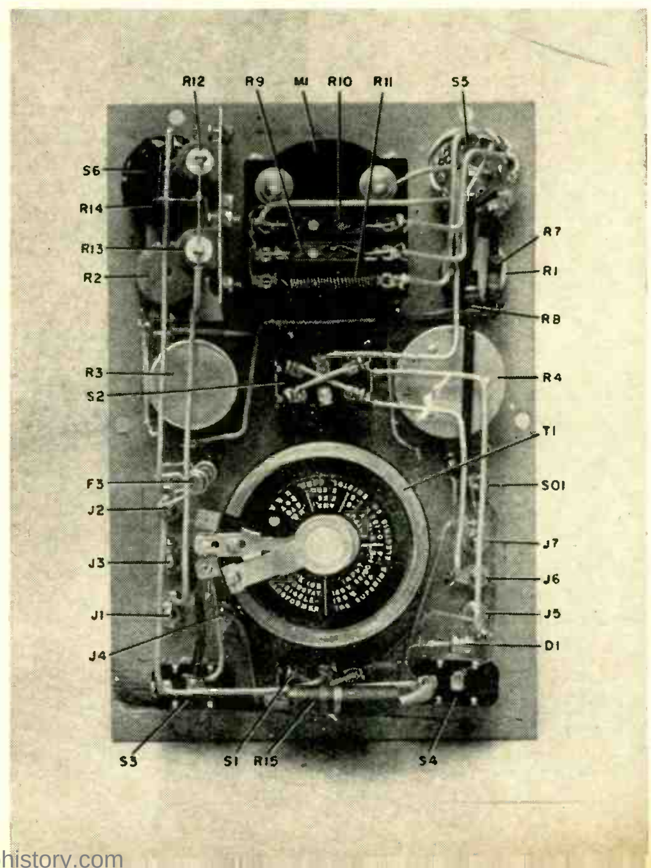
Connect potentiometers *R*1 through *R*4 so that maximum resistance is obtained when the knob is turned completely counterclockwise. Mount transformer *T*2 on the bottom of the case and wire it in after installing the wired and checked panel. Battery *B*1 is supported with a metal clip. Mount four rubber feet on the bottom of the case, and label the panel using transfer decals. Recheck all wiring, particularly in the base-current supply, as an error in wiring *S*5 can damage the meter. In the collector supply, with *S*1 switched to "PNP," terminal "C" should be negative with respect to terminal "E." In the base supply, with *S*2 switched to "PNP," terminal "B" should be negative with respect to "E."

### Operation

Before connecting a transistor or diode to the instrument for test, always set *T*1 to "Zero," *S*1 and *S*2 as required for and transistor type, *S*5 to the lowest range, and the bias pots

Fig. 3. Front and rear views of the front panel showing construction details.



to maximum resistance. To avoid momentary current surges through meter *M1*, open S2 ("Off") before switching S5 to other ranges.

Calibrate the scope before connecting it to the analyzer. As an example, assume that the vertical axis on the scope screen is to represent 5 ma. per inch deflection when S6 is set to the "200" position. A current of 5 ma. d.c. through 200 ohms results in a voltage drop of one volt. Therefore, the scope is calibrated to a vertical sensitivity of one volt peak-to-peak per inch deflection. Similarly, if the required vertical sensitivity is 500 ma. per inch, with S6 set at "20," the scope is calibrated to 10 volts per inch. Use position "20" of S6 for power transistors and the "200" position for low-power transistors.

Connect the transistor according to the "E," "B," and "C" terminals or plug it into the socket. Use a heat sink as required for power transistors. Chassis ground *J4* ("Gnd") connects to the scope ground. For most tests, *J1* ("Com") is also connected to scope ground. When *J1* is grounded, the a.c. line-cord plug must be plugged in a certain way. With the scope connected, S1 "Off," S6 at "2000," and *T1* advanced, reverse the line cord if a double line appears on the screen (due to capacitive leakage currents from *T2*).

The "2000" position of S6 is used only for scope displays of reverse leakage currents of very low leakage transistors and diodes. When using this position, connect *J2* ("Vert") to scope ground and *J1* ("Com") to scope vertical input. Calibrate the scope vertical amplifier to 50 or 100 $\mu$a. per inch. Although the reversed connection takes $V_c$ directly from the collector supply rather than from the semiconductor terminals, it is allowable when the voltage drop across the S6 selected resistor is small compared with the actual voltage across the semiconductor. The reversed connection eliminates the flow of a minute extraneous current through this resistor. Otherwise, this stray current would noticeably affect the scope traces at a scope gain of 50 $\mu$a. per inch.

An important and valuable scope display is the open-base $V_c$-$I_c$ curve of a transistor. This curve shows the reverse-bias collector leakage current $I_{ceo}$ *vs* $V_c$. For this test, switch S2 is opened ("Off") and the transistor is tested as a reverse-biased diode. For very low leakage transistors, use the "2000" position of S6 with scope connections as detailed above. For higher leakage transistors such as power transistors, use the "200" position of S6 and scope connections as indicated on the front panel.

To reverse bias a diode for observation of the leakage or reverse characteristics, connect the positive terminal to "C," negative terminal to "E," place S4 at "D.C.," switch S2 to "NPN," and gradually increase *T1* from zero. Typically, the scope vertical calibration will range from .05 to 5 ma. per inch depending upon diode type.

To obtain the forward characteristics of a diode, which places a forward bias on the diode, S1 is put in "PNP" or the diode connections can be reversed. Set the scope vertical gain as required for the diode forward-current rating. Use the "20" position of S6 for large forward currents and the "200" position for smaller currents. Limit forward currents and reverse voltages to rated values or less. These values, of course, cannot exceed those available from the collector supply.

Zener diodes show a very low reverse current up to the zener voltage followed by a sudden increase in current at the zener voltage. Check these, using either the "20" or "200" position of S6 and limit the zener current to rated values. Zener diodes may be checked up to the maximum available collector voltage of 38 volts peak.

With S4 set to "A.C.," diode *D1* is shorted and an a.c. voltage is applied to the semiconductor. The scope trace will show the forward and a portion of the reverse characteristics simultaneously. Because the scope vertical calibration must be set to accommodate large forward currents, the reverse currents are somewhat obscured unless the diode is very leaky. The resulting L-shaped traces are nevertheless useful because they

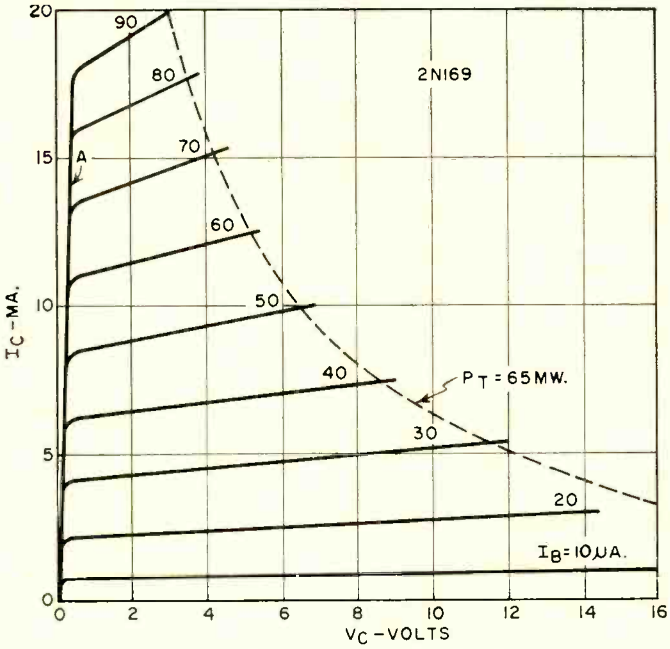



Fig. 4. Family of $V_c$-$I_c$ curves plotted for a 2N169 transistor.

show diodes which are open, shorted, leaky, or which have high forward resistances merely by examination of the trace.

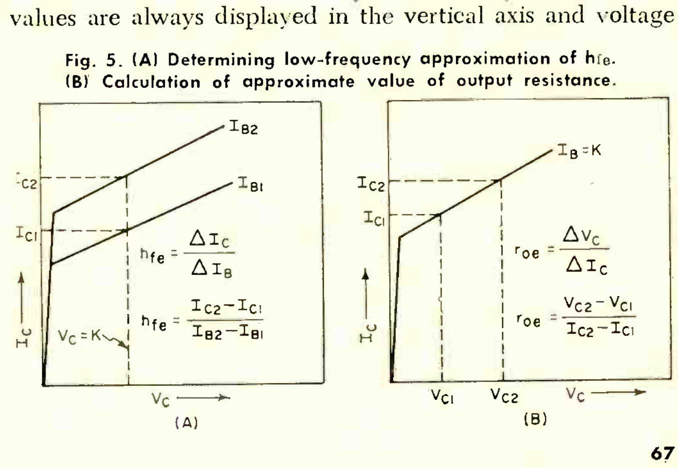
To prepare a graph of the scope display of transistor $V_c$-$I_c$ curves for later comparison tests or study, mark off a sheet of graph paper corresponding to the *V* and *H* calibrations of the scope. At first, as an aid in limiting transistor dissipation, sketch in the maximum dissipation curve $P_T = V_c I_c$. $P_T$ is given in the transistor specifications. Pick several values of $V_c$, calculate corresponding $I_c$ values using the equation, and plot the curve on the graph. Later, this step may be omitted by making mental calculations, as $V_c$ and $I_c$ vary on the display.

Refer to transistor specifications for values of collector breakdown voltage $BV_{cbo}$, maximum collector current $I_c$, and maximum dissipation $P_T$. Keep all scope displays within these limits. If these limits are inadvertently exceeded, but within reason, damage will rarely result because the actual collector dissipation, when using a half-wave collector-supply voltage, is much less than would be the case when using pure d.c. on the collector.

Set the base current to the desired values and always advance *T1* from zero to adjust the size of the trace up to, but not beyond, the $P_T$ curve. Two or three points taken from the horizontal portion of a trace is sufficient to permit drawing the curve on the graph. The steep vertical portion, line *A* of Fig. 4, is taken with $I_b$ set to a high value.

The curves shown in Fig. 4 are plotted in the first quadrant. However, these curves may appear reversed on the scope screen depending on the scope itself. Diode displays may be reversed, inverted, or both, depending upon the scope and diode connections to the analyzer. In every case, current values are always displayed in the vertical axis and voltage

Fig. 5. (A) Determining low-frequency approximation of $h_{fe}$. (B) Calculation of approximate value of output resistance.



in the horizontal axis regardless of the quadrant in which the trace appears. If either of the scope amplifiers is a.c.-coupled, the trace will shift as $I_b$ or $V_c$ is varied. Use the centering controls to reposition the trace for measurements.

### Trace Interpretations

A family of $V_c$-$I_c$ curves, prepared from actual scope traces, is shown in Fig. 4. Much information is available from such curves. The nearly uniform spacing of the curves for $I_b$ values above 20 μa. indicates good linearity as required for large signal applications.

The small-signal, common-emitter forward transfer current ratio with a.c.-shorted output, $h_{fe}$, at times referred to as *beta* or a.c. current gain, is an important transistor parameter. A useful low-frequency approximation of $h_{fe}$ may be calculated from the curves as shown in Fig. 5A. This value is equal to a small change in collector current divided by the corresponding change in base current at a constant collector voltage. Inspection of the curves shows that the gain varies depending upon the operating point. In particular, the gain drops appreciably as $I_c$ drops below 2 ma. Transistor gain figures may vary from 20 to 300.

Next, the common-emitter output resistance, $r_{oe}$, with the input circuit a.c. open-circuited, is equal to a small change in $V_c$ divided by the corresponding change in $I_c$ at a constant base current. The approximate value of output resistance is calculated from the curves as shown in Fig. 5B. Note that $r_{oe}$ drops appreciably as $I_c$ or $I_b$ is increased. Typical values range from 20 ohms for higher power transistors to 100,000 ohms and higher for low-power units.

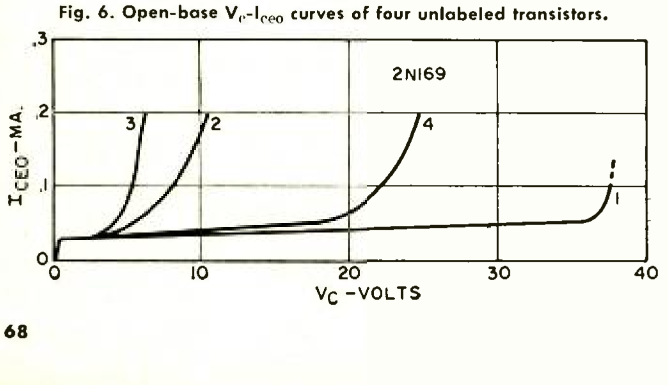
The reciprocal of $r_{oe}$ is the output conductance $h_{oe}$ (hybrid parameter). When matching transistors for use in push-pull amplifiers, try to match both gain and output resistance. Actual calculations are not required. Instead, mark scope screen with a grease pencil and compare other transistors with the markings.

A group of four open-base $V_c$-$I_{ceo}$ curves of four unlabeled transistors similar to type 2N169 is shown in Fig. 6. The rated breakdown voltage $BV_{ceo}$ is 15 volts. Transistor 1 is normal and shows low leakage up to the sharply defined breakdown voltage well in excess of 15 volts. Transistor 4, although showing near-normal leakage at 15 volts, is best limited to operation at 10 volts. Transistors 2 and 3 are obviously unsuitable for use at 15 volts. During tests, when approaching the collector breakdown voltage, use extreme caution as the transistor can be damaged at this point.

By connecting the transistor base lead to "E," collector to "C," and allowing the emitter to float, the scope displays open emitter leakage $I_{cbo}$ *vs* $V_c$. Leakage current $I_{cbo}$ is smaller than $I_{ceo}$. Scope displays are similar. Transistor $I_{cbo}$ leakage current is amplified by the transistor giving rise to the larger $I_{ceo}$ leakage current. To minimize this effect, transistor circuits are often designed to provide a low-resistance d.c. path shunting the base and emitter terminals for passage of $I_{cbo}$. On the open-base tests, try shunting the base to the emitter with various sized resistors and note the effect on the displays.

Transistor $V_c$-$I_c$ curves for the common-collector circuit may be observed by connecting the emitter lead to terminal "C" and the collector lead to terminal "E." S2 is switched as labeled. S1 is switched to "PNP" for *n-p-n* transistors and *vice versa*. The much lower output resistance of the common-collector circuit is shown by the larger inclination of the horizontal portion of the curve. Common-collector gain $h_{fc}$ and output resistance $r_{oc}$ are similarly calculated from the curves. The displays are also valuable for matching and comparison tests between similar semiconductors.

Fig. 6. Open-base $V_c$-$I_{ceo}$ curves of four unlabeled transistors.




### Diodes & Rectifiers

On diode and rectifier tests, with a.c. sweep on the diode (S4 on "A.C."), a shorted diode shows a straight vertical line, a open diode shows a straight horizontal line, and a good diode shows an L-shaped trace which may be inverted or reversed.

With d.c. sweep voltage in the diode (S4 on "D.C."), scope gains may be set for a more detailed display of either the forward or reverse characteristics.

TV selenium rectifiers can be checked in the forward direction for high forward-voltage drop caused by increased forward resistance. Use a horizontal scope gain of two volts per inch or better for this test. Compare a good selenium unit with a poor unit and also with a silicon unit. Note the much lower forward drop and lower dynamic resistance of silicon and germanium rectifiers. Reverse-leakage displays of a selenium unit show an open trace rather than a single line due to the relatively large barrier capacitance of these large area rectifiers. Nevertheless, useful comparison tests can be made by noting the appearance of the trace for good and leaky units.

The analyzer is ideal for use in keeping tabs on the condition of a transistor over a period of time. When a new transistor is obtained, take a few minutes to prepare a graph showing, as a minimum, the open-base and open-emitter curves and two other traces in the middle-bias range. After using the transistor in an experimental circuit, a later comparison check will reveal any major change due to inadvertent abuse. This procedure avoids optimization of a transistor circuit based on using a partially damaged transistor in the circuit.

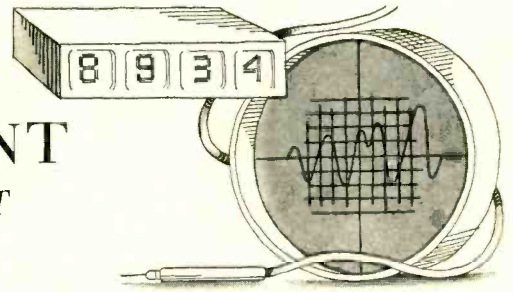
Transistor $V_c$-$I_c$ curves obtained by the dynamic collector sweep-voltage method are similar to the usual static d.c. curves obtained by using pure d.c. on the collector. The methods differ in that the average power dissipated by the transistor is much lower with the dynamic method because of the half-cycle waveform. A comparison of both methods shows comparable gains and a higher output resistance when using the dynamic method. This is due, in part at least, to lower transistor temperatures. Although high-accuracy determination of small signal parameters are difficult to obtain from $V_c$-$I_c$ curves, useful approximations can be calculated.

### Other Effects

A scope trace may drift slightly due to temperature effects, but it should stabilize quickly. If not, dissipation may be excessive or the unit may be defective. All traces should be stable and free of discontinuities or spikes. A hysteresis effect or doubling of horizontal portion of a transistor trace, usually spaced very closely, may be noticed, particularly at high collector currents and dissipations. This effect is normal and varies depending upon the transistor itself. Backing off T1 reduces this effect. A similar hysteresis effect will be noticed on reverse-leakage displays of point-contact diodes.

When using the d.c. sweep voltage, all traces should show a prominent bright dot at the origin of the trace. If this dot is elongated, diode D1 may be leaking excessively, the a.c. plug requires reversing, or the scope amplifiers have insufficient bandwidth. Modern scopes have sufficient bandwidth and phase characteristics for proper display of the characteristics. The scope must be able to pass a 60-cycle square wave without tilt. ▲

# TEST EQUIPMENT
*PRODUCT REPORT*



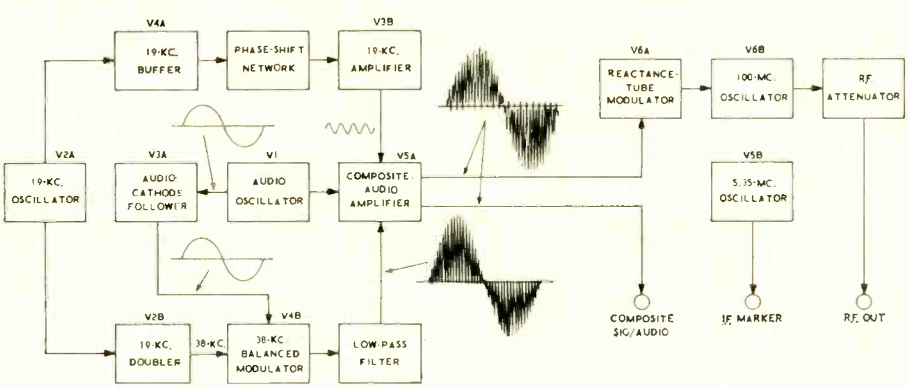

### Heathkit Model IG-112 FM-Stereo Generator

*For copy of manufacturer's brochure, circle No. 57 on coupon (page 15).*

WITH the large and increasing number of FM-stereo tuners and receivers in use, it is imperative that the service technician have on his bench a piece of test equipment that provides "on-the-air" type signals for alignment and adjustment. The *Heathkit* Model IG-112 is just such a unit. This generator has a built-in sweep circuit for r.f. and i.f. alignment and a crystal-controlled marker oscillator with harmonics at 10.7 mc. and at four points in the FM band. In addition, the instrument delivers a variety of FM-stereo and other signals either separately or as modulation on the 100-mc. r.f. carrier.

These signals are: a composite stereo output signal for either left- or right-channel alignment; a special phase test signal (left plus right channels) for accurate phase adjustment of subcarrier transformers; a crystal-controlled, variable-level 19-kc. pilot signal for checking the lock-in range of stereo receivers; a monophonic FM output signal which can be modulated with 400 cps, 1000 cps, or 5000 cps audio; two special modulation frequencies of 38 kc. and either 65 or 67 kc. for adjusting the various doubler and SCA circuits of FM-stereo receivers.

The r.f. sweep signal, with its variable sweep width up to about 750 kc., can be adjusted from the front panel to a clear spot in the band on the receiver being checked. Incidentally, these r.f. signals terminate at a 300-ohm balanced output that can be connected directly to the antenna terminals of the receiver being tested. No separate network for impedance matching or proper balance is required. A three-step (20 db/step) r.f. attenuator, operated by means of three slide switches, prevents receiver overload.




A block diagram of the generator is shown below. A 19-kc. signal is generated in the 19-kc. oscillator section and is doubled to 38 kc. In the 38-kc. balanced modulator, an audio signal from the audio oscillator circuit is added to the 38-kc. subcarrier. The subcarrier is then nulled out, leaving the L+R and L−R double-sideband signals. These are then applied to the composite-signal amplifier circuit.

A small portion of the 19-kc. signal is applied through a buffer and amplifier to the composite-signal amplifier. Here, this pilot signal is mixed with the output from the balanced modulator. The resulting composite signal is then applied to the reactance-tube modulator for the r.f. oscillator.

Note the phase-shift network block in the 19-kc. circuits. This network, used in conjunction with the function switch, introduces a phase shift in the 19-kc. pilot signal with respect to the 38-kc. signal from the balanced modulator. When the phase shift is in one direction, the receiver circuits produce an L-only signal; when the phase shift is in the opposite direction, the receiver circuits produce an R-only signal. With in-phase signals, both L and R signals appear.

The output of the 5.35-mc. marker oscillator is doubled to produce the required 10.7-mc. i.f. marker on a set's response curve. Higher-order harmonics are used to mark the r.f. response every 5.35 mc. from 90.95 (17th harmonic) to 107 mc. (20th harmonic).

The price of the instrument, which is available in kit form, is $99. ▲

### General Radio 1565-A Sound-Level Meter

*For copy of manufacturer's brochure, circle No. 58 on coupon (page 84).*

THE new Type 1565-A sound-level meter, by *General Radio*, uses solid-state circuitry and clever mechanical design to squeeze a *bona fide* sound-level meter into a package that fits easily in one hand and weighs under two pounds.

The *"bona-fide"* part is especially meaningful with this kind of instrument. American and International standards (ASA S1.4-1961 and IEC Publication 123, 1961) set forth detailed requirements for sound-level meters, involving weighting, directionality, crest factor, attenuator accuracy, detector characteristics, meter ballistics, and internal noise level. Because of the widespread acceptance of these standards, serious noise measurements must be made with a qualified sound-level meter if they are to have any standing. Sound-instrument manufacturers also respect these standards by reserving the name "sound-*level* meter" for those instruments that meet all requirements.

The small size of the new sound-level meter is also important. A sound-level meter is as much a field item as it is a laboratory instrument. For the policeman measuring traffic noise or the airport official investigating jet-engine noise, the one-hand size (as well as the battery operation) is vital.

The circuit diagram is shown below. Like all sound-level meters, this one includes microphone, preamplifier, amplifier, weighting networks, attenuator, detector (meter), and power supply.

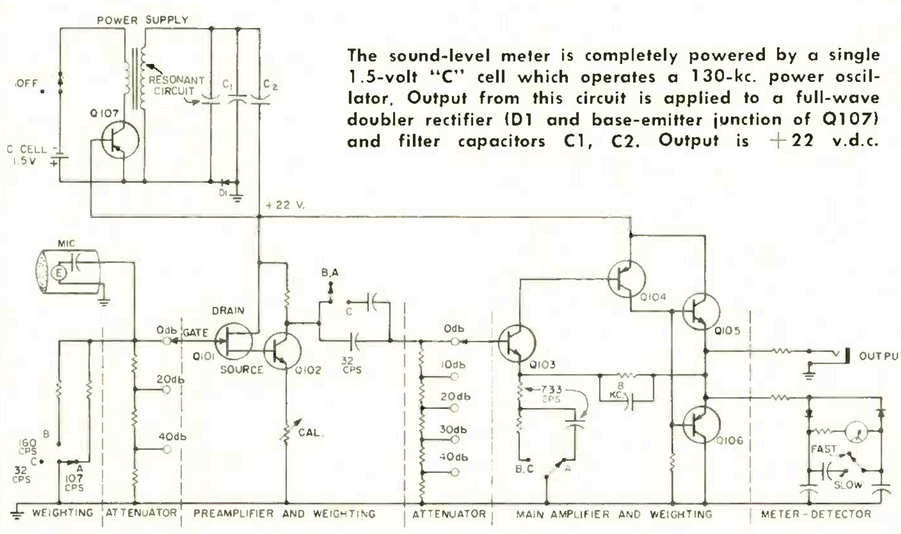
The built-in microphone is a special measurement-grade ceramic unit manufactured by *General Radio*. One of the requirements of the standards is that microphone response be essentially independent of the direction from which the sound comes. This involves not only the microphone itself but also its immediate environment, and the case of the new sound-level meter is specially tapered at the microphone end to minimize the effects of diffraction.

The preamplifier uses two transistors, one a special C620A field-effect transistor (Q101) connected as a source follower. The gain of the other transistor in the preamp (Q102) can be adjusted from the front panel for instrument calibration.

The four-transistor main amplifier uses a 2N1304 and a 2N1305 connected as a complementary pair (Q105, Q106) at the output. Feedback to the emitter of Q103 (an SE-4002) helps stabilize voltage gain.

The attenuator is divided into two sections for best signal-to-noise ratio. One section is located at the input from the microphone, the other between the amplifier's stages. The front-panel attenuator control, calibrated from 50 to 130 db, adjusts attenuation in 10-db steps.


Weighting networks are an important part of any sound-level meter. They function to shape the frequency response of the instrument in accordance with A, B, and C weighting characteristics described in the above-mentioned standards. Certain types of noises are said to be best measured with one or another specific weighting characteristic. Most noise-test codes specify not only the maximum tolerable sound-pressure level but also the weighting to be used, as well as several other measurement conditions. In the Type 1565-A, each coupling and feedback path forms part of the weighting network. To produce the A weighting characteristic, for example, the main-amplifier feedback network provides 6-db/octave roll-off at 733 cps




**The sound-level meter is completely powered by a single 1.5-volt "C" cell which operates a 130-kc. power oscillator. Output from this circuit is applied to a full-wave doubler rectifier (D1 and base-emitter junction of Q107) and filter capacitors C1, C2. Output is +22 v.d.c.**

and 8 kc. The coupling network between amplifiers adds roll-off starting at 32 cps, and the combination of input resistance of the instrument and capacitance of the microphone yields an additional 6-db/octave slope starting at 107 cps.

Either fast or slow meter response can be selected depending on the nature of the noise being measured. Both of these response characteristics are as called for by the standards.

The power supply includes a d.c.-to-d.c. converter to power the transistor circuits from a single 1.5-volt C battery. The circuit is a tuned, self-biased class-C oscillator, operating at 130 kc. The transformer a.c. output is applied to a full-wave voltage-doubler rectifier consisting of diode *D*1, the base-emitter junction of transistor *Q*107 (a 2N1377), and capacitors *C*1 and *C*2. Half the d.c. output voltage biases the transistor in the cut-off region, affording the desired class-C operation with a 70% conversion efficiency. Expected battery life is 35 hours of normal operation.

To use the instrument, one simply holds it so that the microphone is aimed perpendicular to the direction from which the sound is coming and adjusts the two panel controls. One of these is the weighting control, which is usually set to A, B, or C as required by the appropriate code. The other control is the attenuator, which is adjusted for an on-scale meter reading. The sound-pressure level is then the sum of attenuator setting plus meter reading.

An output jack permits use of the sound-level meter to feed an analyzer or recorder. Connection of a vibration pickup in place of the microphone converts the sound-level meter into a vibration meter.

The new sound-level meter is just 3 1/16" x 7⅞" x 2⅛", and it costs $240. ▲

### IMAC Model S-3 Oscilloscope

*For copy of manufacturer's brochure, circle No. 59 on coupon (page 15).*

THE *IMAC* Model S-3 oscilloscope is a rugged, lightweight unit (16 pounds) with a three-inch flat-face CRT. Its circuits are solid-state except for the nuvistor input stage and, of course, the CRT. Power consumption is less than 15 watts, resulting in very cool operation. The majority of the components are located on four glass epoxy-base etched circuit cards. Calibration adjustments are easily accessible when the case is removed.

The unit has features that qualify it for bench and lab work. Its ruggedness and light weight also make it ideal for use by maintenance men and traveling servicemen.

The scope features a d.c. to 6-mc. vertical response, a ten-step calibrated





frequency-compensated attenuator, and a triggered sweep with 18 calibrated sweep rates. The attenuator covers the range of 50 millivolts per division (¼ inch) to 50 volts per division. Base sweep speeds range from 1 microsecond per division to 500 milliseconds per division, extended to 0.2 microsecond per division through a 5X sweep expander.

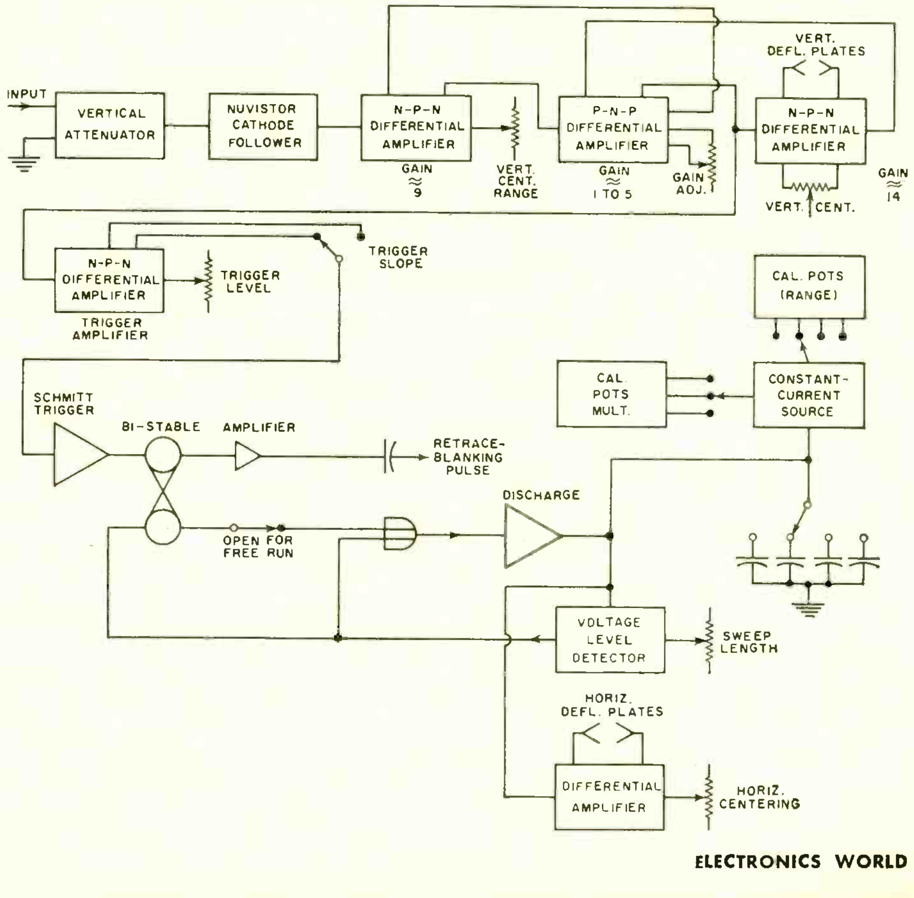
The sweep trigger circuit is stable and positive in action. The controls are simple to use. Adjustments are provided for both trigger slope and level. A sweep-stability control is not necessary as the trace cannot free-run when in the triggered mode. When the trigger-level control is set to the extreme counterclockwise position, the sweep is free-running. The free-run mode is useful in measuring d.c. supply voltages.

The signal first passes through the vertical attenuator (see block diagram). The vertical amplifier has fixed gain such that an input of 50 mv. d.c. causes a deflection of one division. Direct-coupled differential amplifiers are used. Alternating *n-p-n* and *p-n-p* pairs of transistors in successive differential stages allows direct coupling of stages without requiring several successively higher supply voltages. The transistors used are high-speed types having gain-bandwidth products in the range of 100 to 250 mc.

The frequency response is extended by boosting the high frequencies in two of the stages to compensate for deflection-plate capacitance and wiring capacitance. The boost is achieved by connecting a small capacitor between


the emitters of the transistors of the stage. A resistor between the emitters (emitter degeneration) sets the low-frequency gain and maintains it independent of transistor characteristics. The capacitor decreases the degeneration at high frequencies, causing the stage response to rise. Peaking coils are not used, resulting in a response that is flat with gradual roll-off as frequency is increased.

The signal for the trigger circuit is taken from the output of the second vertical amplifier stage. Notice that this is before the vertical centering control. Therefore, although the sync is d.c.-coupled, it is independent of the vertical-position control setting. The vertical signal is applied to a high-gain differential amplifier, where it is compared to a voltage reference set on the "Trig-



ger Level" control. One of the two outputs is selected by the trigger-slope switch and applied to a Schmitt trigger circuit. The output of the Schmitt trigger is a.c.-coupled to a bistable circuit. When a trigger pulse "sets" the bistable circuit, the sweep generator is allowed to generate the sweep voltage. At the end of the sweep, the bistable is reset, holding the sweep until another trigger pulse occurs. The bistable also provides the signal for the a.c.-coupled retrace blanking circuit.

The various sweep rates are set by means of the range and multiplier switches. The constant-current source works on the principle that the transistor collector current is approximately equal to the emitter current, regardless of the collector voltage. With the multiplier on X1, the base of the transistor is connected to − 12 v. The range switch selects the proper timing capacitor and one of six range-calibration potentiometers.

By applying the proper voltage to the calibrated range resistances, the two multiplier calibration settings serve all ranges, and 18 sweep speeds are obtained with eight adjustments.

The instantaneous sweep voltage is compared to the voltage set on the sweep length control. When the two are equal, the discharge circuit is triggered. In addition, the bistable circuit is reset, holding the discharge circuit on, if the free-run switch is closed.

If the free-run switch is open, the discharge circuit remains on only sufficiently long for the timing capacitor to discharge. It then turns off and allows the next sweep to start. The sweep voltage at the timing capacitor is applied to the horizontal amplifier. The second input of the horizontal differential amplifier is the horizontal centering control voltage. The output is applied to the horizontal deflection plates.

The price of the basic oscilloscope unit is $390. ▲

"Of course my QSA's 1, my transmitter is out!"

## Semiconductor Sweeps

(*Continued from page* 32)

the basic circuit is shown in Fig. 6. A series-resonant circuit is connected directly across the d.c. supply. At the start of the sweep, *L* starts to charge *C*, and the high-"*Q*" circuit starts to resonate. In a quarter cycle, *C* has charged to twice the line voltage, and the current through *L* is zero. Slightly past this resonance peak, the SCR is pulsed on with a gate pulse. A new, highly resonant circuit is now formed between the yoke and *C*. (The yoke inductance is much smaller than *L*.) *C* very rapidly starts discharging and building up the yoke field to the point of maximum deflection. Slightly past this point, the circuit will try to reverse current direction as oscillation tries

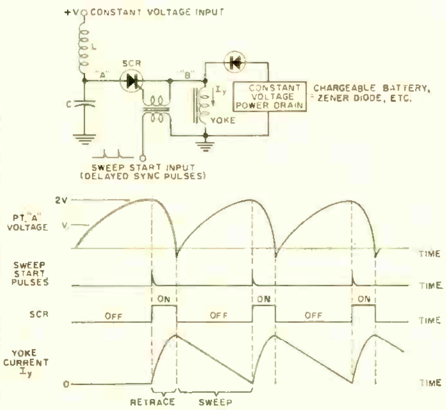



**Fig. 6. The SCR horizontal sweep circuit begins by retracing and all sweep energy is provided during the retrace time. No horizontal oscillator is required in this case since this circuit is self timing.**

to continue. This reverse current turns *off* the SCR, and the two halves of the circuit are once again separate. The left half of the circuit once again begins charging *C* for a new cycle. The right half of the circuit consists of an inductance (the yoke) connected to a constant voltage source *that can absorb energy*. (Assume it is a zener or battery for the present.) The energy in the yoke begins flowing into the supply (actually a drain) in a linear manner, producing the required linear sweep. The sweep continues until there is zero field in the yoke, and the cycle then repeats. The minor fact that the circuit seems to be sweeping backwards is easily eliminated by reversing the yoke leads.

There are two impracticalities to this simplified circuit; namely, the non-symmetrical sweep produced and the requirement for a power drain. These problems are eliminated in the practical circuit of Fig. 7. The yoke current is returned to the power supply *via* a diode and filter arrangement; the rest of the set and the sweep itself form the required power drain. A transformer is added to make the sweep a symmetrical one. This same transformer is the flyback transformer *and* the set power transformer; the entire "B+" requirement for the rest of the set forms the power drain. Any required supply voltage can be provided by changing the number of transformer turns. Additional windings may be added to the transformer for horizontal phase locking, blanking, and a.g.c.

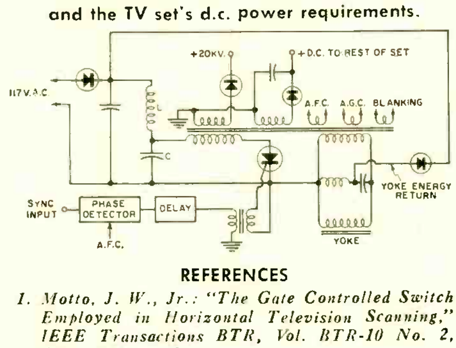
This new circuit could eliminate most of the horizontal circuitry, most of the conventional power supply, and reduce the set's weight and cost.

### Optimum Supply Voltage

At present, there exists considerable controversy over what constitutes an optimum supply voltage for a transistorized television, and the manufacturers seem to be choosing up sides for a pitched battle on this issue. Direct-line operation is the most economical, but the required safety considerations are elaborate, and very high voltage transistors would have to be used in some circuits. The median (24-80 volt) supplies are optimum from a transistor standpoint but require a transformer supply. As supply voltage goes down, the average supply currents go up to provide the same power. This increases the size, cost, and weight of the filter capacitors needed in the supply. Finally, there remain the advantages of the 12-volt supply; namely, the compatibility with batteries and portable operation. These advantages are offset by very high filtering costs (during a.c. operation) and by high current levels required in the power circuits.

Since the choice of a horizontal sweep is intrinsically tied to the choice of supply voltages, no realistic comparison of the three new sweep techniques can be made until the supply question is resolved. All three circuits are capable of solving this critical problem.

**Fig. 7. A practical SCR sweep uses a special transformer to produce both sweep and the TV set's d.c. power requirements.**





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3. *Wheatley, C. F.: "Design Factors for Transistorized Television Deflection Circuits," ibid., p. 72.*
4. *Schwartz, S. A.: "An SCR Horizontal Deflection and High Voltage Circuit," IEEE Transactions BTR, Vol. BTR-9 No. 3, November 1963, p. 9.*
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## Solid-State Power Controls

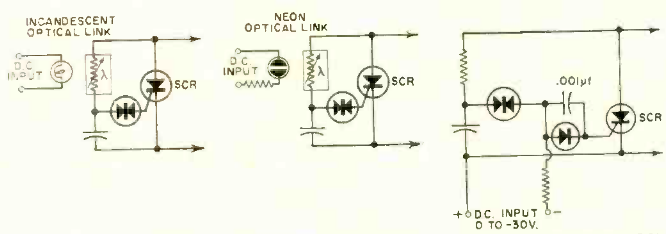
(*Continued from page* 44)

(four-terminal light-photocell pairs), which enhance this possibility, are newly available. An obvious advantage is the complete isolation between input and output signals. These circuits are not too linear and not overly sensitive. A second possibility, shown in Fig. 8C, is to bias the breakdown diode by a varying 0 to −30 volt d.c. control signal. This method is quite linear and extremely sensitive (gains of 10,000 and up are possible) since the control signal does nothing but bias an already reverse-biased diode and does not have to provide power for the SCR turn-on. This method is unilateral and provides no isolation for the control signal.

There seems to be a myth prevailing that it is possible to "feed" random audio signals to the gate of an SCR and expect the load to precisely follow the input signal. Unless the audio consists of a precisely synchronized, phase-shiftable, 60-cps control signal, this concept is incorrect. Audio control may be effected by two means, shown in Fig. 9. The optical links do not care whether the light source is excited by d.c. or a.c. and the slow rise time of the photoresistor integrates the audio signal into a constant resistance value proportional to the audio input power. This method is very economical and provides complete isolation. It is bilateral. It is also non-linear and not too sensitive. Pre-biasing schemes at the light source partially overcome these objections. Linear control is obtained by isolating, rectifying, and filtering the audio as shown in Fig. 9. This method is extremely sensitive.

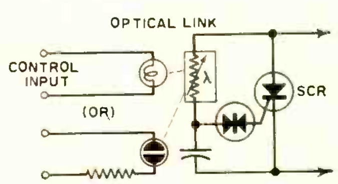
There are most certainly other solid-state power control circuits and control schemes, but most of the ones omitted are either of little current interest or are simply mutations of those we have covered. The surface of this vast field has barely been scratched. The control techniques are so new, at least on an economically practical level, that the controls incorporating such techniques are only beginning to appear commercially.

In addition, the potential of these new techniques is practically limitless. In the not too distant future, we may find that all our electric tools, appliances, and lights will be completely controllable as to speed and brightness rather than simply being turned on and off. ▲

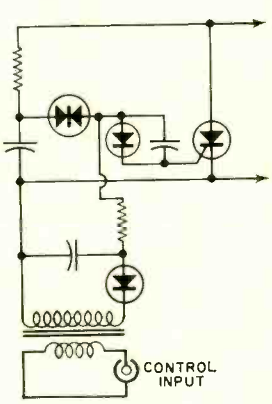



(A) BILATERAL, ISOLATED (B) BILATERAL, ISOLATED (C) UNILATERAL, NO ISOLATION FROM POWER LINE

Fig. 8. Turn-on circuits sensitive to d.c. control voltage.




(A) BILATERAL




(B) UNILATERAL

Fig. 9. Turn-on circuits that are sensitive to audio or low-level 60-cps control signals.

# TRANSISTOR CB-AM CONVERTER

By CHARLES J. HERON
Advanced Development Section
Motorola Inc.

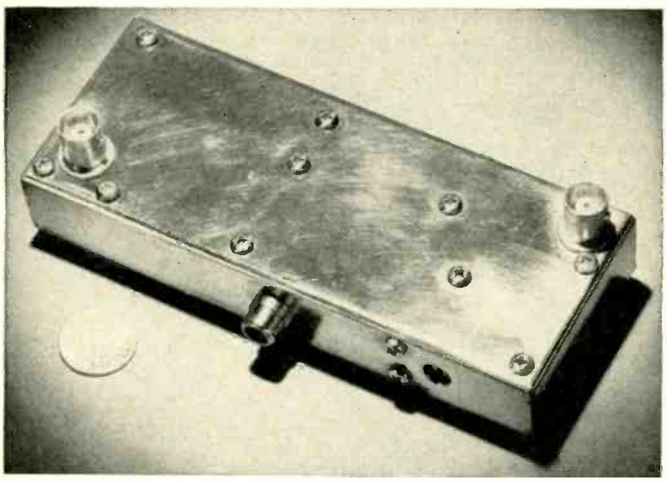
*Mobile unit converts AM car radio into a sensitive dual-conversion superhet receiver for Citizens Radio.*

IF your car has an AM broadcast radio installed, you can readily turn it into a sensitive dual-conversion superhet CB receiver for only a minimum expenditure. Converters for car radios have been available for the amateur bands for years but this 11-meter converter for CB incorporates three unusual features:

1. The converter itself is aligned to the middle of the Citizens Band. The 23 CB channels can be received by tuning the car radio in the same manner as for AM stations.

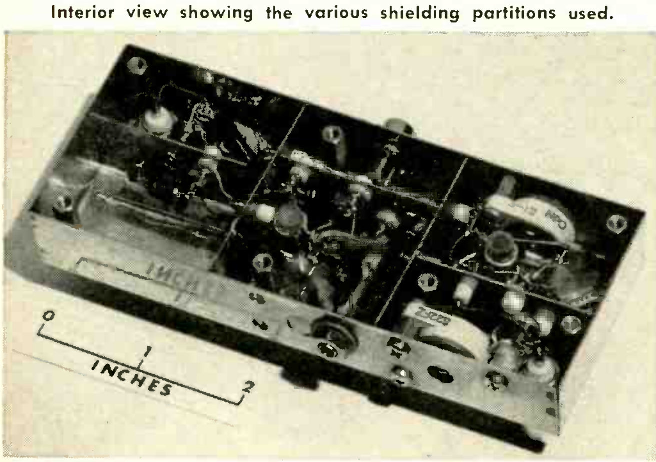
2. The unit features a new type *Motorola* r.f. amplifier transistor which provides excellent sensitivity while maintaining a low noise figure. Being transistorized, the unit requires only about 18 ma. at 12 volts d.c. for operation.

3. The unit can be built quite inexpensively, depending on how many parts the builder has on hand.



Converter was constructed within a 2 x 5 x ¾ inch brass box.

Interior view showing the various shielding partitions used.




### Circuit Description

Coil *L*1 (Fig. 1) with capacitors *C*1 and *C*2, when tuned to resonance at 27 mc., form an impedance match between the antenna (connected to *J*1) and the base of the r.f. amplifier transistor *Q*1. Transistor *Q*1 is a *Motorola* 2N3290 which was selected for this application because of its high gain (35 db at 27 mc.) and its low noise figure (3.8 db). Coil *L*2 and capacitors *C*5 and *C*6 form a broadband tank circuit in the collector of *Q*1, which passes the entire 290-kc. spectrum between 26.965 and 27.255 mc. with negligible loss at the spectrum extremities. Transistor *Q*2, coil *L*3, and capacitors *C*12 and *C*13 form a local oscillator that is tuned to 26.385 mc. This frequency is received from the collector of *Q*2, passed through *C*10 and *R*7, and mixed with the incoming signal as amplified by *Q*1, and applied to the base of *Q*3.

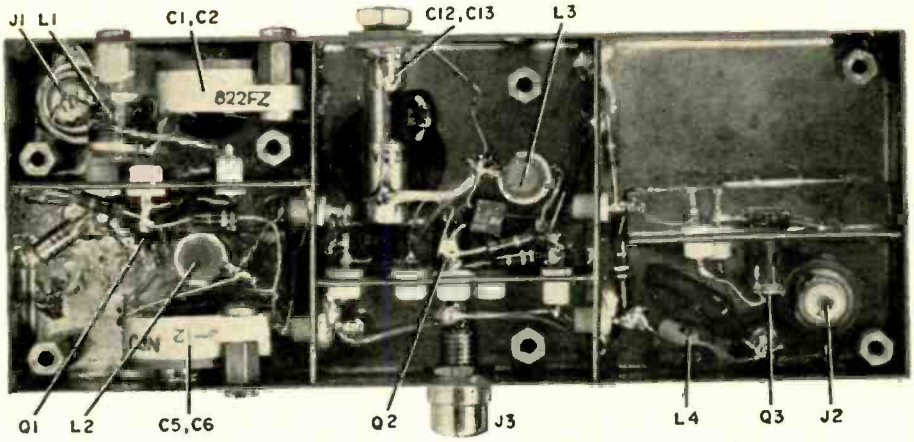
The resultant 700-kc. difference signal is amplified again by transistor *Q*3, which has a fixed 700-kc. resonant tank circuit (*L*4, *C*14, and *C*19). This 700-kc. signal is then coupled through *C*16 to the output connector *J*2. At the connector, the signal can be direct-coupled to the antenna input connector of the automobile AM radio.

The converter oscillator circuit is preset to give a 700-kc. difference signal at 27.085 mc. (channel 11), which is near the center of the Citizens Band. The entire spectrum can be tuned by tuning the AM receiver between 580 kc. (channel 1) and 870 kc. (channel 23).

Since an automobile receiver is fairly well shielded and the r.f. amplifier of the converter passes 27 mc., the converter tends to act as a high-pass filter which attenuates normal AM signals between 580 and 870 kc. A series of tests performed in the locality where the author's unit was being operated showed that even a strong local station on 640 kc. did not interfere with CB signal reception.

### Construction

For compactness, the author built the circuit into a 2" x 5" x ¾" box formed of 0.020 brass. The corners can be soldered by using a small propane torch or a 200-300 watt soldering iron. Partition the box as shown in the photographs. These partitions are used to support components. Holes can be punched or drilled in them at the builder's discretion, keeping in mind that short lead dress of all components is important.



Compact construction along with short, direct leads were employed for the converter.

Solder the partitions into the chassis and install J1, J2, and J3. The ceramic trimmers were mounted with ¼" threaded spacers to the chassis wall and are adjustable through the ¼"-diameter hole in the wall. The author used a slug-tuned glass trimmer in the oscillator section, but the ceramic type designated in the parts list will work equally well but the adjustment is not as fine. If the slug-tuned glass type is used, it must be insulated from the chassis wall where it attaches.

Coils L1, L2, and L3 were wound on ¼"-diameter Lucite rod which was cut ¾" long and threaded in one end to accept a ¼" 4-40 screw. The author used ring collars salvaged from ceramic coil forms for solder lugs on the Lucite rod, but ring collars made from a paper clip will work equally well. After winding the coil, coat with coil dope or radio cement.

It is advisable to install components in the various sections before mounting the three coils as several components are soldered directly to the chassis and require the use of a high-wattage soldering iron which, if held close to the Lucite material, could damage the coils.

Form a bottom plate out of 0.060 brass. Drill and countersink holes to line up with the seven ¾"-long threaded spacers and use flat-head screws to attach the plate to the chassis. While the unit can be checked out without the bottom cover, it must be installed before final alignment.

The converter can be direct-coupled in series with the antenna cable of the automobile radio with the 12-volt "B+" taken from inside the radio so it can be switched on and off with the radio. The converter can be mounted in a small box beneath the dash. It is wired in such a way that it can be switched in and out of the antenna to permit normal operation of the AM radio as required. Align the converter as follows:

1. With the converter coupled in the antenna circuit, turn the car radio on and tune it to 700 kc.

2. Use a signal source, such as a low-power hand-held transceiver operating on channel 11 (27.085 mc.) and adjust C12 until the signal is heard.

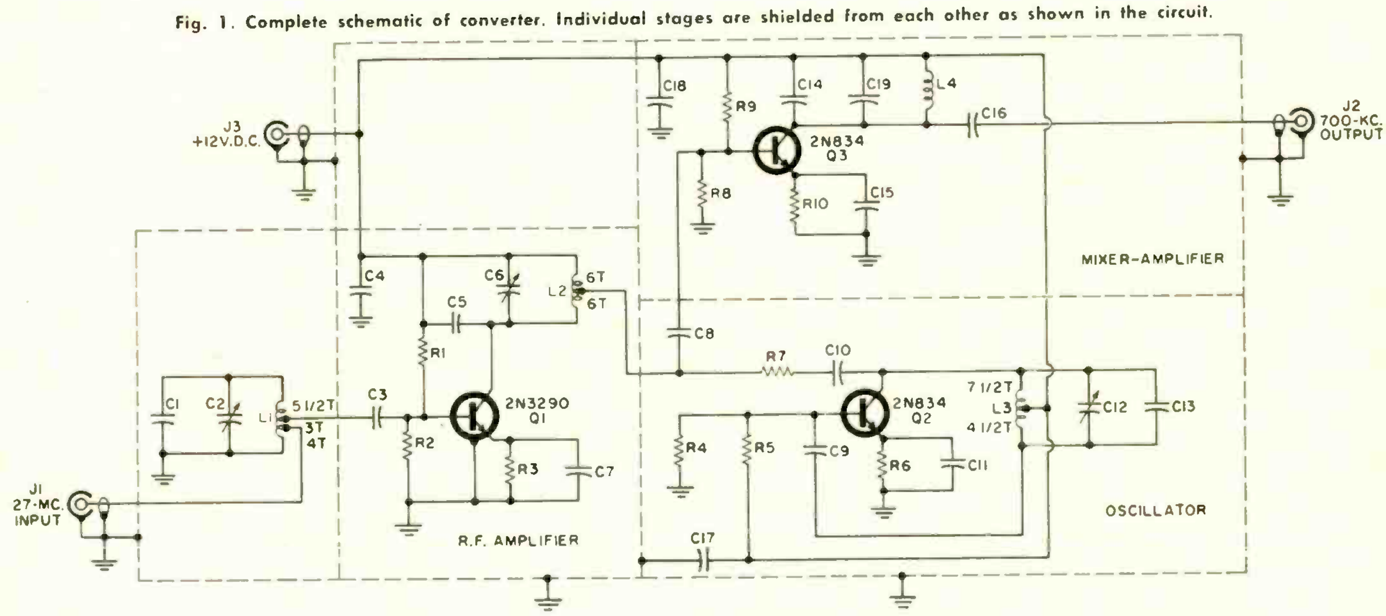
3. Adjust C2 and C6 for a maximum signal. If a 5-watt transmitter is used for alignment, it should be far enough away from the converter so as not to swamp the r.f. section.

Tuning the car radio should permit reception of channel 1 near 580 kc. on the dial through channel 23, near 870 kc. on the dial. The capacitance in the tank circuit of the 700-kc. mixer-amplifier in the converter is large enough so that tuning the capacitor in the auto radio will cause little detuning in the circuit.

While this converter was designed to be used with an auto radio, it will work equally well with transistor AM portables. One point to keep in mind, however, is that the auto radio, while shielded, also uses an external antenna. The transistor portable has a built-in high "Q" ferrite core antenna. In order to use the converter with this type of radio it is necessary to shield the radio itself. Wrapping the radio in aluminum foil will do the job.

The converter will work on voltages from 6 to 12 volts d.c. with only small loss in over-all gain when used on 6 volts. ▲

Fig. 1. Complete schematic of converter. Individual stages are shielded from each other as shown in the circuit.




R1,R5,R9—3900 ohm, ¼ w. res. ±5%
R2,R4,R7,R8—1000 ohm, ¼ w. res. ±5%
R3,R6—560 ohm, ¼ w. res. ±5%
R10—680 ohm, ¼ w. res. ±5%
C1,C5—52 pf. mica capacitor
C2,C6,C12—3-12 pf. var. capacitor (Centralab 822-FZ or equiv.)
C3,C9,C10—.001 μf. mica capacitor
C4,C16,C17,C18—.05 μf. mica capacitor
C7,C8,C15—.01 μf. disc ceramic capacitor
C11—56 pf. mica capacitor
C13—39 pf. mica capacitor
C14—560 pf. mica capacitor
C19—120 pf. mica capacitor
L1—12½ t. #26 en., tapped @ 5½ t. and 3 t., closewound on ¼" dia. Lucite rod (see text).
L2—12 t. #26 en., c.t., wound same as L1.
L3—12 t. #26 en., tapped @ 7½ and 4½ t., wound same as L1.
L4—47 μhy. r.f. choke
J1,J2—BNC connector
J3—RCA phono connector
Q1—2N3290 transistor (Motorola. Can use other n-p-n silicon transistor but with reduced sensitivity and increased noise.)
Q2,Q3—2N834 transistor (Motorola)

# MORE CANADIAN TWO-WAY CHANNELS

By LEO G. SANDS

THERE is a two-radio boom in Canada, too, and the Canadian government is responding to it by assigning new channels in five bands. These bands cover almost 27 mc. of the spectrum.

In the 27.28-28.00-mc. band, which lies between the U. S. Citizens Band and the 10-meter ham band, a limited number of channels, spaced 20 kc. apart, is available for either mobile or fixed stations on a shared basis.

Just above the 10-meter amateur band, Canadian mobile and fixed systems may be operated in the 29.70-30.56-mc. band, also on a shared basis.

The 30.56-50.00-mc. band, which lies between the 6-meter and 10-meter ham bands, is also available to both mobile and fixed systems with 20-kc. channel spacing. New frequencies will be authorized on a shared basis.

Specific frequencies will not be allocated in the new 72.02-72.98 and 75.42-75.98-mc. bands. Instead, licensees will be permitted to use any frequency within these bands, but with no protection from interference from other licensees.

Transmitter power in the three lowest frequency bands is not limited except to the extent that it must not exceed that required to provide satisfactory service. In the 72.02-72.98 and 75.42-75.98-mc. bands, transmitter input power is limited to one watt and antenna gain must not exceed that of a half-wave dipole. The antenna may not be horizontally polarized and must be an integral part of the transmitter-receiver unit. However, when the radio equipment is permanently installed in a vehicle, the antenna may be separated from it.

In some respects the rules of Canada's Department of Transport are more liberal than those of the FCC in the United States. Tone transmission, for example, is permitted in Canada on all five of the new bands. Except under special authority, tone transmission is permitted by the FCC only in the 72.00-72.61 and 75.43-75.70-mc. bands on class-B and class-C Citizens channels, and at frequencies above 952 mc. However, use of tones for establishing and maintaining voice communications (tone squelch and selective signaling), is permitted on all mobile radio channels.

One of the biggest points in favor of the Canadian rules is the limiting of transmitter power to that required for satisfactory service. International treaties and the Communications Act specify that no station shall use more power than required, except in emergencies. Nevertheless, base stations and mobile units have been and are being licensed in the United States to use the *maximum* power permitted by the rules regardless of the distance over which communications is required. In Business and Citizens Radio Services, where frequencies are not coordinated, this practice can cause harmful interference to other licensees sharing the same channel.

On the other hand, the FCC is giving industrial users of the 72.00-72.61 and 75.43-75.70-mc. bands protection against interference from other licensees and restricts the use of these bands to those eligible in the Manufacturers Radio Service.

These bands lie within the 72.76-mc. point-to-point band, between TV channels 4 and 5. Use of this band by point-to-point systems in the U.S. is limited to areas not served by these TV channels. However, low-power Manufacturers Radio Service licensees in these two bands must prevent TVI only within close proximity to TV receivers. In Canada, TVI to channels 4 and 5 is flatly prohibited.

While fixed point-to-point radio systems may be licensed in any of the three lowest frequency bands discussed here, such systems are not generally licensed in the U.S. except in the Citizens Bands, the 27.24-27.28-mc. band, the 72-76-mc. fixed band, and at frequencies above 952 mc. Fixed stations may also be operated in the U.S. on the low-power business channels (3-watt power limit) in the 25-50-mc. and 150-174-mc. bands, but are licensed as mobile stations.

The new Canadian rules also stipulate that within the new bands emission be confined within a 20-kc. wide slot, restricting use to narrow-band FM (± 5 kc. deviation) or AM. Existing wideband FM (± 15 kc. deviation) stations must reduce deviation if interference is caused to adjacent 20-kc. channel U.S. stations within 75 miles or Canadian stations beyond 75 miles. ▲

| Bands (mc.) | Ch. Spacing (kc.) | Power Input (w.) | Ant. Restrictions | Emission |
|---|---|---|---|---|
| 27.28-28.00 | 20 | as required | none | A2,A3 |
| 29.70-30.56 | 20 | as required | none | A2,A3,F2,F3 above 30 mc. |
| 30.56-50.00 | 20 | as required | none | A2,A3,F2,F3 |
| 72.02-72.98* | 20 | one | yes | A2,A3,F2,F3 |
| 75.42-75.98* | 20 | one | yes | A2,A3,F2,F3 |

*All transmitters classed as mobile units.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The result: the HiFi/STEREO REVIEW Model 211 Stereo Test Record!

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- ✓ **Flutter—a test to check whether your turntable's flutter is low, moderate, or high.**
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- **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.**

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The Model 211 Stereo Test Record is a disc that has set the new standard for stereo test recording. There is an overwhelming demand for this record and orders will be filled by ELECTRONICS WORLD promptly upon receipt. 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.

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## Liquid Flow Measurement

(*Continued from page* 40)

mass-type-flow meter is indicated here.

A solution to these problems has been found in a special capacitance flow meter. Theoretical considerations and actual tests show that the dielectric constant of a liquefied gas varies linearly with its density, which is proportional to its mass. It is possible, therefore, to obtain an indication of the mass of a cryogenic fluid from a measurement of its dielectric constant—which can be inferred from a measurement of capacitance existing between two plates immersed in the fluid.

There still remains the problem of determining rate of flow, and this is solved by constructing the capacitor so that its capacitance would vary in proportion to flow. Instead of actual plates, the capacitor (Fig. 6) is made up of two screens mounted in such a way that the fluid must pass through them. The first screen is rigidly attached, while the second is connected to a diaphragm supported on flexible springs which permit it to move farther from the first screen as flow increases and closer when it decreases. The total possible movement is not great but is sufficient to give a measurable change in the electrical capacitance.

The springs supporting the diaphragm are made of a nickel-copper alloy. It is interesting to note that although many metals, including iron and steel, become brittle at extremely low temperatures, nickel-copper alloys, aluminum, and several other metals retain their elasticity. Electrical leads to both screens are brought out through insulated seals. The size and spacing of the screens are chosen on the basis of calculations and experimental work to provide a change in capacitance that varies linearly but inversely with mass rate of flow.

In operation, the capacitor is connected into an oscillator circuit in such a way that the output signal is at a frequency which will accurately change in proportion to any change in the mass rate of flow. As in the case of the turbine meter, the a.c. signal can be used directly for a digital readout, or it can be rectified to provide an analog reading for use with a conventional recorder.

### Dielectric Monitors

Crude oil pumped from wells frequently contains some water, and it is often desirable to have an indication not simply of total flow but rather of the amount of useful oil that is thus obtained. Fortunately, water has a dielectric constant about 40 times greater than oil. It is possible, therefore, to detect a relatively small ratio of water in an oil-and-water emulsion by means of a capacitance measurement. This is done through the use of a device known as a dielectric monitor.

The sensitive element of a dielectric monitor is a capacitor formed by mounting a metal rod concentrically in a section of pipe in the process stream. The rod and the pipe constitute the two plates of the capacitor, and the liquid flowing in the space between them is the dielectric. Both the rod and the pipe are insulated so that the results will not be distorted by conductivity within the fluid.

The capacitor formed in this manner is connected so as to constitute one leg of a capacitance bridge, and the bridge is adjusted so that it is balanced when pure oil is flowing. If any water is present, however, the change in the dielectric constant causes an increase in capacitance which unbalances the bridge, thus producing an error output signal.

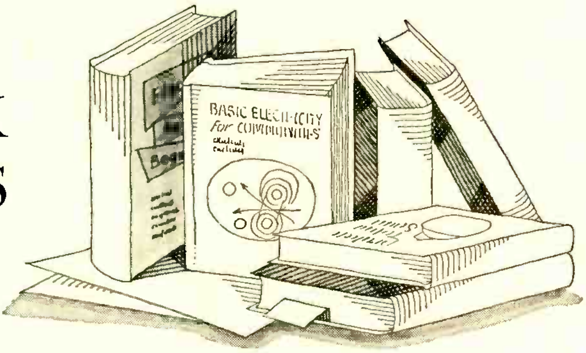
The dielectric constant of oil varies with temperature, and if not corrected this also might cause an unbalance of the bridge. To compensate for this effect, a "captive" specimen of the oil is placed in a capacitance cell in the same stream and is connected into the opposite leg of the bridge. Since it is subject to the same temperature variations, the changes in its capacitance will balance out any capacitance variations that are induced in the sensing element because of temperature variations in the fluid flow.

The error signal from the unbalanced bridge may be utilized in any of several ways. In a simple system, it merely provides a meter reading to show the percent of water, and in this service it is accurate to about 0.1%. A relay system is sometimes added to give an alarm and to divert the stream into a different channel if the contamination rises above a predetermined level.

### Clean Oil Measurement

A more elaborate system utilizes the error signal to record the actual amount of clean oil in a given emulsion. Although the necessary servo system is complex, the general theory is simple. Assume, for example, that clean oil is flowing at the rate of ten barrels per minute and that an integrator is being pulsed at the rate of ten times a minute to record the net clean oil. Next, assume that the water content in the oil increases from zero to 20%, while the flow rate remains constant. The error signal from the bridge would be used to drive a servo motor, which in turn would change the drive ratio of the integrator, so that now it would be pulsed at a rate of only eight times a minute. This correction requires less than a second to accomplish, and the net amount of clean oil is thus recorded. ▲

# BOOK REVIEWS




**"THE RADIO AMATEUR'S HANDBOOK"** compiled and published by the ARRL, Newington, Conn. 592 pages, plus tube tables, index, and 60-page catalogue section. Price $4.00 (U.S.). Soft cover.

This 42nd Edition is an updated and expanded version of earlier volumes and contains all of the basic "how-to" information a ham needs. In 25 chapters the text covers vacuum tubes and semiconductors; receiving systems; oscillators, multipliers, and power amplifiers; code transmission; audio amplifiers and SSB phone; specialized communications systems; checking and monitoring transmissions; power supplies; transmission lines; antennas; wave propagation; v.h.f. receivers and transceivers; v.h.f. transmitters and antennas; mobile and portable emergency equipment; construction practices; measurements; assembling a station; interference with other services; operating a station; plus a 34-page listing of pertinent tube and semiconductor parameters and basing diagrams.

The wealth of information compacted in this handy sized volume gives good indication of why it has been dubbed "the ham's 'bible'."

* * *

**"PROGRESS IN RADIO SCIENCE 1960-1963" VOL. I**, edited by R. W. Beatty. Published by *American Elsevier Publishing Company, Inc.*, New York. 110 pages. Price $9.00.

This is Volume I of eight books covering proceedings of the XIVth General Assembly of URSI held in Tokyo in 1963. This particular volume covers radio standards and measurements and comprises a full account of the review papers presented at the Tokyo General Assembly relevant to the topics under discussion.

Included are abstracts of papers on special topics and selected discussions. Subject matter ranges from atomic and molecular standards of frequency and time, through frequency and time broadcasts, frequency measurements, quartz clocks, radio measurements and standards to about 1 gc., radio measurements, and standards for microwaves. The volume also includes recommendations adopted by the assembly.

Where appropriate, the text is illustrated with line drawings, photographs, charts, and graphs. Extensive reference listings enable the reader seeking additional information to locate sources quickly and easily.

* * *

**"WORLD RADIO TV HANDBOOK"** distributed in the U.S. by *Gilfer Associates*, P.O. Box 239, Park Ridge, New Jersey 07656. Price $4.95 postpaid.

This is the 19th Edition (1965) of this popular reference book for the SWL, broadcaster, and ham. It contains details on every short-wave and television station throughout the world, with listings by country. Radio stations for each country are identified by call and frequency, station personnel and addresses are included, as well as information on radiated power, programs and languages, license fee, identification signals, and network affiliations. In the listing of TV stations, information is given on type of signal, polarization of the antenna, video and line frequency.

* * *

**"PLANNING AND INSTALLING MASTER ANTENNA TV SYSTEMS"** by Lon Cantor. Published by *John F. Rider Publisher, Inc.*, New York. 125 pages. Price $3.95. Soft cover.

The author contends that there is money to be made in installing and maintaining MATV systems and this book is designed to prove his point. The first chapter outlines potential users of such systems and the sources from which the technician can get his leads.

The text then continues with criteria for a good MATV installation: small multiple systems for homes, TV shops and dealer showrooms, small schools; head-end equipment; distribution systems; laying out a system; choosing equipment; typical system design; adding background music or closed-circuit TV to the system; community TV and translators; then concludes with down-to-earth installation and service hints. Seven appendices include such practical aids as db conversion tables, channel frequencies, cable characteristics, attenuator pad construction, resistance of transmission line, and constructing coax cable traps, making the book self-contained.

Lavishly illustrated with line drawings, photographs, block diagrams, and schematics, TV technicians should have no difficulty in mastering the theoretical material in connection with MATV systems.

* * *

**"TECHNICAL REPORT WRITING"** by Rufus P. Turner. Published by *Holt, Rinehart and Winston, Inc.*, New York. Price $3.50. Soft cover.

Not only has technical writing become a profession, but more and more engineers and technicians find that technical writing has become an important, and time-consuming, part of their jobs and often a key to their advancement. To assist those with a good technical background and a basic understanding of English grammar but little or no experience in writing technical reports, Mr. Turner has prepared this practical guidebook.

Practicing what he preaches, the author presents in concise and thoroughly usable form the ground rules for various types of technical reports, including a dissection of the anatomy of the technical report, general procedures, preliminary planning, collecting material, making an outline, writing the rough draft, selecting and preparing illustrations, revising and rewriting, and preparing the final draft.

Six appendices present specimen reports in the various categories.

* * *

**"SOUND WAVES AND LIGHT WAVES"** by Winston E. Kock. Published by *Doubleday & Company, Inc.*, New York. 125 pages. Price $1.25. Soft cover. No. S-40 Anchor Science Study Series.

This is another in the up-to-date, authoritative, and readable series of science books prepared by the Physical Science Study Committee of Educational Services Incorporated and published in uniform format by *Doubleday/Anchor*.

Like the other books in the series, this volume has been prepared by an expert. Dr. Kock was director of acoustic research at *Bell Labs* for many years before joining *Bendix Corporation* in a similar post. Despite his impressive academic background and experience, he covers his topic in simple, easy-to-understand language, amplifying his text material with detailed line drawings and fascinating photographs of various phenomena.

Since the author champions "comparison thinking"—which he feels essential in today's scientific world—the subject of sound and electromagnetic waves are treated together, rather than as separate entities. After a general discussion of wave motion, the text covers the wave nature of sound and light, wave propagation, wave radiation, waveguides, wave patterns, and wave refractors. A bibliography listing additional sources of information completes the book. ▲

## Silk-Screened Boards

(*Continued from page* 48)

be filled in with film. The outer clear border of the silk between the emulsion and the frame can be filled in on the emulsion side with strips of dampened mucilage tape and trimmed to frame size. Only the open circuit pattern will then permit the passage of paint through the screen. Any defects in the emulsion due to incomplete sensitizing or foreign material can be filled in and corrected with thick water soluble water paint.

At this point the copper-clad blank circuit board is prepared for screening by cleaning the copper surface and removing all burrs with a file. An abrasive household cleanser will restore the copper luster. If plain ferric chloride is used for etching, ordinary waterproof poster paint will be sufficient (Item 5). If stronger etchants are used, such as a ferric chloride and additives, it may be necessary to use printed-circuit black, which is a specially prepared screening resist (Item 6).

The screen is now placed with the emulsion side in contact with the blank circuit board or paper, if a trial run is desired. About one teaspoonful of paint is spread the width of the pattern on the silk bordering the circuit inside the screen. Most screening paints or inks are of fairly thick consistency and should not be thinned for printed circuit use. The screen is now held firmly in contact with the copper clad board and a rubber squeegee or piece of rubber ⅜" thick and the width of the circuit is drawn firmly, without excessive pressure, through the paint across the pattern. The screen is lifted vertically away from the board and tapped gently to release the board, should it adhere to the thick paint. Improper screening technique, excessive paint, or movement of the screen may cause smearing of the pattern. In this case, it may be necessary to do several trial prints on paper.

The result will be a painted pattern on the copper resembling the original circuit positive (Fig. 6). You can now print circuits until the paint is exhausted. Variations in screen construction are possible, the more elaborate screens having a hinged bottom board and guides for precut circuit-board blanks.

From this point on, the dried paint pattern will act as a resist in the normal etching process. The board can be floated face down in an etchant solution consisting of one part ferric chloride to three parts water until all the exposed copper is removed. The paint is then removed with turpentine.

One word of caution about cleaning the screen. The emulsion side should never be rubbed. The screen is cleaned by placing it emulsion side down on successive pieces of newspaper while pouring small amounts of turpentine through the screen and wiping the inner silk side until all traces of paint are removed from the circuit pattern. The life of the screen depends on cleaning it properly and on the pressure applied to the silk while screening. If the screen is not to be reused, the silk may be cleaned by using a paint remover and household cleanser (Item 7) with a small brush. ▲

### WHAT TIME IS IT?

**IN an effort to find out what time it is in various parts of the world, engineers of the Hewlett-Packard Co. recently took a pair of portable (230 lb.) cesium-beam atomic standard "clocks" on a 35,000-mile trip to 21 timekeeping centers in 11 nations in 35 days.**

**The purpose of the trip was to measure the exactness of agreement, with microsecond accuracy, the time of day that exists among these centers.**

**Before the trip, the two clocks were taken to Washington, D.C. where they were synchronized with the U.S. Naval Observatory.**

**Referred to WWV some of the time differences measured were: Japan—1.4 msec.; Hawaii—247 msec.; Greenwich Observatory, England—5½ msec.; National Physics Laboratory, England—1.2 msec.; Paris—250 $\mu$sec.; Sweden, 500 $\mu$sec.; Germany—.4 second; Switzerland—1.8 msec.; among others.**

# READER SERVICE PAGE

As a convenience to our readers, we have included two separate reply coupons in this issue which should simplify the process of requesting information on products and services appearing in this issue.

Unfortunately, many companies will not furnish additional information to a home address. Therefore, to assure a reply, make certain that the proper coupon is used.

To get more information, promptly, about products and services mentioned in this issue, simply circle the number corresponding to the ad or editorial mention and send the proper coupon to us. Your request will be sent to the manufacturer immediately.

**FOR PROFESSIONAL USE:** In requesting information on products and services listed in the coupon below it is necessary to fill out the coupon COMPLETELY, stating your company, address, and your function or title. If the coupon is incomplete it cannot be processed.

**FOR GENERAL USE:** In requesting information on products and services listed in the coupon on page 15, you may use your home address.

You can use both coupons, since each contains specific items, if each coupon is filled out completely.

## See Page 15 for "GENERAL USE" Coupon

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 3 | 7 | 9 | 10 | 11 | 12 | 14 | 15 | 16 | 18 | 23 | 26 |
| 35 | 36 | 37 | 38 | 39 | 41 | 42 | 44 | 45 | 46 | 48 | 49 | 50 | 51 |
| 53 | 54 | 58 | 100 | 123 | 128 | 140 | 143 | 144 | 147 | 150 | 403 | 404 | 406 |

**ELECTRONICS WORLD**
**P.O. BOX 7842, PHILADELPHIA 1, PA.**

**(VOID AFTER JULY 31, 1965)** **6**

# NEW PRODUCTS & LITERATURE

*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, fill in coupons appearing on pages 15 and 84.*

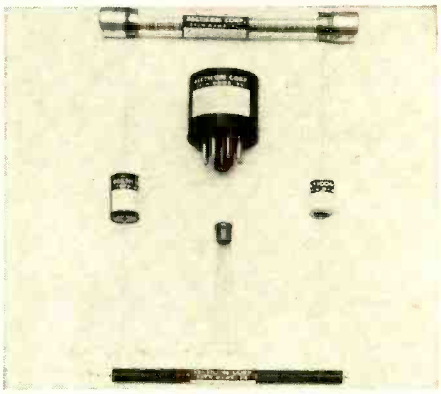
**COMPONENTS • TOOLS • TEST EQUIPMENT • HI-FI • AUDIO • CB • HAM • COMMUNICATIONS**

### HIGH-VOLTAGE SELENIUM RECTIFIERS

1 **Recticon Corporation** has available a complete new line of cartridge-type high-voltage selenium rectifiers for commercial and military applications.

The new units are designed to take current and voltage overloads (as much as 50% over p.r.v. ratings) with no need for special protective circuitry.

The p.r.v. range is from 500 to 20,000 volts.



High stability is exhibited at voltages as great as 50 volts per cell, thereby permitting the smallest possible assembly for a given voltage rating. Current range is 1 ma. to 20 ma. Ambient temperature range is from −65°C to +100°C.

Epoxy-sealed to eliminate end caps and reduce arcing, the units are fully operable in any environment.

### TEST EQUIPMENT LINE

2 **Amphenol-Borg Electronics Corporation** has introduced a comprehensive line of service test instruments including a color generator, a v.h.f.-u.h.f. field-strength meter, and a CRT checker-rejuvenator.

The "Color Commander" is compact enough to fit into a tube caddy yet offers nine test patterns, including three never before available in color generators. It comes in a fitted leatherette case with carrying handle and measures 9" x 5" x 4" and weighs only 3½ pounds.

The second instrument is a v.h.f.-u.h.f. field-strength meter (photo), called the "Signal Commander." This compact (9½" x 4¾" x 3¾", 3½ pound) instrument operates from self-contained batteries and is housed in an integral leatherette-covered case with a handle permitting easy one-handed gripping, so it can be used on rooftops. The optional dipole antenna disassembles for storage in the lid of the case. The meter is designed to meet a wide variety of servicing and laboratory requirements ranging from antenna positioning to measurements of μv. per meter.

The "CRT Commander" is an instrument for testing and rejuvenating both color and black-and-white CRT's. All elements in the tube under test are made active for complete versatility. This solid-state unit measures only 9" x 12" x 5" and weighs 7½ pounds.

### SILICON POWER TRANSISTORS

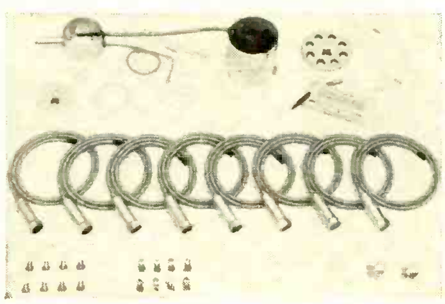
3 **Radio Corporation of America** is now marketing a complete line of silicon power transistors for high-temperature and high-power audio applications. Twenty new units, **RCA** 40309 through 40328, are included in this broad grouping of silicon power audio devices. They offer the OEM market a high-quality silicon transistor for the high-temperature audio socket requirements of 2- to 50-watt systems.

Design engineers will have a broad choice of operation from 13.7 volt supply to 117-volt a.c./d.c. (direct line) operation. The high thermal stability of silicon minimizes the need for bulky heat sinking devices—resulting in more compact circuit designs.

### NOISE-SUPPRESSION KIT

4 **Estes Engineering Company** has recently introduced an economical noise suppression kit designed to fit a wide variety of engines.

The "Electro-Shield" kit comes semi-assembled



and is identical to the firm's custom-made systems. Installation calls for no special tools or skills. It is merely necessary to trim the spark-plug cables to correct length, install fittings at the distributor end, and insert the cables into the distributor shield.

### ALL-CHANNEL HOME TV DISTRIBUTION

5 **Blonder-Tongue Labs, Inc.** has unveiled an all-channel home TV distribution system which is designed to enhance and simplify the reception of both u.h.f. and v.h.f with one complete rooftop-to-outlet installation.

According to the company, the new system, which requires only one wire to a set, would cost only slightly more than a comparable v.h.f.-only system.

### COMPACT OSCILLOSCOPE

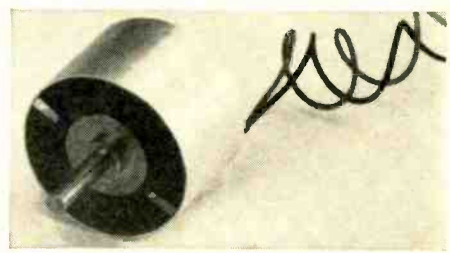
6 **Schaevitz-MCD** is now offering an easy-to-operate portable scope as the "Primer-Scope Mark I." Designed especially for hams, service technicians, and experimenters, the scope incorporates features usually found only in much higher priced units.

The vertical amplifier maximum gain deflection sensitivity is 0.25 volt p-to-p/division d.c. and 6 mv. r.m.s./division a.c. Frequency response is 0 to 75,000 cycles d.c. and 20-75,000 cps a.c. The linear time base has a sweep frequency range continuously adjustable from 20 to 20,000 cps in three steps. Operation is repetitive and either internal or external positive-going polarity is available.

The unit measures 7¼" high, 3½" wide, and 11¼" deep. It weighs 5¾ pounds and can be powered from any 105-125 volt, 60-cycle source.

### MINIATURE D.C. MOTOR

7 **Aeroflex Laboratories** has added a new miniature brushless d.c. torque motor, the TQ 10-1P, to its line. One inch in diameter x 0.70



inch thick, the motor weighs 2 ounces and develops a torque or 1 oz./in. through an angular motion of ± 45 degrees.

At 25 C. power input is 3 watts and resistance is 175 ohms. Sensitivity is 7.6 oz. in./amp., electrical time constant is 2 x 10⁻⁴ sec., and back—e.m.f. is 0.055 volt/rad/sec., unless resistance is altered to meet a specific requirement.

The unit has no commutators, brushes, or slip rings. It is almost frictionless and offers no problems in maintenance, radio noise, or danger of explosion. Features include a unique, permanently magnetized rotor and a special stator winding that develops step-free torque with no mechanical restraints due to friction, motor ripple, or "slot lock" effects.

### COLOR TV-DEGAUSSING COIL

8 **GC Electronics** has recently announced the development of a new, low-cost color-TV degaussing coil, the "Walsco" Model 2592. This compact 7" coil is molded in a high-impact plastic case provided with an extension cord and built-in switch for ease of operation. Complete instructions are furnished with each unit.

### ELECTROLUMINESCENT LAMPS

9 **General Electric Company's** Miniature Lamp Department is now offering an extensive line of electroluminescent lamps which are only 1/32" thick, flexible as playing cards, and suitable for space-saving display areas.

Each panel consists of separate layers of aluminum, phosphors, translucent conductor material, and copper leads—all sealed within a special high-strength film made for this application by **Allied Chemical Corporation.** Called "Aclar," the transparent film provides the necessary electrical insulating properties and prevents cracking, chipping, or peeling. The film protects the light from all weather conditions.

### SHATTERPROOF PLASTIC SHEETS

10 **Westlake Plastics Company** has available transparent polycarbonate plastic sheets, known as "Zelux," in sizes up to 48" x 7" and

in thicknesses up to 1″. The new sheets feature exceptional toughness, outstanding dimensional stability, low water absorption, thermal stability, excellent electrical properties, machineability, and ease of fabrication.

The sheets are suitable for all applications where transparency is required along with exceptional strength.

### EPITAXIAL MICROWAVE DIODES

11 **Sylvania Electric Products Inc.** is in production on a new line of epitaxial microwave mixer diodes which the company claims will increase the range of radar and other communications equipment by approximately 5 percent.

The new units are designed for use in the S and X bands and have noise figures of 5.5 and


6.5 decibels, one-half a decibel lower than obtainable in other currently available microwave diodes.

The new point-contact silicon diodes D5621G and D5623G are designed for use in radar, communications, countermeasures, and related equipment. They offer lower conversion loss, a lower noise figure, and are designed to increase the usable range of radar and related equipment. The improved S-band diodes have been designated D56621G and D5621GR while the X-band are specified as D5623G and D5623GR. These diodes have been thoroughly life-tested and are available in limited quantities from stock.

### MICROMODULE VARIABLE CAPACITORS

12 **JFD Electronics Corporation's** Component Division is now marketing a new series of micromodule "Modutrim" ceramic variable capactors, the MT 200 series.

These new units have dimensions of 0.208″ wide x 0.280″ long x 0.120″ thick, representing a better than 30% reduction in length over previous models. The seven units in the new series have delta-C ranges of 1.6-9.0, 3.0-12.0, 3.5-20.0, 4.0-15.0, 5.0-30.0, 6.5-40.0, and 8.5-50 pf. at working voltages of 50 volts d.c. except for the 1.6-9.0 pf. unit which is rated at 500 volts d.c. Capacitance change closely approximates a straight-line function for the 180-degree rotation. Adjustment torque is within 1-5 in. oz.

### ELECTRONIC DIMMER SWITCH

13 **Ideal Industries, Inc.** is now offering a new electronically controlled dimmer switch for incandescent lighting which will adjust lights from bright to candle glow without flickering. The dimmer provides infinite variation without step-type switching. It is for use on 120-volt, 60-cycle, single-phase input and is available in single-pole or three-way switch arrangements with a connected load rating of 600 watts maximum.

The units have a push-on, push-off switch combined with the rotary dimming control. This feature allows the user to turn the lights on at any preset level of brightness. A 500-watt maximum connected load unit is available with a single-pole rotary switch in the dimmer control.

The circuit is designed around a bilateral semiconductor, which provides full-wave control of the a.c. current. Power loss within the device is negligible, so power consumed is roughly proportional to light-level-setting of the switch. A built-in filter eliminates interference and annoying static in AM radio receivers.

### REED RELAYS FOR PC

14 **Win-Elco** has added the Type SEPC to its line of reed relays for printed-circuit applications. It is a single-ended unit requiring little more space than a transistor, is 0.437 inch in diameter x 1″ high, and is available with Form A, B, or C contacts. Coil voltages are 6, 12, or 24 volts d.c. Contact rating of Form A and B is 10 watts or 0.5 amp; Form C is 3 watts or 0.25 amp. Contacts are hermetically sealed in glass. Magnetic shielding is available if required.

### AUTOMATIC LEVEL CONTROL

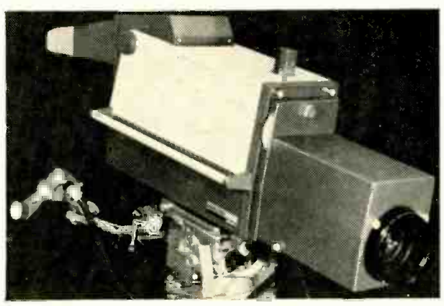
15 **CBS Laboratories** has recently introduced a new transistorized automatic level control for the broadcast industry.

The "Audimax III" increases program power up to 4 to 1, and automatically adjusts program audio levels to provide the best possible signal strength for the broadcaster while improving the program content for the listener.

This new solid-state automatic level control is engineered to monitor and control audio levels without distortion, thumping and pumping, or audio "holes."

### TRANSISTORIZED STUDIO CAMERA

16 **Ampex Corporation** has just introduced a fully transistorized 4½″ image orthicon television camera designed specifically for studio use. The "Mark V," which is made in England by **Marconi Company, Ltd.**, is said to be smaller and lighter than any camera of its type now in production. Controls on the camera include only basic "on-off" and lighting adjustments with all other camera electronics on separate equipment racks, leaving the operator free to concentrate on controlling the position and field of view of the camera.



Features of the new camera include a signal integrated zoom lens which frees the camera from the restriction of having a number of lenses of fixed focal length and allows presetting of up to four zoom positions.

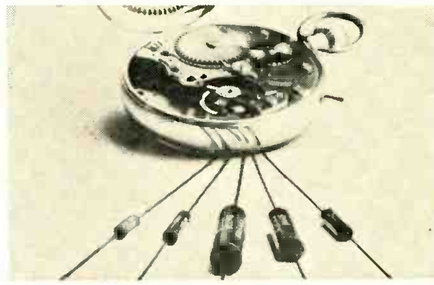
### COLOR-TV RECTIFIER KIT

17 **GC Electronics** is now marketing a new color-TV rectifier replacement kit which should eliminate the need for the technician to carry a large quantity of rectifiers on a color-TV service call.

The #16-500 kit contains one focus, one voltage booster, and one silicon-diode rectifier in a handy clear-plastic box with an up-to-date cross-reference guide. The guide enables the technician to make immediate rectifier replacements on most **RCA, Zenith, G-E, Philco, Emerson**, and many other color sets.

### ULTRA-PRECISE RESISTORS

18 **Speer Carbon Co.** has demonstrated a new line of ultra-precise metal film resistors designed for the increasingly sophisticated equipment in the military and industrial electronics market.



Manufactured in special clean rooms, the new JXP resistors meet all the requirements of MIL-R-10509, Characteristic E, with far less than allowable variations. They are available in tolerances from 1%–0.1% as standard; and tighter tolerances are available on special order.

They can be manufactured to track within 5 PPM/°C of each other over a temperature range of −55 degrees to +170 degrees C.

## HI-FI AUDIO PRODUCTS

### WIDE-ANGLE SPEAKER SYSTEM

19 **Empire Scientific Corporation** is now offering a new and improved version of its "Grenadier" speaker system as the "Grenadier 8000P." The Model 8000P features unique adjustable rear ports which allow bass and treble response to be adjusted to suit individual room acoustics. A low-frequency adjustment in 1-db increments can be obtained by removing the "dynamic reflex" stops while high-frequency adjustment above or below normal response is switched without phase shift by means of a 3-position electronic circuit control located beneath the speaker.

Like the earlier models, frequency response is 25-20,000 cps, impedance is 8 ohms, and the system will handle 100 watts music power. This columnar speaker is 29″ tall x 15¼″ diameter and provides 360° sound dispersion.

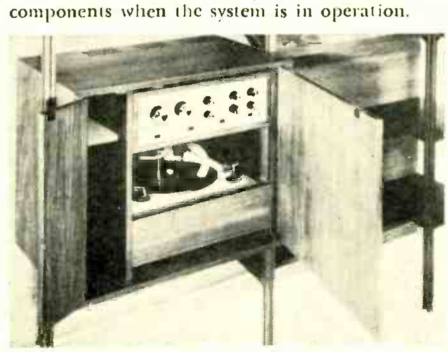
### STEREO TAPE RECORDER LINE

20 **Ampex Corporation** is now offering a new line of stereo tape recorders which is priced considerably lower than its current consumer line. The new "800" line consists of three models, all of which feature solid-state electronics, professional-type vu meters, complete power supply including amplifiers and preamps, "on-off" pilot light, dual capstan drive, and high-quality playback sound.

The Model 865 is a walnut encased recorder, the Model 860 comes in a tan vinyl case, while the Model 850 is a deck. Two Ampex 701 microphones are included with the Models 865 and 860. The Model 860 has a fold-down portable carrying handle. The company is also offering Model 815 bookshelf speakers designed to go with the tape recorders in the 800 series. The speakers are walnut encased and are sold in pairs.

### MODULAR CABINETS FOR HI-FI

21 **Omni Division of Aluminum Extrusions, Inc.** has added three audio cabinets to its line of modular furniture. The cabinets fit the company's 32″ standard module and are finished in oiled walnut to correlate with the firm's other wood components. They are completely vented for air circulation, thus may be closed to conceal components when the system is in operation.



Individual compartments for components such as receivers, tuners, preamps, amplifiers, turntables, and tape decks are side-mounted on ball-bearing, nylon wheel slides, and are removable for ease of component installation and access.

A brochure entitled **"Omni Home Entertainment Centers"** (form 1-65X) contains complete information on the new audio line.

### TABS STOP RECORD SLIPPAGE

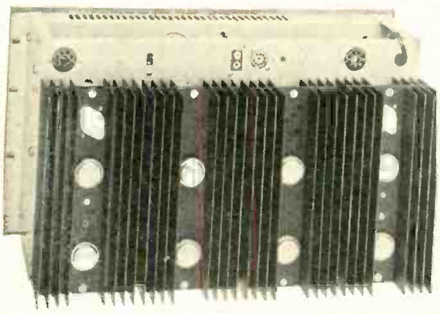
**22** **Treo Co.** is now marketing "Record Tabs," a thin, diamond-like and adhesive back strip designed to eliminate record slippage when a stack of records is being played on an automatic changer. In addition to checking slippage, the "Tabs" also help to cushion each record as it drops.

The product is being marketed in packages which include "Tabs" for 25 records and a placement gauge.

### HEAVY-DUTY INDUSTRIAL AMP

**23** **Rauland-Borg Corporation** has developed an all-transistor, 250-watt amplifier designed for continuous heavy-duty service in commercial and industrial applications, the Model TA250.

The amplifier provides 250 watts r.m.s. (500 watts peak output), has a thermostatically controlled protective relay, back up, fast-acting overload protective relay with self-restoring feature; instant operation; low power consumption; frequency response 50-20,000 cps ± 1.5 db; less than 5% distortion at rated output (less than 3% at 200 watts); noise level 80 db below rated output; and provision for operating the unit from a 24-volt battery.



### SOLID-STATE STEREO RECEIVER

**24** **Harman-Kardon, Inc.** has added the Model SR-400 AM/FM-stereo receiver to its "Stratophonic" line of equipment. The new unit includes an AM/FM-stereo tuner, plus stereo preamp and amplifier. According to the company, the SR-400

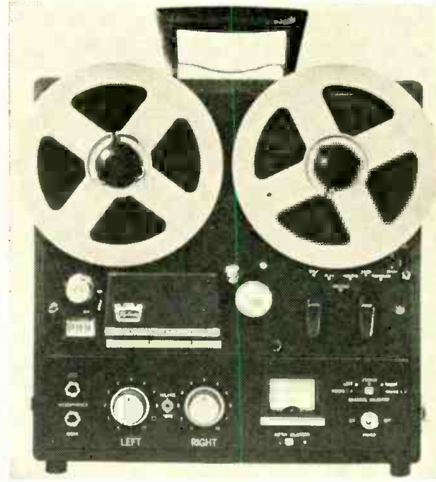
is flat ± 1 db @ 1 watt from 6 to 25,000 cps. IHF music power output is rated at 36 watts, 18 watts per channel. Unusual transient response is indicated by a square-wave rise time of only 5 μsec. Usable FM sensitivity is 2.9 μv., IHF, and spurious response rejection is better than 60 db. AM sensitivity is 60 μv./meter.

The unit features a d'Arsonval tuning meter, stereo indicator light, contour switch, high-cut and low-cut switches, balance control, bass and treble controls, tape recorder output, and two convenience outlets.

The receiver is 14½" wide x 4½" high x 11½" deep.

### LOW-COST STEREO RECORDER

**25** **Roberts Electronics** is marketing a low cost stereo recorder as the Model 1620. The unit features 4-track stereo/mono record/play, record




interlock, edit-pause control, automatic shut-off, professional vu meter, stereo mike inputs, FM-multiplex inputs, separate stereo tone and volume controls. Included are two 7" oval speakers and outputs for extension speakers plus outputs for stereo headphones.

The unit operates at 3¾ and 7½ ips with 15 ips available with an optional accessory.

### 350-WATT P.A. SYSTEM

**26** **Applied Electro Mechanics, Inc.** has recently introduced a new 350-watt, completely portable public address system which is being marketed as the "Loudhailer."

According to the company, the unit is capable of projecting audio signals up to 2½ miles, or up to ten miles with paralleled units. The complete system includes batteries and speakers and weighs less than 50 pounds. The unit is transistorized and built for rough use. The unit is available with electronic siren, general-quarters alarm,

# MOVING?

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and "people repeller," or curdler for riot control. Protective circuitry prevents damage from shorted outputs, overheating, and excessive input supply voltages.

Available inputs include 50, 600, and 2000 ohms as well as a 1-75-ohm output impedance. Operation is over a temperature range of −30 to 140 degrees F at altitudes up to 12,000 feet. The circuit is powered from a 7.5 ampere/hour nickel cadmium battery for two-hours' continuous operation of voice signals at maximum output.

### 360° SPEAKER SYSTEMS

27 **Circle-O-Phonic, Inc.** has recently introduced a new line of speaker systems featuring 360° sound dispersion as the result of a continually revolving speaker which permits sound coverage throughout the area.

The "Roman" series (photo) is available in three versions: with a hermetically sealed 10″ woofer with infinite baffle and 6″ revolving mid/hi-range speaker; with an 8″ or 12″ woofer with a 6″ revolving midrange and a 4″ revolving tweeter.

The system is housed in a hand-rubbed oiled walnut enclosure that measures 22½″ x 12½″ x 12½″. Frequency response is 45-20,000 cps (crossover at 1000 cps) and impedance is 8 ohms. The system will handle 40 watts of program material.

### FOUR-TRACK TAPE RECORDER

28 **North American Philips Company, Inc.** has added the "Continental 201" to its "Norelco" line of tape recorders. The new instrument is a two-speed, four-track recorder equipped with a wide range of built-in features and special accessories.

This mono recorder features dual preamplifiers for stereo playback through an external hi-fi system. It incorporates special facilities for parallel operation and for mixing inputs for the microphone and a radio or phonograph smultaneously. In addition, the unit can be used as a self-contained p.a. system.

The 201 operates at 7½ or 3¾ ips, providing up to 8 hours' playing time from a single seven-inch reel. The unit has a tape pause control and tone control. Complete with a moving coil microphone, the recorder has a frequency response of 60-16,000 cps. The weight is 18 pounds.

## CB-HAM-COMMUNICATIONS

### BUMPER-MOUNTING MOBILE WHIP

29 **B&K/Mark Division of Dynascan Corporation** is now in production on its Model SM-27A "Hot Rod" CB mobile bumper-mounting antenna designed for the 27-mc. CB service.

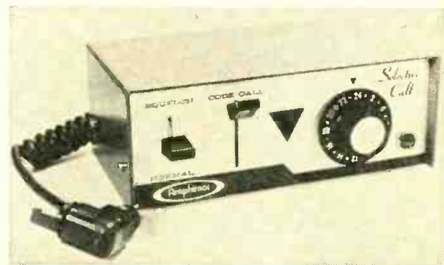
According to the company, the new whip provides "roof-top performance without holes in your car." The feed cable is internally connected to the antenna at its midpoint. This lowers the angle of radiation and extends the communications range because more of the signal travels at ground level. At the same time, because the feedpoint is above deck level when bumper mounted, the signal has almost the same strength in all directions.

The "Hot Rod" is extremely rugged. The top 40-inch whip section is of flexible 17-7ph stainless steel, taper ground. The lower 32-inch section is of aircraft alloy tubular aluminum. The inductor, near the center of the antenna, is covered with long-lasting vinyl. The coaxial feed cable extends 20 feet from the base of the antenna.

### NEW LINE OF CB EQUIPMENT

30 **Amphenol-Borg Electronics Corporation** has entered the CB equipment field with four units: an encoder-decoder, high-performance CB transceivers, low-profile CB transceiver for multi-channel operation, and hand-held transceivers for field communications.

The encoder-decoder, designated the 524 "Selective Call," is a tone-actuated squelch which silences the transceiver to which it is attached until the operator of a similarly equipped transceiver sends the proper 3-tone call.



Although matching the company's CB transceiver in styling, this unit can be used with any CB equipment having an integral 12-volt d.c. supply. The 524 (photo) is completely solid-state and measures 8″ x 5″ x 3″.

Details on the other units offered in this new line will be supplied by the manufacturer on request.

### 12-CHANNEL CB TRANSCEIVER

31 **The Hallicrafters Co.** is now marketing a new 12-channel, fully transistorized CB transceiver with three-stage transmitter and dual-conversion superhet receiver. Sensitivity is better than 1 $\mu$v. for 10 db S/N. Special audio circuitry in the unit allows the use of an external paging speaker. Audio output is 3.5 watts.

A new solid-state noise limiter and internal filtering combine to sharply reduce interference, according to the company. An adjustable squelch circuit and adjacent-channel and image-rejection circuits are also provided. Squelch is dual-zener regulated for absolute stability regardless of supply voltage variations. Battery drain is 0.2 amp. on receive and 1 amp. on transmit.

Chassis dimensions are 2⅝″ high, 6″ long, and 9½″ deep. Construction is rugged for heavy-

duty performance under severe operating conditions. The unit comes complete with push-to-talk microphone, one set of crystals, and a mobile mounting kit. An a.c. power supply for base station installations is available as the P-12.

### 23-CHANNEL CB RECEIVER

32 **Eico Electronic Instrument Co., Inc.** has announced a new 23-channel CB radiotelephone for direct operation from a 12-volt battery or 117-volt a.c. power source.

The "Sentinel-23" employs a frequency synthesizer to obtain crystal-controlled transmission and reception on all of the 23 available CB channels. The desired channel is selected with a single front-panel control and the number of the selected channel appears in an illuminated window.

The dual-conversion superhet receiver circuit has a sensitivity rating of 0.25 $\mu$v. for 10 db S/N. A 3-kc. bandspread control enables optimum

tuning to a station transmitting slightly off frequency. Primary image rejection is better than 60 db.

By means of a front-panel switch, unit may be converted into a mobile or fixed p.a. system, utilizing the built-in 3½-watt amplifier to drive an external speaker. The transceiver has a transistor switching power supply and can be operated directly from a 12-volt d.c. source or 117 volts a.c.

### MONITORING CONVERTER

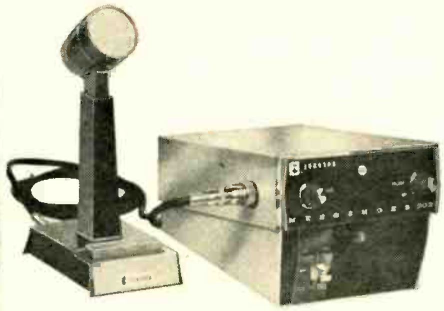
33 **Scientific Associates Corp.** has added a new transistorized model to its line of r.f. converters. Two models of the new v.h.f. converter are available: a fixed frequency unit which permits auto or home radio dial tuning through any


1-mc. segment of the 108-170 mc. range and a tunable unit (photo) to enable continuous tuning across the entire v.h.f. frequency band.

Both models feature a built-in radio squelch circuit which may be internally connected by the purchaser. The unit itself measures only 5" x 3" x 2¼". A front-panel switch permits instant changeover from regular broadcast reception to v.h.f. monitoring.

### BUSINESS/INDUSTRIAL TRANSCEIVER

34 **E. F. Johnson Company** has recently introduced a compact, all-transistor business/industrial two-way transceiver as the "Messenger



303." The new unit is instantly adaptable for base station, mobile, or portable field-pack use and, with an accessory weatherproof speaker, may also be used as a p.a. system.

The unit is designed for use on the business/industrial frequencies between 25 and 50 mc. and is FCC type-accepted. The shock and vibration resistant transceiver is less than 2¼" high, less than 6¼" wide, and just 8¼" deep.

Detailed specifications on the "303" are available from the manufacturer.

# MANUFACTURERS' LITERATURE

### SCOPE TRACES

35 **Jerrold Electronics Corp.,** Industrial Products Division, is currently distributing a 4-page pamphlet demonstrating its method of "total response measurement"—an easy, fast, accurate way of obtaining r.f. measurements as the result of four traces appearing on a scope simultaneously.

A number of scope-trace photographs are provided showing typical applications of this method, along with a reply card to be used for additional technical literature.

### HEAT SINKS

36 **Wakefield Engineering, Inc.** is offering a new 12-page distributor catalogue (No. 1965) covering the company's full line of heat sinks and accessories. Complete with photos, device dimensions, specifications, and weights, the brochure lists nine different series of heat sinks, including featherweight coolers, forced-convection heat sinks, and new king-size heat sinks.

Scattered throughout the booklet are numerous curves showing thermal and other characteristics of the heat sinks discussed.

### COMPONENTS CATALOGUE

37 **Waldom Electronics, Inc.** has released a new 40-page catalogue covering in detail the company's complete stock of terminals, hardware, and components for the electronic and electrical industries.

Solderless terminals and connectors occupy 23 pages in the booklet, while 8 pages are devoted to the firm's broad line of hardware, including screws, washers, cable clamps, and terminal strips.

Three different indexes are provided for quick, convenient reference.

### TARGET RECOGNITION

38 **Radio Corporation of America,** Defense Electronic Products, is now offering a 20-page technical discussion entitled "An Introduction to Radar Target Recognition." Fully illustrated and complete with bibliography, the article presents basic concepts underlying the analysis of foreign satellites passing over the U.S.

The paper first points out the need for reliable identification of unknown objects, especially where defense activities are concerned, and then goes on to explain the numerous problems encountered in satellite identification and how radar is employed for satellite recognition.

### FIXED CARBON RESISTORS

39 **Speer Resistor Division** has recently published a 16-page brochure on the manufacture of its fixed carbon-composition resistors. Printed on heavy stock and containing a number of dramatic photographs, "The **Speer** Resistor Handbook" outlines production methods, quality-control and inspection procedures, specifications, and performance data.

### AUDIO PRODUCTS CATALOGUE

40 **Sonotone Corporation's** Electronic Applications Division has published a 16-page catalogue covering all of its audio products sold to the OEM and distributor markets. The publication illustrates in detail and describes completely the firm's line of ceramic and crystal phono cartridges, replacement needles, tonearms, ceramic microphones, and learning-lab microphone units. It also covers the company's line of speakers and compact high-compliance speaker systems.

### CAPACITOR DATA

41 **Hammarlund Manufacturing Company** has issued a new capacitor catalogue which lists 88 types of standard variable air capacitors stocked by more than 400 of the firm's authorized distributors in the U.S. and Canada.

The catalogue also provides designers of OEM equipment information on a wide range of special capacitors available from the firm, as well as 12 pages of data on standard capacitors.

### SWITCH/LIGHT ASSEMBLY

42 **The Ucinite Company** has issued a data sheet which describes a new "Switch-Lite" assembly incorporating a subminiature switch and illuminated plunger with an independent lamp circuit. The device is suited for designs requiring a s.p.d.t. switch with an integral pilot light.

The bulletin contains complete specifications on this new component.

### FULL-LINE PRODUCT CATALOGUE

43 **Eico Electronic Instrument Company, Inc.** has issued a 36-page 1965 catalogue covering its complete line of kits and wired electronic equipment. The publication covers well over 200 products including hi-fi and stereo components, test and measuring instruments, CB transceivers, ham gear, and educational training aids.

Each item is described in depth with all of the important details of each unit pinpointed for "at-a-glance" identification. Photos illustrate every item.

### MICROMINIATURE LAMPS

44 **Pinlite Division, Kay Electric Co.** has just released a 16-page catalogue covering its full and expanded line of microminiature incandescent lamps for a wide range of applications in micromodules and completed microminiature assemblies.

The catalogue details performance and application features of the new microminiature multi-filament lamp as well as full information on other lamps in the line; graphs and diagrams showing light life-voltage relationships; life expectancy data; response time; use in transistor applications; and vibration and shock resistance.

### ALUMINUM SOLDERING

45 **Aluminum Company of America** has published a comprehensive 124-page handbook on aluminum soldering entitled "Soldering Alcoa Aluminum." Latest in the firm's hard-cover manual series, the fully illustrated book contains 13 chapters dealing extensively with materials, methods, and applications of soldering, as well as safety precautions.

The final chapter is devoted exclusively to data tables, and a glossary and index are provided for handy reference.

### REPORT ON GLASS

46 **Corning Glass Works** is now making available a revised edition of its booklet, "This is Glass." Fifty-six beautifully illustrated pages are devoted to reviewing the history of glass and outlining the basic glass compositions, as well as describing the many uses of glass in science, electronics, lighting, the home, and art.

The newest research discoveries are covered, including bendable, chemically strengthened glass and photochromic glass that automatically darkens when exposed to light and clears when the light source is removed.

### BATTERY BROCHURE

**47** **Sonotone Corporation's** Battery Division has issued a new 4-page product-facility brochure entitled "This is **Sonotone**" which highlights the history and capability of the company's rechargeable nickel-cadmium batteries.

The brochure stresses the high reliability and quality assurance of these batteries and describes the procedures involved in their design and manufacture.

### PLUG GUIDE

**48** **ITT Cannon Electric** is currently offering a new plug catalogue (PG-7) which describes the company's various lines of multicontact electrical connectors. General information is provided concerning each connector series, including miniature circular, power/battery, high-temperature, and printed circuit, and the relationships and differences among the series are fully explained.

Also listed in the guide are other catalogues available for more completely detailed data on specific connector series.

### PRECISION TOOLS

**49** **Jonard Industries Corp.** has recently released a new 16-page precision-tool catalogue containing over 450 custom-design tools, adjusters, and gauges. Intended for maintenance and production engineers in all telecommunications and electronic service industries, the fully illustrated brochure (No. 200) lists 12 different classifications for easy identification. Accompanying diagrams show measurements and exact specifications, and a handy equivalence chart (millimeters to inches) is also provided.

### PRODUCT CATALOGUE

**50** **Alvin & Company, Inc.** is now supplying copies of its new 1965 product catalogue, 164 pages of illustrations and full descriptions of various items for draftsmen, designers, technical illustrators, and students. Included are drawing sets, drafting instruments and materials, new visual-aid equipment, and map and surveying tools. A special 32-page section covers a wide range of templates for a variety of uses.

### R.F. WATTMETERS

**51** **Bird Electronic Corporation** is now distributing a 6-page technical discussion of the firm's "Thruline" series of directional r.f. wattmeters. Entitled "Have Wave, Will Travel," the paper demonstrates how these instruments discriminate between incident and reflected wave power, how to use them most effectively, and what to expect under operating conditions other than routine.

Along with the technical paper, the company is also supplying a 4-page short-form Catalogue SF-65, which includes the "Thruline" series among the r.f. power-measurement equipment listed.

### LOUDSPEAKER CATALOGUE

**52** **Electro-Voice, Inc.** has recently published a fully illustrated, 2-color catalogue of high-efficiency speaker systems and enclosures, high-fidelity loudspeakers, and systems kits. Over 60 different products are covered in this 12-page Catalogue 163, and each product description is accompanied by complete electrical and mechanial specifications.

Featured is the company's "Wolverine" series of full-range and three-way loudspeakers.

### COMPUTER TAPE

**53** **General Kinetics Incorporated** has announced publication of a 12-page illustrated booklet entitled "The Technical View," a discussion of the physical characteristics of magnetic tape, as well as its significance in computer operations.

First of a three-part series on techniques for the control of performance and life expectancy of computer tapes, this concisely written pamphlet outlines the causes of faulty tape, maintenance procedures to be followed to avoid tape failures, and the objectives of a tape-management program.

### SCR TRANSFORMERS

**54** **Aladdin Electronics** has made available two new engineering bulletins on SCR transformers and applications. The first (Vol. 4, No. 4) discusses how SCR transformers may be used with a unijunction transistor, making the trigger circuit sensitive to specific frequencies.

The second application note (Vol. 4, No. 5) covers the design of a unijunction transistor trigger circuit for SCR applications and suggests that triggering may be greatly improved by the use of a pulse transformer rather than resistance coupling. ▲

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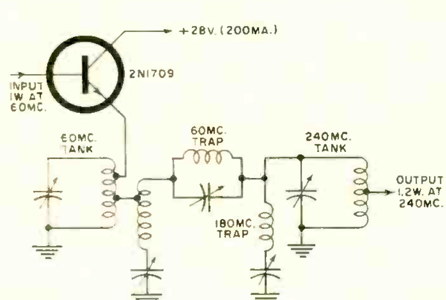

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| HP 500B Freq Mtr. | 150.00 |
| HP 200D Audio Gen. | 95.00 |
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**CIRCLE NO. 221 ON READER SERVICE PAGE**

## Rectifiers & Transistors

| 750 ma. Silicon Diodes "Epoxy" or "Top Hat" PIV | | PIV | | Silicon Power Diode Stud 3 amps. PIV | | PIV | |
|---|---|---|---|---|---|---|---|
| 50 | 5¢ | 600 | 21¢ | 25 | 6¢ | 300 | 25¢ |
| 100 | 7¢ | *700 | 25¢ | 50 | 8¢ | 400 | 28¢ |
| 200 | 10¢ | *800 | 32¢ | 100 | 14¢ | 500 | 35¢ |
| 400 | 14¢ | *900 | 40¢ | 150 | 16¢ | 600 | 40¢ |
| 500 | 18¢ | *Top hat only | | 200 | 22¢ | All tests | |

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10 watt Sil. Zener stud 6-150v .......... 95¢ ea.
1 Watt Zener Diode Axial leads 6v-200v .... 50¢ ea.
Sil. diode stud 1500piv 300 ma .......... 50¢ ea.
18 amp. Stud Sil. rectifier 100 piv 75¢ ea.
Sil diode 1500 piv, 50 ma, axial .......... 35¢ ea.
Hi-Voltage—Silicon epoxy diode, 2½"x⅜"x½",
HOFFMAN—3000 piv—200 ma. .......... $1.49 ea.
HOFFMAN—6000 piv—200 ma. .......... $3.49 ea.
Thermistor, glass bead, 1200 ohms, 600°F. 2/$1.00
Silicon Power Transistors—85 w. 2N1724 $1.50

20 Watt Germanium (internal heat sink)

| | | | |
|---|---|---|---|
| 2n1038 | 6 for $1.00 | 2n1042 | 4 for $1.00 |
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Light sensitive Power transistor TO-3 case, with circuit instructions .......... $1.95 ea.

150 Watt Germanium Power

| | | | |
|---|---|---|---|
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Germanium switching transistors 2N1300 series assorted, tested, PNP or NPN 10 for $1.00
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| 100 | .80 | 1.20 | 400 | 2.10 | 2.70 |
| 150 | .80 | 1.50 | 500 | 2.80 | 3.30 |
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**CIRCLE NO. 140 ON READER SERVICE PAGE**

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SW LISTENERS GUIDE, easy to use. English programming. DOUBLES LISTENING PLEASURE. $2.00 SWL Guide, 218 Gifford, Syracuse, N. Y.

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HI-FI components, tape recorders, sleep learn equipment, tapes. Unusual Values. Free Catalog. Dressner, 1523 Jericho Turnpike, New Hyde Park 10, N.Y.

FREE! Send for money saving stereo catalog #E6W and lowest quotations on your individual component, tape recorder or system requirements. Electronic Values Inc,, 200 West 20th Street, N.Y., N.Y. 10011.

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**DISCOUNTS** on all LP's. Free details. Citadel Record Club, 545 Fifth Ave., Dept. 21, New York 17, N.Y.

## PATENTS

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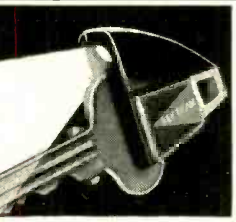

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| Type | Price |
|---|---|
| 00A/UV 200 | 2.00 |
| 01A | 2.00 |
| 0A2 | .90 |
| 0A3 | .90 |
| 0A4G | 1.55 |
| 0B2 | .80 |
| 0B3 | 1.20 |
| 0C3 | .85 |
| 0D3 | .75 |
| 0G3 | 2.75 |
| 0Y4 | 1.20 |
| 0Z4 | .95 |
| 1A3 | 1.95 |
| 1A5 | 1.49 |
| 1A6 | 1.49 |
| 1A7 | 1.95 |
| 1AB5 | .75 |
| 1AD4 | 1.75 |
| 1AE4 | 1.30 |
| 1AF4 | 1.45 |
| 1AG4 | 2.20 |
| 1AH4 | 1.75 |
| 1AJ5 | 1.05 |
| 1AU3 | 1.25 |
| 1AX2 | .95 |
| 1AY2 | .98 |
| 1B3 | .97 |
| 1B4P | 2.00 |
| 1C5 | 1.10 |
| 1C6 | 1.25 |
| 1D5GP | 1.25 |
| 1D7 | 1.25 |
| 1DN5 | .95 |
| 1E5GP | .98 |
| 1E7 | .99 |
| 1F4 | .95 |
| 1F5 | .95 |
| 1F6 | 1.20 |
| 1G3 | .97 |
| 1G4 | 1.75 |
| 1G6 | 1.50 |
| 1H4 | 1.50 |
| 1H5 | 1.19 |
| 1H6 | 1.25 |
| 1J3 | .97 |
| 1J5 | 1.25 |
| 1J6 | 1.25 |
| 1K3 | .97 |
| 1L4 | .95 |
| 1L6 | 2.60 |
| 1LA4 | 1.95 |
| 1LA6 | 1.95 |
| 1LB4 | 2.49 |
| 1LC5 | 1.95 |
| 1LC6 | 1.95 |
| 1LD5 | 1.95 |
| 1LE3 | 1.95 |
| 1LG5 | 2.25 |
| 1LH4 | 2.69 |
| 1LN5 | 2.25 |
| 1N5 | 1.85 |
| 1P5 | 2.25 |
| 1Q5 | 1.95 |
| 1R4 | .80 |
| 1R5 | .99 |
| 1S2A | 1.19 |
| 1S4 | 1.49 |
| 1S5 | .99 |
| 1T4 | .99 |
| 1T5 | 1.00 |
| 1U4 | .99 |
| 1U5 | .97 |
| 1V | 1.85 |
| 1V2 | .79 |
| 1X2B | 1.05 |
| 1Z2 | 3.25 |
| 2A3 | 3.25 |
| 2A5 | 2.95 |
| 2A6 | 3.75 |
| 2A7 | 1.50 |
| 2AF4A | 1.39 |
| 2AH2 | 1.19 |
| 2AS2 | 1.19 |
| 2B3 | 2.70 |
| 2B7 | 1.95 |
| 2BN4 | .98 |
| 2CY5 | 1.15 |
| 2D21 | .75 |
| 2DZ4 | 1.95 |
| 2EA5 | 1.45 |
| 2EN5 | .83 |
| 2ER5 | 1.60 |
| 2FH5 | 1.40 |
| 2FQ5 | 1.95 |
| 2FS5 | 2.55 |
| 2FY5 | 1.49 |
| 2GK5 | 1.57 |
| 2GU5 | 1.69 |
| 2GW5 | 2.40 |
| 2HK5 | .98 |
| 2X2 | .60 |
| 2X2A | 1.30 |
| 3A2 | 1.45 |
| 3A3 | 1.29 |
| 3A4 | .74 |
| 3A5 | 1.19 |
| 3AF4 | 1.49 |
| 3AL5 | .87 |
| 3AT2 | 1.23 |
| 3AU6 | .55 |
| 3AV6 | .68 |
| 3AW3 | 1.31 |
| 3B2 | 1.29 |
| 3B7 | 1.35 |
| 3BA6 | .95 |
| 3BC5 | .89 |
| 3BE6 | .86 |
| 3BN4 | 1.18 |
| 3BN6 | 1.35 |
| 3BU8 | 1.27 |
| 3BY6 | 1.05 |
| 3BZ6 | .84 |
| 3CB6 | .85 |
| 3CE5 | .89 |
| 3CF6 | .98 |
| 3CS6 | .95 |
| 3CY5 | 1.18 |
| 3D6 | 1.49 |
| 3DG4 | 1.35 |
| 3DK6 | .87 |

| Type | Price |
|---|---|
| 3DT6 | .79 |
| 3DZ4 | 1.59 |
| 3EH7 | 1.42 |
| 3EJ7 | 1.42 |
| 3ER5 | 1.35 |
| 3FH5 | .95 |
| 3FS5 | 1.18 |
| 3GK5 | 1.55 |
| 3GS8 | 1.27 |
| 3GW5 | .98 |
| 3HA5 | 1.49 |
| 3HK5 | 1.23 |
| 3H58 | 1.29 |
| 3Q4 | 1.35 |
| 3Q5 | 2.00 |
| 3S4 | 1.10 |
| 3V4 | .93 |
| 4AU6 | .89 |
| 4AV6 | .70 |
| 4BA6 | .85 |
| 4BC5 | .90 |
| 4BC8 | 1.02 |
| 4BL8 | 1.00 |
| 4BN6 | 1.48 |
| 4BQ7 | 1.40 |
| 4BS8 | 1.35 |
| 4BU8 | 1.25 |
| 4BZ6 | .85 |
| 4BZ7 | 1.49 |
| 4CB6 | .87 |
| 4CS6 | .59 |
| 4CY5 | 1.10 |
| 4DE6 | 1.01 |
| 4DK6 | .58 |
| 4DT6 | .87 |
| 4EH7 | 1.47 |
| 4EJ7 | 1.47 |
| 4EM6 | 1.19 |
| 4ES8 | 1.79 |
| 4EW6 | 1.01 |
| 4GK5 | 1.59 |
| 4GM6 | 1.25 |
| 4GS8 | 1.25 |
| 4GZ5 | .91 |
| 4GZ6 | 1.19 |
| 4HA5 | 1.85 |
| 4HC7 | 1.39 |
| 4HM6 | .91 |
| 4HS8 | 1.18 |
| 4HT6 | 1.24 |
| 4JC6 | 1.35 |
| 4JD6 | 1.35 |
| 5AM8 | 1.34 |
| 5AN8 | 1.45 |
| 5AQ5 | .52 |
| 5AR4 | 1.72 |
| 5AS8 | 1.75 |
| 5AT8 | 1.35 |
| 5AU4 | 1.25 |
| 5AV8 | 1.52 |
| 5AW4 | 1.00 |
| 5AZ4 | 1.98 |
| 5B8 | 2.09 |
| 5BC3 | .89 |
| 5BE8 | 1.27 |
| 5BK7 | 1.25 |
| 5BQ7 | 1.45 |
| 5BR8 | .81 |
| 5BT8 | 1.25 |
| 5BW8 | 1.31 |
| 5CG8 | 1.25 |
| 5CL8 | 1.30 |
| 5CM8 | 1.47 |
| 5CQ8 | 1.52 |
| 5CZ5 | 1.70 |
| 5DE8 | 1.15 |
| 5DJ4 | 1.00 |
| 5EA8 | 1.21 |
| 5ES8 | 2.21 |
| 5EU8 | 1.29 |
| 5EW6 | 1.01 |
| 5FG7 | 1.07 |
| 5FV8 | 1.21 |
| 5GH8 | 1.50 |
| 5GJ7 | 1.62 |
| 5GM6 | 1.00 |
| 5GX6 | .89 |
| 5HC7 | 1.49 |
| 5HG8 | 1.69 |
| 5J6 | 1.02 |
| 5KE8 | 1.90 |
| 5T4 | 4.25 |
| 5T8 | 1.35 |
| 5U4 | .75 |
| 5U8 | 1.25 |
| 5V3 | 1.59 |
| 5V4 | 1.45 |
| 5V6 | .65 |
| 5W4 | 1.75 |
| 5X4 | .99 |
| 5X8 | .84 |
| 5Y3 | .65 |
| 5Y4 | 1.45 |
| 5Z3 | 2.00 |
| 5Z4 | 2.95 |
| 6A3 | 2.75 |
| 6A4 | 2.20 |
| 6A6 | 1.75 |
| 6A7 | 3.15 |
| 6ABGT | 1.95 |
| 6A8M | 2.50 |
| 6AB4 | .79 |
| 6AB5 | 3.10 |
| 6AB7 | 2.10 |
| 6AC5 | 2.25 |
| 6AC7 | 1.75 |
| 6AD7 | 3.25 |
| 6AE5 | 2.50 |
| 6AF3 | 1.10 |
| 6AF4 | 1.45 |
| 6AF4A | .99 |
| 6AF6 | 2.65 |
| 6AF11 | 1.95 |
| 6AG5 | .95 |
| 6AG7 | 1.[illegible] |
| 6AH4 | 1.25 |
| 6AH6 | 1.55 |
| 6AJ5 | 2.25 |
| 6AJ8 | 1.73 |
| 6AK5 | 1.50 |
| 6AK6 | .94 |

| Type | Price |
|---|---|
| 6AL3 | 1.00 |
| 6AL5 | .45 |
| 6AL7 | 1.95 |
| 6AL11 | 1.65 |
| 6AM8 | 1.25 |
| 6AN4 | 2.59 |
| 6AN5 | 1.95 |
| 6AN6 | 2.45 |
| 6AN8 | 1.50 |
| 6AQ5 | .79 |
| 6AQ6 | .99 |
| 6AQ7 | 1.55 |
| 6AQ8 | 1.20 |
| 6AR5 | .99 |
| 6AR6 | 1.50 |
| 6AR8 | 2.00 |
| 6AR11 | 1.65 |
| 6AS5 | .79 |
| 6AS6 | 1.00 |
| 6AS7 | 2.85 |
| 6AS8 | 1.45 |
| 6AS11 | 1.95 |
| 6AT6 | .49 |
| 6AT8 | 1.40 |
| 6AU4 | .95 |
| 6AU5 | 1.60 |
| 6AU6 | .52 |
| 6AU7 | .54 |
| 6AU8 | 1.40 |
| 6AV5 | 1.45 |
| 6AV6 | .44 |
| 6AV11 | 1.52 |
| 6AW8 | 1.35 |
| 6AX3 | 1.05 |
| 6AX4 | .94 |
| 6AX5 | 1.15 |
| 6AX7 | 1.25 |
| 6AX8 | 1.34 |
| 6AY3 | 1.05 |
| 6AZ8 | 2.18 |
| 6B4 | 5.95 |
| 6B5 | 4.00 |
| 6B7 | 2.75 |
| 6B8 | 2.50 |
| 6B10 | 1.35 |
| 6BA3 | 1.05 |
| 6BA6 | .49 |
| 6BA7 | 2.15 |
| 6BA8 | 1.48 |
| 6BA11 | 1.45 |
| 6BC4 | 2.10 |
| 6BC5 | .62 |
| 6BC7 | 1.47 |
| 6BC8 | 1.55 |
| 6BD4 | 7.00 |
| 6BD5 | 1.20 |
| 6BD6 | .94 |
| 6BE3 | 1.15 |
| 6BE6 | .84 |
| 6BF5 | 1.39 |
| 6BF6 | .72 |
| 6BF8 | 1.65 |
| 6BG6 | 2.35 |
| 6BH6 | 1.00 |
| 6BH8 | .94 |
| 6BJ6 | .69 |
| 6BJ7 | 1.19 |
| 6BJ8 | 1.35 |
| 6BK4 | 2.95 |
| 6BK5 | 1.42 |
| 6BK7 | 1.29 |
| 6BL7 | 1.19 |
| 6BL8 | 1.52 |
| 6BM8 | 1.10 |
| 6BN4 | .98 |
| 6BN6 | .74 |
| 6BN8 | 1.18 |
| 6BQ5 | .83 |
| 6BQ6/ 6CU6 | 1.45 |
| 6BQ7 | 1.40 |
| 6BR8 | 1.34 |
| 6BS8 | 1.42 |
| 6BU8 | .74 |
| 6BV8 | 1.19 |
| 6BW8 | 1.35 |
| 6BX7 | 1.62 |
| 6BY5 | 1.65 |
| 6BY6 | .98 |
| 6BY8 | 1.01 |
| 6BZ6 | .72 |
| 6BZ7 | 1.45 |
| 6BZ8 | 1.60 |
| 6C4 | .54 |
| 6C5M | 1.60 |
| 6C6 | 2.00 |
| 6C8G | 2.95 |
| 6C10 | 1.53 |
| 6CA4 | .77 |
| 6CA5 | 1.20 |
| 6CA7 | 1.95 |
| 6CB5 | 3.25 |
| 6CB6 | .55 |
| 6CD6 | 2.05 |
| 6CF6 | .95 |
| 6CG7 | .63 |
| 6CG8 | .85 |
| 6CH8 | 2.00 |
| 6CK4 | 1.00 |
| 6CL6 | 1.12 |
| 6CL8 | .94 |
| 6CM6 | 1.29 |
| 6CM7 | .95 |
| 6CM8 | 1.45 |
| 6CN7 | .92 |
| 6CQ4 | 1.25 |
| 6CQ7 | 1.80 |
| 6CQ8 | 1.15 |
| 6CR6 | .91 |
| 6CS6 | .85 |
| 6CS7 | .99 |
| 6CU5 | .84 |
| 6CU6 | 1.45 |
| 6CU8 | 1.59 |
| 6CW4 | 1.69 |
| 6CWS | 1.39 |
| 6CX8 | 1.49 |
| 6CY5 | .99 |
| 6CY7 | 1.22 |
| 6CZ5 | 1.59 |
| 6CZ7 | 1.95 |

| Type | Price |
|---|---|
| 6D4 | 1.75 |
| 6D6 | 2.50 |
| 6D10 | 1.59 |
| 6DA4 | .99 |
| 6DAS | 1.08 |
| 6DB5 | 1.99 |
| 6DB6 | 1.01 |
| 6DC6 | 1.29 |
| 6DC8 | 1.25 |
| 6DE4 | 1.03 |
| 6DE6 | .93 |
| 6DE7 | 1.29 |
| 6DG6 | .95 |
| 6DJ8 | 1.65 |
| 6DK6 | .89 |
| 6DN6 | 2.74 |
| 6DN7 | 1.35 |
| 6DQ5 | 2.75 |
| 6DQ6 | 1.50 |
| 6DR7 | 1.29 |
| 6DS4 | 1.69 |
| 6DS5 | 1.21 |
| 6DT5 | .95 |
| 6DT6 | .75 |
| 6DT8 | 1.35 |
| 6DV4 | 2.39 |
| 6DW4 | 1.39 |
| 6DW5 | 1.55 |
| 6DX8 | 1.19 |
| 6DZ4 | 1.53 |
| 6E5 | 1.89 |
| 6EA5 | 1.55 |
| 6EA7 | 1.47 |
| 6EA8 | 1.19 |
| 6EB5 | 1.75 |
| 6EB8 | 1.60 |
| 6EH5 | 1.10 |
| 6EH7 | .79 |
| 6EH8 | 1.21 |
| 6EJ7 | 1.39 |
| 6EM5 | 1.29 |
| 6EM7 | 1.93 |
| 6EQ7 | 1.10 |
| 6ER5 | 1.35 |
| 6ES5 | 1.15 |
| 6ES8 | 2.19 |
| 6ET7 | 1.60 |
| 6EU7 | 1.03 |
| 6EU8 | 1.25 |
| 6EV5 | 1.10 |
| 6EW6 | .92 |
| 6EW7 | 1.52 |
| 6EY6 | 1.23 |
| 6EX6 | 2.79 |
| 6EZ5 | 1.39 |
| 6EZ8 | 1.41 |
| 6FA7 | 1.10 |
| 6FD7 | 1.73 |
| 6F4 | 3.95 |
| 6F5GT | 1.50 |
| 6F5M | 1.72 |
| 6F6G | 1.95 |
| 6F6M | 2.19 |
| 6F7 | 3.95 |
| 6F8 | 3.25 |
| 6FG5 | 1.99 |
| 6FG6 | 1.[illegible] |
| 6FG7 | 1.10 |
| 6FG8 | 1.75 |
| 6FH5 | .92 |
| 6FJ5 | 2.25 |
| 6FJ7 | 1.39 |
| 6FM7 | 1.31 |
| 6FQ7 | .89 |
| 6FS5 | 1.19 |
| 6FV6 | 1.33 |
| 6FV8 | 1.15 |
| 6FW5 | 1.59 |
| 6FW8 | 3.49 |
| 6FY5 | 1.11 |
| 6G5 | 1.95 |
| 6G6G | 1.55 |
| 6G11 | 1.69 |
| 6GB5 | 1.81 |
| 6GC5 | 1.19 |
| 6GE5 | 1.59 |
| 6GE7 | 1.19 |
| 6GF5 | 1.42 |
| 6GF7 | 1.69 |
| 6GH8 | 1.19 |
| 6GJ5 | 1.69 |
| 6GJ7 | 1.37 |
| 6GK5 | 1.55 |
| 6GK6 | .99 |
| 6GL7 | 1.95 |
| 6GM5 | 1.21 |
| 6GM6 | .91 |
| 6GN8 | 1.35 |
| 6GQ7 | 1.89 |
| 6GR7 | 1.42 |
| 6GT5 | 1.49 |
| 6GV5 | 1.65 |
| 6GV6 | 1.85 |
| 6GW6 | 1.55 |
| 6GW8 | 1.21 |
| 6GX6 | .88 |
| 6GX8 | 1.31 |
| 6GY5 | 1.89 |
| 6GY6 | .87 |
| 6GZ5 | 1.16 |
| 6HA5 | 1.45 |
| 6HB5 | 1.69 |
| 6HF5 | 2.79 |
| 6HF8 | 1.45 |
| 6HG8 | 1.69 |
| 6HJ8 | 1.25 |
| 6HK5 | 1.19 |
| 6HL8 | 1.19 |
| 6HS6 | 1.21 |
| 6HT6 | 1.19 |
| 6HZ6 | .99 |
| 6H6M | .79 |
| 6J4 | 2.95 |
| 6J5G | .95 |
| 6JB6 | 1.76 |
| 6JC8 | 1.15 |
| 6JE6 | 2.99 |
| 6JE8 | 1.49 |
| 6J5M | 1.30 |
| 6J5GT | 1.20 |
| 6J7GT | 1.49 |
| 6J6 | .72 |

| Type | Price |
|---|---|
| 6J7 | 1.85 |
| 6J7G | 1.25 |
| 6J8 | 2.50 |
| 6J11 | 1.82 |
| 6JH6 | .99 |
| 6JH8 | 1.69 |
| 6JK8 | 1.30 |
| 6JS6 | 2.95 |
| 6JT8 | 1.69 |
| 6JV8 | 1.49 |
| 6JZ8 | 1.44 |
| 6K6GT | .95 |
| 6K7 | 1.70 |
| 6K7GT | 1.49 |
| 6K8GT | 1.25 |
| 6K8M | 2.75 |
| 6K11 | 1.49 |
| 6KD8 | 1.39 |
| 6KT8 | 1.23 |
| 6KU8 | 1.15 |
| 6LB8 | 1.49 |
| 6L5G | 1.50 |
| 6L6G | .98 |
| 6L6GA | 1.50 |
| 6L6GB | 1.50 |
| 6L6GC | 1.61 |
| 6L6M | 3.30 |
| 6L7M | 2.50 |
| 6L7G | 1.75 |
| 6M11 | 1.81 |
| 6N5 | 3.10 |
| 6N7G | 1.49 |
| 6N7M | 1.85 |
| 6N7GT | 1.75 |
| 6P5 | 2.50 |
| 6Q7GT | 1.95 |
| 6Q7M | 2.00 |
| 6Q11 | 1.29 |
| 6R7 | 1.75 |
| 6S4 | .56 |
| 6S7 | 1.95 |
| 6S8GT | 1.50 |
| 6SA7GT | 1.39 |
| 6SA7M | 1.49 |
| 6SB7Y | 2.35 |
| 6SC7 | 1.65 |
| 6SD7 | 1.49 |
| 6SF5 | 1.19 |
| 6SF5GT | 1.20 |
| 6SF7 | 1.95 |
| 6SG7 | 1.65 |
| 6SG7GT | 1.45 |
| 6SH7 | 1.21 |
| 6SJ7GT | 1.49 |
| 6SJ7M | 1.49 |
| 6SK7GT | 1.25 |
| 6SK7M | 1.45 |
| 6SL7GT | 1.25 |
| 6SN7GT | .93 |
| 6SQ7GT | 1.25 |
| 6SQ7M | 1.45 |
| 6SR7 | 1.42 |
| 6SU7 | 2.00 |
| 6SS7M | 1.05 |
| 6SS7GT | 1.89 |
| 6SZ7 | 1.25 |
| 6T4 | 1.15 |
| 6T8 | 1.23 |
| 6U5/ 6G5 | 1.95 |
| 6U8 | 1.29 |
| 6U8GT-G | 1.10 |
| 6V3 | 1.79 |
| 6V4 | .59 |
| 6V6GT | .79 |
| 6V6M | 2.39 |
| 6W4 | .89 |
| 6W6GT | 1.03 |
| 6X4 | .60 |
| 6X5GT | .75 |
| 6X8A | 1.30 |
| 6Y6GA | 1.65 |
| 7A4 | 1.75 |
| 7A5 | 1.75 |
| 7A6 | 1.85 |
| 7A7 | 2.25 |
| 7A8 | 2.75 |
| 7AD7 | 1.25 |
| 7AF7 | 1.65 |
| 7AG7 | 2.85 |
| 7AH7 | 1.49 |
| 7AU7 | .67 |
| 7B4 | 2.25 |
| 7B5 | 2.75 |
| 7B6 | 1.25 |
| 7B7 | 2.25 |
| 7B8 | 2.00 |
| 7C4 | 1.15 |
| 7C5 | 1.25 |
| 7C6 | 2.75 |
| 7C7 | 1.25 |
| 7E5 | 1.25 |
| 7E6 | 1.25 |
| 7E7 | 1.33 |
| 7EY6 | 1.10 |
| 7F7 | 2.10 |
| 7F8 | 3.10 |
| 7G7 | 1.65 |
| 7H7 | 1.65 |
| 7HG8 | 1.29 |
| 7J7 | 2.50 |
| 7K7 | 3.00 |
| 7L7 | 1.99 |
| 7N7 | 2.75 |
| 7Q7 | 1.85 |
| 7R7 | 2.25 |
| 7S7 | 1.79 |
| 7V7 | 1.81 |
| 7W7 | 2.45 |
| 7X6 | 1.35 |
| 7X7 | 2.75 |
| 7Y4 | 2.25 |
| 7Y7 | 1.79 |
| 7Z4 | 1.95 |
| 8AU8 | 1.50 |
| 8AW8 | 1.35 |
| 8BH8 | 1.36 |
| 8BQ5 | .99 |
| 8CG7 | .95 |

| Type | Price |
|---|---|
| 8CM7 | 1.07 |
| 8CN7 | 1.05 |
| 8CS7 | .98 |
| 8CX8 | 1.60 |
| 8EB8 | 1.50 |
| 8EM5 | 1.19 |
| 8ET7 | 1.60 |
| 8FQ7 | .95 |
| 8GJ7 | 1.31 |
| 8GN8 | 1.27 |
| 8JV8 | 1.42 |
| 8KA8 | 1.55 |
| 9A8 | 1.40 |
| 9AU7 | 1.05 |
| 9BR7 | 1.32 |
| 9CL8 | 1.10 |
| 9EA8 | 1.49 |
| 9U8 | .99 |
| 10AL11 | 1.69 |
| 10BQ5 | 1.45 |
| 10C8 | 1.49 |
| 10DE7 | 1.29 |
| 10DX8 | 1.37 |
| 10EG7 | 1.49 |
| 10EM7 | 1.75 |
| 10EW7 | 1.45 |
| 10GN8 | 1.30 |
| 10HF8 | 1.75 |
| 10HT8 | 1.21 |
| 10JA8 | 1.35 |
| 10JY8 | 1.49 |
| 10KU8 | 1.15 |
| 10Y | .95 |
| 11CY7 | 1.10 |
| 11JE8 | 1.49 |
| 11KV8 | 2.35 |
| 12A4 | .95 |
| 12A5 | 1.25 |
| 12A6 | .89 |
| 12A7 | 1.95 |
| 12A8 | 2.95 |
| 12A11 | 1.69 |
| 12AB5 | .95 |
| 12AC6 | .75 |
| 12AD6 | .79 |
| 12AE6 | .79 |
| 12AE7 | 1.25 |
| 12AF3 | .95 |
| 12AF6 | .98 |
| 12AG6 | 1.49 |
| 12AJ6 | .91 |
| 12AL5 | .71 |
| 12AL8 | 2.45 |
| 12AL11 | 1.[illegible] |
| 12AQ5 | .85 |
| 12AT6 | .55 |
| 12AT7 | 1.05 |
| 12AU6 | .69 |
| 12AU7 | .90 |
| 12AV5 | 1.50 |
| 12AV6 | .59 |
| 12AV7 | 1.25 |
| 12AW6 | 1.10 |
| 12AX3 | 1.03 |
| 12AX4 | .75 |
| 12AX6 | .91 |
| 12AX7 | .92 |
| 12AY3 | 1.05 |
| 12AY7 | 1.55 |
| 12AZ7 | 1.00 |
| 12B4 | 1.00 |
| 12BA6 | .60 |
| 12BA7 | 1.90 |
| 12BD6 | .72 |
| 12BE3 | .99 |
| 12BE6 | .61 |
| 12BF6 | .68 |
| 12BH7 | .91 |
| 12BK5 | 1.22 |
| 12BL6 | .89 |
| 12BN6 | 1.48 |
| 12BQ6/ CU6 | 1.55 |
| 12BR7 | 1.15 |
| 12BQ6/ CU6 | 1.55 |
| 12BV7 | 1.32 |
| 12BW4 | 1.07 |
| 12BY7 | 1.15 |
| 12BZ6 | .76 |
| 12BZ7 | .95 |
| 12C5/ 12CU5 | .89 |
| 12CA5 | 1.00 |
| 12CN5 | 1.20 |
| 12CR6 | 1.00 |
| 12CS6 | .95 |
| 12CT8 | 1.60 |
| 12CU6/ BQ6 | 1.55 |
| 12CX6 | 1.05 |
| 12D4 | 1.05 |
| 12DB5 | 1.05 |
| 12DE5 | .92 |
| 12DE8 | 1.19 |
| 12DK7 | 1.05 |
| 12DL8 | 2.20 |
| 12DQ6 | 1.55 |
| 12DQ7 | 1.29 |
| 12DS7 | 1.40 |
| 12DT5 | 1.15 |
| 12DT7 | 1.05 |
| 12DT8 | 1.40 |
| 12DW7 | 1.19 |
| 12DY8 | 3.20 |
| 12DW8 | 1.25 |
| 12EC8 | 1.35 |
| 12EA6 | .99 |
| 12DZ6 | .98 |
| 12ED5 | .98 |
| 12EG6 | 1.03 |
| 12EK6 | .98 |
| 12EL6 | .71 |
| 12EM6 | 1.14 |
| 12EZ6 | .83 |
| 12F5 | 1.60 |
| 12F8 | .99 |
| 12FA6 | .97 |
| 12FK6 | .83 |
| 12FM6 | .81 |

| Type | Price |
|---|---|
| 12FQ8 | 1.19 |
| 12FR8 | 1.48 |
| 12FX5 | .96 |
| 12FX8 | 1.27 |
| 12GA6 | .91 |
| 12GC6 | 1.15 |
| 12GE5 | 1.46 |
| 12GW6 | 1.15 |
| 12H6 | 1.40 |
| 12J5 | 1.21 |
| 12J8 | 1.21 |
| 12JT6 | 1.97 |
| 12JB6 | 2.30 |
| 12K5 | 1.19 |
| 12K8G | 1.50 |
| 12K8M | 2.95 |
| 12L6 | .79 |
| 12L8 | .50 |
| 12Q7GT | 1.39 |
| 12Q7M | 1.50 |
| 12R5 | 1.[illegible] |
| 12SA7 | 1.60 |
| 12SA7GT | 1.60 |
| 12SC7M | 1.95 |
| 12SF5GT | 1.19 |
| 12SF5M | 1.50 |
| 12SF7M | 1.75 |
| 12SJ7GT | 1.35 |
| 12SG7M | 1.39 |
| 12SH7 | 1.55 / 1.25 |
| TYPE | PRICE |
| 12SJ7M | 1.39 |
| 12SK7GT | 1.45 |
| 12SK7M | 1.35 |
| 12SL7GT | 1.30 |
| 12SN7 | .89 |
| 12SQ7GT | 1.35 |
| 12SR7 | 1.95 |
| 12U7 | .95 |
| 12V6 | .95 |
| 12W6 | .89 |
| 12X4 | .59 |
| 13DE7 | 1.12 |
| 13DR7 | 1.29 |
| 13EM7 | 1.83 |
| 13FD7 | 1.89 |
| 13FM7 | 1.15 |
| 13GF7 | 1.79 |
| 14A4 | 1.45 |
| 14A5 | 1.35 |
| 14A7 | 1.39 |
| 14AF7 | 1.65 |
| 14B6 | 1.69 |
| 14B8 | 1.95 |
| 14C5 | 1.75 |
| 14C7 | 2.35 |
| 14E6 | 1.39 |
| 14E7 | 1.39 |
| 14F7 | 3.00 |
| 14F8 | 2.40 |
| 14GT8 | .95 |
| 14H7 | 1.95 |
| 14J7 | 1.95 |
| 14N7 | [illegible] |
| 14Q7 | 2.10 |
| 14R7 | 2.40 |
| 14S7 | 1.9[illegible] |
| 14W7 | 1.85 |
| 14X7 | [illegible] |
| 14Y4 | 1.75 |
| 15AF11 | 1.95 |
| 15CW5 | 1.02 |
| 15FY7 | 1.29 |
| 15HB6 | 1.25 |
| 15KY8 | 1.89 |
| 16AQ3 | .98 |
| 16GK6 | 1.25 |
| 16GK6 | 1.15 |
| 16GY5 | 1.03 |
| 17AX3 | 1.03 |
| 17AX4 | .89 |
| 17AY3 | .98 |
| 17BE3 | 1.19 |
| 17BQ6 | 1.49 |
| 17BS3 | 1.15 |
| 17C5 | 2.35 |
| 17C9 | 1.95 |
| 17D4 | 1.07 |
| 17DE4 | 1.25 |
| 17DM4 | 1.19 |
| 17DQ6 | 1.15 |
| 17DQ7 | 1.75 |
| 17EW8 | .99 |
| 17GE5 | 1.50 |
| 17GJ5 | 1.75 |
| 17GV5 | 1.69 |
| 17GW6 | 1.49 |
| 17H3 | .93 |
| 17HC8 | 1.24 |
| 17JB6 | 1.95 |
| 17JM6 | 1.15 |
| 17JN6 | 1.70 |
| 17JZ8 | 1.19 |
| 17L6 | 1.45 |
| 17LD8 | 1.35 |
| 17W6 | 1.15 |
| 18A5 | 1.55 |
| 18FW6 | .75 |
| 18FX6 | .79 |
| 18FY6 | .69 |
| 18GD6 | .81 |
| 19 | 1.00 |
| 19AU4 | 1.40 |
| 19BG6 | 1.95 |
| 19C8 | 1.25 |
| 19CL8 | 1.25 |
| 19EA8 | 1.19 |
| 19GQ7 | 1.99 |
| 19HV8 | 1.41 |
| 19JN8 | 1.20 |

| Type | Price |
|---|---|
| 1909 | 1.15 |
| 19T8 | 1.25 |
| 2050 | 1.25 |
| 21EX6 | 1.95 |
| 21GY5 | 1.49 |
| 21HB5 | 1.65 |
| 22BH3 | 1.15 |
| 22BW3 | 1.21 |
| 22DE4 | 1.15 |
| 22JG6 | 1.95 |
| 25A7 | 3.25 |
| 25AC5 | 2.50 |
| 25AX4 | 1.19 |
| 25AV5 | 1.65 |
| 25AX4 | .95 |
| 25BK5 | 1.15 |
| 25BQ6 | 1.45 |
| 25B8 | 1.93 |
| 25C5 | .66 |
| 25CA5 | 1.15 |
| 25CD6 | 2.10 |
| 25CU6 | 1.70 |
| 25DK4 | .63 |
| 25DN6 | 1.95 |
| 25EH5 | .82 |
| 25F5 | 1.29 |
| 25L6 | .75 |
| 25W4 | .95 |
| 25Z5 | 1.70 |
| 25Z6 | 1.10 |
| 27GB5 | 1.49 |
| 32ET5 | .89 |
| 32L7 | .85 |
| 33GY7 | 1.95 |
| 34DG5 | .95 |
| 34GD5 | .83 |
| 35A5 | 2.30 |
| 35B5 | 1.20 |
| 35C5 | .73 |
| 35EH5 | .83 |
| 35L6 | .87 |
| 35W4 | .40 |
| 35Y4 | 1.80 |
| 35Z3 | 1.49 |
| 35Z5 | .65 |
| 50A5 | 2.35 |
| 50B5 | .89 |
| 50C5 | .72 |
| 50DC4 | .64 |
| 50FH5 | .87 |
| 50FY8 | 2.50 |
| 50HC6 | .86 |
| 50L6 | .95 |
| 50X6 | 2.35 |
| 50HK6 | .86 |
| 50Y6 | 1.70 |
| 50Y7 | 1.65 |
| 60FX5 | .95 |
| 70L7 | .89 |
| 117L7 | 3.50 |
| 117N7 | 4.50 |
| 117P7 | 4.25 |
| 117Z3 | 1.60 |
| 117Z6 | 2.75 |
| 22 | 1.15 |
| 24A | 1.35 |
| 26 | 1.40 |
| 27 | 1.60 |
| 28D7 | 1.50 |
| 30 | 1.25 |
| 31 | 1.50 |
| 32 | 1.15 |
| 33 | 1.15 |
| 34 | 1.15 |
| 35-51 | 1.50 |
| 36 | 1.50 |
| 37 | 1.10 |
| 38 | 1.50 |
| 39/44 | .95 |
| 41 | 1.40 |
| 42 | 1.85 |
| 43 | 2.85 |
| 45 | 3.25 |
| 45Z3 | .55 |
| 46 | .95 |
| 47 | 3.00 |
| 48 | 4.00 |
| 49 | 3.50 |
| 50 | 1.75 |
| 53 | 3.50 |
| 55 | 2.75 |
| 56 | 1.25 |
| 57 | 1.50 |
| 58 | 1.50 |
| 59 | 3.00 |
| 71A | 1.25 |
| 75 | 2.50 |
| 76 | 1.50 |
| 78 | 1.50 |
| 80 | 1.25 |
| 81 | 1.35 |
| 82 | 1.49 |
| 83 | 2.50 |
| 83V | 3.00 |
| 84/6Z4 | 1.40 |
| 85 | .98 |
| 89 | 1.50 |
| 5881 | 2.05 |
| 89Y | 2.00 |
| 6146 | 2.50 |
| 6146W | 5.95 |
| 6336 | 4.75 |
| 6336A | 9.50 |
| 6550 | 3.25 |
| 807 | .75 |
| 809 | 3.75 |
| ECC83/ 12AX7 | .90 |
| EL34/ 6CA7 | 1.85 |
| EL84/ 6BQ5 | .85 |
| EZ80/ 6V4 | .55 |
| GZ34/ 5AR4 | 1.50 |
| 6550MP | 7.00 |
| KT88 | 4.95 |
| KT88MP | 11.00 |

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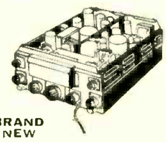
### 15 Tubes 435 to 500 MC



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**UHF Antenna Assembly** ........ 2.45
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|---|---|---|---|
| BC-453 Receiver 190-550 Kc. | $14.95 | $18.95 | P.U.R. |
| BC-454 Receiver 3-6 Mc. | $15.95 | | P.U.R. |
| BC-455 Receiver 6-9 Mc. | $13.95 | $19.50 | P.U.R. |

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BRAND NEW ........ **$13.95**
Like New ........$8.95
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| **UPM-19** Pulse Generator—2650-2950 MC | Used: | 39.50 |
| **URM-23** Attenuators—1000 to 4000 MC | New: | 14.95 |
| **TS-102B** Range Calibrator | New: | 18.95 |
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| **TS-118/AP** RF Wattmeter | Used: | 39.50 |
| **TS-28/UPN** Synchroscope | Used: | 50.00 |
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| 26 | 27 | 28 | 29 | 30 |
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## ADVERTISERS INDEX



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# How to replace top quality tubes with identical top quality tubes

Most of the quality TV sets you are presently servicing were designed around special Frame Grid tubes originated by Amperex. More and more tube types originated by Amperex are going into the sets you'll be handling in the future. Amperex Frame Grid tubes provide 55% higher gain-bandwidth, simplify TV circuitry and speed up your servicing because their extraordinary uniformity virtually eliminates need for realignment when you replace tubes.

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| | 6EH7 | 6EJ7 | 6ER5 | 6ES8 | 6FY5 | 6GJ7 | 6GK5 | 6HA5 | 6HG8 | 7HG8 | 8GJ7 |

If your distributor does not yet have all the Amperex types you need, please be patient—in some areas the demand keeps gaining on the supply. Amperex Electronic Corporation, Hicksville, Long Island, New York 11802.

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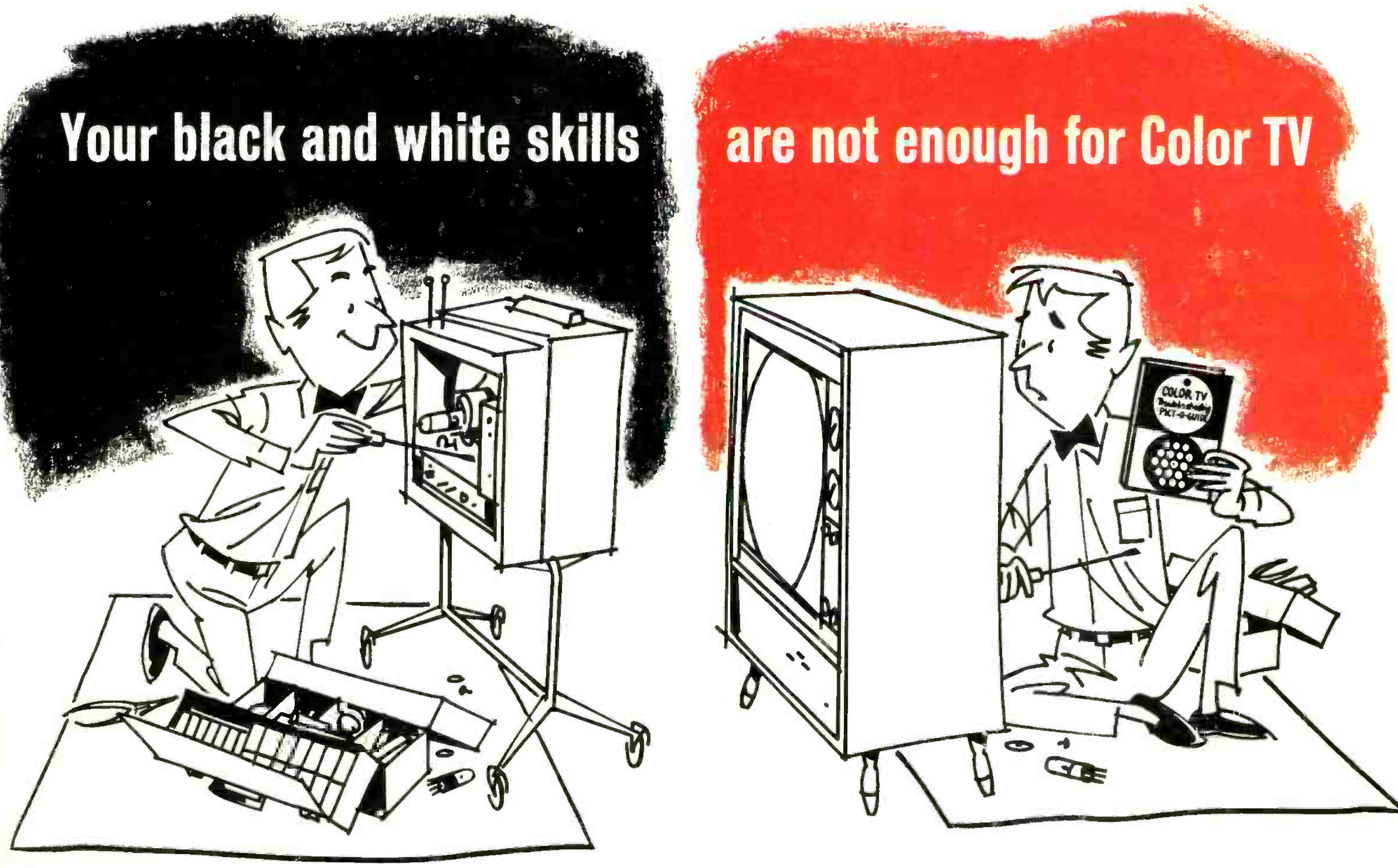
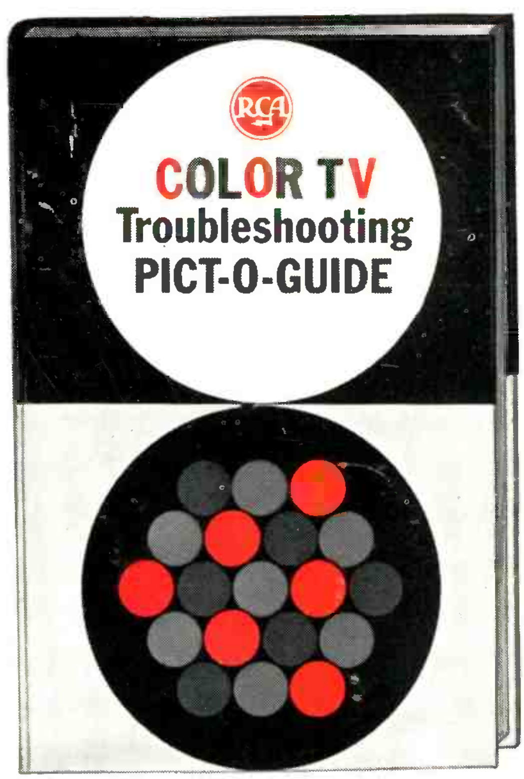



# You need this book to help you cash in on Color TV business




(For a complete course in the principles and practices of color TV you will find the 8 lesson Color TV Home Study Course by RCA Institutes, 1A1325, invaluable.)

NEW RCA COLOR TV TROUBLESHOOTING PICT-O-GUIDE, 1A1389

You're missing more and more chances for profit if you're not in color TV service. There are 3 million color sets in use now... and the total should be at least 5 million by the end of the year.

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WHAT THE RCA COLOR TV PICT-O-GUIDE GIVES YOU:

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- ☐ Functions of the Color Set Controls
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