Electronics World

OCTOBER, 1964
50 CENTS

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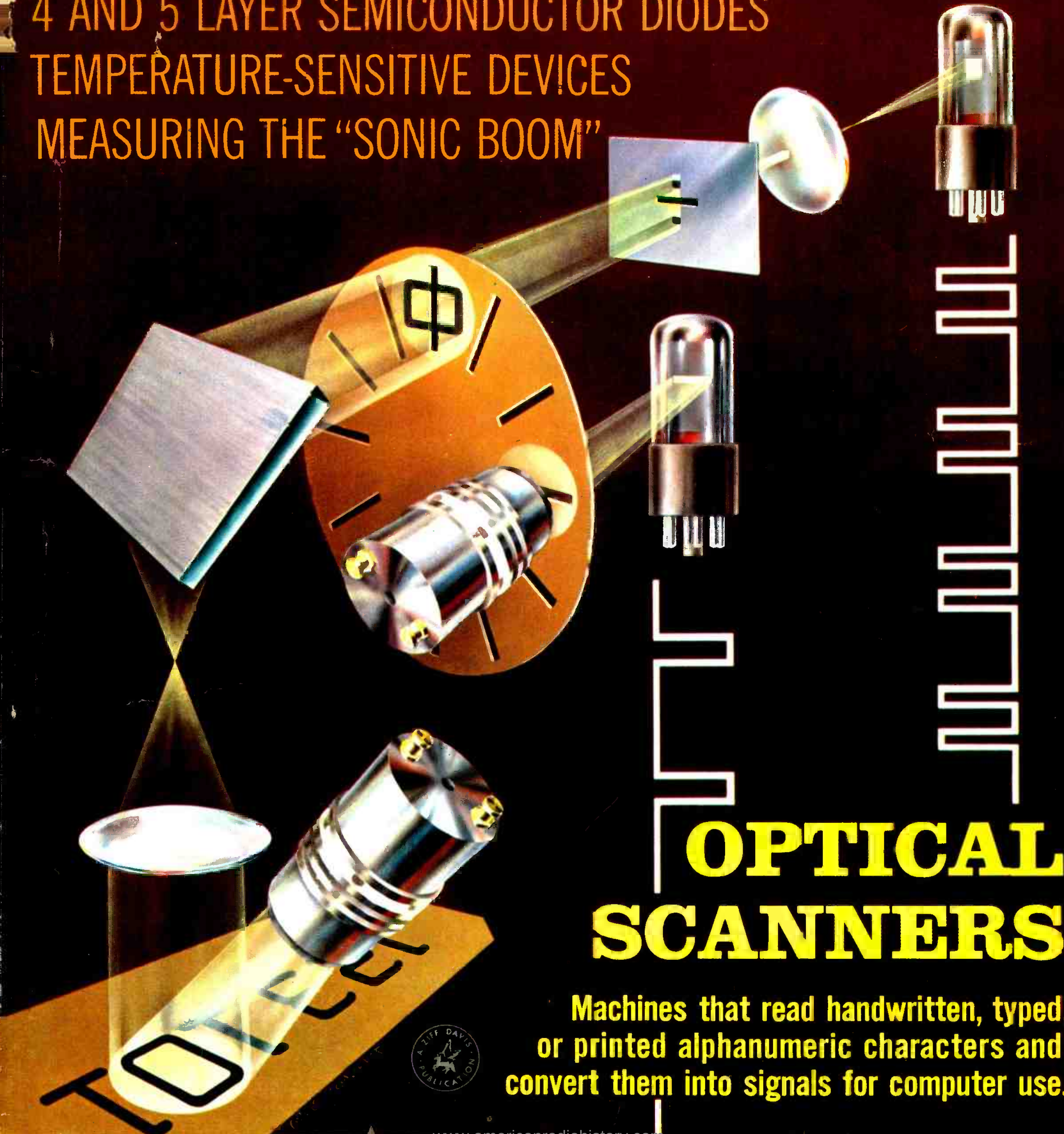

OPTICAL SCANNERS

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Since NRI pioneered equipment units to provide ACTUAL ON-THE-JOB EXPERIENCE in home training, NRI instructors have invested many thousands of man hours in testing, changing, retesting, improving NRI equipment to simplify and speed training. Unlike other schools "stock" or "standard" equipment is not good enough. NRI equipment is custom designed EXCLUSIVELY FOR TRAINING. It demonstrates theories, circuit action, defects; you get experience in operation, maintenance, trouble shooting.

These Men Trained for Success with NRI—YOU CAN, TOO

"I want to thank NRI for making it all possible," says Robert L. L'Heureux of Needham, Mass., who sought our job consultant's advice in making job applications and is now an Assistant Field Engineer in the DATAmatic Div. of Minneapolis-Honeywell, working on data processing systems.

His own full-time Radio-TV Servicing Shop has brought steadily rising income to Harlin C. Robertson of Oroville, Calif. In addition to employing a full-time technician, two NRI men work for him part-time. He remarks about NRI training, "I think it's tops."

Even before finishing his NRI training, Thomas F. Favaloro, Shelburne, N.Y., obtained a position with Technical Appliance Corp. Now he is foreman in charge of government and communications divisions. He writes, "As far as I am concerned, NRI training is responsible for my whole future."

"I can recommend the NRI course to anyone who has a desire to get ahead," says Gerald L. Roberts, of Champaign, Ill., whose Communications training helped him become an Electronic Technician at the Coordinated Science Laboratory, U. of Illinois, working on Naval research projects.

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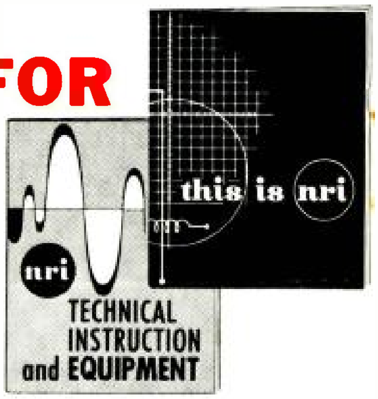

Read the story of NRI's 50 years of pioneering and leadership in training men at home for careers in Electronics. Read about NRI's philosophy of training; its reputation among leaders of the Electronics industry; read about our specialized instruction plans and see pictures of equipment you get. Whatever your age or status, the continuing increase in career opportunities in the ever-growing, ever-changing Electronics industry should interest you. Mail the postage-free form today.

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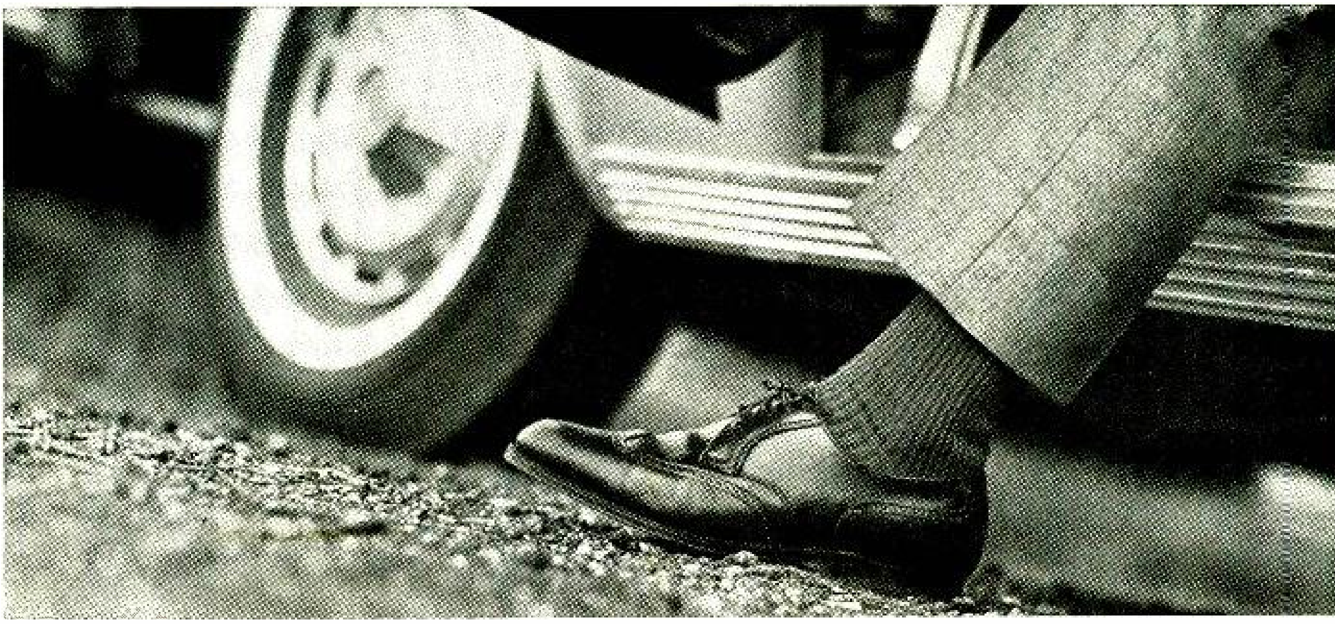

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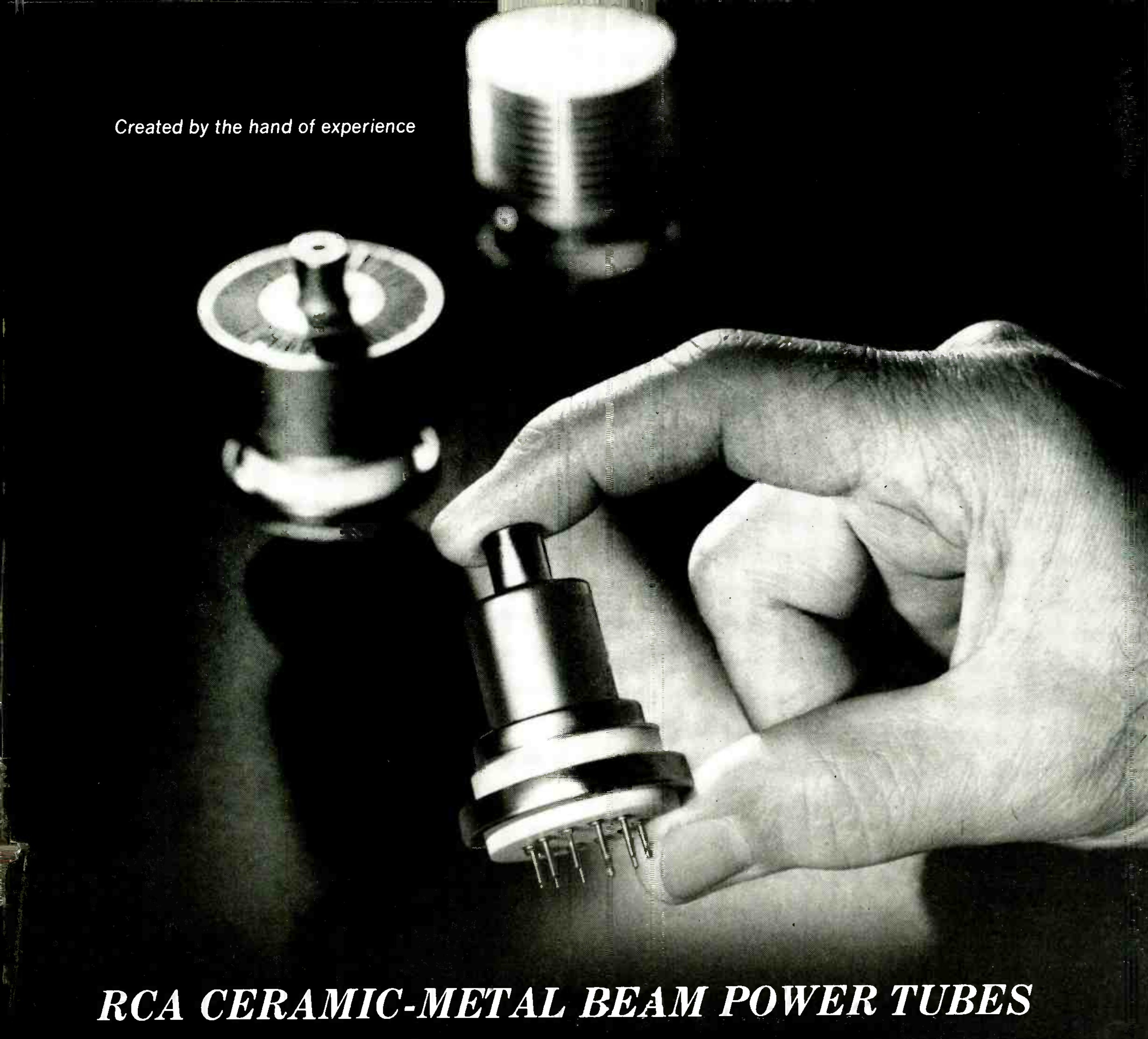

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8072	Conduction	100*	700	50 175 470	110 105 85
8121	Forced-air	150	1500	50 470	275 235
8122	Forced-air	400	2000	50 470	375 300
8462 (Quick-heating)	Conduction	100*	700	50 175 470	110 105 85

*May be higher, depending on heat-sink design

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Electronics World

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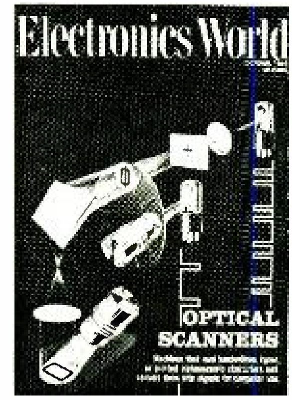
VOL. 72, No. 4

MONTHLY FEATURES



THIS MONTH'S COVER symbolizes the mechanical scanning system used in some Farrington readers (optical scanners). As the printed document moves through the reader, the numbers are illuminated and imaged on a photomultiplier tube through an optical system and a rotating scanning disc and a fixed plate slit. A second light source, shining through the slits in the scanning disc, causes a multiplier tube to produce a timing signal. The output signals are applied to logic circuits where character recognition takes place. For details, see page 33. (Illustration: Otto Markevics.)

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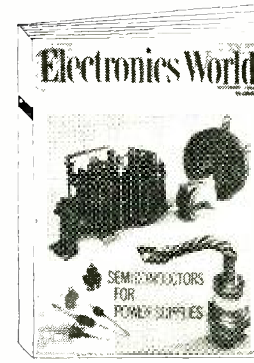

SEMICONDUCTORS FOR POWER SUPPLIES
Which semiconductor rectifier should be used in which circuit? William Gutzwiller of G-E's Rectifier Components Department, discusses this problem and points out the proper choice for specific applications.

SCR AUTOMOTIVE IGNITION SYSTEM
Complete details on the construction of a capacitive discharge ignition system, using a silicon controlled rectifier.

TRANSISTORS VS TUBES IN TWO-WAY RADIO
Will transistors replace tubes in 2-way systems? Howard H. Rice of Motorola presents the many pros and cons.

COMPUTER INPUT-OUTPUT EQUIPMENT
The central computer communicates with its human user by means of magnetic tape, punched-card machines, perforated tape, and various high-speed printers. Ed Bukstein explains how this is done.

COMMUNICATING IN A HIGH-NOISE ENVIRONMENT
Robert P. Devaney, Systems Engr. of Roanwall Corp. tells how to improve communications in a high-noise environment. Most communications systems use microphones, usually in relatively quiet areas. When vocal communications must be established from noisy locations, the choice of microphones, earphones, and communications systems is critical.

VIBRATION INSTRUMENTATION
Unwanted vibration in a mechanical component usually spells trouble—if not corrected in time. Various ways of detecting the different types of vibration are discussed in this article.

SHIELDED CABLES
There are many types of shielded cables. This article discusses their characteristics and points out how to make the proper choice of cable for a specific application.

AUDIO-COMPRESSION PREAMP
Jess C. Wright of Cubic Corp. describes the design and construction of a circuit using negative feedback to produce 20 db of audio compression with low distortion and wide frequency range. The circuit can be used with low-level microphones in p.a., recording, and modulator applications.

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

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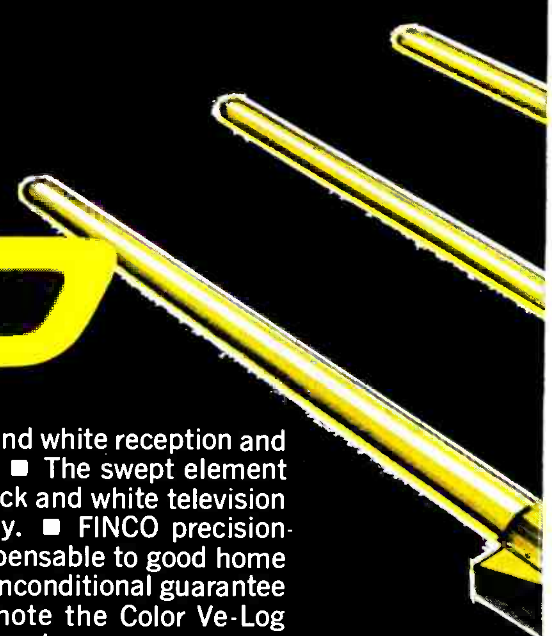
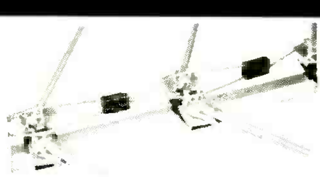
The antenna that challenges

NEW *Swept Element* "COLOR-VE-

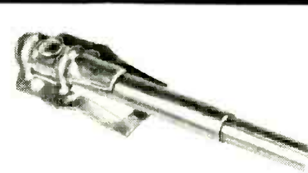
BY FINCO



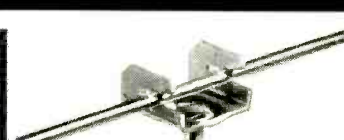
Finco's Color Ve-Log challenges all competition on color or black and white reception and stands behind this challenge with a "Guarantee of Supremacy". ■ The swept element design assures the finest in brilliant color and sharply defined black and white television reception – as well as superb FM monaural and stereo quality. ■ FINCO precision-engineered features make these advanced-design antennas indispensable to good home sight-and-sound systems. And, of course, they carry the famous unconditional guarantee from the leading manufacturer in the field – FINCO. ■ Promote the Color Ve-Log Antennas with pride, sell them with confidence, and profit handsomely.



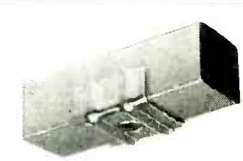
One-piece cross-over drive line assembly has no joints between adjacent driven elements. Eliminates loose connections, shorts, broken drive line sections. Polystyrene snap-lock spacers, with center 'air insulator' space.



Elements are made of triple thick aluminum to stand up in severe weather. Die stamped bracket fastened with tough, thick-gauge rivet holds proportional length sleeve reinforcing shell into which element fits.



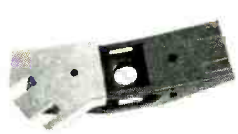
First from Finco and exclusive — double contact between drive line and driven element bracket assembly for perfect drive-line support and electrical continuity. Positive, vibration-free, non-corrosive contact.



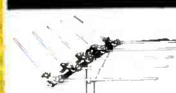
Boom reinforcing back up brackets at elements add triple strength to the riveted assembly, mounted on a rigid, non-crushable 1" heavy duty square boom. Boom rolled square from 1¼" diameter round aluminum for increased strength.

Write for color brochure #20-307, Dept. 410

Finco's boom-mast bracket, rust-proofed by zinc plate-gold di-chromate dip process, is the finest available. It has positioned cleats to assure sag-free positive direction of the antenna. Locks tight. Can't tilt. Antenna stays in proper position at all times.



High impact polystyrene insulators are reinforced with strong aluminum shields. This gives quadruple strength in supporting triple-thick snap-in elements. Lifetime assembly with fitted aluminum cup to hold oversize aluminum rivet.



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5 driven elements
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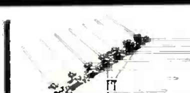

VL-7
7 element VHF-FM
7 driven elements
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15 element VHF-FM
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6 parasitic elements
List price $46.95

VL-18
18 element VHF-FM
9 driven elements
9 parasitic elements
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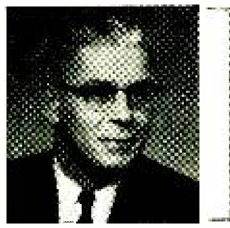


For the record

WM. A. STOCKLIN, EDITOR

AN EXCITING SUMMER

THE months of July and August are usually the least exciting ones of the year—insofar as our industry is concerned. So it has been for many past years with nearly everyone planning time off for vacations. This year, however, conditions seemed different. Most executives were readily available during these hot summer months. There was excitement and enthusiasm throughout our industry and all were looking forward to a record-breaking fall and winter market.

For those on our staff who had hoped for a summer vacation, Florida in winter might not be too bad.

This October issue is a "bonus package" for all our readers. With its 132 pages, it is our largest monthly issue since November 1961. This alone indicates a belief on the part of manufacturers in a bright future for the electronics industry. It also means more editorial pages for our readers and, with an industry that is moving ahead, the opportunity for reporting on new and exciting developments is much greater.

For those who are not familiar with our publication STEREO/HI-FI DIRECTORY (available September 22nd), it is a complete directory of component hi-fi equipment. This is an annual publication which is compiled and edited by the EW staff. With its 188 pages, it too has broken all previous records. It is the largest issue thus far and contains more listings than ever before. The changes over last year's edition are predominantly in tuners and amplifiers. There are more transistorized versions than ever, with some of the major manufacturers completely eliminating all-tube versions. Mahogany and blonde cabinets for equipment and speakers are less plentiful, with walnut finishes rising in popularity.

Outside of our own publishing field, there were several outstanding news events during the past few months which will affect every one of us in one way or another.

Pay TV: Sylvester L. ("Pat") Weaver, Jr., president of *Subscription Television, Inc.* did get his pay-TV system in operation in Los Angeles on July 1 as planned, much to our surprise, but with some disappointments and criticism. It had been hoped that 20,000 subscribers each would be signed up in Los Angeles and San Francisco but the LA service started with 4000 subscribers while the SF operation has just gotten underway as this is being written in late August.

There is a lot at stake. Although Mr. Weaver claims that both pay- and free-TV can co-exist, we feel that only one can ultimately survive. Motion picture theaters are obviously opposed and it is estimated that some $2 million will be spent on a campaign which California voters will decide in a November referendum. Since pay-TV is a closed-circuit operation, the FCC is not involved. It seems rather strange to us that any legal action or vote can prevent its continued operation. The chances are that if the referendum is defeated at the polls, the company will probably be upheld in subsequent legal action.

We believe that the decision should be made not at the polls but by either subscribing to the service or not. The determining factor will be whether or not the firm will be able to obtain top-rated programs which will induce some 30,000 customers to pay $10 a month for service. If it can, the operation should be profitable within a year.

FCC Sets New CB Rules: Although delayed for about a year, the FCC has finally issued new and tighter rules, to be effective Nov. 1, that should do much to stop the illegal and hobby-type operation so prevalent on the Citizens Band. Out of 23 available CB channels, 16 of them must be for use only between units of the same station and call; the other 7 can be used only for legitimate reasons between units of different stations. Whether the rule changes will curtail total sales for the industry is difficult to evaluate at this time. Robert Halligan, president of *The Hallicrafters Company*, and Bernard Levine, president of *Vernitron Corporation*, both manufacturers of CB equipment, emphatically believe that they will increase sales. Time alone will tell. For details on the rule changes, see page 78 of this issue.

Congratulations to JPL: The Jet Propulsion Laboratories, after much criticism for past failures, has finally succeeded in its "Ranger VII" program of television close-up photos of the moon. All equipment performed beyond expectations. The final results yielded 4316 photographs of the moon that were so detailed that topographic features less than 3 feet across are discernible. Never before in history—and this includes the Russian moon probes—has man learned so much about the geographical makeup of the moon's surface. It was, without question, one of the most complicated scientific and engineering feats attempted by man. Literally thousands of things could have gone wrong and doomed the flight. Congratulations to JPL and to some 50,000 people in government, industry, universities, and the scientific community who participated in the program. ▲


As electronics moves ahead in the space age...
will you be left behind?
CREI

THE SPACE AGE AND AUTOMATION ARE CHANGING THE ELECTRONICS INDUSTRY. JOBS ARE FEWER, HIRING REQUIREMENTS TOUGHER. THERE IS VIRTUALLY NO DEMAND FOR MEN WITH ORDINARY QUALIFICATIONS. BUT MEN WITH SPECIALIZED KNOWLEDGE OF NEW AND EXPANDING AREAS OF ELECTRONICS ARE STILL IN SHORT SUPPLY.

Because you work in electronics, you know the cold, hard facts about employment opportunities in this field today. Many men are unemployed or will soon lose their jobs because the electronics they know is out-of-date and they have failed to learn enough about new developments to pull their weight on the job. Other men are unemployed because the routine jobs they held have been eliminated by the new automated manufacturing techniques of the space age.

Yet, at the same time that many men are being let go, leading companies are searching for men with specialized knowledge of new and expanding areas of electronics.

WILL THE SPACE AGE END YOUR CAREER IN ELECTRONICS? OR WILL IT OPEN UP NEW OPPORTUNITIES FOR YOU?

That depends on whether or not you supplement your education in electronics with the new knowledge required by employers today. If you don't, you can forget about your career in electronics. Guiding space vehicles demands knowledge that didn't exist when you went to school—and is almost impossible to acquire on the job. And, even if you work for a company that is not directly involved in space, it is probably already using techniques developed in the space program.

If you bring your education up to space age standards, you can look forward to a rewarding and exciting career as a sought-after specialist in one of the new and advanced areas of electronics.

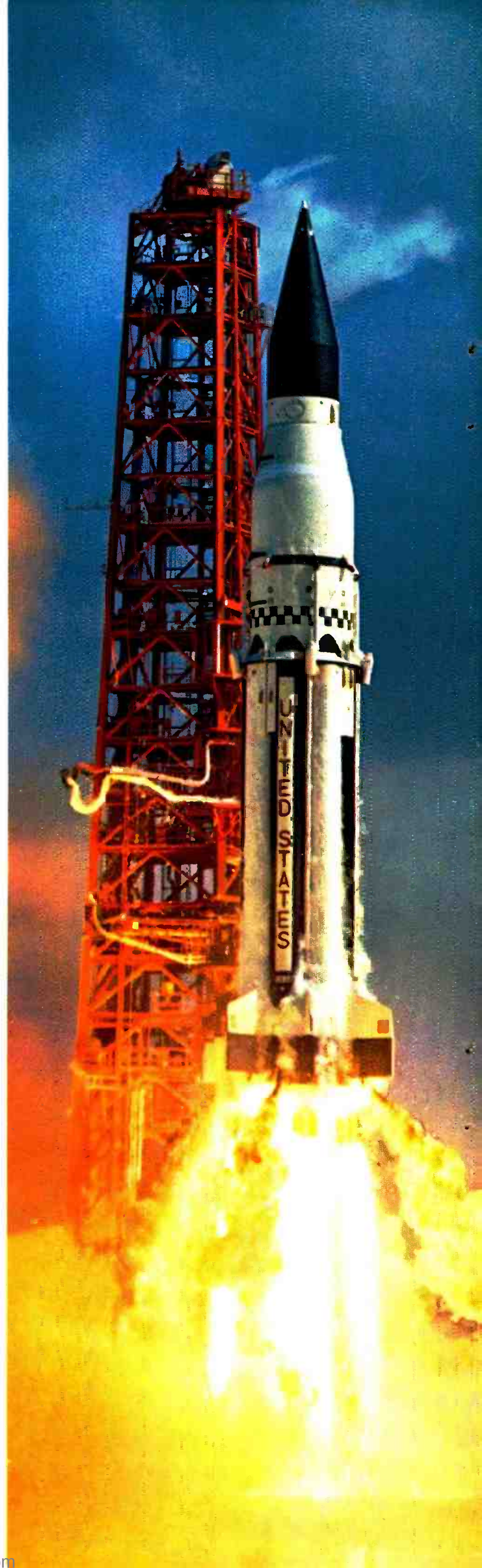
CREI CAN HELP YOU MOVE INTO THE SPACE AGE

CREI offers you Home Study Programs planned to help you protect your future in electronics by updating your education to space age requirements.

CREI's Programs in Space Electronics enable you to study at home, on your own schedule—through methods developed in more than 37 years of experience in education through home study.

Long and painstaking effort has been devoted to the preparation of these programs. CREI faculty members visited 14 government and private technical organizations in the space effort to determine exactly what knowledge of electronics they want in men they employ. Engineers and scientists from some of these organizations have been retained as consultants to supply the technical material for these programs.

Photographs courtesy of National Aeronautics & Space Administration

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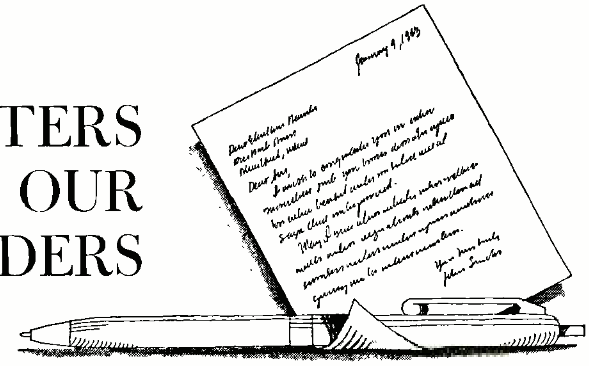
LETTERS FROM OUR READERS



OUR JUNE ISSUE

To the Editors:

In reference to your June issue of ELECTRONICS WORLD, which was devoted to the Goddard Space Flight Center, I am thoroughly pleased and delighted with the section and sincerely hope that this type of coverage will continue.

I feel that the information presented has materially increased my knowledge and understanding of our efforts and progress in various fields of space technology, especially in electronics.

This issue has been for me one of the most interesting and informative magazines that I have ever read.

LARRY H. BANDY
56th Signal Corps
Fort Lewis, Wash.

Thanks to Reader Bandy and to others that we have heard from complimenting us on this issue. We have also received several requests for reprints of the section dealing with Goddard, which we have been happy to honor.—Editors.

* * *

U.H.F. TV CONVERTER TESTS

To the Editors:

This is in reference to the article "Results of EW Tests on U.H.F. Converters" which appeared in your July issue. This letter is addressed to the "Method of Measurement" section appended to the article.

It is not clear whether this is intended to be a description of the standard procedure used to measure oscillator radiation (51 IRE 17S1) or whether this is a description of the test procedure actually used by the two testing outfits whose measurements are reported in your article. Since the method of measurement in your article departs in several respects from the IRE standard, measurements made pursuant to your article would not be acceptable for determining compliance with our requirements.

Assuming that the measurements reported in your article were made in accordance with the method of measurement described therein, may we suggest that you caution your readers not to take these measurements as evidence of compliance or non-compliance, although the radiated fields reported for several of the converters are sufficiently large as to be reasonably conclusive of non-compliance.

For your information, we note the following discrepancies between the IRE 51 IRE 17S1 and the method described in your article. First, however, may we call attention to what appears to be a typographical error in the citation in the fourth line of the third paragraph. The number of the IRE standard is 51 *IRE* 17S1, not "51 and 1751."

The IRE standard specifies that the receiver (or converter) under test be connected to a simple dipole constructed of ½ inch tubing mounted at a fixed height of 30 feet. Details for the construction of an appropriate dipole are contained in Supplement 2 to the IRE standard. For u.h.f. television receivers (and for converters) the dipole shall be 12 inches from end to end.

In contrast to this, the method of measurement in your article calls for using a folded dipole, half-wave at the frequency of operation, mounted on a relatively short mast of unspecified height with provision to vary the height.

Another area of discrepancy is the statement that the level of the received signal (oscillator radiation from the u.h.f. converter) is determined from the signal generator plus the 6-db pad shown in your Fig. 4. While this setup is satisfactory for determining the number of microvolts at the input terminals of the field-strength meter, this value of microvolts must be multiplied by the antenna constant for the measuring antenna in order to determine the field strength in microvolts per meter. Actual practice in measuring field strength is to determine the microvolts input to the field-strength meter (the meter reading times attenuator setting) and multiply this by the antenna constant taken from the manufacturer's manual to give the measured field strength in microvolts per meter.

BEN F. WAPLE
Federal Communications Comm.
Washington, D. C.

Our thanks to Mr. Waple for pointing out the typographical error regarding 51 IRE 17S1. The description of the test procedure is that employed by certain manufacturers, and the section "Measurement Techniques" points out that the

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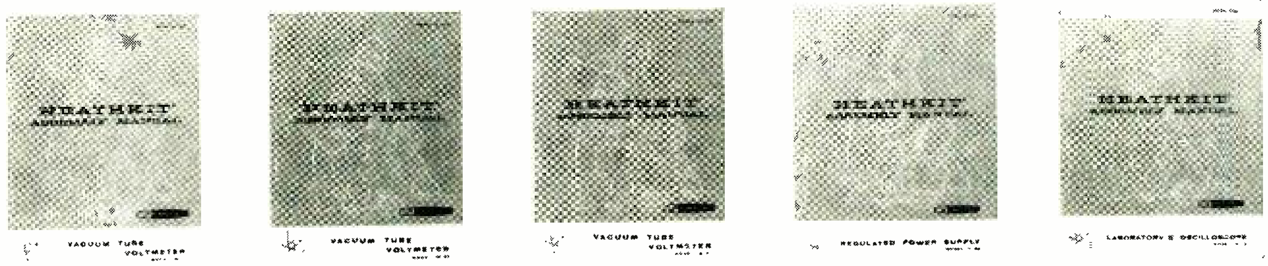

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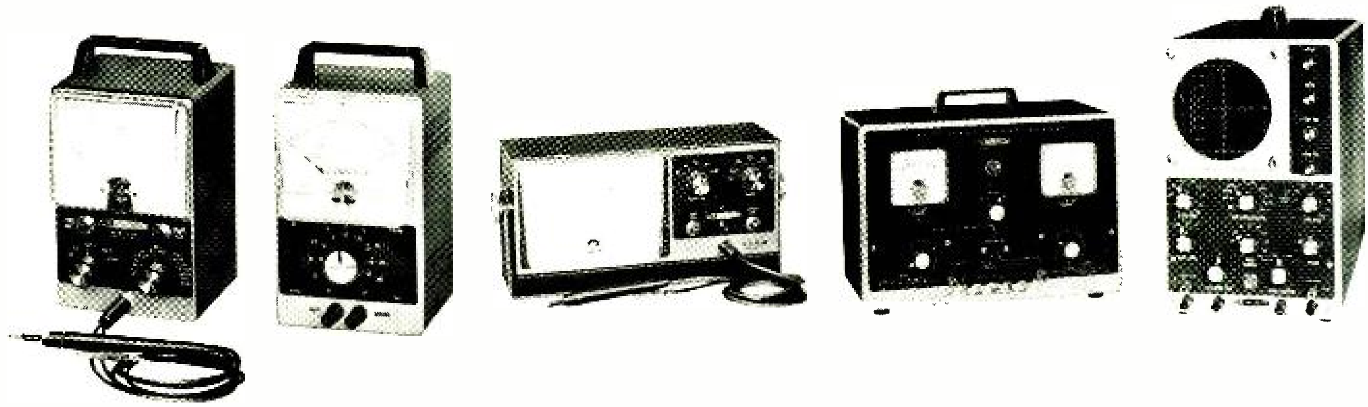

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IM-11 SPECIFICATIONS—Meter scales: DC & AC (RMS): 0-1, 5, 15, 50, 150, 500, 1500 volts full scale. **AC peak-to-peak:** 0-4, 14, 40, 140, 400, 1400, 4000. **Resistance:** 10 ohm center scale x1, x10, x100, x1000, x10K, x100K, x1 meg. Measures .1 ohm to 1000 megohms with internal battery. **Meter:** 4½" 200 ua movement. **Multipliers:** 1% precision type. **Input resistance DC:** 11 megohms (1 megohm in probe) on all ranges. **Circuit:** Balanced bridge (push-pull using twin triode). **Accuracy:** DC ±3%, AC ±5% of full scale. **Frequency response:** ±1 db, 25 cps to 1 mc (600 ohm source). **Tubes:** 12AU, 6AL5. **Battery requirements:** 1.5 volt, size "C" flashlight cell. **Power requirements:** 105-125 volt 50/60 cycle AC, 10 watts. **Dimensions:** 7⅜" H x 4-11/16" W x 4⅛" D.

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IM-13 SPECIFICATIONS—Meter scales DC & AC (RMS): 0-1.5, 5, 15, 50, 150, 500, 1500 volts full scale (1.5 and 5 volt AC ranges read on separate scales). **Ohmmeter:** Scale with 10 ohm center x1, x10, x100, x1000, x10K, x100K, x1 meg. Measures 1 ohm to 1000 megohms with internal battery. **Dividers:** 1% precision type. **Meter:** 6" 200 ua movement. **DC Input resistance:** 11 megohms (1 megohm in probe) on all ranges. **AC Input impedance:** 1 megohm shunted by 40 uuf (measured at input terminals). **Circuit:** Balanced bridge (push-pull) using twin triode. **Accuracy:** DC ±3%, AC ±5% of full scale. **Frequency response:** ±1 db 25 cps to 1 mc (600 ohm source). **Tubes:** 12AU7, 6AL5. **Battery:** 1.5 volt size "C" flashlight cell. **Power requirements:** 105-125 volts 50/60 cycle AC 10 watts. **Dimensions:** 5" H x 12-11/16" W x 4¾" D.

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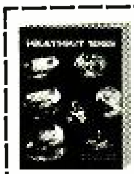
IO-12 SPECIFICATIONS—(Vertical) Sensitivity: 0.025 volts RMS per inch at 1 kc. **Frequency response (referred to 1 kc level):** ±1 db 8 cps to 2.5 mc; +1.5 to −5 db, 3 cps to 5 mc; response at 3.58 mc.—2.2 db. **Rise time:** 0.08 microseconds or less. **Input impedance:** (at 1 KC) 2.7 megohms at X1; 3.3 megohms at X10 and X100. **(Horizontal Channel) Sensitivity:** 0.3 volts RMS per inch at 1 kc. **Frequency response:** ±1 db 1 cps to 200 kc; ±3 db 1 cps to 400 kc. **Input impedance:** 4.9 megohms at 1 kc. **Sweep generator:** Range—10 cps to 500kc in five steps, variable, plus any 2 switch-selected preset sweep frequencies in this range. **Synchronizing:** automatic lock-in circuit using self-limiting synchronizing cathode follower. **Power requirements:** 105-125 volts 50/60 cycles AC at 80 watts; fused. **Dimensions:** 14⅛" H x 8⅝" W x 16" D.



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IRE standard was followed with certain exceptions that were noted in the text. Evidently the test laboratories wanted to present the "worst-case" conditions by employing a tuned dipole and a mutual antenna arrangement that would duplicate the conditions found on a typical rooftop. The short mast was used to reduce the effect of physical motion of the antennas due to wind gusts.

If the measuring technique described in Mr. Waple's letter were followed, then the radiation figures would be somewhat different than those given in the article. Although there are many variables involved, the figures probably would be somewhat lower in value. However, the radiation from the offending converters was sufficiently above the 1000-μv./m. figure so as to definitely indicate non-compliance.—Editors.

* * *

To the Editors:

We are indeed pleased with the article on the "Results of EW Tests on U.H.F. Converters" (July issue) and we are certainly pleased with the performance of the *Blonder-Tongue* converter.

This article may be pioneering in the publishing profession since you give names and performance figures which may cause the FCC some real concern. I hope that this does not rebound to your disadvantage, since this kind of reporting provides a real service to the electronics technician.

Isaac S. Blonder
Blonder-Tongue Laboratories, Inc.
Newark, N. J.

Thanks to Mr. Blonder and to others in the industry we have heard from, both by mail and by phone, on this important and useful article. We would like to point out that some of the manufacturers mentioned in the article have several other models of u.h.f. converters available. The figures given apply only to those specific models mentioned in the article.—Editors.

* * *

PLUMBING THE MICROWAVE CIRCUIT

To the Editors:

In Fig. 8 of your article "Plumbing the Microwave Circuit" (June issue) showing a laboratory setup for testing a variable attenuator, the attenuator under test should be shown between the slotted section and the tuning stub.

If installed as shown on the left (power) side of the slotted line, the v.s.w.r. of the item under test will only change the available power to the load but not the v.s.w.r. reading. The v.s.w.r. as read on the indicator will change only if the item under test is installed between the slotted section and the tuning stub on its right (load) side.

Murray Elchitz
Canadian Aviation Electronics Ltd.
Winnipeg, Manitoba ▲

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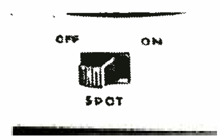
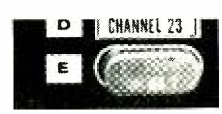
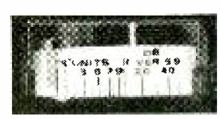


Spotting Switch
Operates with front-panel crystal socket, & generates a signal to tune receiver to exact frequency of selected crystal.



Front-Panel Crystal Socket
Enables changing transmit crystal to any of 23 CB channels without removing cabinet.



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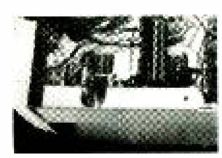

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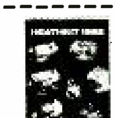
Minimizes interference with TV sets operating in surrounding area.



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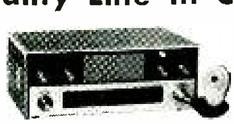

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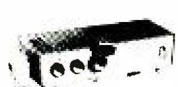

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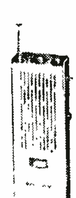

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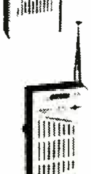

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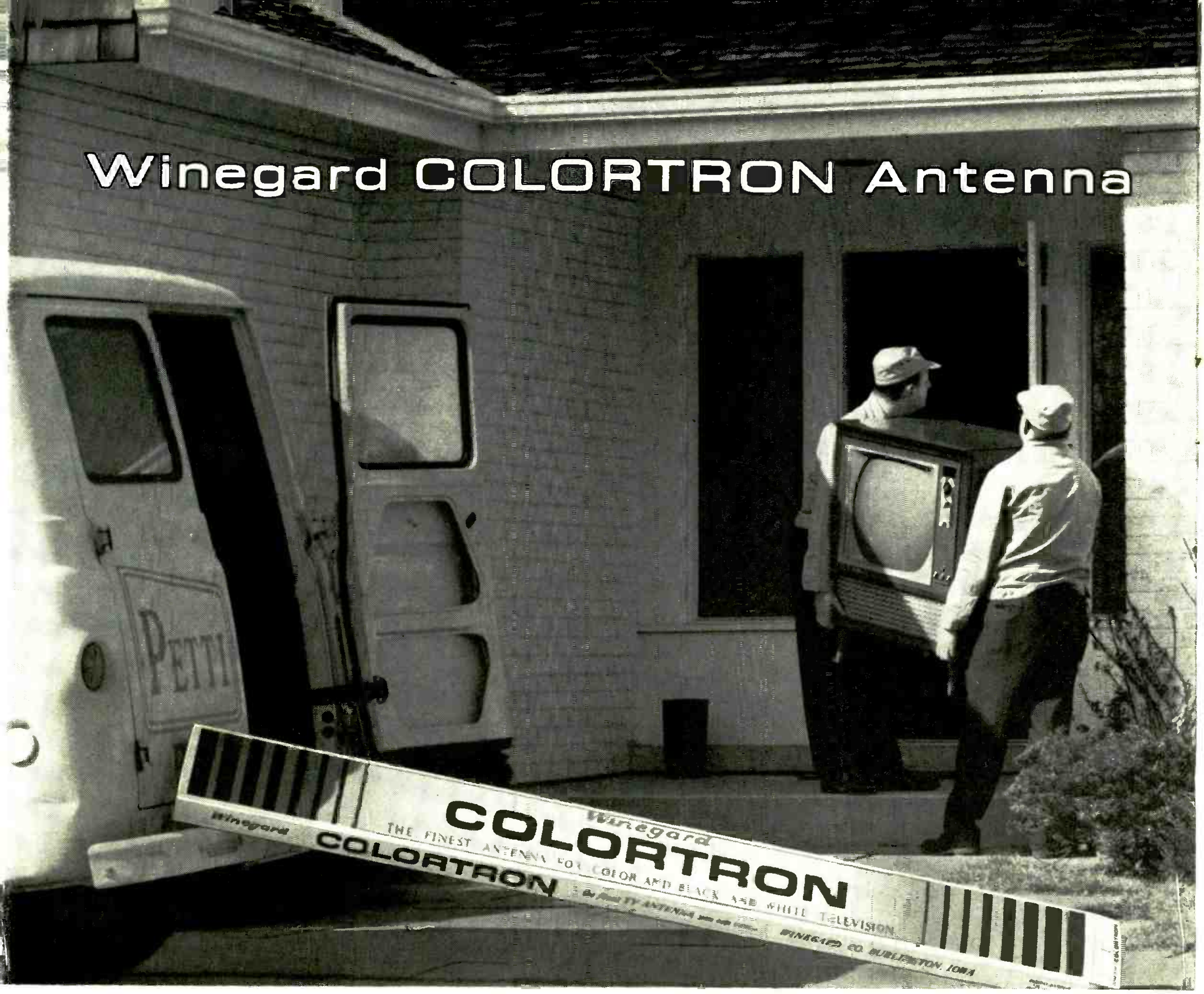


The Colortron Antenna's "BALANCED DESIGN" is the Winegard secret of superior color reception!

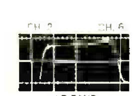
It takes a combination of high gain, accurate impedance match, complete band width and pinpoint directivity to make the perfect color antenna. Only the Winegard Colortron gives you all 4 with BALANCED DESIGN.

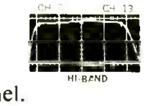
What is Balanced Design? It's not enough to design an antenna for high gain alone and expect good color reception. A high gain antenna without *accurate impedance match* is ineffective. Or an antenna with *good band width* but *poor directivity characteristics* is unsuitable for color. The Winegard Colortron is the one antenna with *balanced design*, excellence in *all* the important characteristics that a good color antenna requires.

For example:

Gain and Bandwidth—A superior color antenna must have high gain and complete bandwidth as well. But the response must be *flat* if it is to be effective. Peaks and valleys in the curve of a high gain antenna can result in acceptable color on one channel and poor color on another.

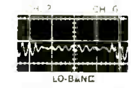
No all-channel VHF-TV antenna has more gain with complete bandwidth across each and every channel than the Colortron. Look at the Colortron frequency response in this oscilloscope photo. Note the consistent high gain in *all* channels. Note the absence of suck-outs and roll-off on end channels. The flat portion of the curve extends on the low band from the channel 2 picture carrier past the channel 6 sound carrier. On the high band, it is flat from the channel 7 picture carrier to the channel 13 sound carrier. There is less than ½ DB variance over any channel.

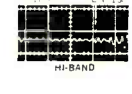




Impedance Match—the two 300 ohm "T" matched Colortron driven elements have far better impedance match than *any* antenna using multiple 75 ohm driven elements. The Colortron transfers *maximum* signal to the line without loss or phase distortion through mismatch. Winegard's "T" matched driven elements cost more to make, but we know the precision results are well worth the added manufacturing expense . . . because a mismatched antenna causes loss of picture quality which *might* get by in black & white, but becomes highly disturbing in color.

The oscilloscope photo here shows the Colortron VSWR curve (impedance match). No current VHF-TV antenna compares with it across all 12 channels.





Directivity—Equally important for superior color pictures is freedom from interference and ghosts. Therefore, an antenna with sharp directivity and good signal-to-noise characteristics is necessary. Extraneous signals picked up at the back and sides produce objectionable noise and ghosts in black and white reception . . . frequently ruin color reception.

Winegard's Colortron has the most ideal directivity pattern of any all channel VHF antenna made. It has no spurious side or large back lobes . . . is absolutely dead on both sides. Colortron does not pick up extraneous signals, and even has a higher front-to-back ratio than a single channel yagi.


TYPICAL CHANNEL

Look at this Colortron polar pattern. No other VHF-TV antenna has sharper directivity on a channel-for-channel comparison.

BALANCED DESIGN COLORTRONS HAVE SUPERIOR MECHANICAL FEATURES, TOO!

Every square inch of the Colortron has been engineered for maximum strength, minimum weight and minimum wind loading. Even the insulators are designed for low wind resistance. The result is a streamlined, lightweight antenna that stays stronger longer. Colortrons have been wind tested to 100 mph.

Colortrons are simpler to put up, too. Easier to carry up a ladder and mount on a high mast. No extra weight and bulk to frustrate the antenna installer.

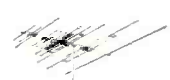
And, you can see the difference in quality when you examine a Winegard COLORTRON. The GOLD ANODIZED finish is bright weather-proof gold that *won't fade*, rust or corrode. It's the same finish specified by the Navy for military antennas. Full attention is paid to every detail.

Winegard Helps You Sell—does more national advertising *than all other brands combined*. When you sell Winegard, you sell a brand your customer knows . . . backed by a *written factory guarantee of satisfaction*.

It's not surprising that Winegard leads the field in the number of antennas installed with color sets. And Colortrons have been installed by the hundreds of thousands for black and white sets too —for the antenna that's best for color is best for black and white as well. Why don't you try a *balanced design* Colortron and see for yourself?


COLORTRON ANTENNA
Model C-44 • Gold Anodized • $64.95


COLORTRON ANTENNA
Model C-43 • Gold Anodized • $51.90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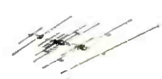
COLORTRON ANTENNA
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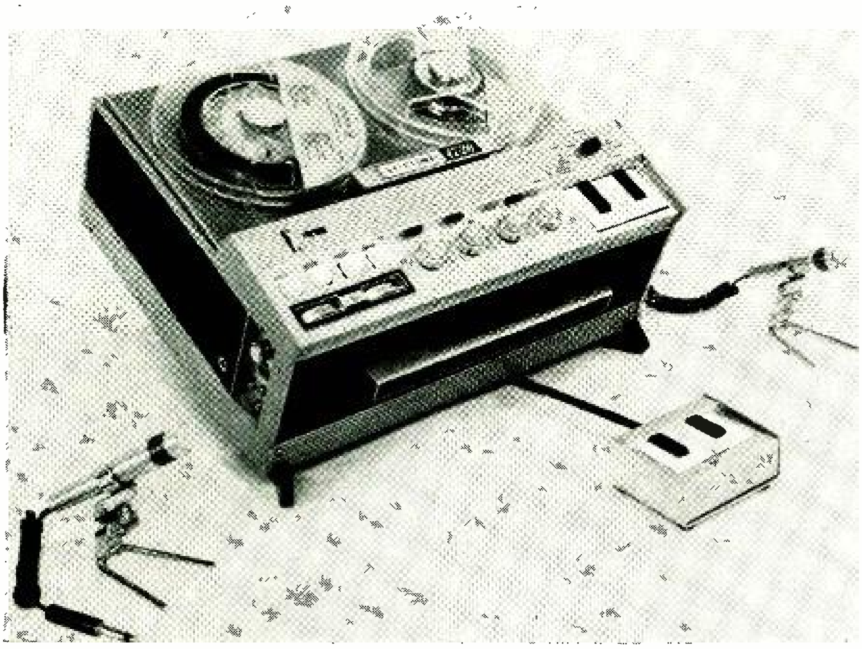
HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

Vernon 47/26 Tape Recorder
Shure V-15 Phono Cartridge

Vernon 47/26 Tape Recorder

For copy of manufacturer's brochure, circle No. 63 on coupon (page 13).



IN its styling and performance features, the *Vernon* 47/26 tape recorder is refreshingly different from other recorders, both domestic and foreign, which we have tested. The 47/26 is imported from Japan by *Vernon Audio Division* of Mount Vernon, New York.

The name of this recorder is a clue to its circuit complexity, which involves a total of 47 transistors and 26 diodes. Its electronics portions are fully solid-state and are constructed on plug-in printed-circuit boards for ease of maintenance. In addition to separate stereo record and playback preamplifiers, the unit has a pair of 10-watt power amplifiers, using OTL (output transformerless) output stages. These amplifiers drive the built-in 5" monitor speakers, or external speaker systems. The tape transport motors may be switched off, so that the amplifiers can be used as a part of a home music system or as a public-address amplifier.

The recorder is housed in an attractive, compact, and rugged all-metal case. Die-castings are used liberally for rigidity and dimensional control. In spite of its small size (15⅝"x12¾"x6⅞"), it weighs 44 pounds. The drive mechanism uses three motors, controlled by a unique "piano-key" button grouping. The keys have a feather light touch and operate the motors through an interlocked system of flip-flops, diode gates, and one-shot multivibrators. Incorrect operation of the mechanism is virtually impossible.

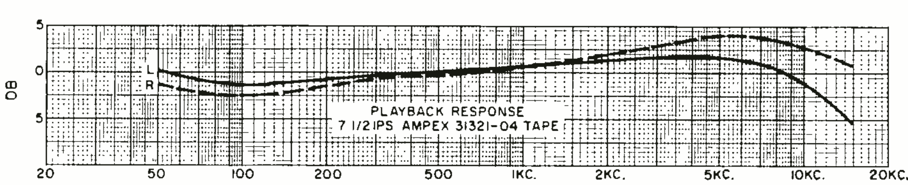
The tape may be switched to either fast-forward or rewind directly from normal speed or from a standstill. Unlike other recorders, it can be switched from a fast speed to normal playing speed. The tape comes to a smooth stop, pauses a couple of seconds, and proceeds to play. The built-in time delay prevents any possibility of tape breakage or stretching. It may also be rocked back and forth between fast-forward and rewind to locate a particular portion of the tape, with the aid of the index counter.

The "black keys" of the piano-type keyboard must be pressed simultaneously with the "Play" key to make a recording. Red lights indicate when either or both channels are recording. Stopping the tape or going to a fast speed releases the recording buttons. If it is desired to temporarily stop the tape without dropping out of "Record," the "Pause" button does this instantly. Another press on it and the tape is instantly in motion.

Two push-buttons select the playback mode through the internal speakers, or external speakers if they are plugged in (which disconnects the internal speakers). The buttons allow mono reproduction of either track through both speakers, stereo playback, or shutting off both speakers when playing through an external power amplifier. Another push-button switches the output from the input stages to the tape playback amplifier, in order to compare the incoming signal with the recorded signal. The two tape speeds of 7½ and 3¾ ips are selected by a switch which electrically changes the capstan motor speed, as well as shutting off the motor in a third position, while leaving the amplifiers operating.

There is an automatic stop when the tape runs off either reel. By sticking a piece of conductive metal foil on each end of a reel of tape, an automatic repeat feature may be used. This automatically rewinds the tape after playing and repeats the play for as long as may be desired.

Two sets of concentric controls set



Scott's top rated LT-110 FM Stereo Tuner Kit now at a new low price...$139.95!

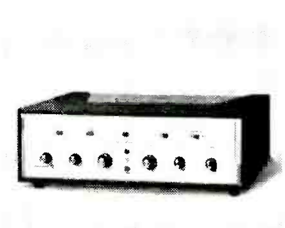
"...1.88 uv sensitivity by a home alignment procedure without instruments...an exceptional feat..." Electronics Illustrated

Here's terrific news for kit builders! Now, the famous Scott LT-110 tuner kit . . . the same kit top rated by every audio expert . . . the same superbly engineered FM Stereo tuner built by thousands of hi fi enthusiasts . . . is now available in handsome new styling at a truly modest price.

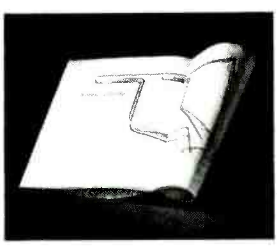
Look at the outstanding features of this superb tuner. It includes a heavily silver-plated front end that is pre-wired and tested in Scott's engineering laboratories. The critical multiplex section is also completely pre-wired and tested with the most advanced multiplex equipment available. Among the LT-110-B's many pluses: Stereo Separation in excess of 30 db, Sonic Monitor Stereo indicator, 60 db signal-to-noise ratio, sensitive tuning meter.

Here's what the technical editor of Electronics Illustrated said about the LT-110: "If you have hesitated to go into stereo FM because of imagined complexities and highly technical skills and knowledge that might be required, fear no more. The LT-110 shows you how to enjoy stereo FM the easy way."

New LK-72B 80-Watt Stereo Amplifier Kit. Here's a popular integrated stereo amplifier kit at an outstanding price. Rugged stereo output stages deliver 80-watts, can be used with any speaker systems. Every conceivable control feature is found on this versatile amplifier including a switched front panel headphone output, complete recording facilities, and provision for driving a third or center channel loudspeaker system without additional amplification. Only $149.95



LK-48B 48-Watt Complete Stereo Amplifier Kit. More than enough power for the majority of music systems. The all-new LK-48B has two new convenience features, a switched front panel headphone output for private listening, and a powered center channel output to drive extension speakers. 13 front panel controls. Complete tape recording facilities. Typical Scott luxury features include all-aluminum chassis and DC-operated heaters for lowest hum. Only $129.95



Exclusive FULL-COLOR instruction Book "eliminates just about the last possible chance of wiring errors . . ." Every part and every wire are shown in natural color and proper position. In addition, each full-color illustration in the instruction book is accompanied by its own PART-CHART, another Scott exclusive. The actual parts described in the illustration are placed in the exact sequence in which they are used.

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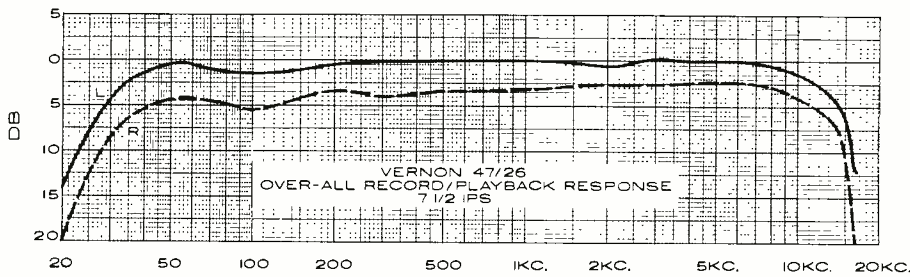


recording and playback levels, with the aid of twin illuminated "vu-type" meters. A unique tone control offers a smooth transition from loudness compensation, to bass boost, to flat response and finally treble boost, effective only on playback. Each channel has inputs for two high-level sources and a microphone. They may be selected individually or mixed. By suitable internal cross-patching from one channel to the other, sound-on-sound, echo, and other special effects may be created.

The 7½-ips playback response of the 47/26, as measured with the *Ampex* 31321-04 tape, was within ±3 db from 50 to 15,000 cps. The over-all record/playback response was quite flat and smooth. At 7½ ips, it was down 2.5 db at 35 and 12,000 cps, and 5 db down at 28 and 14,500 cps. At 3¾ ips, it was within ±3 db from 30 to 8500 cps. These measurements were made with the tone controls in the indicated "flat response" setting and can be modified as desired by use of the tone control.

The wow and flutter were very low, measuring 0.03% and 0.05% respectively at 7½ ips with the *Ampex* 31326-01 test tape. The tape speeds, measured with a tape strobe, were exact. The fast tape handling was unusually fast, requiring less than 50 seconds to move 1200 feet of tape. The signal-to-noise ratio averaged 45 db at 7½ ips and 46.5 db at 3¾ ips. The noise was essentially all hiss, with little or no hum present.

The amplifier section frequency was down 3 db at 25 and 15,000 cps, in the flat tone-control position. The treble boost was a very mild 3 db maximum in the 8000 cps to 10,000 cps region. The "bass boost" was actually a strong treble cut, beginning at a few hundred cps and reaching a maximum of about 13 db. The power output of the amplifiers, although nominally rated at 10 watts per channel, varied from about 10 watts into a 4-ohm load, to about 6 watts into a 16-ohm load. Intermodulation distortion on one channel of the test unit was under 1% up to several watts output, with a 16-ohm load, and under 3% up to more than 10 watts output into a 4-ohm load. The IM distortion of the other channel was higher at low levels, but decreased to normal levels at several watts output.

When making recordings at 7½ ips from an FM tuner, no change in sound quality (other than a very slight increase in hiss level) could be heard when comparing the incoming and outgoing signals from the recorder. At 3¾ ips, only a slight dulling of extreme high frequencies distinguished the two signals. The over-all sound quality of this recorder is compatible in every way with the finest home music systems, when played through an external amplifier and speaker systems. Its internal amplifiers and speakers are quite adequate for monitoring or casual listening. The built-in amplifiers were able to drive medium-efficiency speaker systems with very pleasing sound quality.

The tape transport is, without a doubt, the most fool-proof we have ever used. No matter how the controls are misused, it is impossible to break, spill, stretch, or accidentally erase a tape. The recorder can be mounted horizontally, vertically on the removable bases provided, or at any other angle. It runs cool and requires only a minimal amount of ventilation.

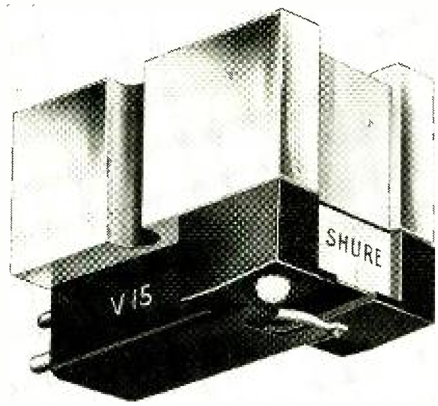
The manufacturer also makes available a dynamic microphone, the DF-1, which is well suited for use with the 47/26 recorder. We found the quality of the DF-1 microphone to be perfectly satisfactory for general home or other nonprofessional recording. Another accessory is a remote-control unit which plugs into the recorder. It has a duplicate set of "piano keys" which allow control of all tape transport functions up to a distance of about 20 feet from the recorder.

The *Vernon* 47/26 recorder, with plastic cover, all cables, and mounting accessories, sells for $600.00. ▲

Shure V-15 Phono Cartridge

For copy of manufacturer's brochure, circle No. 64 on coupon (page 13).

RECENTLY, the significance of the vertical angle between the generating elements of a phono cartridge and the record surface has received wide publicity. It has been shown, both theoretically and practically, that the vertical angles of the recording cutter stylus and the playback cartridge stylus should be identical. The chief result of an appreciable departure from this condition is



an increase in playback distortion, mostly second harmonic. There is general industry agreement that a 15-degree vertical angle in the playback system is optimum for playing older records as well as those made with more recent cutter designs.

The new *Shure* V-15 "Stereo Dynetic" cartridge is designed with a 15-degree vertical tracking angle. Like other *Shure* cartridges, it is a moving-magnet design, with an easily removable stylus assembly. The stylus compliance is 25×10^{-6} cm./dyne in both lateral and vertical planes, which calls for a tracking force between ¾ gram and 1½ grams. Forces greater than 1½ grams are not recommended. If the pickup is dropped, or excessive vertical force applied for any reason, the stylus retracts until a small plastic button on the stylus assembly contacts the record surface. This protects the stylus from accidental damage, and also does away with the pops and clicks caused by record scratches produced by rough handling of the pickup.

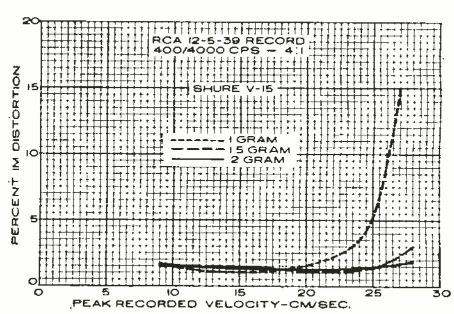
A unique feature of the cartridge is its elliptical stylus. One of the inherent weaknesses of disc recordings is the fact that the cutting and playback styli have different shapes. Records are cut with a sharp-edged stylus and played back with a conical stylus. The inability of the playback stylus to trace precisely the groove modulation cut by the recording stylus leads to "pinch-effect" distortion, as well as a loss of high-frequency response near the inner grooves of the record, where the recorded wavelength becomes comparable to the stylus dimensions.

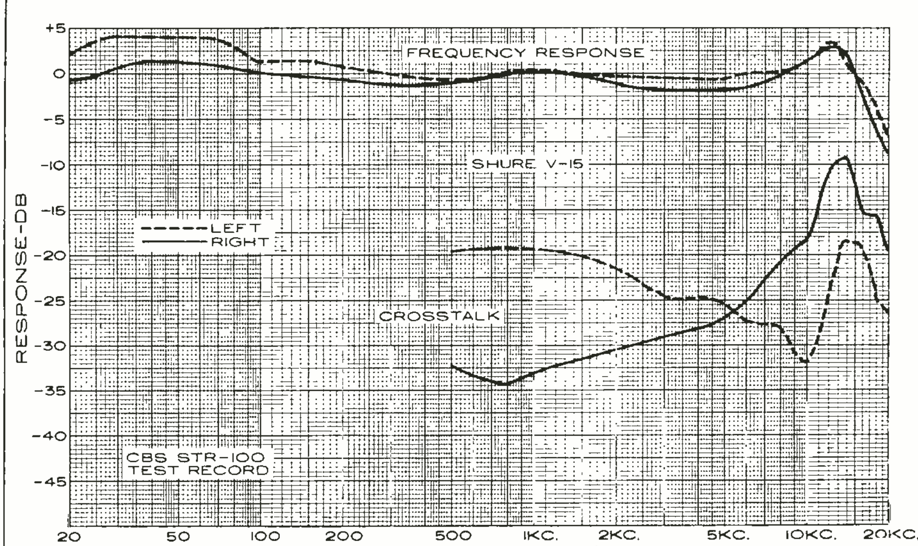
One approach to the solution of this problem has been the use of a smaller tip radius on the playback stylus. Some stereo cartridges have conical styli with 0.4-mil tip radius, or even less. These can produce a noticeable improvement in clarity and reduced distortion near the end of a record. However, they are unsuitable for playing mono LP records which were designed for a 1-mil playback stylus. The small tipped styli tend to "rattle around" in the bottom of a mono LP groove, producing unpleasant distortion.

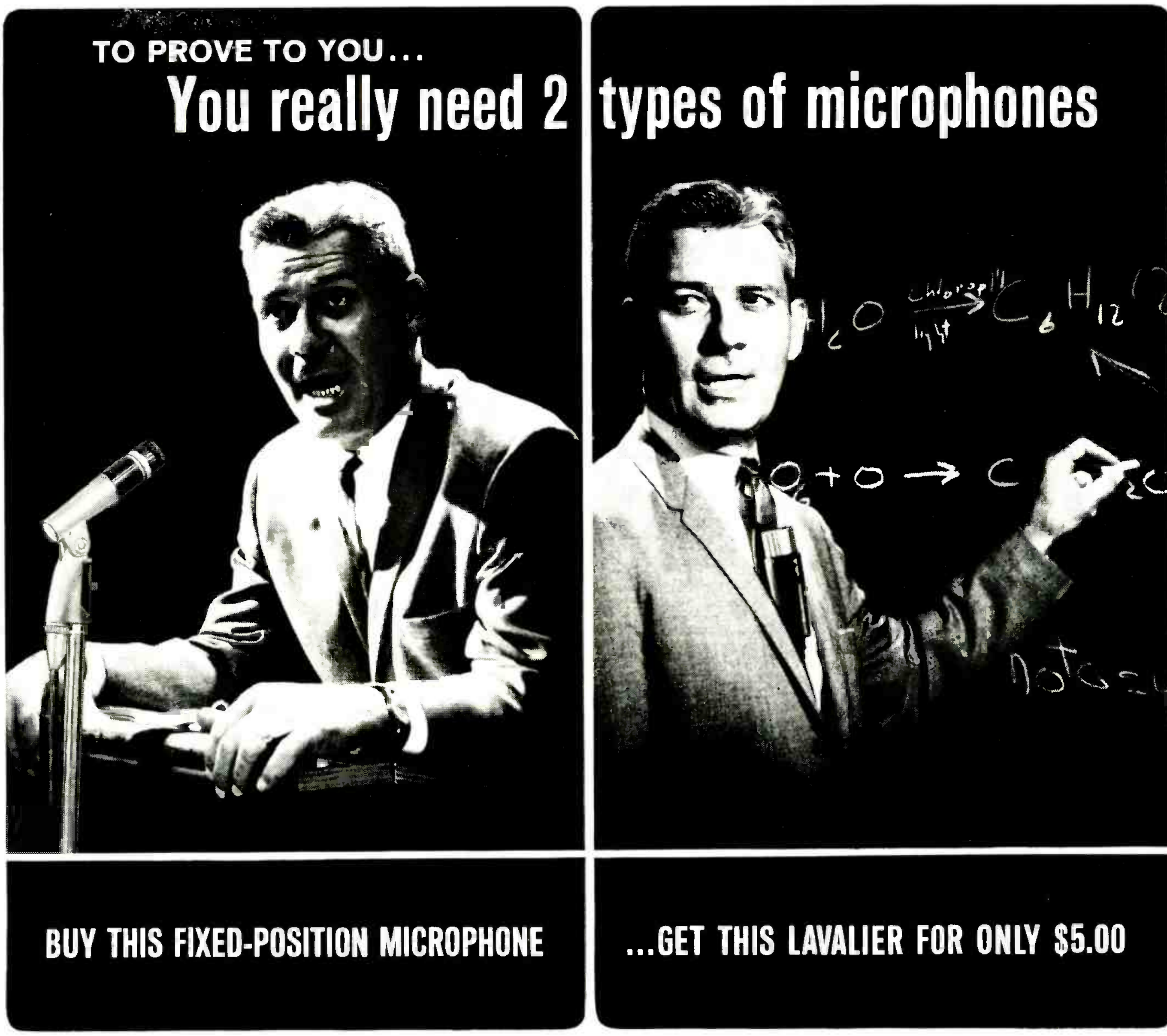
Another approach has been the use of an elliptical stylus. This has a larger radius at right angles to the groove and a small radius on the portion of the stylus which contacts the groove walls. The short wavelengths of high-frequency groove modulations are readily traced by the small edge radius, while the large frontal radius keeps the stylus from "bottoming" in the record groove.

Elliptical styli have been tried several times in the past by various manufacturers. They have usually been offered on experimental or limited-production cartridges. Difficulties in manufacturing the diamond styli have prevented widespread application of this concept. *Shure* has now introduced the elliptical

(*Continued on page* 105)







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This special limited-time offer applies to the famous Unidyne II and III series and other fine Shure microphones listed below.* Unidyne III is the only cardioid microphone with pick-up pattern symmetrical about axis and uniform at all frequencies. Outstanding for voice or instruments.

*Models 300, 315, 330, 333, 55SW, 55S, 545, 545S, 546, 556S, 576, 578, 578S. A Shure Lavalier for only $5.00 with each, when you send in your guarantee registration card. Offer expires December 31, 1964.

For lecturers, teachers, ministers, managers, public speaking requires the freedom and flexibility of a second microphone. The ability to move around while talking frees the speaker for writing on a blackboard or handling visuals, makes any speaker more interesting, more effective. Prove it to yourself for only $5.00 when you buy a Shure Microphone for fixed-location use.

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That's all there is to do. Your microphone will be sent to you post paid. Sorry, no C.O.D.s.

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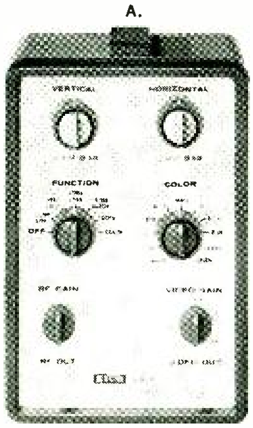
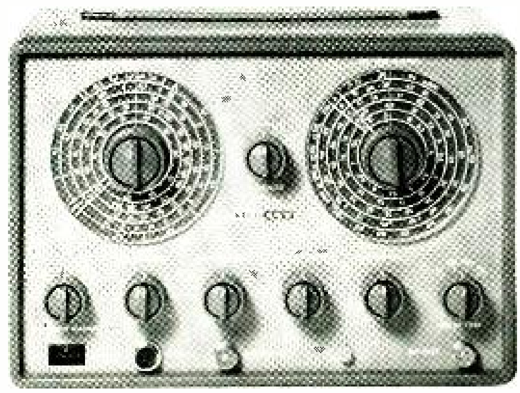
EICO's complete new color TV lab for the pro

A.



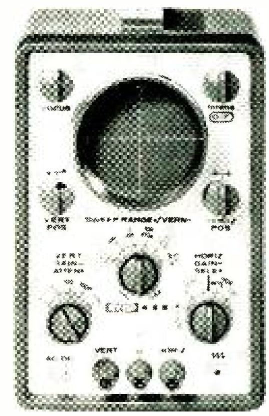
Model 380

B.



Model 369

C.



Model 435

Color TV servicing is a job for professionals—and **Eico's new color TV test equipment** is designed to their requirements. Professional service engineers can't afford to waste time on apparent set troubles caused by makeshift, inaccurate test signals, or on test equipment that is inherently difficult to use or incapable of fast, accurate determinations. Critical professionals know they can depend on EICO for accuracy, reliability, and laboratory standard performance. Moreover, EICO has now successfully reduced equipment size while improving performance, to permit convenient on-location servicing. No wonder the pros choose EICO!

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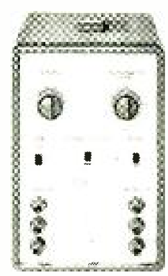

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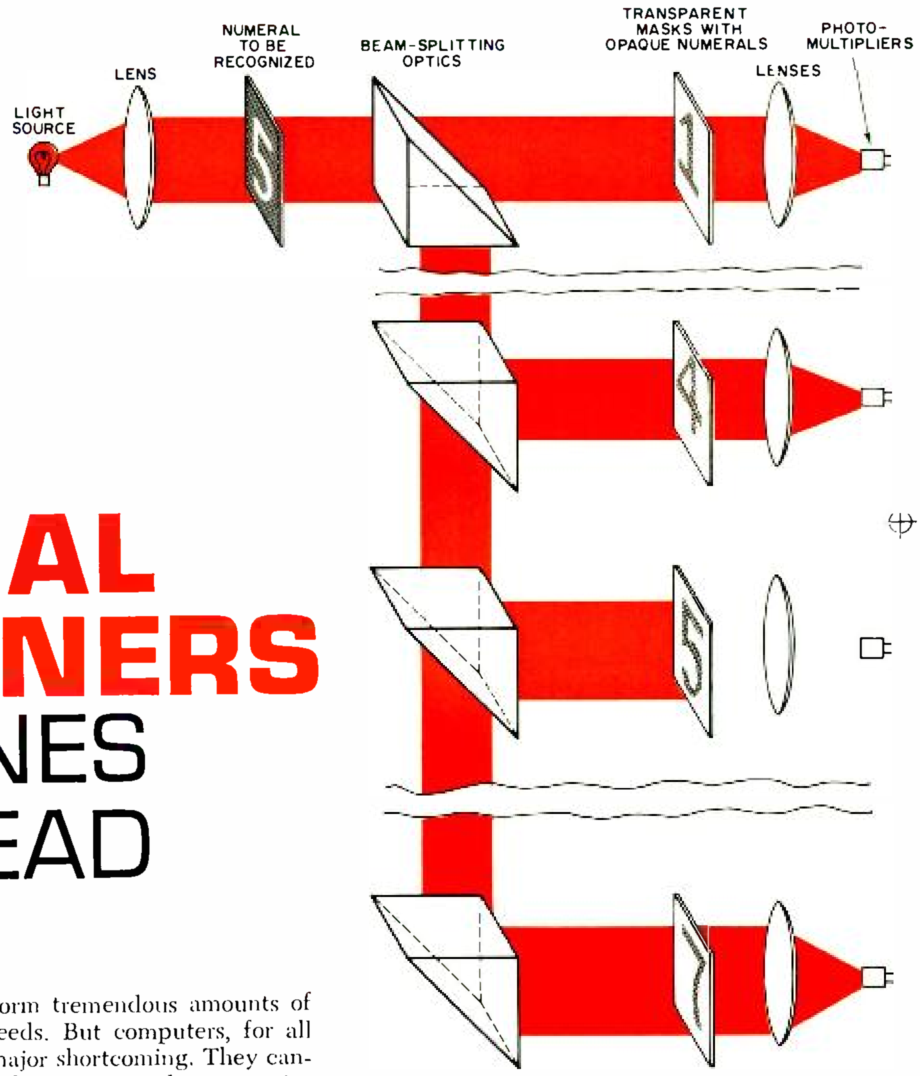
A survey of the various techniques that are now under development and in present use for the translation of printed or written alphanumeric characters into computer signals.



OPTICAL SCANNERS MACHINES THAT READ

By KEN GILMORE

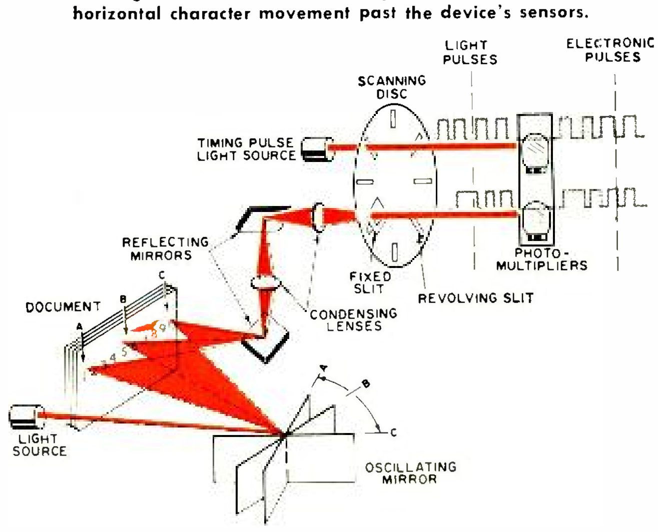
TODAY'S computers perform tremendous amounts of work at unbelievable speeds. But computers, for all their abilities, have one major shortcoming. They cannot read documents designed for human eyes—the mountains of bills, receipts, sales slips, vouchers, forms, and other papers that keep our society running. As a result, the job of coding information so that computers can use it is, for the most part, still done slowly, expensively, and inaccurately—by hand.

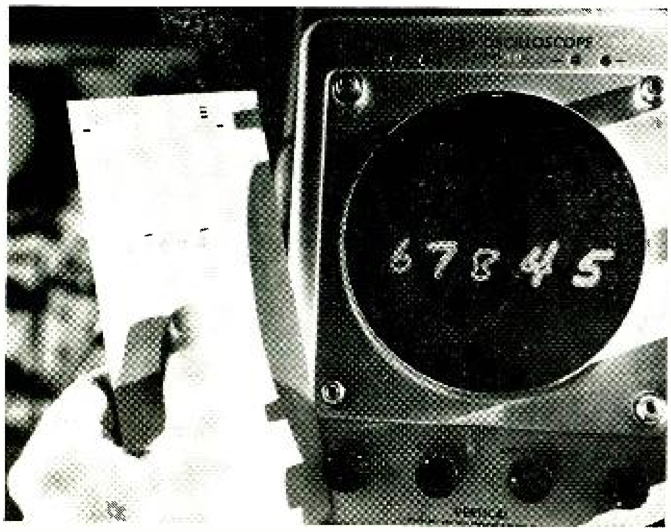
At last, though, this great bottleneck is being broken. More than a score of companies are now working on optical reading machines—devices that scan typewritten or printed words and numbers and translate them into punched cards or digital signals automatically, with speed, accuracy, and economy far beyond human ability. (Optical reading machines should not be confused with *magnetic* reading machines, designed to identify numbers on the bottom of checks. For a full explanation of this quite different system, see ELECTRONICS WORLD, April, 1963.)

A large number of optical reading machines are already at work, doing a wide variety of jobs. A battery of optical scanners keeps track of the more than 600,000 dividend checks and the hundreds of thousands of warrants, proxies, and other stockholder documents the *American Telephone and Telegraph Company* sends out periodically. A majority of the country's major oil companies now read incoming gasoline credit card charge slips with automatic machines. (You may have noticed the stylized printing designed especially for machine reading on some of your own credit cards.) Many of our major insurance companies, utilities, and other firms

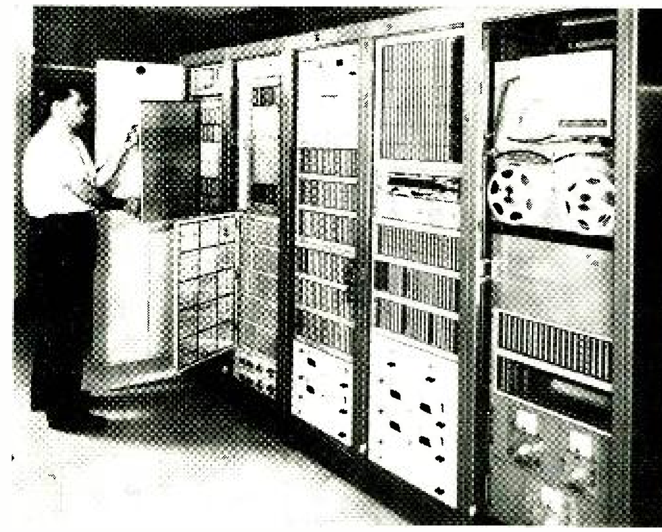
Fig. 1. Mask-matching technique. Transmitted image coincides with only one mask, that of the "5," so no light passes through that mask. In this case the number to be recognized is transparent. Optical methods of projecting numbers written on paper have also been devised.

Fig. 2. Alternate Farrington reading scheme, using oscillating mirror rather than moving document to produce horizontal character movement past the device's sensors.





Display on scope shows number presented to logic circuits of experimental IBM reader. A card with the same digits as the one at the left has been placed in the reader. The logic circuits guide the scanning beam on a moving circular path around the written characters to detect the line edges and extract the other data required for proper recognition.



By 1965, some U.S. mail will be electronically read and sorted by ZIP code. As a preliminary step, this recognition equipment, designed by Philco, has been delivered to the Post Office Department for extensive testing and evaluation. The equipment reads mail addresses and controls sorting machine. This system will greatly speed up the distribution of mail.

now read returned premium notices and their customers' bills by means of machine.

The experience of one company shows why firms that handle large volumes of documents are turning to automatic reading. Back in 1955, the *Reader's Digest Book Club* was sending out some 15- to 20,000,000 books a year in four quarterly shipments, recruiting temporary help to handle each tremendous mailing. To eliminate the inefficiency inherent in such a system, the company bought a specially designed machine from a small firm called *Intelligent Machines Research* (later to become a division of *Farrington Manufacturing Company* and the country's leading producer of reading machines). The original device, which could read through the entire subscription list in a few days and prepare computer instructions for label printing, is still in operation. *Digest* officials report that the scanner—first optical reader to go into commercial service in the United States—has saved its original price every six months both in terms of very much reduced labor costs and increased efficiency.

Three Principal Approaches

Optical reading machines working on many different principles have been built. Most effort, however, has gone into three main approaches: template or mask matching, feature extraction, and matrix matching.

The first approach—*mask matching*—is the simplest. The image of a character to be recognized—say a "5"—is projected on a series of transparent masks, each containing a single character printed in black (Fig. 1). When the image is projected on the mask containing the 5, the projected image coincides exactly with the printed image and all light is blocked. Since there is some mismatch as the 5 is projected on all other masks, some light shines through each and falls on each photomultiplier except the one behind the 5. The mask that blocked all light is easily detected by the photocells, and the character is thus identified. Optical systems can be designed to project a number or letter to be recognized on all masks either simultaneously or else in a sequential manner.

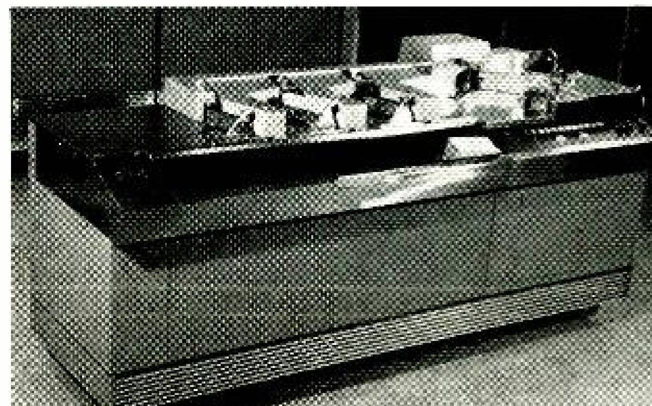
Although such a machine is attractively simple in principle and construction, it has several major disadvantages. Character size, registration, and alignment are extremely critical. A system designed to recognize one type face has a high error rate on any other. Also, most documents in business, government, and science that could be efficiently read by machines are typewritten. And typed characters, when examined under magnification, are far from perfect. Lines are broken, open areas filled in, edges fuzzy. Mask-matching systems do poorly on such type. For this reason, mask-matching techniques have been largely abandoned.

Most commercial readers today are based on one of two more versatile approaches: feature extraction or matrix matching. *Farrington* machines, although they vary somewhat from model to model in scanning geometry and recognition circuitry, illustrate the first approach mentioned.

Feature Extraction

The illustration on the cover shows the mechanical scanning system of one *Farrington* reader. The combined movements of the character (and its projected image) and the scanning disc cause successive vertical slices of the character to be projected through the fixed plate slit onto the photomultiplier. The scan can be compared to a television raster except that the scanning rates are interchanged: the high-speed vertical sweep is supplied by the spinning disc and the fixed slit, while the slower horizontal sweep is produced by the movement of the document. (Note: On the cover illustration the fast sweep is vertical with respect to the numbers on the document but due to the mechanical arrangement shown, this scanning is done horizontally across the image

An RCA-developed optical character reader takes advantage of scanning ability of the TV vidicon tube. The device reads data on 90,000 utility bills or insurance premium notices an hour.



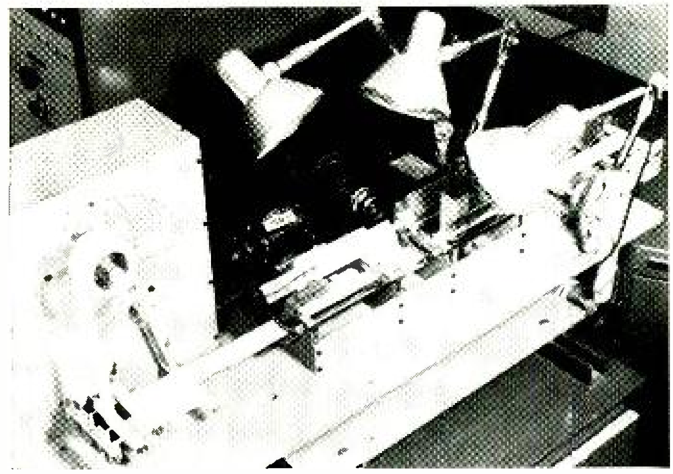
Main units of IBM experimental multifont optical character reader are shown here. Power supply and scanner are in the background, a part of identification circuitry is at right. The text, as seen by the scanner, is displayed on TV screen.

which is turned 90° at the scanning disc. As the document moves horizontally through the reader, the images of the numbers move vertically at the scanning disc.)

Fig. 2 illustrates a slightly different arrangement using an oscillating mirror for the horizontal motion. A typical scanning pattern and the waveforms generated by representative scans in either system are shown in Fig. 3.

The waveforms are sent to a recognition logic section for feature extraction. The logic section determines the presence or absence of such features as a horizontal top, bottom, or middle bar, short or long vertical bars on right or left, and so on. A "2" for example, must have a horizontal top, middle, and bottom bar, and short vertical bars on the top right and lower left. Characteristics the machine seeks in other numbers are shown in Fig. 4.

The machine determines which features are present and absent by analyzing the waveforms in a series of logical

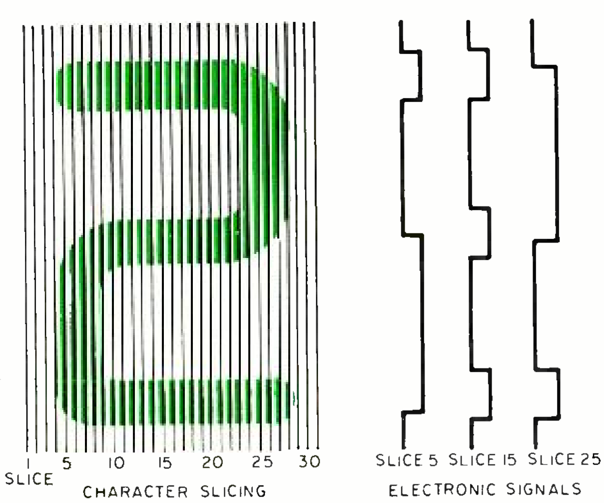


As the paper tape being read on this machine moves past the reading station, a spinning 4-sided mirror reflects images of numbers being read through a lens onto photomultiplier reading heads. The reader was built by Rabinow Engineering to read the fare tapes made by Swedish streetcar conductors.

steps. The block diagram in Fig. 5, for example, illustrates the subroutine for detecting long vertical lines. Since the line to be analyzed may be imperfect with small missing portions, this circuit is designed to ignore small breaks. At the same time, it must detect longer breaks, such as the clear break in the vertical sides of a well-formed "8."

The waveforms A through E in Fig. 5 illustrate the detection process for a long vertical line with minor breaks. The signal to be analyzed (A) is presented to the detector circuit and inverted (B) by $I1$ so that the short missing portions show up as positive pulses. If these missing pulses are shorter than the timing interval of measuring circuit $M1$, they are eliminated, and do not appear at the $M1$ output (C). The signal is inverted again (D) by $I2$ and presented to the second measuring circuit ($M2$), whose interval is set to detect a long line. This circuit produces an output only if the signal is of greater duration than its measuring interval. Since a long signal is present, $M2$ produces an output pulse, which indicates the presence of a long vertical line. Two primer circuits, $P1$ and $P2$, determine whether the line is on the right or left of the character being detected. Timing circuits turn one of them on when the first edge of the character is detected, the other at the other end of the letter. Since the output of $M2$ is fed to both in parallel, an output from one indicates the right side; the other, the left.

Fig. 3. (Left) Electronic signals that are produced during optical scanning of the numeral "2" are illustrated below. Fig. 4. (Right) Simplified truth table for numerical characters. Abbreviations are for horizontal top (HT), horizontal middle (HM), horizontal bottom (HB), short vertical upper left (SVUL), short vertical upper right (SVUR); short vertical lower left (SVLL), short vertical lower right (SVLR), long vertical left (LVL), and finally, long vertical right (LVR).



	0	1	2	3	4	5	6	7	8	9
HT	+	−	+	+	−	+	−	+	+	+
HM	−	−	+	+	+	+	+	−	+	+
HB	+	+	+	+	−	+	+	−	+	−
SVUL		−	−	−	+	+		−	+	+
SVUR			+			−	−		+	
SVLL		−	+	−	−	−		−	+	−
SVLR			−			+	+		+	
LVL	+		−		−	−	+			−
LVR	+	+	−	+	+	−	−	+		+

Documents to be read are fed to paper-handling equipment at front of this Farrington reader. Associated electronic equipment, including recognition logic, is housed in the cabinet.

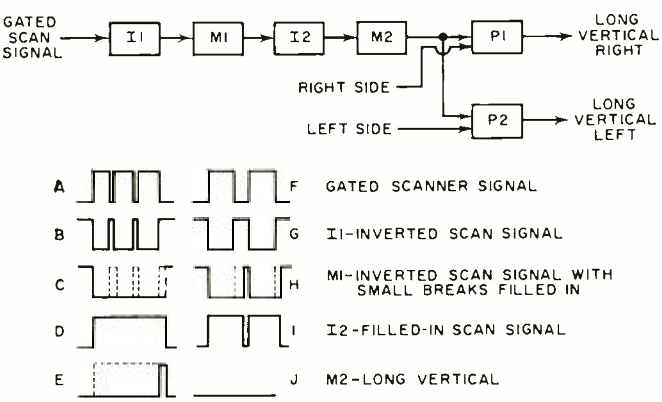


Fig. 5. Subroutine for detecting long vertical lines in spite of small imperfections. Timing circuits identify horizontal position.

When a number that does not contain a long vertical–such as an "8"–is presented to the circuit, the timing circuits discriminate as shown in waveforms F through J in Fig. 5. Since the peak in the inverted signal (G) is of longer duration than the timing interval of *M1*, it appears at the output of *M1* (H) and is inverted (I). Neither of the two long positive pulses is as long as the timing interval of *M2*, so this timing circuit produces no output. Subroutines of about the same complexity are used to determine the presence or absence of other vertical and horizontal strokes.

A final logical operation identifies the character by checking the outputs of the nine feature-extraction subroutines. (Fig. 6.) Each feature-extraction subroutine has two outputs, one of which is activated if the circuit detects a feature it is designed to respond to, the other if it doesn't. The recognition circuits for individual numbers are connected to all subroutine outputs used in the identification of that number, and generate an output signal only if they detect the proper pattern of "on's" and "off's" at the outputs of the various subroutines. For the "zero" to be identified, for example, Fig. 4 shows that the identification logic must detect a horizontal top and bottom, and long vertical left and right lines. In addition, it must *not* detect a horizontal middle. Thus the "zero" recognition circuit, as shown in Fig. 6, is connected to the "on" outputs of the four feature subroutines it must detect, and to the "off" output of the particular one of the subroutines which must be missing. The other subroutines play no role in the generation of a signal for a "zero."

The Matrix Matcher

Another major type of machine in operation today matches information derived from the character to be recognized with a different kind of criteria stored or wired into its circuitry. A reader built by *Rabinow Engineering* illustrates this.

The image of the character sweeps past a row of photocells (Fig. 7 A through G). Timing circuits sample the image at five points (B through F) and store the signals detected in a shift register. At sample time 1, for example, a fourth photocell from the bottom is the only one detecting a signal, and this information is stored in the shift register as shown. As the figure continues to move across the photocells, outputs at subsequent sampling times are also stored in the register. When the sampling is finished, the character is shifted down in the shift register to the "standard" position.

Each of the 60 elements in the shift register is represented

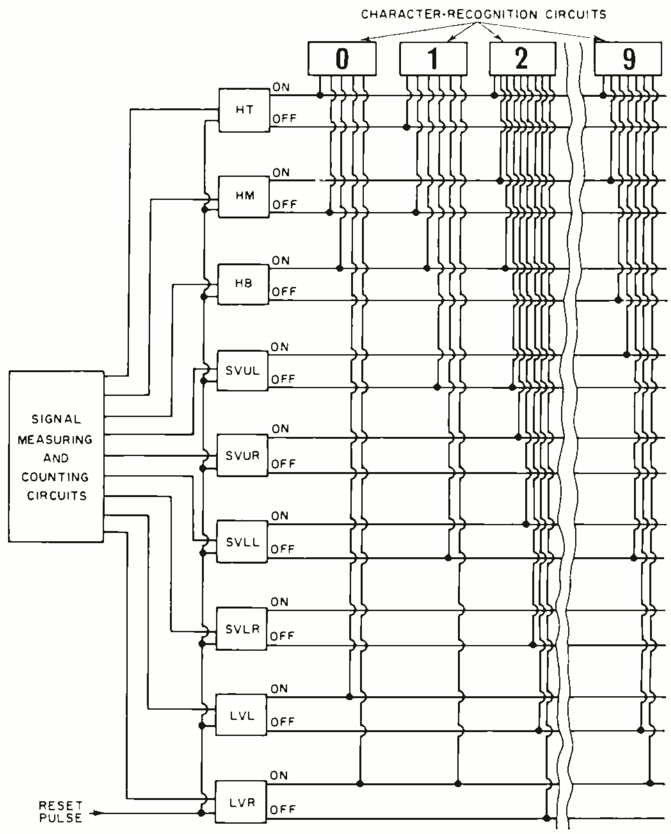
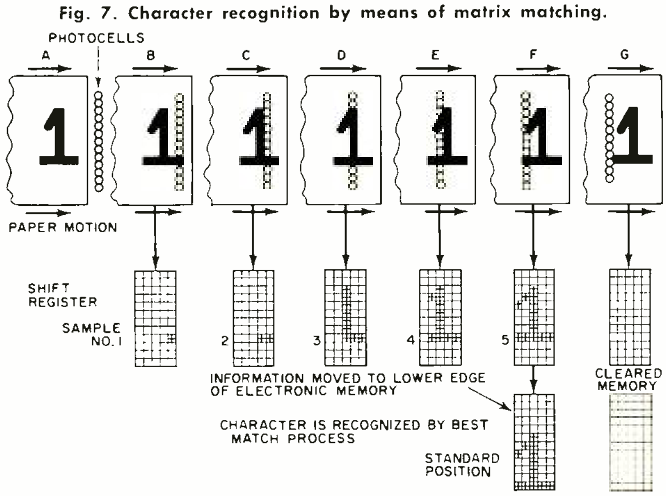


Fig. 6. Final operation with feature-extraction subroutines.

Fig. 7. Character recognition by means of matrix matching.



by a flip-flop circuit (Fig. 8). Normally, all circuits are in the "white" position. If a black area corresponding to a particular position in the register is detected during the character sensing, the flip-flop representing that position changes to the "black" position.

Once the number has been detected, stored in the shift register, and shifted to the standard position, the outputs of the flip-flop circuits are applied in parallel to a series of resistor matrixes (a separate one for each character to be recognized) for character identification (Fig. 9). As can be seen, a resistor is wired to the output of each flip-flop that should have a "black" output for the character to be detected.

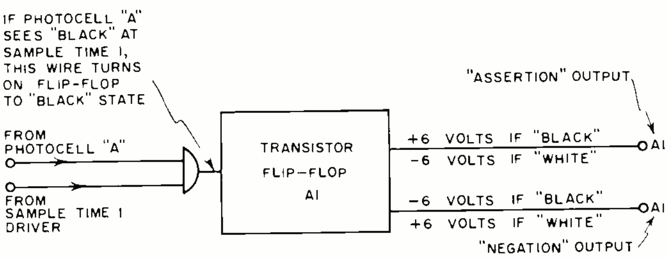


Fig. 8. One stage of electronic memory in matrix matcher.

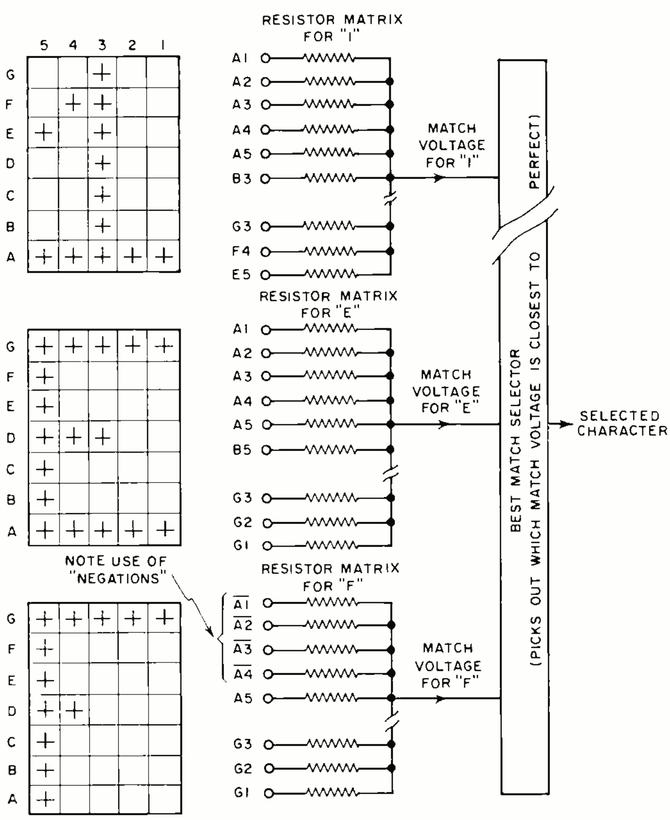


Fig. 9. Resistor matrixes are used for character recognition.

When the number "1" is stored in the shift register, for example the output of each of the assertion outputs of each of these flip-flops will be +6 v.; all other flip-flops will be registering −6 v. If +6 v. is applied to every resistor of the "1" matrix, then +6 v. will appear at the input of the "best match" selector. No other matrix will have only positive voltages applied to its resistors.

Take the "E" matrix, for example. Plus 6 v. will appear at 8 of its resistors, but −6 v. will appear at 9 others. Its resistors will operate as a voltage divider, and a potential of just below 0 v. will appear at the matrix output. The "1" matrix, in other words, has an output of +6 v., while all others show either a lower positive voltage or a negative potential. The "best match" selector therefore identifies the character as a "1."

As is the case with the feature-extraction technique, a character need not be perfect to be identified. Some of the flip-flops can be in the wrong state, and the voltage generated consequently somewhat below +6 v., yet the machine will find the highest voltage and identify it as the "best match." In practice such machines can correctly identify quite poorly typed characters.

As seen in Fig. 8, each flip-flop has a "negation" output, as well as its normal "assertion" output. While most normal recognition is accomplished with the assertion circuits, negation outputs are used to help distinguish between similar characters such as "E" and "F." The matrix for the letter "F" (Fig. 9) has four "negatives" and a "positive" along its bottom row, for example, to distinguish it from the "E" which has five positives. Thus the voltage difference generated by "E" and "F," which, without the use of negation outputs, would tend to be small, is made larger, and the two can be differentiated more easily.

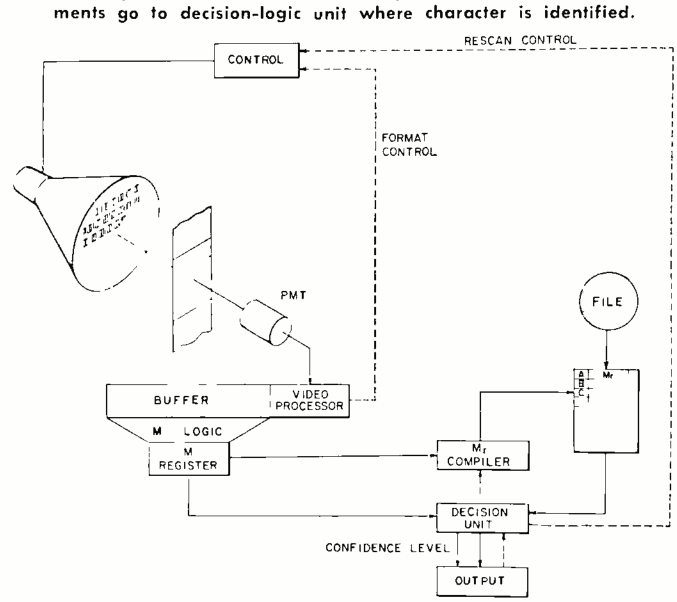
Still another technique can be used in a matrix-matching system to distinguish between similar letters, such as "O" and "Q." Instead of using identical resistors at each matrix position, those that sense the tail of the "Q" are of a lower value. Thus the voltages generated by the tail are disproportionately large, and the tail receives greater weight in the machine's decision process. This principle of emphasizing parts of the character particularly important in its recognition is applied wherever similarities tend to make identification difficult.

Matrix-matching machines can be made more versatile by providing a number of different resistor matrixes for each character to be recognized. One matrix, for example, might be designed to recognize the capital letter "R," another a lower case "r". Still others might be provided to recognize the same letter in various other type faces.

Many Variations

Although most current machines operate either on feature-extraction or matrix-matching principles, there are many variations. The *Farrington* machine cited earlier, for example, develops its scanning pattern with a combination of spinning disc and document movement. (*Continued on page* 84)

Fig. 10. Block diagram of main components of experimental multifont optical character reader built by IBM. CRT beam scans the text to be read, and resulting output signal from photomultiplier tube enters the buffer. Then the signal goes into the measurement-logic unit, where each character's distinguishing features are determined. If the machine is being trained to recognize a new type font, these features are sent to a measurement reference compiler and then stored on magnetic tape. When the machine actually reads text, the measurements go to decision-logic unit where character is identified.



TAPE-WINDING NOMOGRAM

By FRED BLECHMAN

These charts make it simple to wind the correct amount of tape on various reel sizes for different recording times.

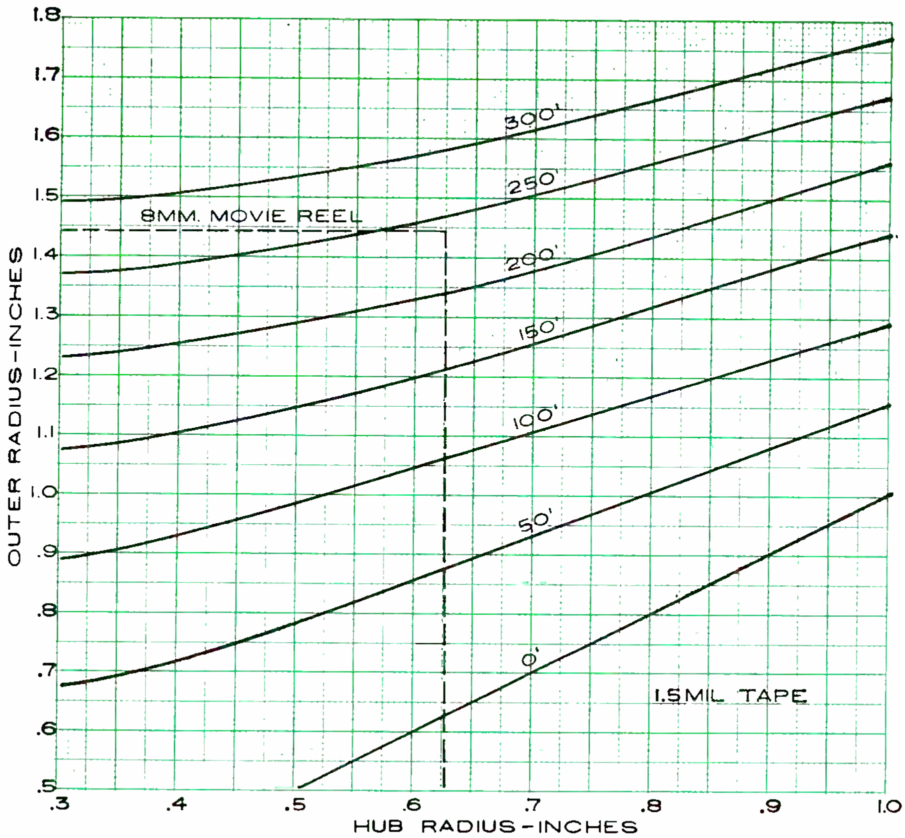
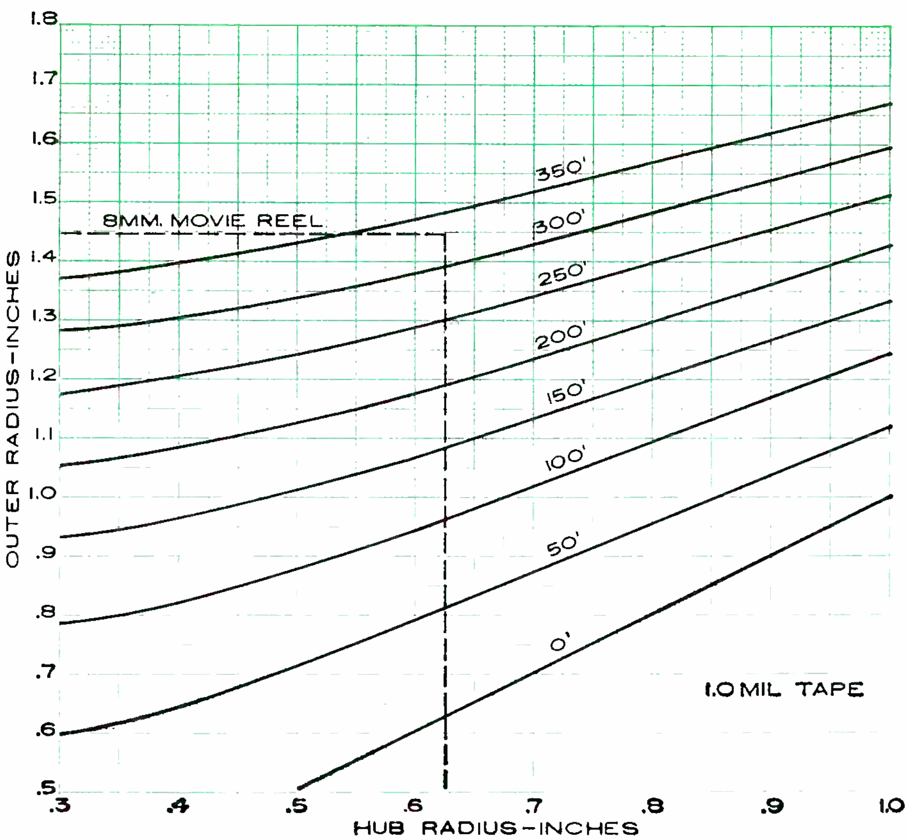


Fig. 1. Outer and inner radii for tape winding using 1.5-mil magnetic tape. Note: Dashed lines in Figs. 1, 2, 4 show maximum outer radius of 8-mm reel.

Fig. 2. Outer and inner radii for tape winding using 1.0-mil magnetic tape.

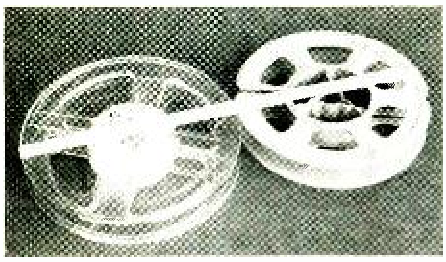


If you have occasion to make a large number of short recordings or if you do much corresponding *via* tape, it doesn't take long before you have an array of different-sized reels holding unknown lengths of tape. Since these lengths are not known, the recording time is unknown, especially since three different thicknesses of tape are in common use.

When you wish to record a tape of a specific length or to wind your own tapes from larger reels for economy, you are faced with a seemingly complex problem. One solution is to spend valuable time running entire tapes through the recorder at a known speed and calculating the length. There is, however, a much faster and easier way—take two simple measurements with a common inch-scale and use the charts that accompany this article.

Fig. 3 is a nomogram of tape length and recording time at various standard speeds. To use it you only need a straightedge. For example, you wish to know how long 150 feet of tape will run at 3¾ ips. Lay the straightedge on the nomogram so it intersects the 150-foot marking on the left scale and the 3¾-ips marking on the diagonal scale: the result (8 minutes) will be found where the straightedge crosses the right side of the scale.

Next, let us consider Figs. 1, 2, and 4. Suppose you wish to wind 8 small reels of 150 feet each from a 7", 1200-foot reel of 1.5-mil tape. First measure the hub radius of the small reels you intend to use. (Common 8-mm. movie reels, often used by tape-respondants, have a hub radius of .625 inch.) Enter Fig. 1 (1.5-mil tape) at the hub radius on the horizontal scale and move vertically upward until you intersect the 150-foot curve. The proper radius for this tape winding length will be found directly across on the vertical scale. Now all you do is mark this "outer radius" on the reels with a pencil or



Commonly used small reels include the 3¼-in. diameter reel that holds 600 feet of .5-mil tape (left) and the 8-mm. movie reel (right).

Fig. 3. (Upper right) Tape length versus record-play time nomogram for various tape speeds.

Fig. 4. (Lower right) Outer and inner radii for tape winding using .5-mil magnetic tape.

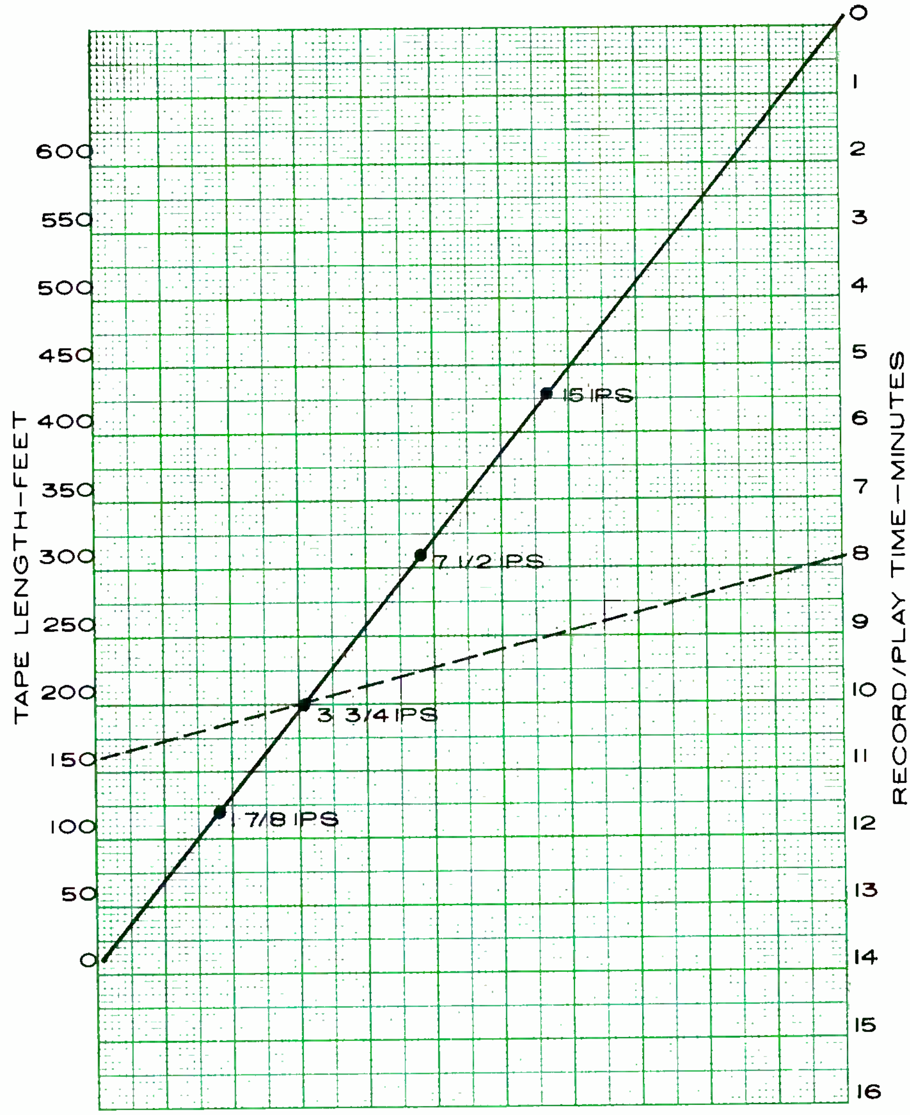
felt-pen and fast-forward wind tape from the large reel to the marked point on the small reels. This will give you within a few percent of 150 feet on each small reel. If you are using 1-mil tape, utilize Fig. 2 in the same manner, and Fig. 4 for .5-mil tape.

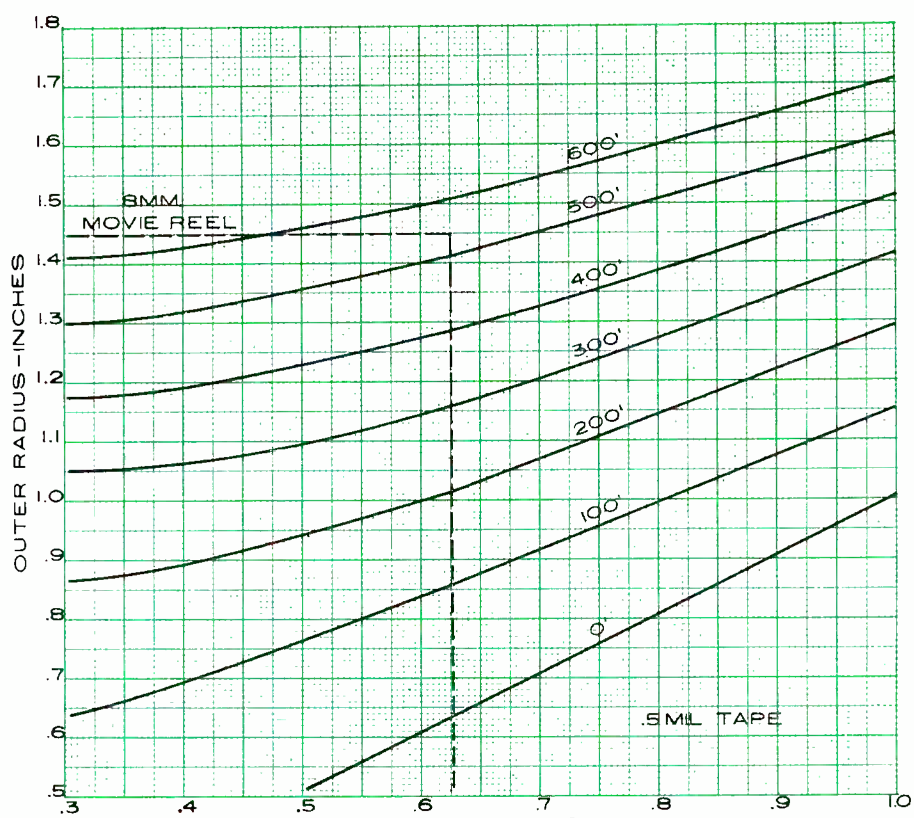
Of course, these curves can also be used to determine unknown tape length by measuring the hub and tape winding radii; however, you must know the tape thickness. The easiest thing to do in this case is to run the tape through the machine at 7½ ips for exactly four minutes; this will be 150 feet. Measure the hub and tape radii on the takeup reel and find which of the three charts (Fig. 1, 2, or 4) has these coordinates intersecting at the 150-foot curve. This, of course, tells you the tape thickness, since each chart is for a *different* tape thickness.

Figs. 1, 2, and 4 are based on the formula: $L = K\,(R^2 - r^2)$ where L = tape length in feet, K = tape thickness/air gap constant, R = outer tape radius in inches, r = reel hub radius in inches.

The "fly in the ointment" here is that there are three different common tape thicknesses and an undefined air gap between tape layers. The author has found, experimentally, the factor K for each tape thickness. This was found to be: 314 for .5-mil tape, 193 for 1-mil tape, and 140 for 1.5-mil tape. The results, using these formulas, are good to within 2%, close enough for most uses.

Liberal use of plain leader tapes will allow marking the tape length at each end of the reel. The box should also be marked with the tape length. Keep the charts handy, stored with your tape accessories, and you'll probably find yourself using them often. Fig. 3 is especially useful. Since the largest tapes normally used in correspondence do not exceed 3¼", 600-foot reels, no attempt has been made in these charts to cover larger reels or longer tapes. The formulas will, however, work for larger reels. ▲



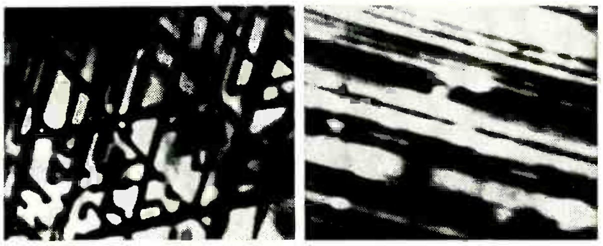


RECENT DEVELOPMENTS in ELECTRONICS

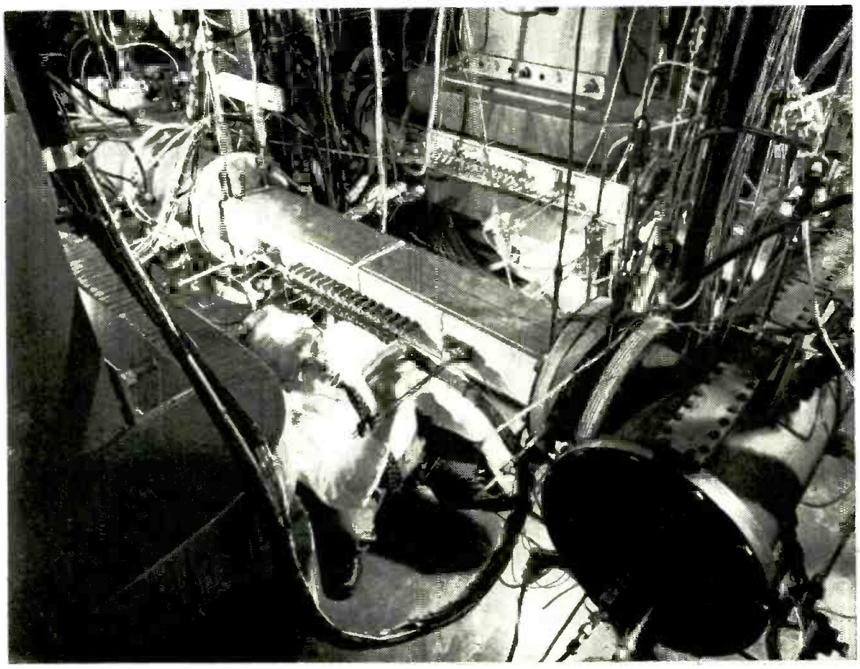
Ultrasonic Leak Detector. (Above) A new method of detecting leaks in pressurized telephone cables is used by repairman shown. The leak is found with the aid of a compact ultrasonic transceiver, made by Delcon Corp. The device operates on a frequency of 35 to 45 kc. It detects high-frequency hissing sounds emanating from tiny leaks from as far away as fifty feet on busy streets, while not responding at all to the audible noises made by the traffic.

Plasma-Jet Generator. (Above) A free-burning plasma jet with a brilliance three times as great as any other steady light source on earth was demonstrated recently at Columbia University's Electronics Research Lab. The jet, operating at 20,000 degrees, easily boiled tungsten and cut through concrete. The plasma jet consists of a highly ionized gas, such as argon, that is fed under pressure through a porous anode at the center of the generator face. Up to 450 amps of current at 40 to 60 volts flows from 3 cathodes to the anode in a continuous arc discharge. The gas is instantly ionized by the arc as it emerges from the anode, and conducts the heavy current forming the jet.

Wireless TV Camera. (Above) A new TV pickup tube has made possible the development of a wireless TV camera with studio quality. The camera, used first by CBS to cover the Republican National Convention, weighs under 29 lbs. including transmitter and power supply. The tube, made by Philips, though far smaller than a studio image-orthicon, nonetheless meets the same operational standards and characteristics.

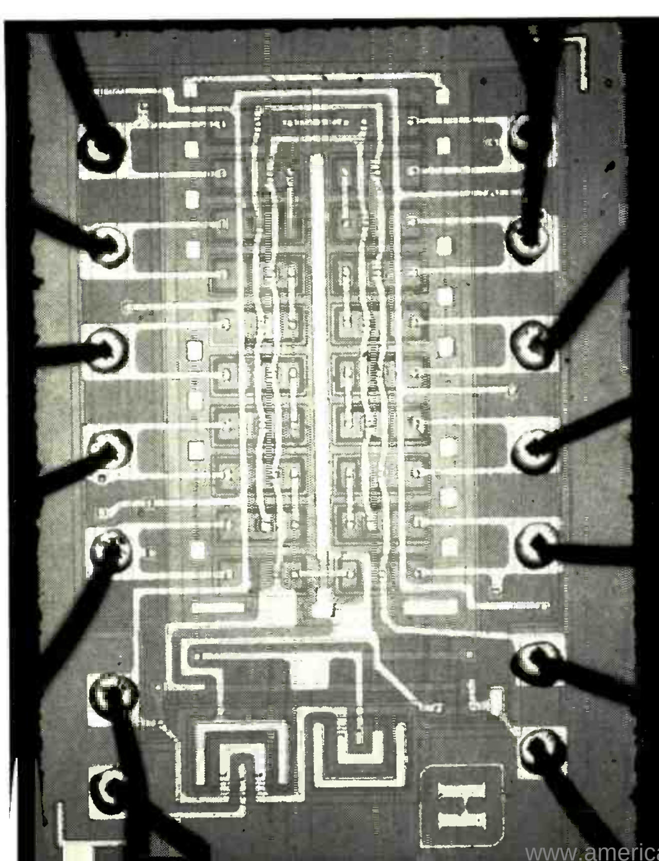


Scanning Electron Microscope. (Above) The photomicrographs show two different internal views of crystal imperfections in a silicon diode. The photos were taken with a scanning electron microscope, developed at Bell Laboratories, at magnifications of about 700X. Using this technique, scientists can "look inside" semiconductor diodes using a finely focused electron beam in order to study internal crystal defects. Variations in the beam energy permit various degrees of penetration.



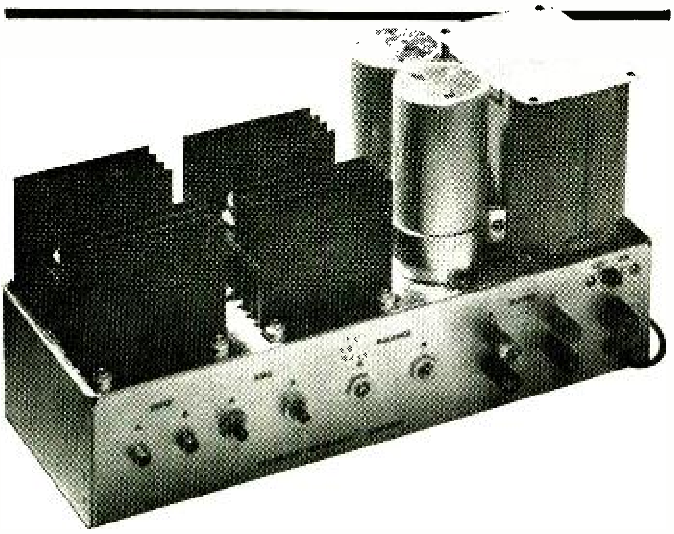
Experimental MHD Generator. (Left) A new research machine for testing the feasibility of electric power generation in space by magnetohydrodynamics, or MHD, is shown here. The machine combines a generator and motor in a closed, self-contained loop—the first such MHD device to operate entirely without moving apparatus of any kind. The equipment fits between the poles of strong magnets. Two end pieces complete the loop, through which a white-hot plasma of helium and cesium circulates continuously during the machine's operation. Power is generated by the passage of the highly ionized gas mixture through the magnetic field. The experimental system was developed by Westinghouse for the United States Air Force.

Artificial Quartz Crystals. (Right) The first factory in Europe for the commercial production of artificial quartz crystals was announced by ITT's Standard Telephones and Cables Ltd. The new $2.8 million production facility will produce crystals for the electronics industry. Until now, the electronics industry in Europe had been dependent on supplies of natural crystalline quartz. These crystals were expensive and large wastage resulted from irregularities and natural defects. The artificial crystals are grown from scrap chips of quartz dissolved in solution at elevated temperatures within heavy-walled pressure vessels. At the proper temperatures and at pressures up to 30,000 psi, the dissolved chips deposit in the form of a large crystal onto a "seed" crystal previously placed in vessel.



Microelectronic Decade Counter. (Left) The decade counter shown, developed by Honeywell, is described as the semiconductor industry's most complex monolithic integrated circuit. The silicon chip contains some 59 components on a single silicon chip measuring only .088 by .138 inch in size. These components are 23 transistors, 16 resistors and, for the first time, 20 silicon controlled rectifiers. Initial packaging will be in a 14-lead, low-profile TO-5 can. The circuit is a 10-stage ring counter which is to be incorporated in an electronic fuze, cascading four decades to form a decimal counter. In the fuze example, reliability and design simplicity will be increased markedly with the reduction in external leads to 14 from the 185 in present use. The digital circuit is designed for a counting rate exceeding 100 kc., operates from 4.5 volts, and dissipates 25 mw.

the "TRANSISTOR WILLIAMSON"



STEREO POWER AMPLIFIER

Design details of an all-solid-state dual 30-watt power amplifier. Recently developed transistors are employed in a complementary push-pull emitter-follower output circuit.

By KEITH H. SUEKER

Semiconductor Div., Westinghouse Electric Corp.

Editor's Note: The following circuit is a basic power amplifier. It must be used with a preamp which has equalization, tone, and volume controls. The associated preamp may be either a vacuum-tube or transistor type, and either a commercial unit or home-built. Requirements for the preamp are given in the article.

Listening tests on the amplifier confirm its fine qualities. Reproduced sound was clean and open and we were very pleased with its performance. Lab tests on the unit showed that it meets and, in some cases, exceeds the figures given by the author. For example, maximum mid-frequency steady-state power output before clipping was found to be 28 watts at 8 ohms and 36 watts at 4 ohms. With both channels driven, power dropped less than 1½ db.

IN 1947, D.T.N. Williamson developed the advanced-design "Williamson" amplifier circuit, which has since become world famous. With various modifications and refinements, including the "ultra-linear" connections, the original circuit can still be recognized in the vast majority of today's vacuum-tube high-fidelity amplifiers. As wide-range output transformers became generally available at reasonable prices, "Williamson" amplifiers were built literally by the millions and sound reproduction in the home rapidly reached new levels of quality. Modern vacuum-tube amplifiers of this basic type are capable of performance levels, including flat frequency response, good transient characteristics and low distortion, substantially better than the best available input and output transducers (*i.e.*, microphones, pickups, and speaker systems). The amplifier, then, is certainly not often the limiting factor in system performance. Nonetheless, the search goes on for better amplifier circuitry, and each year the art advances a bit closer to perfection.

Much of the current interest in amplifier development involves transistor "output-transformerless" (OTL) circuitry. Elimination of the output transformer reduces the size and weight of the amplifier and subtracts a substantial cost element in high-power circuits. The relative merits of transistors *versus* vacuum-tube amplifiers in general have been endlessly (and entertainingly) debated, and it seems pointless merely to add fuel to the fire. Rather, it is the intention of this article to describe an OTL transistor amplifier of unusual design which can take the place of the Williamson amplifier for the home constructor. It incorporates all the basic virtues of the Williamson circuit as regards the use of standard components, ease of mechanical assembly, foolproof operation, freedom from complicated adjustments, and a high level of technical performance at a reasonable cost.

Design Considerations

The design of an amplifier usually starts with the output circuit since it is this stage which determines amplifier power capabilities. The transistor amplifier designer has available a number of basic OTL output circuits and options within these circuits. The field is soon narrowed down, however, by practical considerations. First, push-pull operation is mandatory for all but the lowest power levels; second, class B operation is certainly desirable for high-power output and good utilization of semiconductor capabilities; third, for the home constructor, it is preferable to use a circuit which has "intrinsic linearity"—one which does not depend on selection or matching of transistors. Finally, elimination of the driver transformer is another desirable goal.

Both of the widely used OTL circuits, the "followed emitter-follower" of Fig. 1A and the "single-ended push-pull circuit" of Fig. 1B fail to satisfy one of the basic requirements. The followed emitter-follower is not capable of class-B operation and the single-ended push-pull circuit usually requires transistor matching with substantial feedback for low distortion.

The secret of success in this new amplifier is the complementary push-pull emitter-follower circuit shown in Fig. 1C. In this circuit, the transistors are driven by a common a.c. signal and phase inversion is inherent in the *p-n-p—n-p-n* arrangement. Each side operates as a true emitter-follower in coupling its signal polarity to the load. The basic circuit is not new but the lack of *n-p-n* transistors of moderate cost and high power capacity has precluded its use for entertainment amplifiers. However, the recent development by *Westinghouse* of the low-cost "OEM Line" of *n-p-n* silicon power transistors for commercial and entertainment service makes the circuit eminently practical from a cost standpoint. The present amplifier is the successful result of a feasibility study on this circuit approach.

The "OEM Line" was developed from military *n-p-n* silicon transistor designs. The 151-152 series transistors, available from the manufacturer's local distributors, are 100-watt, 6-ampere units which come in various gains and voltage classes through 200 volts. These designs have hard-soldered junctions and are entirely free from secondary breakdown effects when operated within maximum ratings. All units are mounted in single-ended cases with 5/16-24 studs and they may be operated at junction temperatures to 150° C.

The 152-06 transistor chosen for this amplifier has a gain (h_{FE} or d.c. *beta*) range of 18 to 75 at 1.5 amperes collector current and a V_{CE} rating of 60 volts at 150° C. It is somewhat overrated for this amplifier since the germanium output transistors, operating on identical heat sinks, are rated at 105° C junction temperature. Thus, the silicon transistors never get near their maximum junction temperatures when operating in this circuit.

Circuit Description

The complete amplifier circuit is shown in Fig. 2. One of the stereo channels has been omitted since it is identical to the one shown. The two channels are completely separate except for the common chassis and power supply. Total parts cost for the entire unit is about $90.00.

The power supply itself is a double full-wave unit (a bridge circuit, with transformer center-tap grounded) utilizing a husky power transformer and silicon diodes. Output voltages are plus and minus 30 volts nominal to ground. The combination of low transformer impedance, silicon rectifiers, and high output capacitance provides excellent regulation for the class-B loads. While transistor regulators would reduce the ripple and stabilize the voltage still more, they were felt to be an unnecessary complication. Emitter-follow-

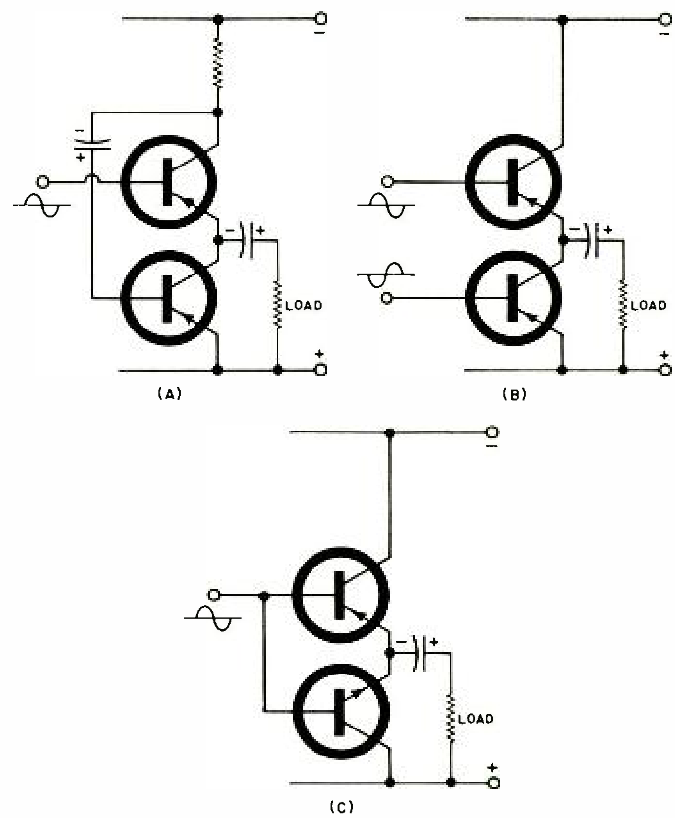
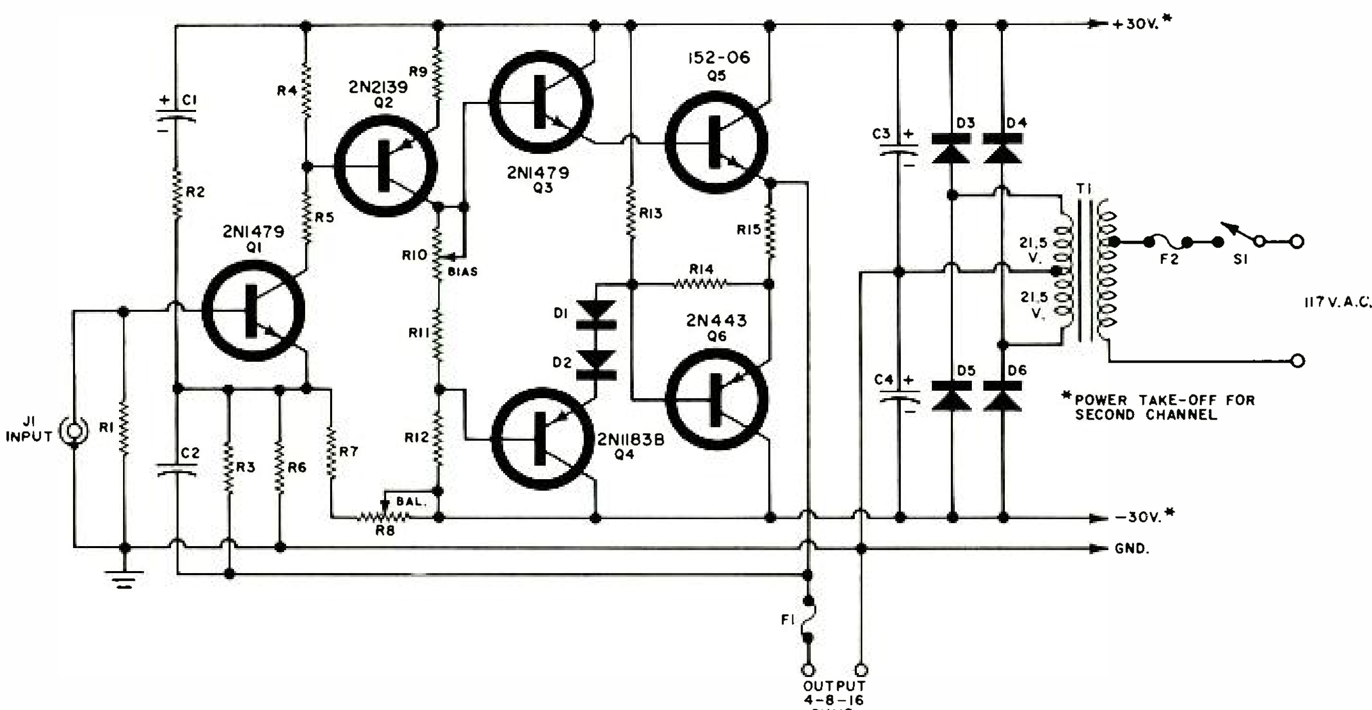
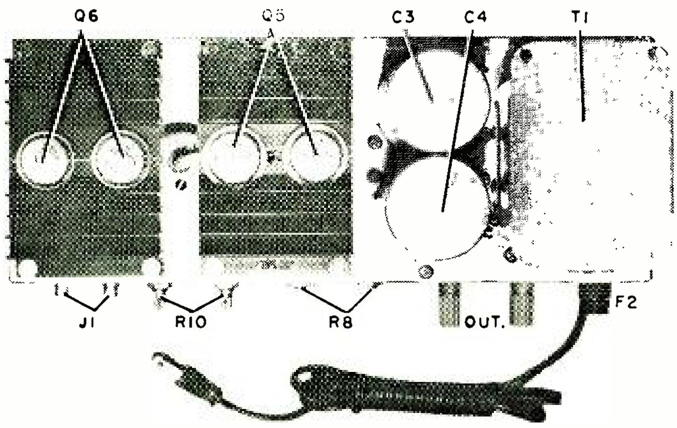


Fig. 1. (A) Followed emitter-follower output circuit. (B) Single-ended push-pull circuit. (C) Complementary emitter-follower.

Fig. 2. Schematic showing one channel and power supply of stereo amplifier. All parts that are shown must be duplicated for the second channel of the amplifier with the exception of the power transformer, rectifiers, and filter capacitors.



R1—1000 ohm, ½ w. res.
R2—6800 ohm, ½ w. res.
R3—2200 ohm, ½ w. res.
R4—100 ohm, ½ w. res.
R5—470 ohm, ½ w. res.
R6—220 ohm, ½ w. res.
R7—1800 ohm, ½ w. res.
R8—500 ohm, 1 w. pot.
R9—10 ohm, ½ w. res.
R10—25 ohm, 1 w. pot.
R11—24 ohm, ½ w. res.
R12—400 ohm, 5 w. res.
R13—700 ohm, 5 w. res.
R14—10 ohm, ½ w. res.
R15—1 ohm, 5 w. res.
C1—2 µf., 50 v. elec. capacitor
C2—.002 µf. ceramic capacitor
C3,C4—4500 µf., 50 v. elec. capacitor
F1,F2—2 amp fuse (3AG)
J1—Phono jack
S1—S.p.s.t. slide switch
T1—Power trans. 17-21.5 v. @ 1.5 amps; (UTC S-77)
D1,D2—1.6 amp, 50 p.r.v. silicon diode (1N1217)
D3,D4,D5,D6—5 amp, 100 p.r.v. silicon diode (Westinghouse 366B)
Q1,Q3—2N1479 transistor (with Wakefield NF-207 fins)
Q2—2N2139 transistor (mounted to chassis with insulation)
Q4—2N1183B transistor (mounted to chassis with insulation)
Q5—152-06 transistor (Westinghouse, on Wakefield NC-421 heat sink)
Q6—2N443 transistor (on Wakefield NC-421 heat sink)



The stereo amplifier is built on a 13"x 5"x 3" aluminum chassis.

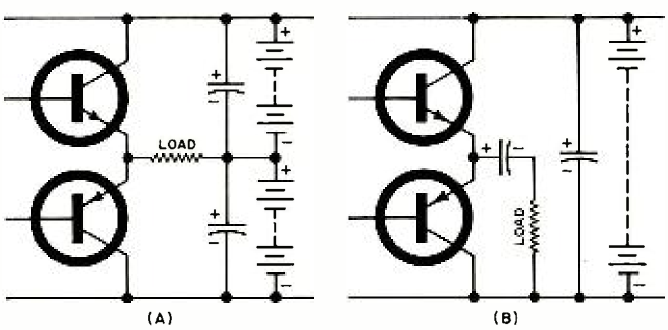


Fig. 3. (A) Direct-coupled output. (B) Capacitor-coupled output.

ers are not critically dependent on supply regulation and the amplifier performance is excellent as designed. Long-term dependibility has been assured through the use of conservative transformer and diode ratings combined with a generous voltage margin on the filter capacitors. Output fuses are used to protect the speakers from any possible component malfunction.

A dual-polarity power supply with direct coupling to the speakers was chosen in preference to a single-polarity power supply with capacitor coupling to the speakers in order to obtain d.c. amplification and to save the space and cost of one large capacitor. The two possible output circuits are shown in Figs. 3A and 3B. Fig. 3A shows the dual power supply with direct coupling and Fig. 3B shows capacitor coupling with a single-polarity power supply. Notice that the circuit of Fig. 3B requires a power-supply filter capacitor and two output coupling capacitors (one for each channel), whereas the circuit of Fig. 3A requires only the two filter capacitors.

Output coupling capacitors are often used in commercial transistor amplifiers since they limit the energy of transients fed to the speaker system through incorrect connections and similar mishaps. Thus, they render the commercial units somewhat more fool-proof. Balance drift is also less of a problem since an unbalance does not put d.c. into the speakers.

The choice between these two circuits is more one of preference than basic circuit requirements and an amplifier of perhaps equally satisfactory performance could be developed with capacitor output coupling. With the circuit chosen, however, the amplifier will handle d.c. inputs and there is simply no question about adequate low-frequency response, phase shift, or recovery from overload. Also, intermodulation distortion is reduced to negligible levels.

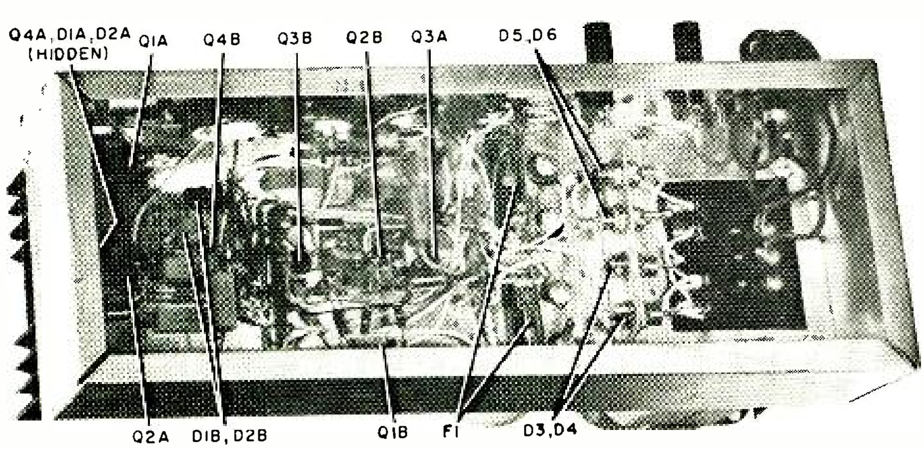
Turning now to the amplifier proper, transistors Q5 and Q6 form the push-pull, emitter-follower output circuit which is the heart of this design. Note that Q5, an *n-p-n* silicon transistor, is an emitter-follower which has its collector connected to +30 volts and its emitter connected through the load (speaker) to ground. Signals at the base of Q5 which have a positive potential above ground are coupled with nearly unity voltage gain (and, of course, a large power gain) to the load. For negative signals, Q5 simply cuts off.

The current gain is boosted by Q3, also an *n-p-n* silicon transistor, in the Darlington connection. Both units must be capable of handling V_{CE} swings to nearly 60 volts—twice the supply voltage—with saturation input signals. Q3 provides sufficient base drive for Q5 to produce linear output peaks up to 5 amperes with low-impedance loads. Although a base shunting resistor and a series emitter resistor are usually required to prevent thermal runaway in Darlington pairs, Q3 and Q5 are stable without them—even at elevated temperatures. This is a fundamental (and rather satisfying) advantage of silicon transistors.

The other half of the output circuit consists of germanium *p-n-p* transistors Q4 and Q6, also connected as a Darlington pair. Q6 is an emitter-follower which operates exactly the same as Q5 except that Q6 couples negative-polarity signals to the load. Since the germanium and silicon transistors are somewhat different in their input characteristics, compensating elements are required to balance the output circuit. Silicon diodes *D*1 and *D*2 add a constant voltage drop between Q4 and Q6 to balance the higher input threshold voltages of Q3 and Q5. The total series drop of two germanium transistors and two silicon diodes nicely matches the series drop of two silicon transistors.

Similarly, *R*15 provides a series resistance which balances the higher input resistance of the silicon transistors. Although the balancing function of *R*15 could be accomplished by a resistor between Q4 and Q6, *R*15 provides bias stabilization through emitter degeneration in the location shown. It also balances a slight drop in driver output on positive swings. Although the output impedance is raised slightly, the increase is of no practical importance. *R*14 prevents thermal runaway in Q6 by providing a shunt path for leakage current. The need for this resistor was verified experimentally. *R*13 provides a reverse bias to the base of Q6 and dramatically reduces high-frequency distortion in the amplifier.

The two halves of the output circuit are driven by Q2, a relatively high-power class-A amplifier which also provides all the voltage gain in the amplifier. This stage operates across the entire 60-volt series output of the two power



Beneath the two large heat sinks and atop the chassis are mounted Q4A, Q2A, Q4B (under the two Q6's) and Q3B, Q2B, Q3A (under the two Q5's). Transistors Q1A and Q1B are mounted by their leads underneath the chasis. This particular layout is not particularly critical and other arrangements can be employed if desired. (The letters A and B refer to component parts used in channels A and B.)

supply sections. The output resistance is low enough so that it provides a stiff voltage source to the output stage even at high signal levels. The output resistance approaches 400 ohms as a maximum at peak negative voltage swings. At zero signal it is 200 ohms and at peak positive swings it drops to less than 20 ohms. This characteristic is ideal for the output stage since the silicon transistors have a somewhat lower gain and consequently require more base drive than the germanium units. This is especially true at high signal levels.

Resistors *R*10 and *R*11 provide forward bias for *Q*3 and *Q*4. Enough range is provided to bias *Q*5 and *Q*6 from cut-off to some 300 ma. Normal operation is at an idling current of about 150 ma. *R*9 provides emitter degeneration sufficient to linearize *Q*2 and permit it to be driven as a voltage amplifier from a low-impedance source. *R*9 also causes a drop of 1.5 volts on positive peaks which introduces a slight asymmetry in the drive. On negative peaks, the drive to *Q*3 and *Q*4 approaches a nominal 30 volts negative whereas on positive peaks it approaches 28.5 volts positive. This effect is balanced out by the drop in *R*15 which was mentioned earlier. The net result of these various compensations is to reduce the distortion to less than 3% at full output even without feedback.

The drive to *Q*2 is provided by *Q*1, another class-A amplifier. *R*4 loads the collector circuit of *Q*1 and provides a low-impedance voltage source for *Q*2. *R*5 serves simply to decrease collector dissipation in *Q*1 by reducing the static collector voltage. Forward bias for *Q*1 is supplied by *R*7 and *R*8 with *R*8 serving as the balance control for the amplifier. This biasing scheme is a little unusual in that biasing is more commonly done in the base input. The circuit shown was developed to keep the base of *Q*1 at a nominal zero volts with respect to ground so as to facilitate operation from balanced d.c. inputs. *R*6 sets the bias voltage and also provides emitter degeneration to linearize *Q*1 for voltage source inputs. *R*1 is the base return for the bias current. It is a low enough resistance so that shorting the input causes only a small change in the output balance.

About 6 db of over-all negative feedback is fed to the emitter of *Q*1 through *R*3. This feedback reduces the distortion still further and stabilizes the d.c. balance of *Q*5 and *Q*6. *C*2 was chosen to optimize square-wave response and eliminate a slight overshoot. The series *C*1-*R*2 circuit, which looks rather strange at first glance, is a "filter." Power-supply ripple is balanced in the push-pull output circuit but is coupled into the amplifier through the single-ended driver stages. *R*2 introduces an opposing ripple derived from the positive bus and *C*1 isolates the emitter from the d.c. voltage. This stratagem reduces residual output ripple by approximately 12 db. The value of *R*2 is not especially critical and the ripple compensation holds constant over a supply voltage range from 105 to 125 volts.

One of the prices paid for the use of rugged and dependable alloy-junction transistors is intrinsically poor high-frequency response. The a.c. *beta* of *Q*6 drops severely above 5 kc. but the gain loss *per se* is offset by high driver current capacity and the emitter-follower circuit. A related phenomenon in *Q*6 and a source of considerable distortion is the slow turn-off time. When the amplifier is driven at high levels, the collector current of *Q*6 does not fall off immediately as base drive is reduced. In fact, the lag is on the order of 20 microseconds. At low frequencies this causes no problem at all but at frequencies above 5 kc. the distortion becomes serious. At 20 kc., *Q*6 adds a considerable "tail" to one side of the sine wave. In addition, the delay in collector current fall-off means that both *Q*5 and *Q*6 are in conduction at the same time for an appreciable portion of the cycle. This leads to high current demand from the power supply and rapid overheating of *Q*5 and *Q*6.

The turn-off delay in a transistor is caused by the finite time required to sweep current carriers out of the base re-

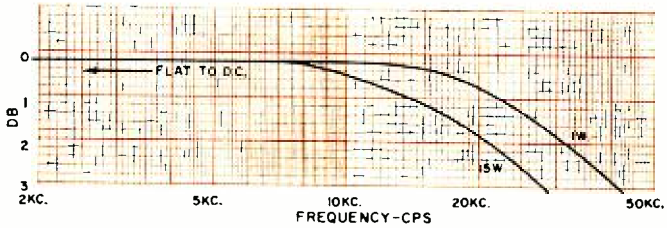


Fig. 4. Frequency response of unit into an 8-ohm output load.

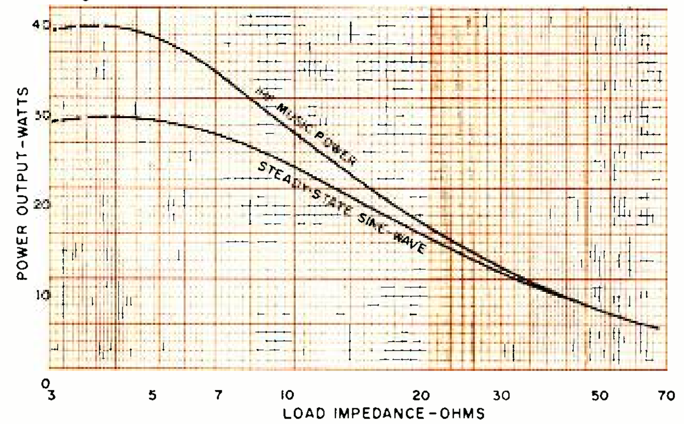


Fig. 5. Maximum power output (one channel) for various loads.

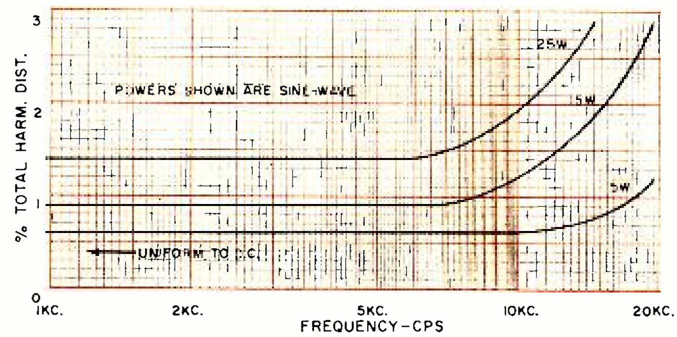


Fig. 6. Distortion characteristics into an 8-ohm output load.

gion. Whereas these carriers will slowly migrate out of the base region with no reverse voltage applied, the process can be greatly accelerated by forcing momentary reverse current flow with reverse bias. This is the function performed by *R*13. When *Q*4 is conducting, there is a net positive bias on *Q*6. When *Q*4 cuts off at the end of a negative half cycle, *R*13 provides a 40-ma. reverse pulse into the base of *Q*6 and forces rapid turn-off. *R*14 serves to limit the reverse bias voltage to approximately 0.5 volt.

Performance

The characteristics of the amplifier are shown in Figs. 4, 5, and 6. Fig. 4 shows the 1-watt frequency response to be absolutely flat from d.c. to above 10,000 cps and down only 0.5 db at 20,000 cps. At 15-watt output, the response is down about 0.5 db at 10,000 cps and 1.5 db at 20,000 cps. For all practical purposes, the amplifier has a flat response throughout the entire audio range.

Maximum power output curves for various load impedances are shown in Fig. 5 for both sine-wave input and IHF "music" input. As in all class-B amplifiers, the maximum power output is limited by power-supply regulation. The sine-wave curve was taken with constant line voltage of 120 volts and represents the clipping threshold. Harmonic distortion under these conditions is less than 2% at all frequencies from d.c. to 5000 cps. Below 20 cps, the maximum peak power output drops slightly due to filter capacitor inadequacy, and the d.c. maximum peak power output is down about 2 db with a 4-ohm load. At higher load impedances, this effect disappears. With a stiff power supply, the IHF curve applies. This curve represents the amplifier output capacity for short-duration music bursts which do not drag down the power-supply voltage. Note that the amplifier can deliver an instantaneous peak output of 80 watts (twice the average value of 40 watts) per channel into a 4-ohm load. This will create a rather decent din in the average living room.

Distortion curves are shown in Fig. 6. These were taken with continuous sine-wave drive and an 8-ohm load. The curves have an unusual appearance since each represents a combination of two distortion sources. At frequencies below the break point in each curve, the indicated distortion is primarily due to power-supply ripple at the high unbalanced load currents. This is measured as "distortion," of course, even though it is not caused by amplifier non-linearity. It is not evident in listening tests. Above the break point, the distortion due to the germanium transistor turn-off time becomes very apparent. However, program material with such a high energy content at high frequencies is virtually non-existent. The 1000-cps square-wave response shown in the photograph is free from overshoot and yet has an excellent rise time. There is no tilt at any frequency.

Thermal limitations in the output transistors prevent the amplifier from operating continuously at maximum power output. In the low- and mid-frequency regions, it will handle continuous sine-wave outputs to about 6 db below maximum with both channels operating. At frequencies above 5 kc., the output should be limited to several watts except for short-duration testing. These power limits can be raised considerably by forced cooling of the heat sinks, but the addition of a blower is not worth the expense and nuisance unless the amplifier is to be used for special work. In normal music listening, the amplifier can be driven to full output on peaks without overheating.

Construction & Adjustments

The completed amplifier is constructed on a single 13" x 5" x 3" aluminum chassis. Lead lengths and parts placement are of no consequence and can be varied to suit individual taste. The various germanium driver transistors are mounted directly to the chassis with appropriate insulating kits. The silicon drivers are all equipped with clip-on heat sinks and either socket-mounted or soldered to terminal strips. Since the output transistors generate considerable heat, they are mounted on extruded aluminum heat sinks without insulation. The heat sinks themselves are insulated from the chassis with Teflon stand-off insulators. Both germanium output transistors are mounted on one heat sink and both silicon units on the other. All should be securely fastened to allow optimum heat transfer, and the use of a silicone grease between base and heat sink is recommended.

General construction details of the amplifier are self-evident from the photographs. Assembly is easy despite the rather compact construction. The outputs were terminated in binding posts primarily from the author's experience in fighting with various plugs and screw terminals over the years.

The only adjustments necessary to place the amplifier into operation are the bias and balance controls. For optimum operation, a resistor approximately equal to the d.c. resistance of the speaker voice coil should be connected to one channel. With the input open, the balance control should then be adjusted for zero d.c. volts at the output. Next, the bias should be set to 150 ma. as measured with a voltmeter across *R*15 (150 ma. equals 0.15 volt). Some interaction should be expected between bias and balance adjustments. This procedure should then be repeated for the other channel. Both bias and balance should be re-adjusted after about 5 to 10 minutes of operation so as to allow for the slight balance drift during warmup. No further adjustments should be necessary.

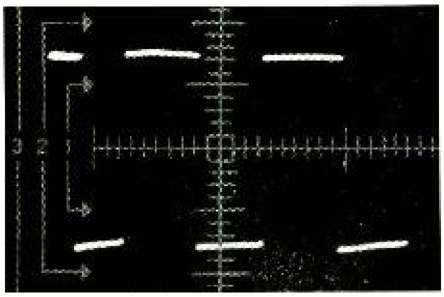
The low input impedance of this amplifier will pose a problem if it is to be used with vacuum-tube preamplifiers. Unless the preamp is equipped with a cathode-follower output, it will probably not develop sufficient power to drive the amplifier. This problem may be solved by adding a cathode follower or a transistor amplifier to the preamp output so as to provide a source impedance below 1000 ohms. The driver stage must produce an undistorted output of 2 volts r.m.s. to drive the amplifier to full power. A coupling capacitor of at least 20 μf. capacity (with low d.c. leakage) should be used.

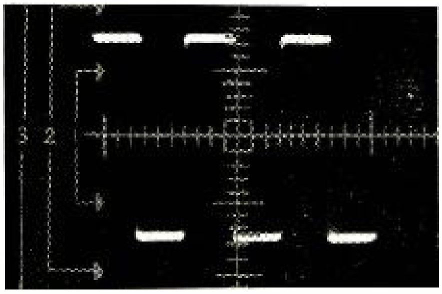
(Editor's Note: A cathode-follower may be added to a preamp quite simply. Half of a 12AU7 can be used with a 1-meg. grid resistor and a 1000-ohm cathode resistor. The plate is connected directly to a +100-volt source. A 20-μf., 25-volt electrolytic is connected between the cathode and the input of the transistor amplifier. With a 4-volt signal on the grid, the cathode-follower should deliver about 2 volts to the amplifier. If the output coupling capacitor from the preamp is much less than about 20 μf., bass response will be down considerably. If it is not convenient to replace the capacitor with a much larger value, bass boost and treble cut must be used in the preamp to restore the over-all preamplifier-amplifier response to flat.)

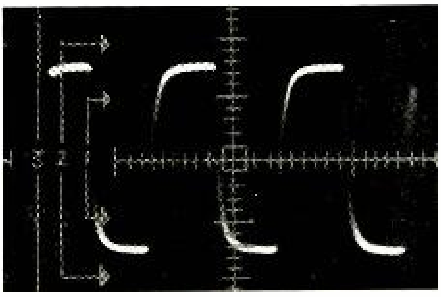
The amplifier may be used with virtually any speaker system as long as the voice-coil *resistance* is above 3 ohms. If the output stage is loaded with lower resistance values, the d.c. feedback drops off and the output balance may shift excessively with temperature or line voltage. The amplifier is completely stable with an open-circuited output and it cannot be damaged from momentary overdrive.

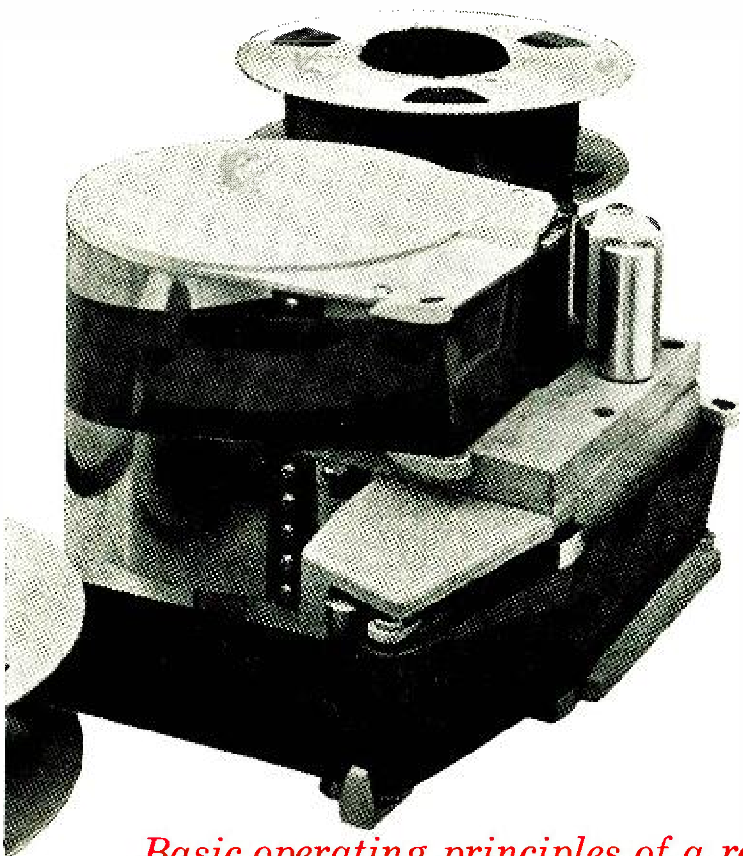
The author sincerely hopes that this transistor amplifier circuit will prove a worthy competitor to the Williamson circuit in ease of assembly and operational performance. Those readers who build the amplifier as described should experience a minimum of construction difficulties. At the same time, it is hoped that some will take this article as a starting point for further amplifier development work based on the complementary output circuit. A capacitor-coupled output arrangement, for instance, has already been discussed. The use of diffused germanium transistors could also be explored. There are any number of ways in which this present amplifier can surely be improved with future efforts. Until such second-generation designs appear, however, here is the "Transistor Williamson." ▲

Square-wave response at 20 cps (left), 1000 cps (center), and 10,000 cps (right). Slight tilt at 20 cps is due to oscilloscope.









HELICAL VIDEO RECORDER FOR TELEVISION

By JOSEPH ROIZEN
Ampex Corporation

Close-up showing tape-travel arrangement. Tape comes off supply reel at left, passes over guides and video erase head in front of machine, turns toward rear, takes half-turn around scan assembly with its spinning video record heads, goes around exit guide at front, passes audio head, then goes between capstan and pinch roller to take-up reel at right.

Basic operating principles of a rotating-head portable recorder that is widely employed for educational, medical, industrial applications.

HELICAL recording of video signals is one approach to the problem of magnetic recording of television images for educational, industrial, and broadcasting applications. In this system, the tape is scanned by a rotating video head assembly, containing one or two heads, which records tracks at a narrow angle to the edge of the tape. The tape may be either a 2-inch or 1-inch width and carries the video information in approximately 80% of its center area, while the audio and control timing signals are recorded in narrow longitudinal tracks along the top and bottom edges.

In the single-head configuration, the tape is wrapped in a full helix with the head scan covering one or two fields and the crossover period synchronized so as to occur in the vertical blanking interval. In the more common two-head configuration, each head records or plays back one field, but enough track overlap exists to allow switching from head to head during the vertical interval.

The helical recorder consists of a transport system with take-up and supply reels, a scanning assembly, means of guiding the tape, and a tape-tension control system. The signal system consists of a modulator, record amplifier, playback preamplifier, sequence switcher, demodulator, and video amplifier (Fig. 1). The servo system is made up of a head-drum servo, a capstan servo, and a tape-tension servo in the more sophisticated models of video tape recorders.

The Tape Transport

The tape transport consists of a rigid deep casting on which are mounted all of the components for pulling, guiding, and recording on the tape. The scan assembly is in the center of the transport and is made up of a hollow, circular casting about 7 inches in diameter with a cutaway through the center to permit the rotating drum containing the magnetic transducers to make contact with the tape wrapped around the helix. The drum itself holds two such transducers in exact 180° displacement with adjustable mechanical wedges that permit accurate tip projection and dihedral

Fig. 1. Simplified block diagram of the video tape recorder.

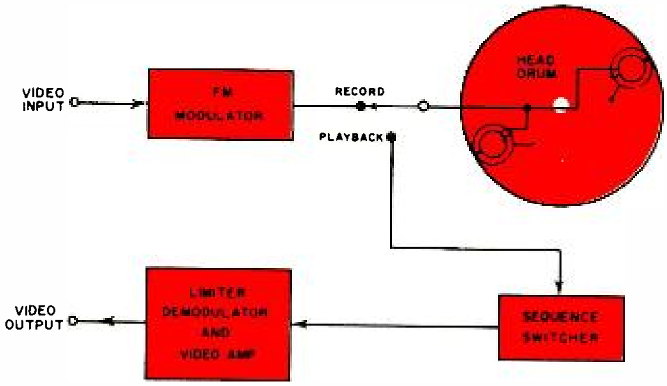
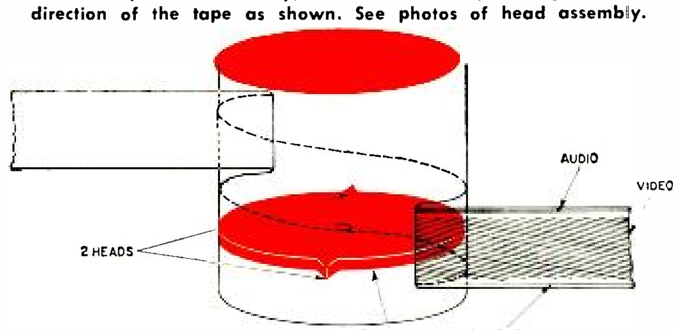


Fig. 2. The head drum contains two rotating video record heads. In this illustration the tape loop has been opened up to show the head position. Actually, there is no abrupt change in the direction of the tape as shown. See photos of head assembly.



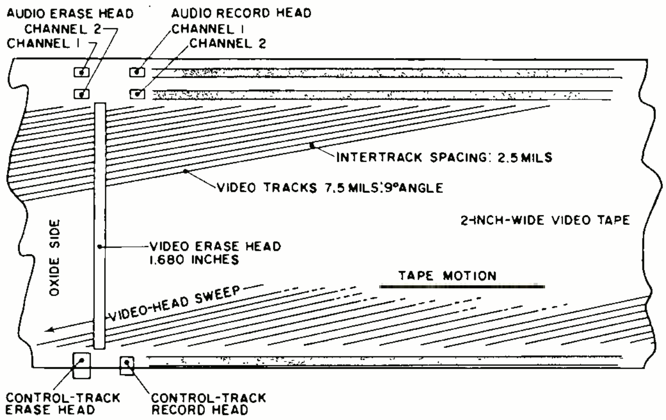
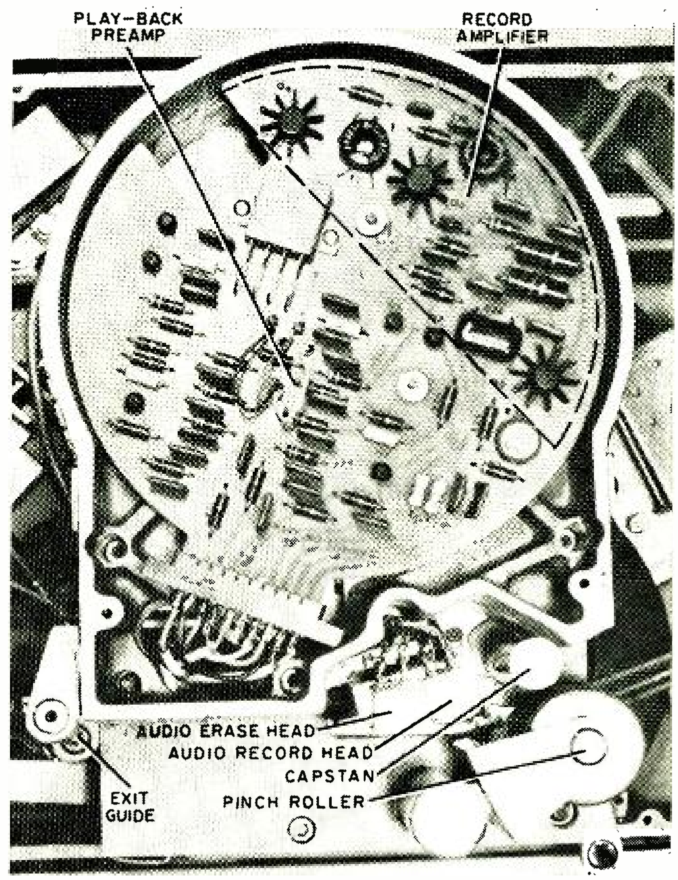


Fig. 3. The track pattern that is laid down by the recorder.

The Ampex VR-1500 two-video-head helical tape recorder for TV.



The scan assembly of the recorder with the top cover removed.

positioning of the writing gap (Fig. 2). The two transducers are connected into the system through a set of slip rings and brushes mounted in the center of the drum assembly. The tape is guided around the scan assembly by an inlet and outlet guide which are canted so as to produce the necessary helical track configuration.

The video scanning heads write tracks at 9° to the edge of the tape and the effective writing speed is 650 inches per second. These tracks are 7.5 mils wide with a 2.5-mil guard band, thus providing a track-to-track center spacing of 10 mils (Fig. 3). Three longitudinal tracks are recorded at both edges of the tape, two audio tracks being at the upper edge and a 50-mil control track at the lower edge. These three tracks are written by stationary heads mounted on the scan assembly, with suitable erase heads eliminating any remanent video components.

The longitudinal tape speed is 3.709 inches per second. This may appear to be an odd choice, but was selected for the reason that it produces a recording geometry which places the horizontal sync pulses recorded on the tape in a 90° pattern to the scan angle (Fig. 4). This means that regardless of tape motion or lack of it, the scanning head will see similar information as it scans across from track-to-track and can, therefore, maintain an image under stop, slow, or fast-motion conditions.

As this recorder is expected to be operated by non-technical personnel, a number of mechanical innovations were included to simplify operations and avoid human error. Tape motion is controlled from a single knob (called a "joy stick") which can occupy five positions. Its straight-up condition is off. Pushing it to the left puts the tape in rewind, to the right in fast-forward, down into play mode, and up into the record-ready mode. To avoid accidental erasure of the material already recorded on the tape, a push-button must be engaged to initiate record after the joy stick is canted up. In this way no conflicting mode can be engaged. To further insure against the possibility that rapid switching from one mode to another would cause a sudden tension on the tape, a motion-sensing device, which consists of a silicone-damped vane actuated by any longitudinal tape motion, operates a pair of microswitches that disable the motors until the tape comes to rest. It is possible then to rapidly switch from full fast-forward into play without stretching the tape.

Since tape tension is an important factor, a tape-tension sensing arm is located ahead of the scan assembly and is mechanically linked to a brake on the tape supply reel motor. An electrical adjustment labeled "skew" sets the central operating point of the tape tension arm through a variable solenoid and it can be adjusted by observing optimum perpendicularity of vertical lines in the playback image.

The Scanning Assembly

The scanning assembly has mounted on it, in addition to the video head drum, all of the record and playback heads which lay signals on the tape. The tape must drop through its own width in a little over 180° of the scan area. This is accomplished by tilted entry and exit guides which establish the 9° angle. No other guiding is used in the scan assembly and the natural compliance of the 2-inch tape is depended upon for the precision positioning necessary to achieve interchangeability of recorded tapes from machine to machine. The two video transducers mounted on the edge of the head drum are positioned so as to project into the tape by about five mils. Their angular position is adjusted by a small mechanical wedging device and signals from the rotating heads are recovered through a slip-ring and brush assembly which is connected to a plug-in circuit board in the top of the scan assembly. Head penetration of the tape means that the head will wear; therefore, head exchange has been simplified by requiring only the unsoldering of two leads and the

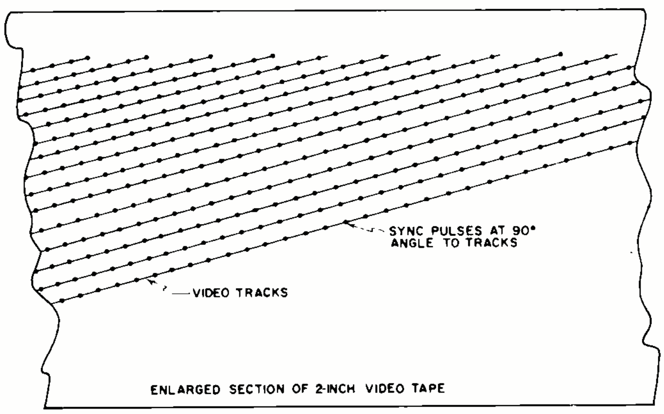


Fig. 4. Sync-pulse alignment shown by dots on the video tracks. The tape speed employed for recording is 3.709 inches per sec.

removing of one screw. However, after the new head is installed, the proper amount of penetration and positioning must be re-adjusted with the aid of a jig and a test tape.

The Signal System

As with transverse video recorders, the helical recorder also requires changing the character of the video signal before it can be adequately recorded on magnetic tape. It is necessary to use an FM modulator whose frequency is controlled by the video signal amplitude. The range of frequencies then produced fall into a more acceptable passband for the magnetic recording process. In addition to this, constant-level FM can be amplified and limited in playback so as to achieve immunity from signal dropouts due to tape surface defects.

The composite video signal entering the recorder has its amplitude adjusted by a potentiometer which establishes the deviation of the oscillator. It is also pre-emphasized to provide for the reduction of sensitivity of the variable oscillator to higher frequency information. The variable oscillator is driven to 53.4 mc. for black level and 54.7 mc. at peak white and is applied to a mixer receiving a stable 50-mc. signal from a local oscillator. The output is the difference signal ranging from 3.4 mc. at sync tip to 4.7 mc. at peak white. This signal is then applied to r.f. amplifiers and push-pull head drivers which record the constant amplitude FM on tape. Video heads are driven simultaneously.

In playback, the signal recovered from the video heads is amplified by independent preamplifiers and then placed in proper sequence by a switcher driven from the head drum tachometer. The continuous r.f. output is amplified and limited several times to provide a constant amplitude signal into the demodulator regardless of variations in signal level encountered by the individual heads. The demodulator is a pulse-counter type and its output is amplified and applied to a low-impedance driver which provides the 75-ohm low-impedance output required for normal video-distribution systems. To permit proper adjustment of tracking, which maximizes signal output from the video heads, a portion of the r.f. signal coming from the switcher is rectified and applied to a meter. The tracking control is then adjusted for maximum reading on the meter. This same meter is utilized in the record mode as a peak-indicating device and is calibrated to show a 1-volt input level indicating adequate amount of video signal reaching the recording heads from the recorder operation.

The Servo System

The underlying principle of the helical-scan recorder is that a full field of television information is recorded with one scan of each video head. Obviously, it is preferable to have the switching from head to head occur during the vertical blanking interval so that it will not affect the playback image. In order to do this, the rotating head drum recording the television signal must be synchronized with the incoming television information and positionally controlled so that the physical initiation of each scan is in time with the start of the picture period. The incoming video signal, in addition to driving the modulator, is also amplified and applied to a sync stripper which extracts vertical sync information and drives the head-drum servo. A 30-cps tachometer pulse generated by the head drum is compared in a phase comparator with the pulse derived from this vertical sync and, in case of error, a control voltage is generated to drive the head-drum oscillator to the correct phase and frequency. The output of this oscillator is amplified and supplies power to the 4-pole induction motor rotating the head drum. This guarantees that the drum will remain locked to the incoming video signal during record. The tachometer pulses from the head drum are also recorded at the lower edge of the tape. These will be used in playback for timing information. Tape tension during record is maintained at a constant preset level.

In playback, the pulses are recovered from the control track and are compared in phase with the drum tachometer. Any error signal will once more change the frequency of the 60-cps oscillator driving the drum so that the same relationship that existed in record will be re-established in playback. A hysteresis synchronous motor is used to drive the capstan and achieves a low flutter rate required for accurate longitudinal timing information coming from the control track. A recorder used for closed-circuit applications requires only a head-drum servo, since manual controls are provided for setting tape tension and capstan position. However, if the recorder is to be used for broadcast purposes, it is necessary to maintain both proper tension and time-base stability constantly. This is accomplished by two additional electronic servo systems.

The tape-tension servo is driven by horizontal sync derived from the video output of the playback signal. Any time-base error that is detected in horizontal sync from tape develops an error voltage which positions the tension arm automatically to bring the horizontal frequency back to the normal 15,750 cps.

The capstan must also be servoed. To do this, the capstan is driven from an oscillator whose output is raised to the proper level by a power amplifier. This isolates the capstan from the power-line frequency variations and permits it to maintain accurate tracking during playback by slaving it directly to the drum tachometer of the recorder.

Performance Characteristics

The over-all performance of this recorder meets most closed-circuit and certain broadcast applications. Its video bandpass is 3.5 mc., which is approximately equal to a good home receiver. The signal-to-noise ratio is on the order of 40 db (peak-to-peak video to r.m.s. noise). The two audio channels will handle 60 cps to 10 kc. within ± 2 db at better than 42 db signal-to-noise ratio. The audio tracks can be recorded and erased independently, permitting additional commentary to be added after a video recording has been made. An accessory to the machine that permits stopping the tape motion or controlling it incrementally allows playback of the tapes at slower than normal speeds, giving either stop-frame or slow-motion reproduction on the video monitor.

This type of video recorder has been used as an educational tool by many ETV systems throughout the country. It has also been applied to sports training in baseball, football, golf, and to the monitoring of sporting events at race tracks and soccer stadia. In the medical field, it has served to record moving radiology images derived from television-monitored image intensifiers. As quantities of these recorders become available and manufacturing techniques permit lower prices, there will be an ever increasing application of helical-scan recorders in all aspects of television. ▲

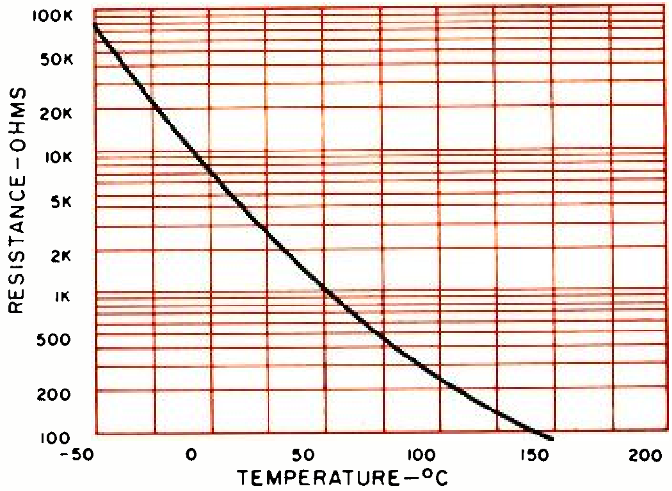


Fig. 1. Resistance-temperature curve for a typical thermistor.

When the resistance of a circuit component can be changed by temperature, it can find many applications in electronic circuits.

Temperature Sensitive Devices

By JOHN R. COLLINS

WHEN a missile blasts off its launching pad, it carries a temperature sensor to measure the wide range of temperatures encountered in outer space and to convert the information into electrical signals for relay back to earth. Other temperature sensors control the flow of cryogenic fluids used as fuel. High-speed aircraft carry temperature sensors to monitor critical surface and engine temperatures. In the industrial sector, precision temperature sensors have made possible better control of automatic processes and greatly improved analytical instruments.

Devices that change in resistance with a change in temperature have been used for many years. They are finding ever wider application for the obvious reason that for recording or control purposes it is easier to convert resistance variations into a signal than it is to convert the level of mercury in a conventional thermometer to an electrical signal.

As in the case of many other components, military and industrial demands have led to the discovery of new and better materials and the development of better temperature transducers. Sensitivity is an important consideration, and materials have been developed that will respond to very small temperature changes. As applications become more sophisticated, however, more attention is devoted to producing temperature sensors that show negligible hysteresis and aging, that have resistance-temperature curves of particular shapes, and that are standardized so that a new sensor can be installed in a sensitive instrument without extensive recalibration of that, and associated instruments.

Thermistors

Thermistors, which are used not only for temperature measurement but also for a variety of detection and control purposes, are the most versatile temperature sensors. They come in many sizes and shapes, including discs, wafers, rods, and beads. Their useful range is from about −50°C to +300°C, and they usually exhibit pronounced negative temperature coefficient characteristics.

As shown in Fig. 1, a typical thermistor with nominal resistance of 4000 ohms at 25°C will change from 100 ohms at 160°C to about 88,000 ohms at −40°C. This represents an average change of more than 400 ohms per degree. Even though the greatest changes are to be found at the lowest temperatures, the over-all sensitivity is remarkable, and temperature measurements to 1/1000 of a degree are possible. Such a wide range of resistance values is not an unmixed blessing, however, since it is not easy to measure accurately both very high and very low temperatures with the same instrument.

Thermistors are made of various metallic oxides, including those of manganese, nickel, copper, and cobalt, which are fused to form ceramic materials. Resistance changes result from the incorporation of oxides in which the metal is in two valence states, permitting the migration of electrons from an atom in one state to a neighboring atom in a different state. Increased migration with a temperature rise causes thermistors to exhibit a negative temperature coefficient of resistance.

The operational characteristics of a thermistor depend not only on its chemical composition, but also on its physical shape and dimensions and how it is mounted. The most significant characteristics are the following:

Cold resistance: The resistance at a nominal temperature, usually 77°F (25°C). The range of available resistance values compares with those of ordinary resistors. Commercial types from a few ohms to several megohms are shelf items, and any desired value can be supplied on a custom basis.

Thermal time constant: The time required for a thermistor to change from its initial temperature to 63 percent of the temperature of the surrounding medium when no electrical power is being dissipated in it. Thus, if a thermistor at 25°C is placed in an oven at 125°C, its thermal time-constant would be the time needed for it to reach 88°C—that is, 63 percent of the total difference of 100 degrees. This factor is influenced by the size and shape of the thermistor, since tiny beads and thin rods are more readily heated and exhibit faster response than larger, more solidly constructed thermistors. Typical values range from a few seconds to several minutes.

Dissipation constant: The power needed to raise the temperature of a thermistor one degree above the ambient, usually measured in milliwatts per degree C. This characteristic is affected by the surrounding medium (air, oil, water, etc.) and by the method of mounting, since the body temperature of the thermistor obviously will not rise if the heat is carried away as fast as it is generated.

The dissipation constant is a measure of the self-heating properties of a thermistor. While self-heating is undesirable in most electronic components, many uses have been devised for this effect in thermistors. Perhaps the most common is surge protection, especially for radio tube filaments. The cold resistance of a tungsten filament is much less than its hot resistance, consequently when a radio or television set is first turned on a sudden surge of current will sometimes cause a filament to burn out. The danger is greatly reduced by placing a thermistor in series with the filament string. Since the cold resistance of the thermistor is high, it permits only a small current to flow at first. By the time the thermistor resistance has dropped to a minimum, the tube filaments have warmed up gradually to their full, hot resistance.

Other Applications

The telephone industry is one of the largest users of thermistors. Some years ago, long-distance telephone calls were often distorted because the resistance of copper wire increases as the temperature increases. Since the amplifiers along the line could not be re-adjusted to compensate for temperature changes, the voices were often either too loud or too low. The difficulty was solved by inserting specially selected thermistors in the lines with characteristics exactly the reverse of copper wire. Under this condition, the total line resistance is always the same regardless of temperature, and the amplifiers can be permanently adjusted for the proper speech level.

Thermistors are now made with such precision and sensitivity that they can perform tasks not previously possible. One such application is that of a hypsometer to determine altitude by means of air pressure. Since the rarefied air found at high altitudes will not dissipate heat as fast as the denser air at lower levels, a thermistor at high altitudes will evidence more self-heating and thus lower resistance.

Sensitive rate-of-flow meters are based on the principle that moving air or liquid will cool a thermistor faster than a static medium, the cooling effect being proportional to the rate of flow. A related application is the use of thermistors for an unconventional rate-of-climb meter for aircraft. A thermistor is inserted in a tube leading to a bottle of air. As the aircraft ascends, air rushing from the bottle to equalize the inside and outside pressure cools the thermistor, thus increasing its resistance.

Devices such as the above are, of course, affected by ambient conditions and it is necessary to compensate for temperature changes to obtain accurate results. This is done by utilizing a carefully matched pair of thermistors, connected in a Wheatstone bridge arrangement, as in Fig. 2. The reference thermistor is subjected to the same temperature as the sensing thermistor, but not to the pressure difference in the case of the hypsometer or to motion of the medium in the case of flow and rate-of-climb meters. Accordingly, the difference in resistance between the two thermistors will be due solely to the conditions it is desired to measure.

Different gases exhibit individual heat-dissipation characteristics, a fact that provides a means for determining both the identity and proportional amounts of various ingredients in a mixture. The system, known as gas chromatography, is widely used in the petroleum industry and other branches of chemistry for rapid, accurate checks on the elements in a process stream. In practice, the test sample is vaporized and carried by an inert gas through a system of tubes and filters where it is separated into its individual components by a fractionating process. A thermistor bridge circuit at the output measures the amount of each element (from the time needed for its passage) and identifies it by its heat-dissipation properties. A pen recorder provides a permanent record. Because of the speed with which such analyses can be made and the comparative simplicity, the electronic thermistor method of gas chromatography is becoming popular for monitoring industrial chemical processes.

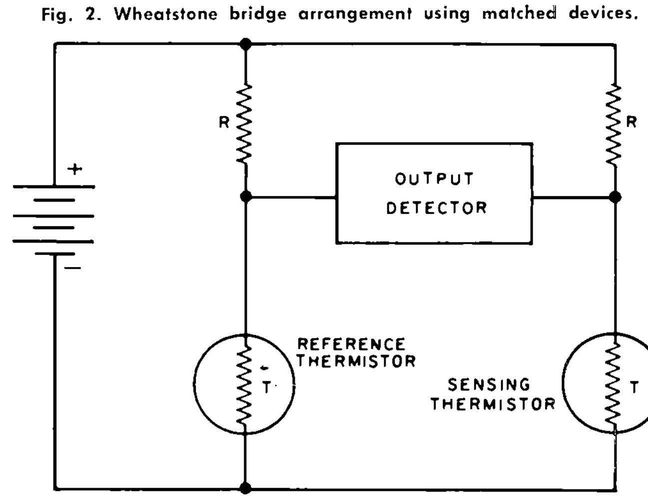
Positive TC Thermistors

Although thermistors traditionally have a negative temperature coefficient (TC) of resistance, recent research has developed a class whose resistance increases with increased temperature. They are made from barium and strontium titanates containing a small fraction of lanthanum. By varying the composition, a number of different characteristic curves can be obtained.

Some of the advantages of a positive temperature coefficient are immediately obvious. A negative TC thermistor is subject to thermal runaway, since current passing through it raises its temperature, causing a reduction in its resistance which, in turn, leads to still further current increase and further reduction in resistance. Because positive TC thermistors are not subject to this effect, they often provide more stable operation in simpler control circuits than negative TC types. Furthermore, the combination of positive and negative TC thermistors, in either series or parallel, makes possible a variety of response curves for specialized compensation or control functions.

It is not entirely clear how positive TC thermistors work. It appears, however, that the effect is based on a transition

Fig. 2. Wheatstone bridge arrangement using matched devices.



This platinum resistance-temperature standard gives highly accurate indications in the range between −200°C and +500°C.

of crystal structure from one phase to another. Below about 110°C, a tetragonal crystal structure is stable, while above that temperature, a cubic structure is stable. The actual transition temperature can be varied within limits in the manufacturing process.

Although some positive TC thermistors exhibit fairly smooth characteristic curves (Fig. 4A), others, as in Fig. 4B, maintain almost constant resistance over a very broad range until a critical temperature is reached, whereupon they immediately jump to a very high resistance. The action is like that of a switch and has been utilized for switching purposes in such applications as protection of large motors. If a motor is overloaded or becomes jammed, its armature current rises and may overheat and damage the armature coil. However, a positive TC thermistor, connected in series with the armature coil and in close contact with it, senses a condition of overheating and reacts at once by switching a large resistance into the circuit to limit current.

Indirectly heated thermistors have an electrically isolated heater in close thermal coupling with the thermistor. In this case, the voltage-current or current-time characteristic is replaced with the temperature-resistance characteristic of the thermistor. These indirectly heated thermistors are used in a.c.-to-d.c. transfer devices, automatic control devices, and for fluid-flow measurements.

Silicon Resistors

Experience gained in the manufacture of transistors has led to the production of temperature-sensitive silicon resistors. Although pure silicon has a negative temperature coefficient of resistance, silicon doped with an infinitesimal impurity of boron exhibits a positive temperature coefficient from about −150°C to +300°C. Beyond these two extremes, the characteristic reverses and again becomes negative. Within the positive range, the specific resistivity is dependent almost entirely on the amount of boron impurity. With modern semiconductor manufacturing methods, this can be held to a very close tolerance, so it is not difficult to obtain silicon resistors with identical characteristics.

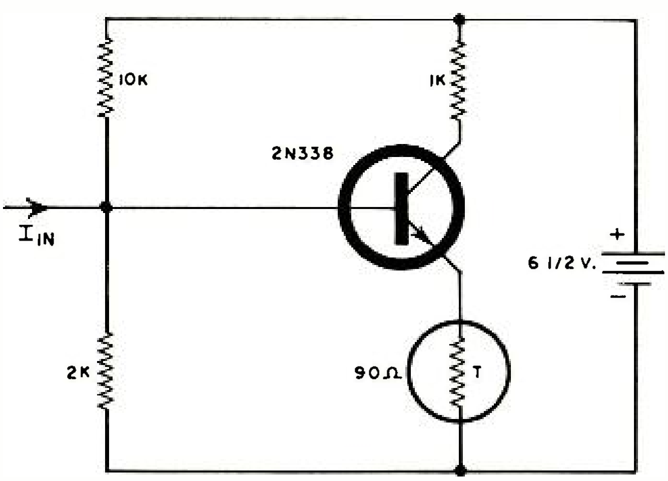
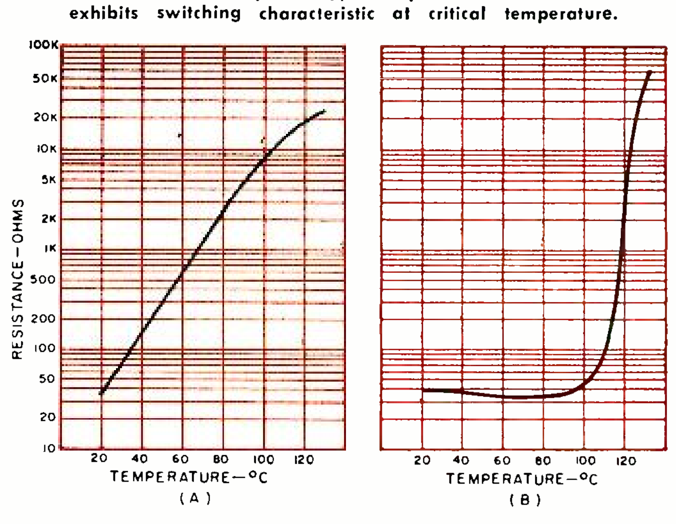


Fig. 3. Transistor amplifier with temperature compensation.

Fig. 4. (A) Positive TC thermistor shows relatively smooth characteristic. (B) Special type of positive TC thermistor exhibits switching characteristic at critical temperature.



Silicon resistors do not exhibit as pronounced resistance changes with temperature as ordinary thermistors. This is an advantage for measuring a wide range of temperatures, since it places a smaller demand on the measuring instrument. A typical silicon resistor has a temperature coefficient of resistance of +0.7%/°C which is nearly constant from −60°C to +150°C. Typical thermal time constants range from 9 seconds for small glass bead elements to 64 seconds for larger types enclosed in a metal can.

An important application of silicon resistors is temperature compensation in silicon transistor circuits. Silicon transistors have a useful range from −65°C to +200°C, but transistor parameters are sensitive to temperature changes and some form of compensation is usually required to insure proper performance over a broad range.

Temperature rise in a transistor may be due either to environment or self-heating. In either case, a temperature change causes a change in the transistor's operating point and its characteristics. If the shift is appreciable, a cumulative effect which can cause thermal runaway may occur, permanently damaging the transistor. The condition may be compensated for by the inclusion of a silicon resistor alone, or sometimes by a shaping network made up of a silicon resistor and one or more carbon resistors. The method of connection varies with circuit design. A typical arrangement is shown in Fig. 3, where the silicon resistor is connected in the emitter circuit. As temperature increases, the resistance of the silicon resistor also increases, causing the base current of the transistor to decline. As a result, the collector current remains practically stable over a range from −50°C to +150°C. This is a familiar circuit to set designers.

Platinum Sensors

Pure, annealed, strain-free platinum has many things to recommend it for temperature measurement. Its resistance-temperature relationship is precisely defined by a mathematical formula, does not change with time, and is known to a number of decimal places. A platinum sensor with resistance of 100 ohms at 0°C, for example, will have resistance of 0.14353 ohm at −260°C and 381.19474 ohms at 800°C. Hysteresis is negligible, so resistance is the same at any given point whether the temperature is increasing or decreasing. Its useful range is extremely broad, extending from about −260°C to 1000°C.

Platinum sensors incorporate a platinum resistor made from fully annealed, high-purity platinum wire coiled inside ceramic tubes. This type of construction supports the wire without strain, makes it resistant to vibration, and leaves it free to expand in its supporting tubes. The ceramic tubes are coated with gold to improve thermal conductivity, and the entire unit is enclosed in a hermetically sealed, stainless-steel case. The configuration of the sensor is governed by the intended end use.

Immersion-type temperature sensors are used for various fluid temperature measurements in pipes, ducts, and tanks on missiles, rockets, and aircraft. In liquid, these may have a thermal time constant as short as 0.5 second. Other platinum sensors include types for measuring the temperature of skins, walls, pipes, and electronic components. So-called "total temperature" sensors measure the combination of ambient temperature and the Mach number of high-velocity gases in pipes and ducts or outside of jet aircraft. ▲

HOW CAPACITORS CHANGE V.T.V.M. READINGS

By H. Q. DUGUID

Changing characteristics of the input capacitors of your v.t.v.m. can produce reading errors. Here is an explanation of why it happens and what you can do.

DOES your v.t.v.m. return to zero immediately after measuring a high d.c. voltage, or does the meter pointer hover a division or two up-scale for some minutes before returning to zero? The rapid up-scale meter travel can be particularly annoying if you have to switch to the lowest range for another measurement without waiting. Do the measured values of a.c. voltage taken on the higher ranges seem to be low while the readings taken on the lower ranges seem about right? If the answer to either question is yes, then input capacitors of your v.t.v.m. may require replacement.

Fig. 1 shows the input section of a typical peak-to-peak v.t.v.m. This input circuit consists of a half-wave voltage-doubling rectifier and switched voltage dividers—one for a.c. and the other for d.c. Capacitors *C*1, *C*2, and *C*3 range in value from .02 to .1 μf. with the different values encountered representing compromises used in an attempt to reduce problems that will be discussed in this article.

The delay in the meter pointer's return to zero after a high-level d.c. voltage has been measured, is due to a phenomenon called "dielectric absorption" that prolongs the discharge of capacitor *C*1 beyond the time theoretically required. For the period of time that it takes for *C*1 to discharge through the voltage divider consisting of *R*5 through *R*11 (the v.t.v.m. is in one of the d.c. positions), the meter pointer cannot return to zero. Momentarily shorting the input terminals does not help as the pointer will move up-scale again after the short is removed. We can be sure we are not having trouble due to a gassy vacuum tube in the bridge circuit if the meter pointer does return to zero after several minutes. This phenomenon is also active when capacitor *C*1 is charging as when making a reading—this is why the meter pointer seems to take a long time to make the last bit of movement to full deflection.

Fig. 2 shows an equivalent circuit for a capacitor which can explain the mechanism of dielectric absorption. The overall capacitor acts as though a portion of its capacitance is connected to the terminals through a very high resistance. This will explain why some capacitors seem to regain a charge after being momentarily short-circuited. What happens in the case of the momentary short-circuit of a charged capacitor, is that the charge stored in the portion of the capacitor shown as C_B is not readily discharged and leaks into C_A *via* *R*. The time delay is occasioned by the large effective value of *R*. In charging, the capacitor takes a little extra time to fully charge as the portion shown as C_B must charge through *R*. Conventional wax-filled, bypass capacitors will show quite a bit of dielectric absorption. Fortunately, other types show much less.

The solution to the problem is to replace *C*1 of Fig. 1 with a capacitor which does not exhibit this characteristic, or at least has only minimum dielectric absorption. Because insulation resistance is also important, the best replacement would be a hermetically sealed (glass- or ceramic-to-metal) capacitor.

On the a.c. ranges, capacitors *C*2 and *C*3 of Fig. 1 are used in a half-wave, voltage-doubling rectifier circuit. The right side of *V*1, together with *C*2, bias the left side of *V*1 so that *C*3 charges to a voltage very nearly equal to the input peak-to-peak a.c. voltage. The voltage doubler is fed through *C*1 whose function is to block any input d.c., and slight leakage in *C*2 or *C*3 due to low insulation resistance will only cause a small error in the reading. The greatest effect is to lower the (*Continued on page* 82)

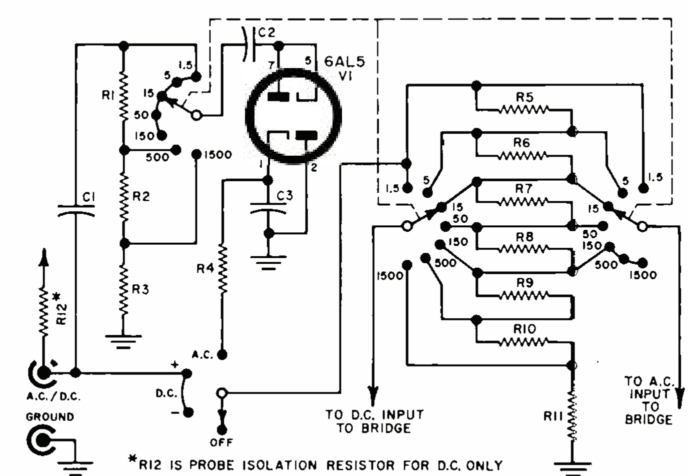
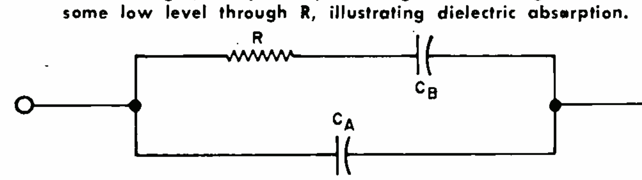


Fig. 1. Although C1 is not in the d.c. circuit of this typical v.t.v.m. input, it influences d.c. readings. Other capacitors play important role in inaccurate a.c. measurements.

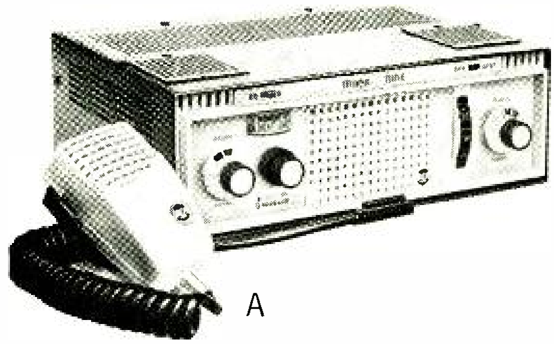
Fig. 2. Capacitor equivalent circuit. When ends are shorted, C_A discharges, C_B partially discharges then charges C_A to some low level through R, illustrating dielectric absorption.



NEW CITIZENS BAND CIRCUITS

By LEN BUCKWALTER

A transceiver that employs electronic switching, a unit with provision for "bull-horn" operation, and a selective-caller with transistor gating.



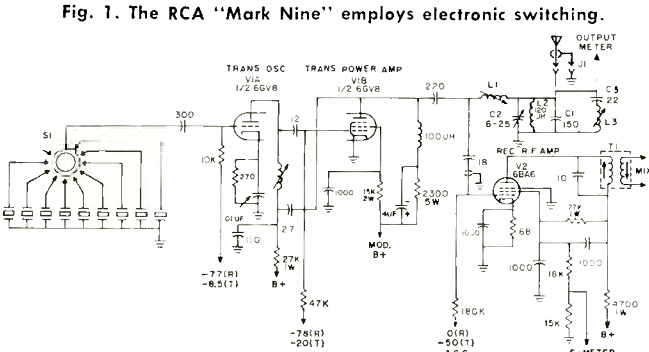
A

B

C

ALTHOUGH the three devices to be described differ markedly in what they achieve, there is a recognizable common denominator. Somewhere in each of the circuits, changes in operating bias provide a key function. In *RCA's* new "Mark Nine" transceiver, for example, a huge swing in grid bias underlies a disarmingly simple system of electronic switching. *General Radiotelephone's* MC-6 transceiver partly depends on bias in the performance of its "bull-horn" provision. Finally, the recent *Cadre* selective-calling system contains a transistor gate whose action is triggered by bias changes. These varied applications for bias not only suggest increased sophistication in CB equipment, but a move from the mechanical to the electronic, especially in the very important switching functions.

Fig. 1. The RCA "Mark Nine" employs electronic switching.



RCA "Mark Nine" Transceiver

Newest in the *RCA*[1] series of CB transceivers is the "Mark Nine" (A). A 9-channel unit, it includes a complement of useful operating features: squelch, noise limiter, metering, manual receiver tuning, and spotting switch. One feature is notable by its absence—a "transmit-receive" relay. This electromechanical component, which tends to require frequent cleaning or contact burnishing, is replaced in the "Mark Nine" by a simple, straightforward technique of electronic switching.

The partial schematic of the "Mark Nine" in Fig. 1 shows the transmitter stages: crystal oscillator *V1A* and power amplifier *V1B*. Also shown is the receiver's r.f. amplifier, *V2*. Near the top of the schematic, a single tank circuit for both receiver and transmitter is formed by *L1*, *C1*, and trimmer *C2*. (Choke *L2* shorts static discharges to ground; *C3* and *L3* suppress transmitter harmonics.) A significant aspect of the circuit is that an external antenna is permanently connected to both transmitter output and receiver input. Electronic switching, based on bias changes, effects the necessary changeover.

Assuming the unit is on receive, we see that the grids of both transmitter stages, *V1A* and *V1B* are impressed with negative bias in excess of −75 volts d.c. Although these tubes are connected to their "B+" source, they are held inactive by cut-off bias. (Bias voltage is tapped from the power supply.) When the operator presses his push-to-talk button, the high bias is shorted to ground and the tubes commence to conduct, producing r.f. output to the antenna. Notice, too, that the transmitter signal is also applied to the grid of the receiver r.f. amplifier. This causes the receiver to develop inordinately high a.g.c. voltage at its detector. Fed back along the a.g.c. line, about −50 volts d.c. cuts off the receiver. At this time too, the push-to-talk switch disconnects the loudspeaker and receiver muting is complete. Thus, what could be a troublesome multi-contact relay (often with four different changeover functions) is considerably improved upon and, what is more, considerably simplified with a bias source and mike switch.

General Radiotelephone MC-6

Included in the new MC-6 transceiver (B) by *General Radiotelephone*[2] is a circuit feature which should be welcomed by the sea-going CB'er, and operators engaged in search and rescue, crowd control, or outdoor events. It is a "bull-horn" provision. The transceiver can double as a mobile public-address system. An extra speaker, the bull-horn, is required to fulfill the function. *General's* approach differs significantly from other, earlier solutions to the problem of utilizing the CB set's existing audio amplifier. It is not simply an extra speaker jack. Rather, it provides refined circuitry so that the operator may switch smoothly from normal CB to p.a. operation. An incoming message in the receiver, for example, can be quickly relayed to people several blocks away or up to a half-mile over water.

The circuits concerned with bull-horn operation are shown in Fig. 2, a partial schematic of the MC-6 transceiver. Several major switching and control functions occur here, primarily dealing with connections to the audio amplifier and transmitter. We'll consider the audio amplifier in a normal mode—reproducing sound in the set's internal loudspeaker. Audio modulator *V1* feeds signal through output (and modulator) transformer *T1*. Audio passes through a selector switch marked "R.-B.H." (radio-bull-horn) and finally to the set's loudspeaker. Incoming signals are heard.

A second set of "R.-B.H." contacts, positioned to the left, control the transmitter. (These contacts play a role in bull-horn operation, as will be shown in a moment.) During normal reception, the transmitter is held inactive by a high negative grid bias (−100 volts d.c.) applied by the power supply. When the operator wishes to transmit, the hold-off bias is shorted by the push-to-talk mike button and transmitter stages are released for activity. The shorting action may be traced through the radio-bull-horn switch to pin 2 of the mike connector and mike assembly.

Now assume that the operator wants bull-horn operation. The "Radio-Bull-Horn" switch is flipped to "Bull Horn" to establish two circuit reconnections. Note that the "R.-B.H." switch pole moves off the −100 volts d.c. bias source. This action produces the desired result: when the mike button is pressed, it cannot short out the negative bias and the transmitter is held inactive. The second reconnection is at the audio transformer secondary; audio is applied to the bull-horn jack. Also, the internal speaker is disconnected to prevent acoustic feedback *via* the nearby mike.

Thus, the CB'er uses the same mike for CB transmission over the air as for local bull-horn operation. Approximately six watts of audio power are available for the public-address function. Since the set's regular volume control does not regulate audio power applied to the bull horn, the manufacturer suggests an optional 20-ohm wirewound potentiometer in the horn line for level control, especially if conditions are favorable to feedback.

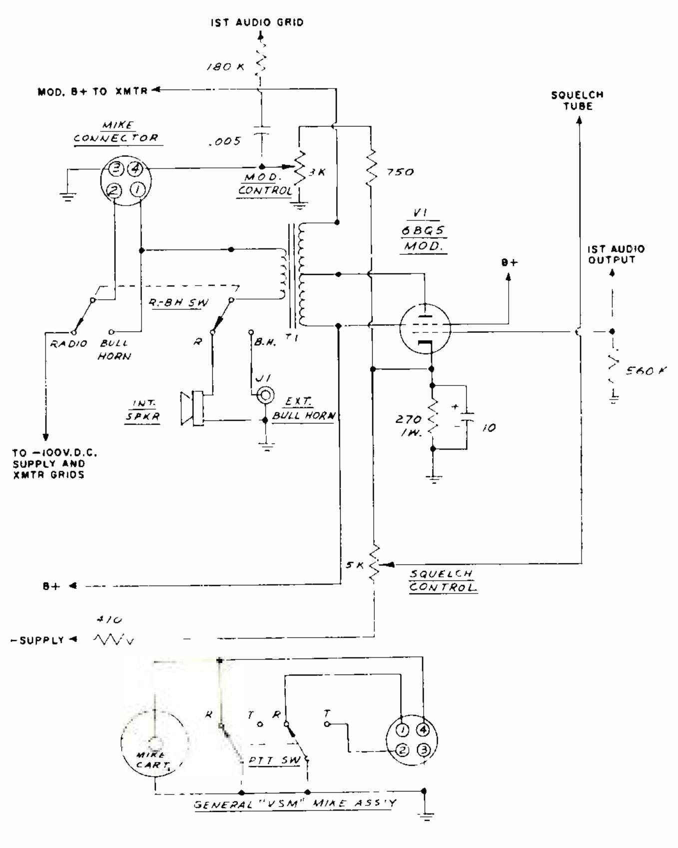
Cadre Model 524 Selective Call

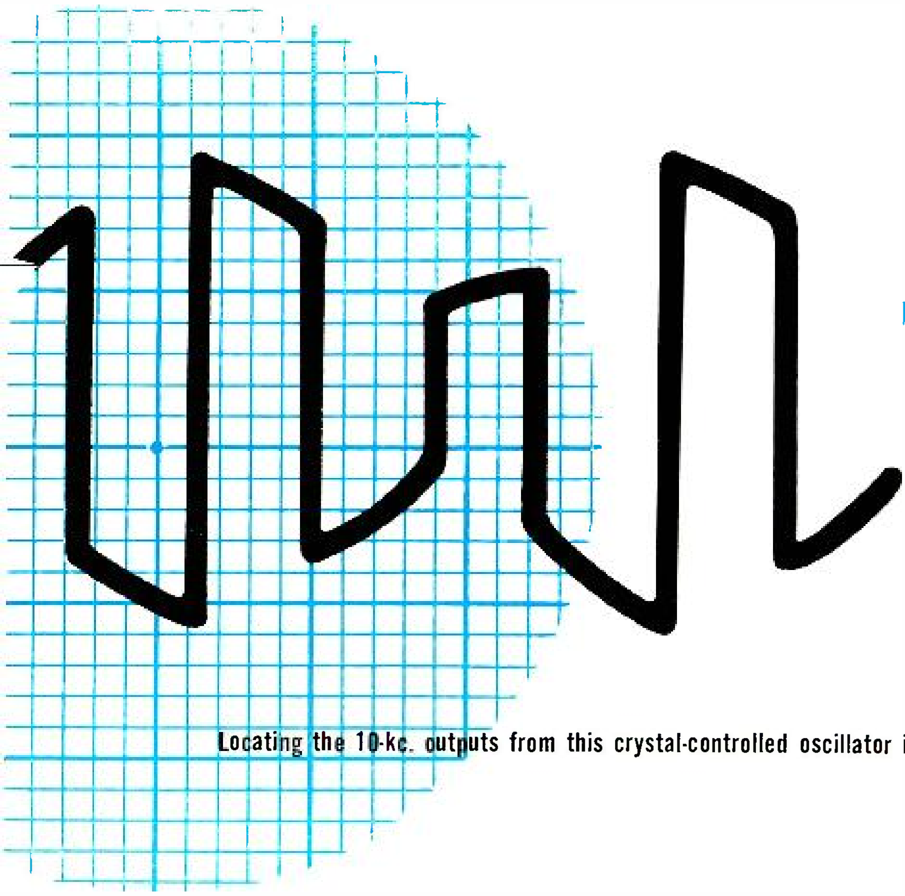
Calling systems for CB, which selectively open a receiver to an incoming signal, tend to divide into two types. The simpler is the 1-tone system. It performs satisfactorily, but is subject to occasional false operation when heterodynes simulate the desired tone during crowded-band conditions. Increased resistance to falsing is possible with the second major system: the 2-tone code in which audio signals are sent simultaneously. Latest in the series is a 3-tone design recently announced by *Cadre*[3] for the new Model 524 unit (C). Not only does it add a third tone for more elaborate coding (and many more tone combinations) but tones are sent in sequence. This is in contrast to the earlier simultaneous or tone-burst method. To meet FCC specifications, the time period for the entire 3-tone cycle occurs within the required 5-second limit.

As shown in photo (C), a selector dial on the front panel provides a choice of up to 24 different tone codes. (Additional 24-group codes are also available.) Once the desired code number is selected by the operator, the "Code Call" switch is firmly depressed. This action is roughly equivalent to the operation of a 3-minute egg timer, only here, the lever takes about 3 seconds to return, automatically, to the rest position. The delay provides the necessary circuit action which strings out the three tones in sequence. The tones are processed for transmit and receive by a resonant-reed relay, as in some other call systems, but with several novel differences. Let's consider, first, what occurs during the encoding function to establish the desired tone code. The resulting audio energy will be applied to the transceiver modulator for transmission over the air. (The system works with nearly any transceiver and a 12-v. d.c. source.)

The schematic of Fig. 3 is the complete device. After the operator depresses the "Code Call" switch (at top left), the three wipers of S1 proceed to move across their associated fixed contacts. The first tone is generated as wiper 7 touches contact 5, an action which impresses 12 volts d.c. on contact 5. This potential is then fed through the "Code Selector Switch," S2, and ultimately reaches one of the four electromagnetic coils at the right side (*Continued on page 90*)

Fig. 2. The General Radiotelephone bull-horn circuitry.





TONE-MODULATED FREQUENCY CALIBRATOR

By RONALD L. IVES

Locating the 10-kc. outputs from this crystal-controlled oscillator is easy once the tone modulation is turned on.

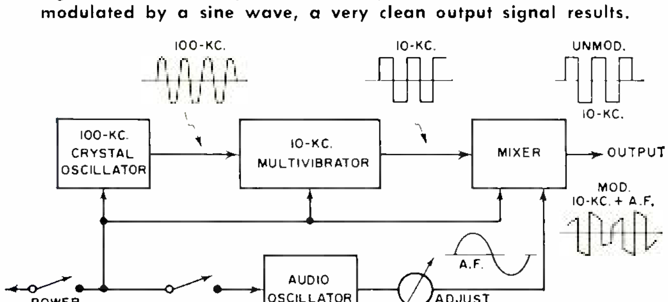
ALTHOUGH the crystal oscillator was discovered more than 40 years ago, and the combination of crystal oscillator and multivibrator has been in widespread use for more than 30 years, the very real problem of identifying signals from the calibration oscillator remains with us. In many areas, where a large number of unmodulated carriers are on the air, such identification becomes quite difficult.

To eliminate this difficulty, a number of neon-oscillator-modulated calibration oscillators have been tried. These pulse-modulated calibration oscillators give an identifiable signal and work fairly well in a rough way. Unfortunately, the saw-tooth modulation produced by the neon tube oscillator is hard to control, so that overmodulation, splatter, and spurious signals are usually produced, particularly in the very low-frequency bands which are now becoming important for the transmission of standard time and frequency signals.

Curing these troubles is theoretically quite simple. If the calibration oscillator is sinusoidally modulated at anything less than 100 percent, splatter and its attendant evils will be absent. Additionally, if the modulation frequency is a low-frequency audio tone, the calibration signals will not only be aurally identifiable but will not "spread all over the dial".

The functional diagram of a 10-kc. calibration oscillator with sinusoidal modulation is shown in Fig. 1. Here, the standard signal is produced by a 100-kc. crystal oscillator,

Fig. 1. When the square-wave output of the multivibrator is modulated by a sine wave, a very clean output signal results.



which can be adjusted to zero beat with WWV or any other desired standard. This oscillator drives a 10-kc. multivibrator, producing a square-wave output whose accuracy is a direct function of the accuracy of the 100-kc. crystal oscillator.

The 10-kc. square-wave signal is fed to a mixer, where it is combined with an audio signal produced by the audio oscillator. Audio output amplitude is adjustable, so that modulation percentage can be set at an optimum value. Mixer output is the calibration signal, consisting of the 10-kc. square-wave signal modulated by the sinusoidal audio signal. Switching is provided so that the modulation can be used or omitted, as desired.

The completed calibration oscillator, minus power supply and switches, can be constructed with conventional components in and on a 2¼″ by 2¼″ by 5″ utility box (*LMB* 108) without encountering "packing-factor" trouble.

Power is obtained from an external source through the 4-pin power plug. The two power switches ("Main" and "Tone") are located remote from the calibration oscillator, preferably on the receiver using the device.

Circuit

The circuit of the calibration oscillator is shown in Fig. 2. Note that all circuits are entirely conventional. With the exception of the crystal and the multivibrator components, no resistor or capacitor value is critical, so that "off-the-shelf" components can be used without difficulty. A wide variety of circuit modifications can be used without impairing performance, and tube substitutions are practicable.

Construction

Building a calibration oscillator of this type is not difficult, but careful planning of work sequence is desirable to avoid problems of parts installation and placement. Layout as shown in Figs. 3 and 4 seems very close to ideal.

First mount the tube sockets, with filament pins forward. Then mount the crystal socket, the trimmer (*C*1), and the audio inductor (*L*1). Be sure that the adjusting screw of this inductor is accessible when the calibrator is mounted in the equipment. It should be oriented to the rear. Follow this by mounting the power plug, the audio volume control

(*R*21), and the signal output fitting, which here is made from a small right-angle "Weatherhead" fitting and a *Switchcraft* type 5501 MP miniature male microphone plug. Another type of connector may be used here, but the oscillator output should be shielded to prevent local radio interference on a number of frequencies.

At this stage, wire the filament circuits, the direct plate connections, and make as many grounds as possible, using small soldering lugs held under the socket mounting screws. When this is completed, wire the crystal oscillator complete except for the output capacitor (*C*4); the grid and cathode circuits of the mixer; and the audio oscillator except for the .1-µf. ceramic plate capacitors (*C*13 and *C*14). Mount all components parallel to the chassis, as shown in Figs. 3 and 4.

Resistor *R*19 of the audio oscillator is directly behind the crystal socket and is not visible in the photographs. At this point, more than half of the construction is completed.

To mount the remaining mixer components and most of the multivibrator components, make a centerboard for the chassis box using a sheet of perforated fiberglass epoxy board, such as *Vector* T28, and mount the remaining resistors and capacitors. As arranged here, most of them are mounted on the high-frequency side (Fig. 3), only the second plate capacitor of the multivibrator (*C*5), the first plate capacitor (*C*6), and the mixer output capacitor (*C*9) being on the low-frequency side (Fig. 4). Most of the interconnections are made on the low-frequency side, using #22 bare tinned copper wire, insulated with Teflon sleeving where necessary.

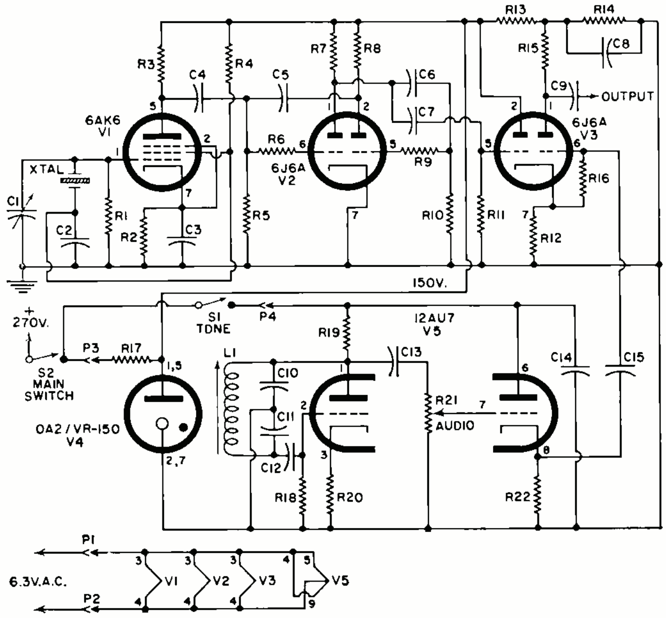
Mounting and interconnection of the components can be done before the centerboard is mounted in the chassis box. Final connections to the tube sockets are made after the centerboard is firmly mounted in place. The coupling capacitor from the multivibrator to the mixer (*C*7) is supported by its leads between the plate end of *R*7 and pin 5 of the *V*3 socket.

Connections on the low-frequency side of the centerboard (Fig. 4) are best made in the following order. Run a short length of insulated wire from the center of the output connector to the output end of the output isolating capacitor (*C*9). Install *C*14 as close to the centerboard and as far toward the input plug as practicable. Install *C*8 from the high end of *R*15 to ground, keeping it close to the centerboard and as far toward the output connector as possible.

Next, install the power resistor *R*17 by means of a through bolt on the front panel of the box close to the input plug. Because it will run warm, fiber washers should be used at both ends of the resistor to compensate for expansion and to augment the insulation. A 20-watt resistor is used as it has a large radiating surface and hence runs cool in this particular circuit.

Lastly, install *C*13 from the audio volume control (*R*21, high end) to pin 1 of the *V*5 socket, using a small tie point held by one of the *L*1 mounting screws for the outer support. Connect *C*10 from pin 1 to *V*5 socket to ground, which is made at a soldering lug held by the forward crystal socket mounting screw (next to *C*1).

This completes the wiring, (*Continued on page* 96)



R1—.47 meg., ½ w. res.
R2—3300 ohm, 1 w. carbon res.
R3—150,000 ohm, ½ w. carbon res.
R4, R11, R16, R18—100,000 ohm, ½ w. carbon res.
R5, R10—39,000 ohm, ½ w. carbon res.
R6, R7, R8, R9—47,000 ohm, ½ w. carbon res.
R12—270 ohm, 1 w. carbon res.
R13—10,000 ohm, 2 w. carbon res.
R14—6800 ohm, 2 w. carbon res.
R15—4700 ohm, 2 w. carbon res.
R17—1000 ohm, 20 w. wirewound res.
R19—15,000 ohm, 2 w. carbon res.
R20—1000 ohm, 1 w. carbon res.
R21—10,000 ohm pot
R22—470 ohm, 1 w. carbon res.
C1—3.9-50 pf. APC var. capacitor
C2—150 pf. tubular ceramic
C3—.003 µf. disc ceramic
C4, C9—10 pf. tubular ceramic
C5—560 pf. tubular ceramic
C6—510 pf. tubular ceramic
C7—220 pf. tubular ceramic
C8, C10, C13, C14—.1 µf., 600 v. ceramic capacitor
C11, C12—.02 µf. disc ceramic
C15—.1 µf. tubular metallized paper capacitor
L1—3.4 hy. adj. inductor, adjustable −45%+85% at 7 ma. d.c. (UTC VIC-14)
S1, S2—S.p.s.t. switch
Xtal.—100 kc. crystal (Bliley Type KV3)
P1-P4—4-pin power plug
V1—6AK6 tube
V2, V3—6J6A tube
V4—0A2/VR-150 tube
V5—12AU7 tube

Fig. 2. Power for the calibration oscillator comes from an external source. Both power switches are also external and can be mounted at the receiver using the test calibrator.

Fig. 3. Interior view of the high-frequency side of the unit.

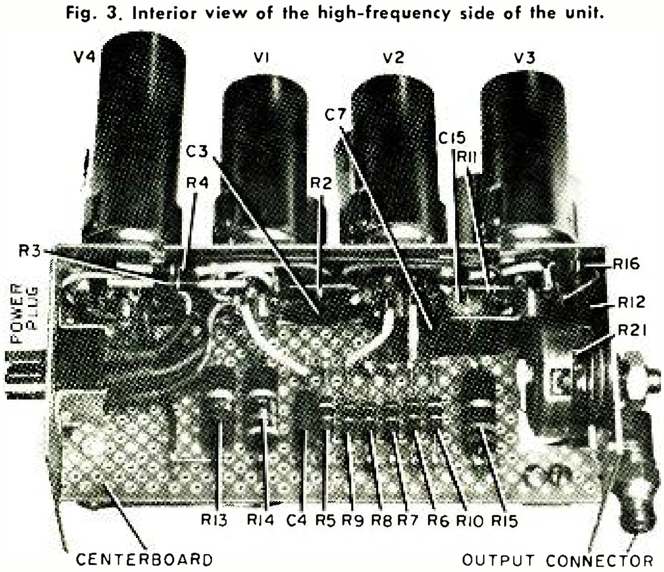
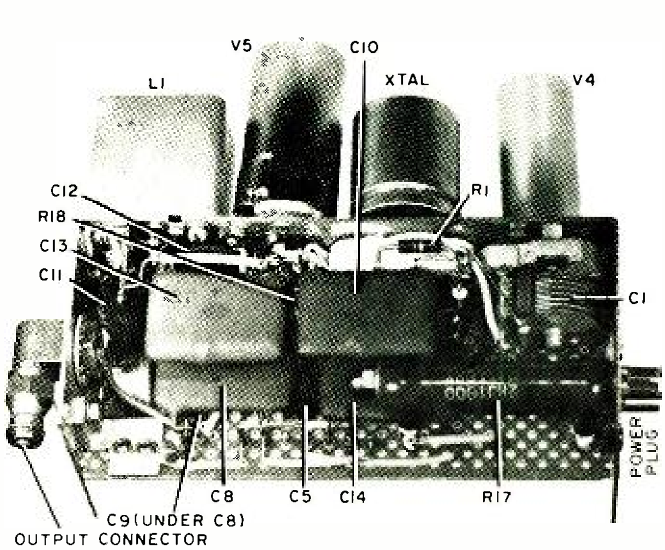


Fig. 4. Interior view of the low-frequency side of the device.



MEASURING THE "SONIC BOOM"

An F-104, with Oklahoma City in background, is employed to simulate a supersonic transport of the future.

Using electronic instrumentation, FAA technicians have measured effects of jet aircraft shock waves upon residential structures.

By JIM KYLE

ELECTRONIC instrumentation is being applied in fields ranging from missile testing to medical diagnosis. One interesting application of electronic instrumentation, which at the same time illustrates clearly the particular problems and techniques involved, was in connection with the early flight-test stages of the Supersonic Transport Research Project of the Federal Aviation Agency.

The specific test program was designed to gather as much data as possible as a basis for setting up FAA rules governing operation of supersonic transports when the plane becomes available. To gather this data, the FAA selected a typical midwestern city (Oklahoma City) with an aggregate population of nearly a million, and scheduled eight supersonic flights daily over this area for a six-month period.

The object was to determine the effects of the supersonic flights—mainly the accompanying "sonic boom"—on both the populace and the structures. Only time can tell the effects upon the people involved, but electronics is providing the answer to the structural effects.

The way in which this test was instrumented provides a good illustration of how electronic instrumentation is used by industry to solve non-electronic problems.

Factors to be Measured

The first step in applying electronic instrumentation of any sort must be to determine exactly what physical quantities are to be measured. This requirement, in turn, means that the instrumentation engineer must be briefed on the phenomenon expected during any test. In this case, the phenomenon of interest is the "sonic boom" produced by an aircraft in supersonic flight.

While the boom sounds to the ear almost exactly like the detonation of a large quantity of explosive at a considerable distance, the actual creation and propagation of the boom is a completely different process. An oversimplified analogy likens the sonic boom produced by a supersonic aircraft to the visible wake produced on the surface of a still lake by a speedboat.

In both cases, the moving object is traveling at high speed through a fluid medium which is, for all practical purposes, not compressible. (Air loses its compressibility at approximately the pressure produced by an object moving through it at the speed of sound.) Since the fluid can't be compressed, it must be shoved out of the way by brute force. This force represents a transfer of energy from the moving object to the medium, and the energy must be dissipated by the medium.

In the lake, the energy creates a wave which radiates symmetrically about the moving object. In the air, a similar shock wave is created.

Both these waves are difficult to detect in the medium itself. The water wave makes itself known as a turbulence at the shore, and the shock wave in the air makes itself known as a pressure wave (after some of its energy has been dissipated) very similar to a single-impulse sound wave. Fig. 1 illustrates the similarities between the two types of waves, while Fig. 2A shows the waveform to be expected from a sonic boom.

In Fig. 2A, two distinct impulses are obvious. The first represents the beginning of the boom or "bow wave," while the second represents the last effect or "tail wave." The horizontal line, which resembles the baseline of an oscilloscope display, represents normal atmospheric pressure level. When the shock wave arrives it creates a near-instantaneous "overpressure" (first vertical line) which decays linearly until the "tail wave" arrives (second vertical line), at which time pressure level returns to normal almost instantly.

The "tail wave" referred to is the return of air to the space left empty just behind the aircraft; occasionally, both impulse waves may be heard by the human ear, but more frequently only a single impulse is audible.

The strength of the boom is measured in pounds-per-square-foot of "overpressure," and the maximum overpressure of interest during these tests was 2 lbs./ft.^{2} A practical supersonic transport is not expected to produce an overpressure of this magnitude at ground level.

Since, for the purposes of the test, each boom produced was planned to be as nearly identical to every other boom as was possible, one of the primary questions electronics was called upon to answer was "How much overpressure was produced by each pass?"

However, the effects of the overpressure upon typical commercial and residential structures were also of great interest. An overpressure of 2 lbs./ft.^{2} represents only an increase of about 0.1% above normal atmospheric pressure of 15 lbs./in.^{2} But this pressure change takes place in a matter of milliseconds and on the roof of a 25 by 40 foot building this represents an impact of approximately one ton. So the second question put to the instrumentation engineers was "How does a typical structure respond to this impact?"

Since the structure's response divides into two broad areas, the *amount* of movement and the *speed* with which it occurs, this question subdivides into two specific questions: "How much does the structure move?" and "How rapidly does it do this?"

At this point, and not before, electronics enters the picture. The three quantities to be measured are air pressure, structural movement, and speed of structural response. The measurements must be made accurately, continuously during the test period, and the results must be preserved in some sort of permanent form for future analysis.

Actual Instrumentation

Actual instrumentation of the test involved little new circuitry, according to the NASA specialists who supervised the work. Virtually all was accomplished with "off-the-shelf" equipment of the commercially available sort. But in several cases, the equipment was modified somewhat to meet the needs of the job at hand. And the real secret to this, and all other instrumentation projects, was in the planning and system approach.

Test engineers consider the pressure measurements on each run to be the most important instrumentation result, as they provided a control and standardization for all other test results, so this area will be examined first.

Looking again at Fig. 2A, the theoretical waveform of a sonic boom, it can be seen that this is a complex wave indeed. The distance from horizontal line to the first vertical peak represents the absolute increase, but the decay rate and the negative peak are also important quantities.

A standard pressure transducer is a calibrated capacitor microphone, such as the W.E. 640-AA. Microphones of this type have a frequency response rated at 5 cps to 10 kc., but this response is not sufficient to reproduce the pressure wave from a sonic boom accurately. The top waveform in Fig. 2B shows the trace resulting when a normal capacitor microphone is employed; the decay rate information is missing, although the peaks are reproduced.

Those familiar with analog-computer techniques will recognize that this output is a differentiated version of the waveform. The differentiation is a result of the inherent capacitance of the microphone, yet no other type of transducer provides acceptable performance.

A new type of electronic unit has recently been put on the market and is designed to provide frequency response down to d.c. in this application. It employs an r.f. oscillator and detector circuit with the microphone connected in such a manner that pressure changes cause an interaction on the

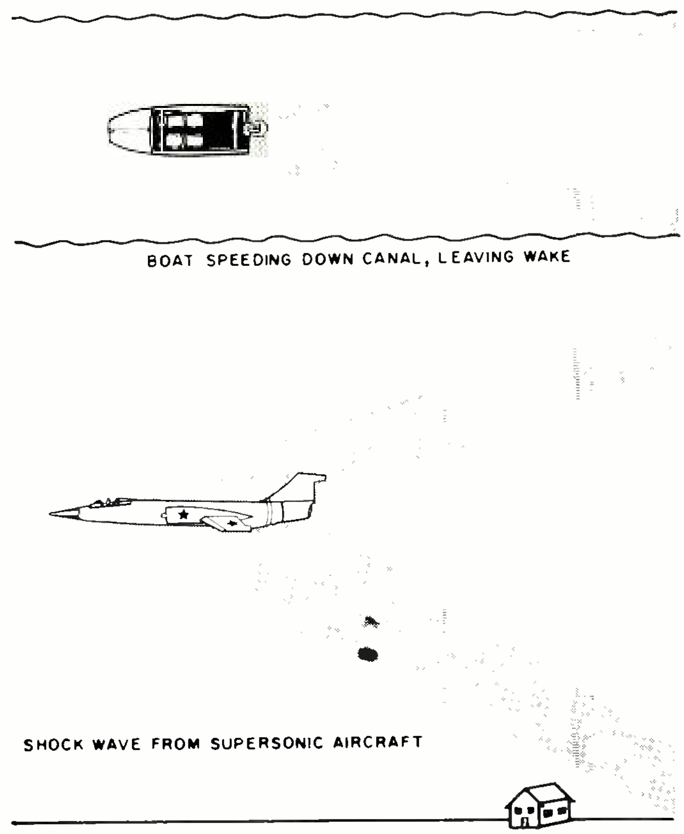


Fig. 1. Speeding boat and plane both produce wakes, one in water the other in air. At supersonic speeds, a jet aircraft is able to produce a severe shock wave as illustrated.

Shown here is a portion of the instrumentation installed in the test houses. At extreme right are two recording oscillographs which provide readout for structural-response measurements. Next to the oscillographs is bank of automatic bridge equipment for strain gages. Light-colored case with 16 knobs on front is calibration box for accelerometers. On table, center, is thermocouple readout and current amplifier assembly. Cables lead to inverter which provides power from 28-v. batteries.

circuit, resulting in output voltage variations. Even though the frequency response of the electronic unit is flat to d.c., system response is still limited to 1 cps by microphone design—and that is still not sufficient to reproduce the sonic booms. The center waveform of Fig. 2B shows the result.

To make the low-frequency response extend far enough down to reproduce the decay portion of the waveform accurately, NASA technicians participating in the test program resorted to modification of the microphones. Standard microphones are "vented," that is, the enclosed air behind the diaphragm is allowed to escape through specially designed vents. This preserves high-frequency response, and eliminates undesired peaks and valleys in the total response curve.

By changing the length of the vents, technicians were able to extend the low-frequency response to the extreme of only −3 db at 0.1 cps (see lower waveform in Fig. 2B). The limit was reached when thermal expansion of trapped air with minute changes in temperature produced more diaphragm movement than did changes in external pressure.

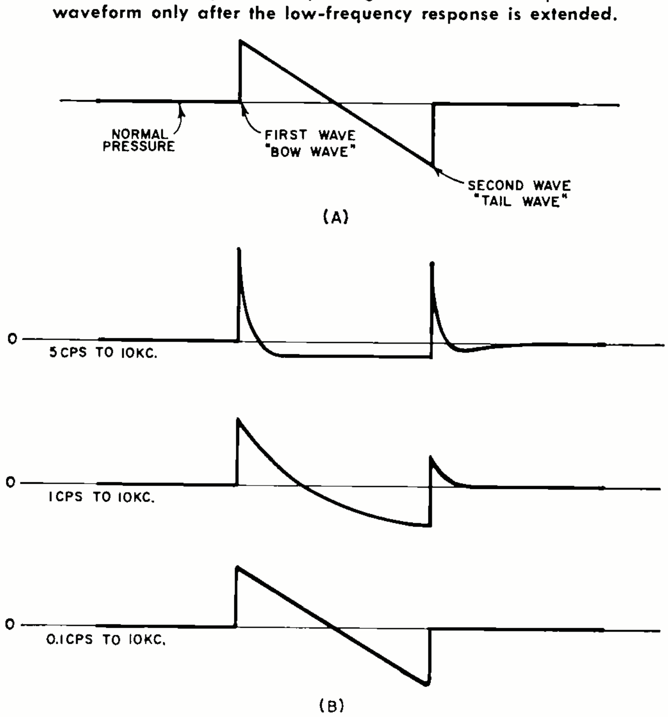
To tune the vents, ordinary surgical tubing was used and trimmed to length by a trial-and-error process. The completed equipment was then calibrated at NASA's Langley Field laboratories, prior to being shipped to Oklahoma City for the tests.

The complete pressure-measuring unit consists of the modified microphone, its associated electronic unit, a current amplifier, and a recording oscillograph. Two such units are installed at each of three test sites, although only one oscillograph is used at each site. Fig. 3 is a block diagram of this portion of the system. One of the pressure units is installed outdoors, at ground level, in the center of a 4-foot-square plywood board, and the other is installed inside the structure. The board is used to establish a standardized reflecting surface surrounding the microphone so that all exterior measurements can be directly intercompared.

Structural Response

The structure response measurement is done with two types of instruments. The amount of movement is detected by semiconductor strain gages, which are affixed to key points such as rafters and joists of the buildings. Sensitivity of these gages is extremely high; movements as little as one microinch are detectable. Each was installed by a NASA specialist, and average time for each installation was 6½ hours.

Fig. 2. (A) Waveform showing pressure changes during sonic boom. (B) Microphone output signal matches the pressure waveform only after the low-frequency response is extended.



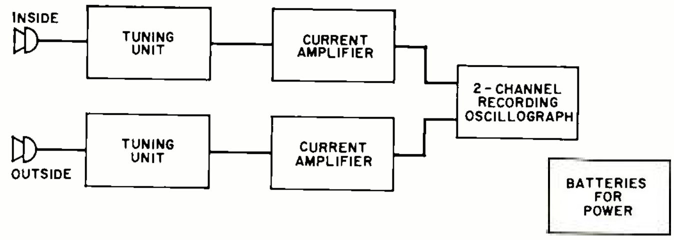


Fig. 3. Block diagram of the pressure-measuring unit.

The strain gages are used in a Wheatstone-bridge circuit. Each gage's resistance changes according to the change in its length and the resistance change is measured by recording the resulting change in bridge output voltage. This voltage is extremely small and is amplified by a carrier amplifier, which is another off-the-shelf item.

Fifteen of these strain gages are spotted at key points throughout one of the three test structures (each of which is an actual residence, rented by the FAA especially for the tests; average age is about 5 years). The other two test sites are used for pressure measurements only. The output of the 15 strain-gage channels terminates at one *CEC* recording oscillograph.

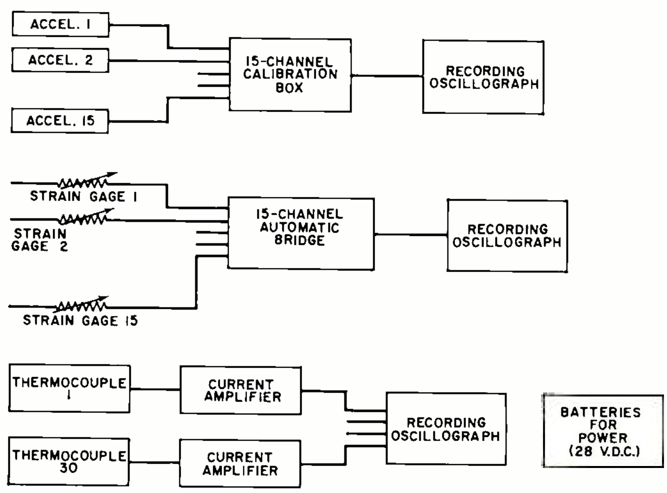


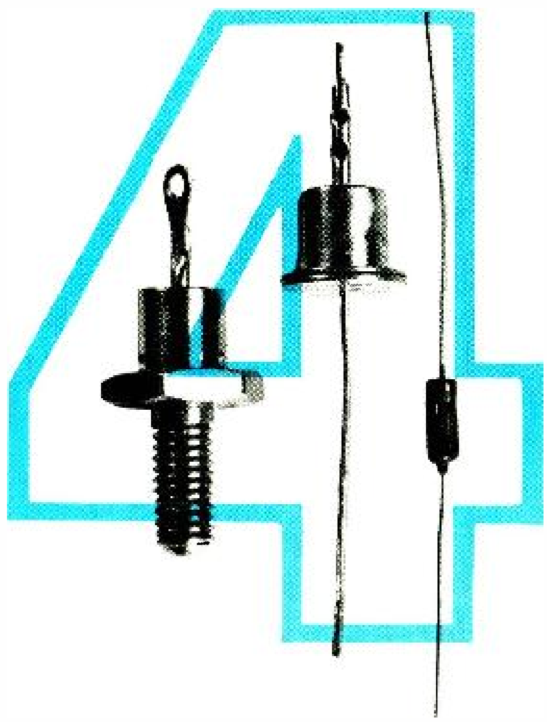
Fig. 4. Block diagram of the response-measurement system.

Motion of the structure is measured by accelerometers, which are used in pairs. One of each pair measures east-west acceleration, while the other measures the north-south components.

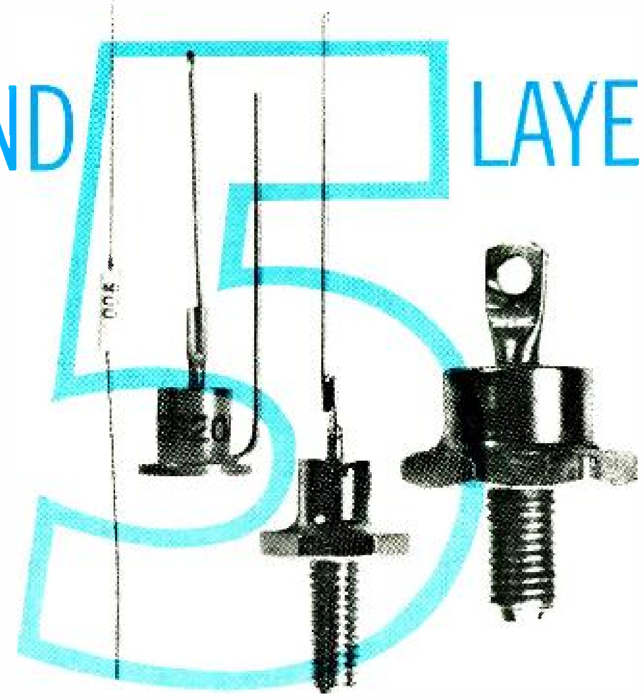
The particular accelerometers chosen for this application are of the servo type in which a feedback signal is developed and amplified to maintain the reference mass virtually stationary with respect to the accelerometer case. This "error signal" is taken as the accelerometer output. By proper choice of amplifier gain (accomplished by a plug-in resistive shunt network in the feedback loop), the range may be chosen as anywhere from 0.1 gravity acceleration "full scale" to as high as 60 G's. In this test, maximum range is in the region of 0.25 G.

The accelerometers are calibrated by use of "angle blocks" which, in turn, use the earth's gravitational pull as a reference standard. The accelerometer is simply placed on one of the angle surfaces of the block and its output noted, then compared with the standard acceleration force computed as corresponding to that angle.

Fifteen channels of accelerometer readout are used for structural response; three additional instruments are buried underground at the fully instrumented test site to detect the seismic effects of the (*Continued on page* 88)



(Left) Some typical four-layer diodes. From left to right, a 5-amp. stud-mount, a 1-amp. top-hat, and a 250-ma. glass-encapsulated unit. Normal voltage range from 20 to 200 volts for these. (Below) Typical five-layer diodes. From left to right, 30-v. trigger diode, 5-amp. power-control diode, 7-amp., and 20-amp. bilateral switching diodes. Equivalent 110-volt power-control capabilities of the last three of these particular units are: 600, 800, and 2200 watts.



4 AND 5 LAYER SEMICONDUCTOR DIODES

These avalanche-mode semiconductor switches have many applications—including high-power audio amplifiers, d.c. transformers, dimmers, computer counters, and radar-modulator circuits.

By DONALD E. LANCASTER

HIGH-powered audio amplifiers using nothing but diodes, d.c. transformers that can step high voltage down, and 5-kw. light dimmers with only five low-cost parts are just a few of the more noteworthy functions that the four- and five-layer semiconductor diodes can perform. These currently available, economical devices can also be used in a wide range of other applications, such as in memories, multivibrators, counters, oscillators, frequency dividers, function generators, switches and triggers, and radar modulators—to name just a scant few.

Basic Operation

These diodes are avalanche-mode semiconductor switches, identical to a gateless silicon controlled rectifier. In the "off" state, the diode impedance is very high, into the tens of megohms. Pulsing the diode while in the "off" state will cause avalanche-mode turn-on, usually in times much less than a microsecond. The "on" state is the very low impedance of a forward-biased diode, so low that the load current must be limited to a safe value, lest the diode destroy itself. The turn-on method is basically different from the conventional SCR gate turn-on and has the advantage of being many times faster. This fast turn-on allows four- and five-layer diodes to operate into the hundreds of kilocycles as power-control devices. This is well in excess of conventional SCR capability.

The four-layer diode is unilateral and will only operate in one current direction. The five-layer diode is bilateral and operates equally well in either current direction. These diodes have ratings varying from milliwatt to kilowatt power-control capability, currents from a few milliamperes to tens of amps., and breakdown (trigger) voltages varying from 20 to 400 volts. Higher ratings are entirely practical. Cost is about the same as an equivalent power SCR.

There are many manufacturers of these diodes. *Clevite* offers a complete line of four-layer devices, while *Transitron* offers a broad line of five-layer devices. Other manufacturers are *Texas Instruments*, *Hunt Electronics*, *General Electric*, and *Western Electric*, to name only a few. Specific device information is available from each manufacturer in the form of data sheets and application notes.

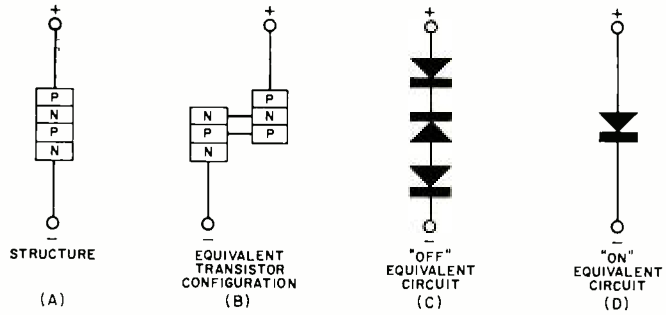


Fig. 1. Four-layer diode structure and equivalent circuits.

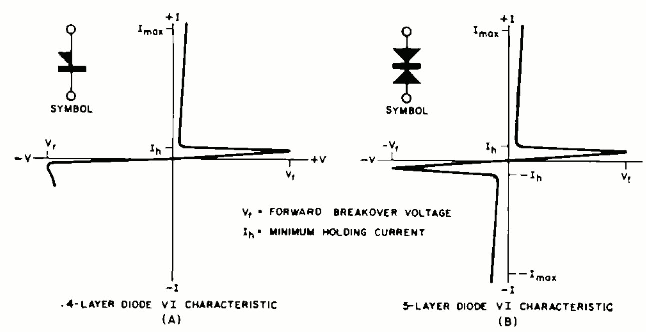


Fig. 2. Both diode types remain "off" until V_f is exceeded, then they rapidly switch "on." Diodes remain "on" as long as current exceeds I_h. If current falls below this value or reverses, then the diode will quickly switch to the "off" state.

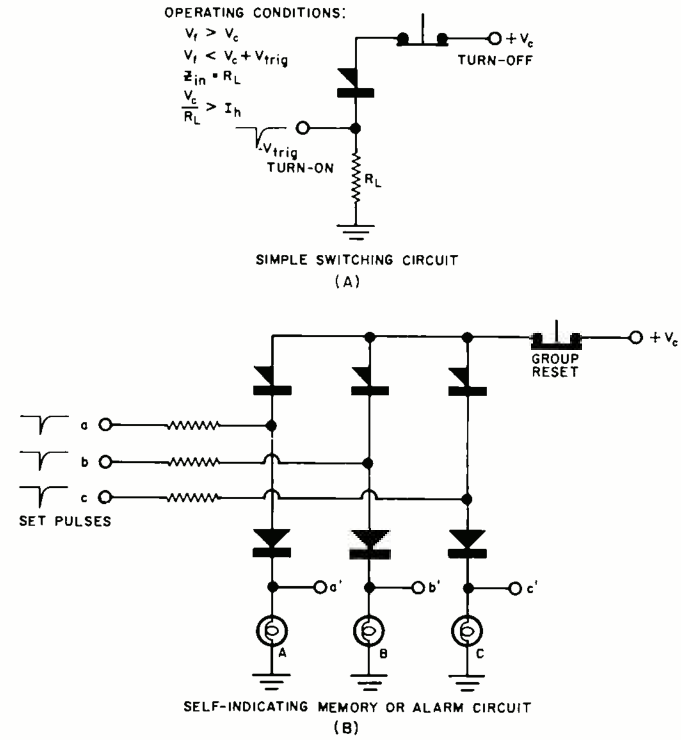


Fig. 3. Diode may be switched "on" by pulsing it in such a way that V_f is exceeded. Diode remains on after pulse ends. Turn-off occurs when the load current is interrupted briefly.

In avalanche-mode turn-on, most of the turn-on energy is provided by the load itself and not by the triggering signal. This trigger merely initiates the turn-on activity. Perhaps this is somewhat like removing a bottom can of a grocery store display. Very little energy is needed to knock one can loose, compared to the total energy produced during this "avalanche" breakdown. Because of this trigger sensitivity, the four-layer diode is inherently a high-gain device. Trigger signals work into what is virtually an open circuit while directly controlling low-impedance, high-power loads.

Turn-off is usually accomplished by letting the main load current drop to a very low or negative value. This is usually relatively easy to do. When discharging a capacitor, the diodes simply stop conducting when the capacitor is discharged. The a.c. line zeros may be used for resetting. A commutating or "speed-up" (a misnomer) capacitor can turn a second diode off as a first one turns on. Many circuits require the inherent locking quality of the turn-on. Here turn-off is accomplished by mechanically or electrically interrupting the load current.

Fig. 1A shows graphically the structure of a four-layer diode. This is seen to consist of four alternate layers of *n*- and *p*-type semiconductor material, normally silicon. An equivalent transistor configuration, shown in Fig. 1B, is useful in understanding the turn-on mechanism. Here an *n-p-n* and *p-n-p* transistor form a locked-pair configuration. If the current gain of each transistor was much less than unity, any current passing through the pair would be rapidly "de-amplified" and the pair would then assume an open circuit, or "off" state. Suppose the current gain were greater than unity. This is possible due to actual device internal feedback. Now, any current flowing through the device will be amplified, and the locked pair will assume a saturated or "on" state. Current is then load-limited only.

By suitably controlling parameters during diode fabrication, the current gain of the four-layer diode is made highly dependent upon the current itself. At low (leakage) currents, the current gain is much less than unity, and the diode stays off. As long as the forward bias on the diode is below the reverse breakdown rating of the middle *n-p* junction, the current gain stays low and the diode stays off. If the reverse breakdown is exceeded, quite a large current will flow. This large current causes a large current gain, and the diode rapidly saturates and assumes the "on" state. This results in the "off" equivalent circuit of Fig. 1C and the "on" equivalent circuit of Fig. 1D.

To turn an "off" diode on, it must be pulsed in the forward voltage direction with a voltage high enough to avalanche the structure. To turn an "on" diode off, the load current must be reduced to a low or negative value.

The turn-on and turn-off mechanisms result in the volt-ampere (*VI*) characteristics shown in Fig. 2. The forward-avalanche (turn-on) voltage is indicated by V_f, the maximum permissible current by I_{max}, and the minimum holding current by I_h. A four-layer diode is never operated in the reverse current direction and care must be taken to observe diode polarity and to limit any circuit reverse voltage to a value that is small compared to V_f. A five-layer diode may be thought of as two four-layer diodes in inverse parallel, and thus operates equally well in either current direction.

Generally, the steady-state I_{max} will be much lower than the pulse I_{max} rating for a low duty cycle. This current rating is based on thermal considerations. For very low duty cycles, pulses that are in the order of a hundred amperes and higher peak currents may be readily handled.

Switching Circuit

A simple switching circuit is shown in Fig. 3A. The diode is chosen to have a V_f higher than the supply voltage V_c, and thus will not turn on of its own accord. If a negative turn-on pulse is applied to the load side of the diode, the diode voltage will be equal to the sum of V_c and the negative trigger voltage V_{trig}. If this voltage exceeds V_f, the diode will turn on. Load current will then flow through R_L. If the load current exceeds I_h, the diode holding current, the diode will stay on. The diode may be turned off by interrupting the load current. This basic circuit may be used as a memory circuit to "remember" the passing of a trigger pulse.

The input impedance of this circuit is R_L when the diode is off and zero when the diode is on. Two modifications allow the input impedance to become very high in either state. By adding a conventional diode in series with the load such that the turn-on trigger will back-bias it, the off impedance becomes very high. As soon as the four-layer diode starts to turn on, the conventional diode becomes forward-biased and does not interfere with load turn-on. Since the turn-on input impedance is now virtually an open circuit, an arbitrarily large resistance may be placed in the trigger line without effect. This allows a high input impedance should a trigger pulse arrive after a diode has already turned on due to a previous pulse.

This results in the more practical circuit of Fig. 3B, a circuit which serves as an annunciator or paging device, or as a self-indicating computer memory. Electrical outputs at a', b' and c' are zero when the diodes are off and V_c when the diodes are on. An electronic gate may replace the group reset button that is shown in the diagram, and individual resets could be provided in each diode line.

Sawtooth Oscillator

The sawtooth oscillator of Fig. 4A uses a four-layer diode. The circuit is identical to the conventional neon-lamp or glow-tube relaxation oscillator, with the exception of the load resistor R_L which must be used to limit the capacitor discharge current to a safe value (usually 10 amperes or more peak current).

The performance is markedly different. The ratio of scan time to retrace time is much higher than a gas tube can provide. Output is referenced to ground instead of the usual 50-volt dropout level of neons. The circuit is temperature-, radiation-, and light-stable. Considerable oscillator power can be produced by such a circuit. For oscillation, V_f must be lower than V_c. For a good sawtooth waveform (a linear ramp instead of an exponential charging curve), V_c should be much higher than V_f. The higher V_c, the better the circuit linearity.

The circuit operation is based upon R charging C until the voltage across C equals V_f. At this point, the diode turns on, discharging C, and turns off. The cycle then repeats. R must be chosen large enough that the charging current will be less than the holding current of the diode. Otherwise, the diode will lock on after one cycle and remain on until V_c is removed. When operated in this mode, the circuit becomes a time-delay generator instead of an oscillator.

The sawtooth oscillator may be synchronized to any frequency *higher* than its free-running frequency by supplying negative trigger pulses to the four-layer diode (Fig. 4B). The diode will now turn on at the instant the sync pulse and the capacitor voltage, when added together, exceed V_f. By controlling sync pulse amplitude, the oscillator may be made to lock on any submultiple of the input frequency, giving frequency division by two, three, four, or five. Division higher than five requires exact control of circuit voltages, sync amplitude, and pulse jitter, but is entirely reasonable. Placing the load resistor in the diode leg of the circuit will produce positive output pulses, while placing the load resistor in the capacitor leg will produce negative output pulses. These pulses may be used to sync additional stages.

The locked-oscillator frequency divider of Fig. 4C is an application of the sawtooth oscillator as a tone generator for an electronic organ. The input oscillator is synchronized to the input pulses at frequency F_0. Each oscillator is synchronized at one-half the previous oscillator frequency, producing lower and lower notes, each spaced exactly one octave apart. The waveform produced is rich in harmonics and readily distorted to produce the various voices of the organ stops. Twelve such chains are needed to produce all the notes. Tuning is by trimming each R and C to yield a

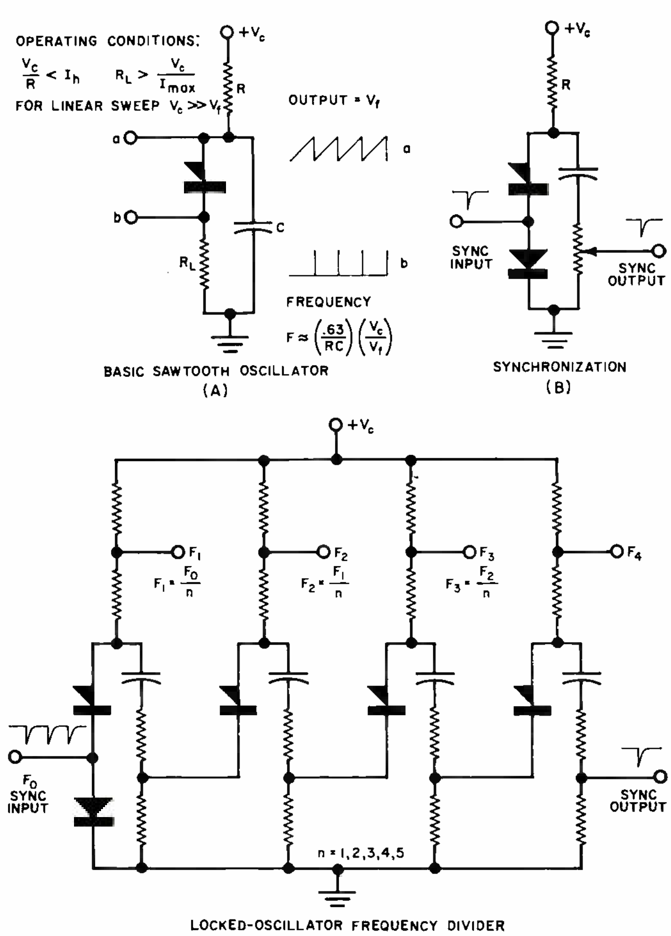


Fig. 4. Four-layer diode sawtooth generators, frequency dividers.

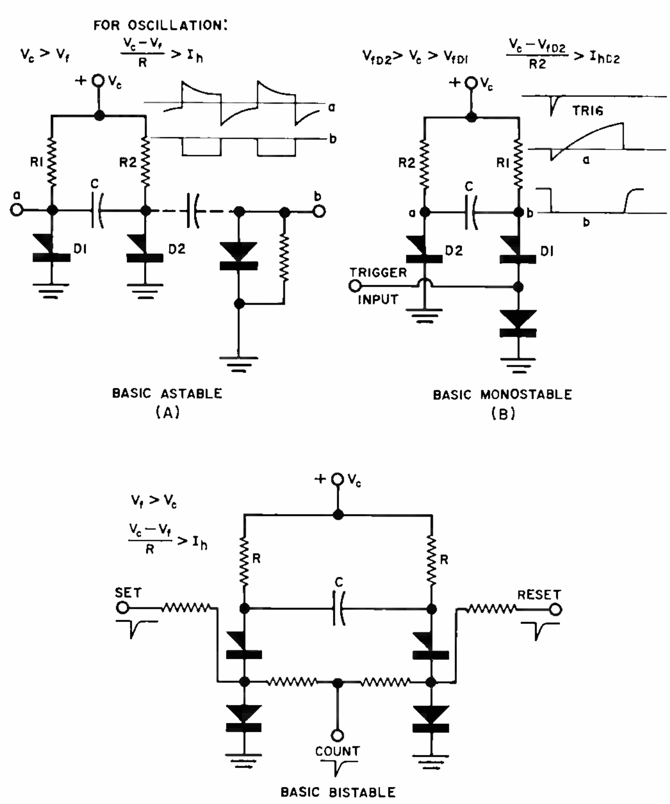


Fig. 5. "P-n-p-n" multivibrators. The astable circuit (A) leads to a family of square- and rectangular-wave generators, pulse generators, and oscillators. The monostable circuit (B) extends into time-delay circuits, ramp generators, delay networks, gated oscillators, sweeps, and pulse shapers. The bistable circuit (C) yields counters, frequency dividers, computer logic, gates, power inverters, shift registers, and memory circuits.

free-running frequency a bit below half the sync frequency.

By alternately dividing by five and then two, the same circuit can provide decade division with only two stages per decade. This is useful for clock and counting chains.

Multivibrators

Where the ultimate in speed is not a requirement, four-layer diodes make excellent astable, monostable, or bistable multivibrators. The present upper switching speed is around two megacycles. These circuits are all based upon the use of a commutating capacitor. The capacitor assumes a charge during one state of the multivibrator, and then uses this charge to turn off one diode as the other one is pulsed on.

Fig. 5 shows some multibrator possibilities. Fig. 5A is an astable (free-running) circuit. Assume the left diode (*D1*) has just turned on. This clamps the left end of commutating capacitor *C* at ground. *C* now starts charging toward V_c through *R2*. When the right end of *C* exceeds V_f of the right diode (*D2*), the right diode turns on. The charge on *C* cannot change in the brief turn-on time of the right diode, so the left end of *C* must swing negative by an amount equal to $-V_f$ as the right diode turns on.

This turns off the left diode. The circuit has just changed state, and now the cycle repeats in the opposite direction. An additional diode, a conventional one, may be used to clamp an output to ground to give a true square-wave output.

Various forms of monostable operation are possible, and generally make use of two diodes with different breakdown voltages, or of a circuit in which one side is provided holding current and the other is not. These circuits are useful for sweep generation, one-shot time delays, and pulse-delay networks. Fig. 5B shows one possible form of such a circuit.

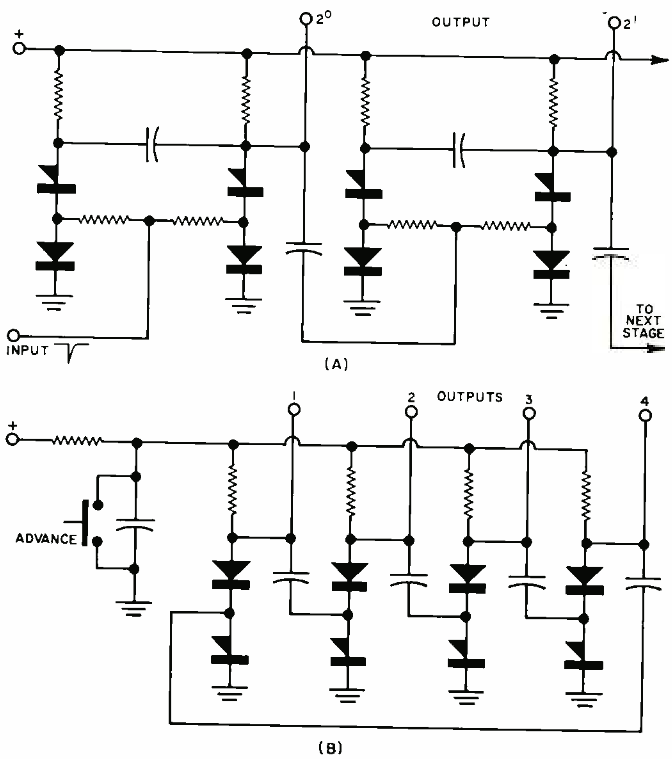


Fig. 6. (A) Binary and (B) ring counter cricuits using diodes.

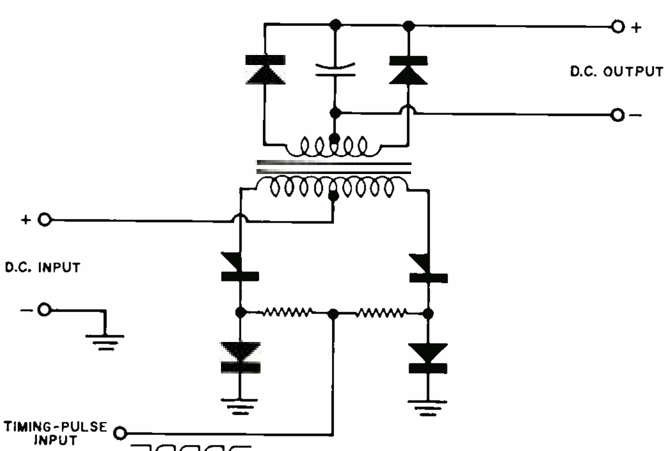


Fig. 7. Unlike circuits with transistors, this circuit can step voltages down as well as up. A 600-v. input could yield a 12-v. d.c. output. Power capability to over 1 kw. may be achieved. Circuit is essentially a power bistable. Transformer senses a.c. primary current and induces secondary voltage of desired step-up or step-down ratio. Rectifiers and filter convert this voltage to d.c. Circuit may be made self-oscillating by deriving trigger pulses from transformer itself. By omitting the rectifiers, circuit becomes a d.c. to a.c. inverter arrangement.

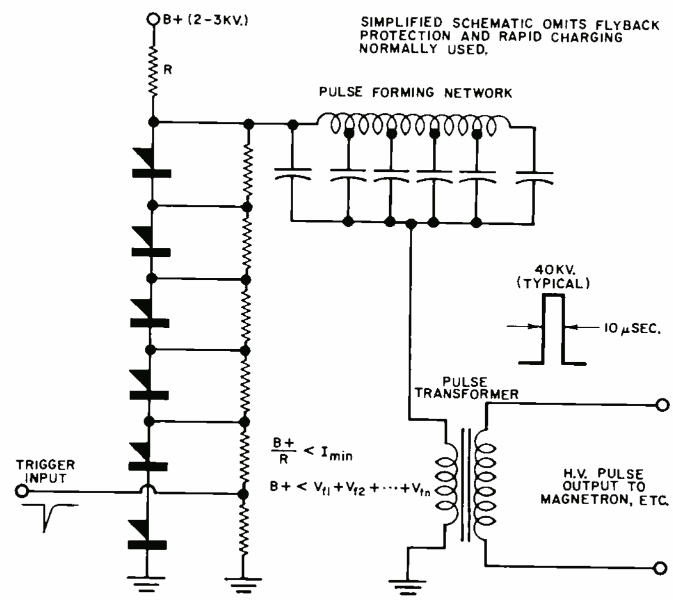


Fig. 8. Radar pulse modulator using string of 4-layer diodes.

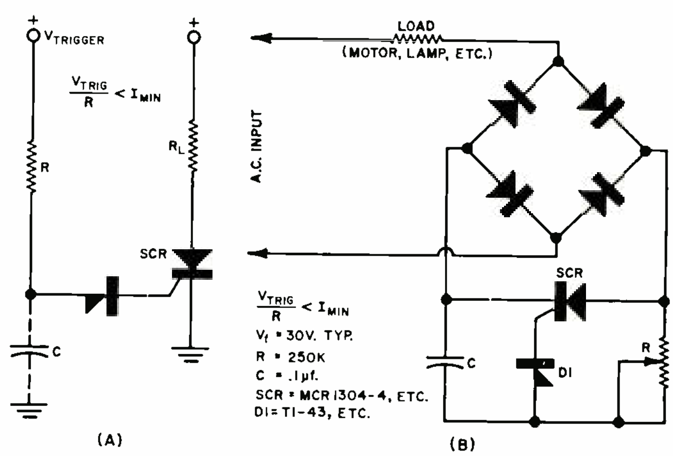


Fig. 9. (A) Addition of 4-layer diode to SCR results in accurate and stable trigger source. Low-power input signal will trigger SCR into conduction if trigger voltage exceeds V_f. As a voltage-level detector or threshold indicator, a very low-power signal can directly control kilowatts of power. An integrator is built by adding C, which is charged by the energy of the input signal. If V_c reaches V_f, the SCR is turned on. (B) A.c. power control used as a light dimmer or motor speed control. At the beginning of an a.c. half-cycle, the charge on C is zero. C then starts to charge through R. When V_c reaches V_f, the SCR turns on, discharges C, and remains on for the remainder of the half-cycle. The SCR then effectively completes the load circuit through the bridge rectifier, providing power for the load. The smaller R is, the faster C will charge, and the earlier the SCR will turn on in each half-cycle. This results in increasing power reaching the load.

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The bistable circuit of Fig. 5C consists of two four-layer diodes. Both are supplied sufficient holding current. Both have breakdown voltages in excess of V_c. The circuit is stable. The commutating capacitor (C) turns off the "on" diode whenever the "off" diode is pulsed on by a trigger pulse. In the diagram, "set" pulses will turn the left diode on, while "reset" pulses will turn the right diode on. By pulsing the diodes simultaneously with a short pulse, the bistable will count, alternating states for every successive input pulse. The circuit is self-steering, as long as the trigger pulses are short compared to the *RC* time constant of the commutating circuit that is employed.

It is possible to cascade binaries to count or divide by 2, 4, 8, 16, etc. or, by the addition of feedback, a binary chain may count to any whole number and then reset. Fig. 6A is such a circuit. The ring counter of Fig. 6B uses a different prin-

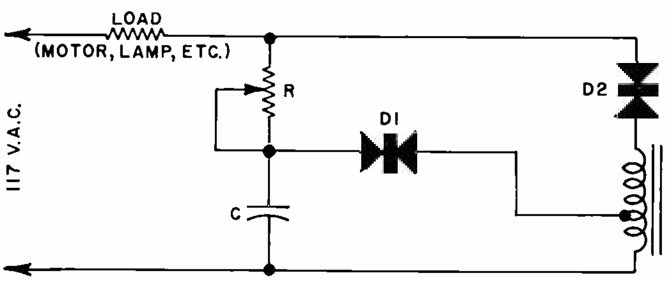

Fig. 10. A light dimmer and power-tool control using 5-layer diodes. No bridge rectifiers or special switching arrangements are needed for single-turn full-wave control. D1, R, and C produce a firing pulse, just as in the SCR circuit. This pulse is stepped up by the pulse transformer to trigger the main 5-layer diode D2. Average load power is determined by how early in each half-cycle D2 turns on. Power control up to around 5 kw. may be achieved using currently available diodes.

ciple for operation; a commutating capacitor routes diode turn-on always to the next sequential stage. Only the capacitor to the right of the "on" stage can charge .

To advance the circuit, the trigger capacitor on the input is momentarily shorted. This removes V_c from all the diodes, and all diodes turn off. The trigger capacitor then starts charging toward V_c, bringing the diodes up with it. The voltage on the diode immediately to the right of the one that was on has a "head start" toward firing due to the charge on the commutating capacitor. This diode then turns on, and the circuit has advanced one stage. Modifications of this technique allow add-subtract counting. Shift-register circuitry is somewhat similar to this arrangement.

Other Applications

Use of a power binary allows a d.c.-to-d.c. transformer circuit. Operation is identical to conventional transistor power converters, except that very high input voltages may be easily accommodated, unlike the 50-60 volt limitation of most transistorized converters. The diode can operate at a high frequency (100 kc.), minimizing the requirements for transformer iron and secondary filtering. Fig. 7 is a circuit of this type. Modifications allow the circuit to become self-oscillating, self-starting, and short-circuit proof. A kilowatt power handling ability may be realized, at efficiencies upwards of 90 percent.

Fig. 8 illustrates the use of four-layer diodes in a radar modulator circuit. This circuit provides the short, high-voltage pulses required by a magnetron or other microwave power tube. The small diodes here replace the less efficient thyratron or pulse tube normally used. Additional circuitry can provide short duty cycles and give flyback protection to the basic design.

An important application of small 30-volt four-layer diodes is as trigger devices for silicon controlled rectifiers in voltage-

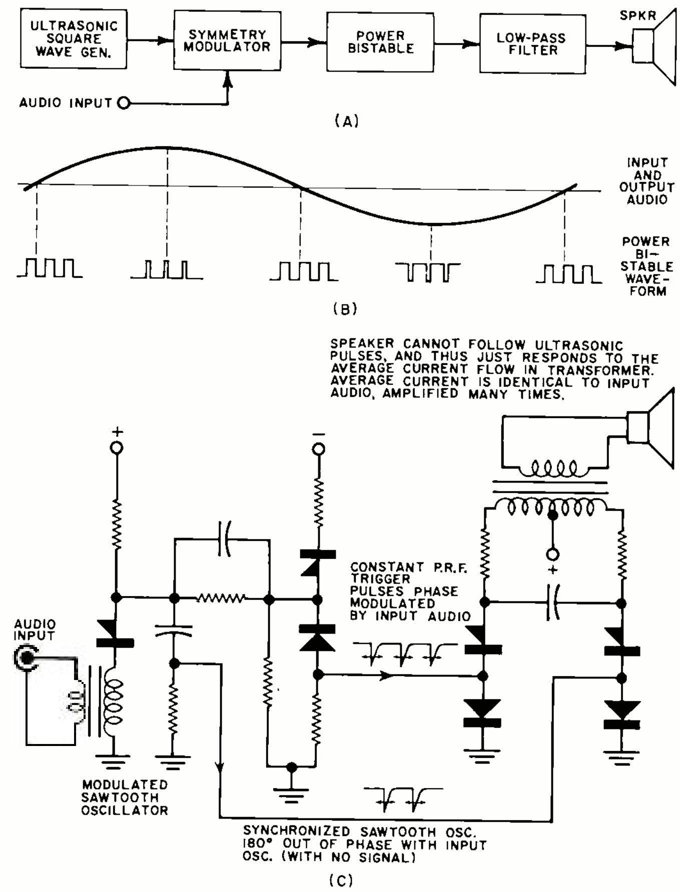

Fig. 11. A transistorless, tubeless audio amplifier which is capable of high gain and power outputs to about 1 kw.

level sensing, integrating, and phase-control applications. Fig. 9 details some of these circuit possibilities.

The SCR light dimmer/power-tool control shown in Fig. 9B requires the use of a bridge rectifier, two SCR's, or a fancy switching arrangement to allow full-range a.c. control. This is due to the unilateral control capability of the SCR. The circuit of Fig. 10 uses a five-layer bilateral diode to trigger a five-layer bilateral power diode. This circuit accomplishes the same function as the circuit of Fig. 9B using only five low cost parts. Dimmers and power-tool controls to 5 kw. of power may make use of this simple circuit.

It is possible to use four-layer diodes as extremely high powered audio amplifiers. Power capability up to 1 kw. of audio at very low distortion may be achieved. This is done by operating a power binary at an ultrasonic frequency, perhaps as high as 60 kc. Input audio is used to symmetry-modulate a 60-kc. oscillator which provides trigger pulses for the power bistable circuit. An output transformer senses the unbalanced current flow in the power bistable due to the asymmetry caused by the input audio. This current unbalance is directly proportional to the input audio, amplified many times.

Since all the diodes operate switching mode, very little heat is generated in any of the semiconductors and the circuit operates very much cooler than any linear amplifier would. A wide-band output transformer is required for this circuit. By direct coupling the input, a frequency response of d.c. to 15 kc. can be achieved using currently available diodes. This circuit is diagrammed in Fig. 11.

In this article we have discussed some of the fairly recent types of four- and five-layer semiconductor diodes. Some of the most important applications of these diodes have been described briefly. As time goes on and as more designers become aware of the uses of these diodes, we can expect to see their use increase considerably in a wide range of electronics equipment. ▲

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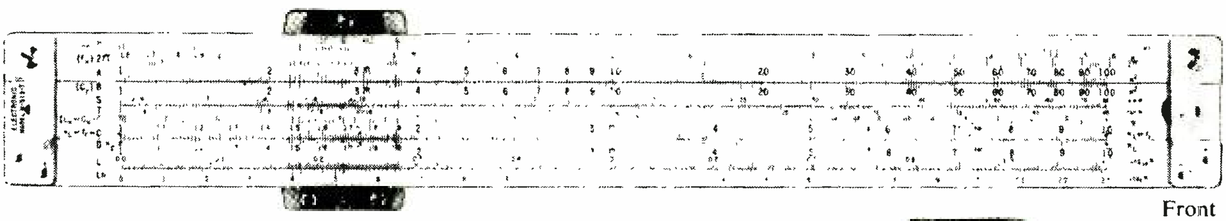

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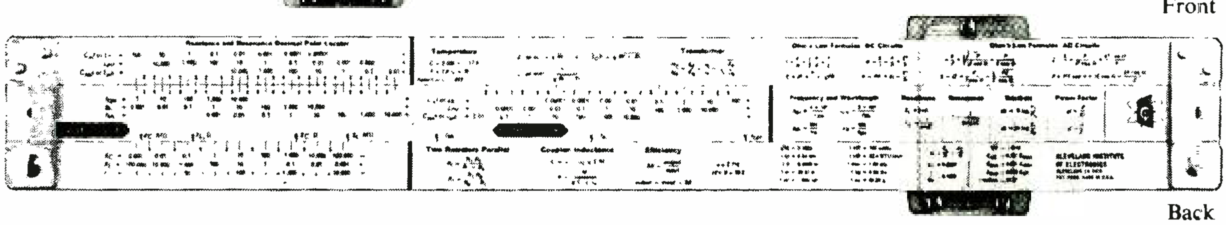

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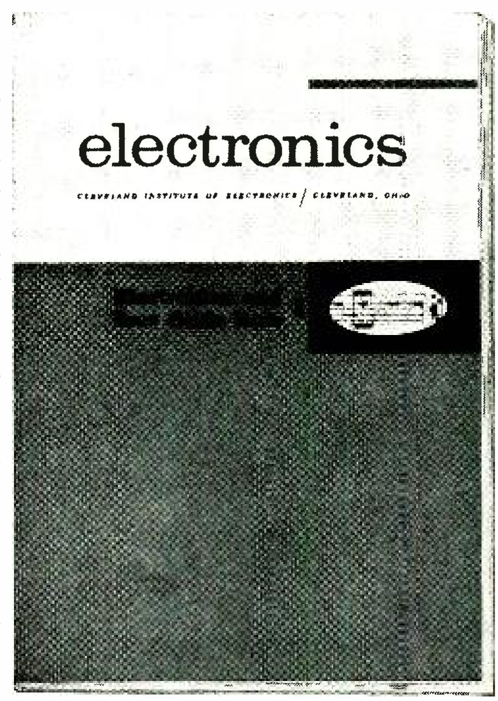

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There is a right way and a wrong way to recharge nickel cadmium batteries—as experience shows.

RECHARGING CADMIUM CELLS

AFTER a long, hot, humid summer, the advent of cool nights and crisp, sunny days was most welcome. The exhilarating weather put added spring into Barney's step as he whistled his way into the back room of Mac's Service Shop this jewel-like morning of late September. He found Mac, his employer, alternately studying some printed sheets and poking around with a stubby finger in the broken fragments of what looked like the remains of a beat-up flashlight battery.

"Top of the morning to you, Boss!" Barney said gaily, slipping into his shop coat. "What are you doing, trying to read the future of electronics in the B-leaves? Get it? Tea leaves and 'B' (for battery) 'leaves' or remains!"

"I get it, but I wish I didn't," Mac retorted, grimacing painfully at the terrible pun. "A thing like that so early in the morning could ruin a man's whole day. If you must know, I'm studying cause and effect. The broken pieces of this battery are the effect; these letters and spec sheets from the battery manufacturer outline the probable cause."

"Okay, okay! You can talk plainer than that. Give with the story."

"Well, these fragments are all that remain of one of two 6-volt rechargeable nickel cadmium batteries a friend of mine was using to power a transistorized transceiver. The batteries were self-contained in the strong high-impact-type plastic case of the transceiver, and connections from the two batteries hooked in series were brought to contacts on the outside of the case. When the batteries ran down, case and all could be placed in a charger overnight for recharging.

"A few weeks back the transceiver was lent to an acquaintance, who used the instrument until the batteries were so low it would no longer operate. Then the transceiver was returned, and the owner placed it in the charger atop a desk where he usually works and closed up his shop for the night.

"When he opened up the next morning, he was astonished to find that some time during the night one of the nickel cadmium batteries had exploded with terrific force. The explosion had blown the case and the printed circuit of the transceiver to bits. The charging unit was damaged, and small pieces of the case and battery were strewn all over the room. My friend thanked his lucky stars he had not been sitting at the desk when this happened, for very likely he would have been seriously injured. Luckily the transceiver was still in warranty and was replaced with a new one from the manufacturer. This satisfied my friend, who concluded the explosion was some sort of fluke that never would be repeated.

"I, however, wasn't satisfied. I kept wondering why the battery exploded and if the explosion could have been prevented. Finally I wrote the battery manufacturer and asked him for specification sheets on his batteries to see if I could get a clue as to why the battery exploded.

"Going through the literature I received, I found that two basic types of nickel cadmium cells were produced. Batteries intended to replace ordinary 'D' size dry cells had a nominal voltage of 1.25 volts and came in a wide current-capacity range from 600 milliampere/hours to 5.6 ampere/hours. It was stressed all batteries should be charged at a constant current rate, and each current-capacity cell had its own maximum and minimum charging current specifications. The maximum current rate could be safely applied to the batteries up to 48 hours continuously. Maximum charging currents varied from 70 to 560 ma., with the higher currents being used on the higher current-capacity cells.

"The restrictions on charging current were intended to keep gassing of the cells to a minimum, but each of the cells in this group was further provided with an automatic resealable pressure relief vent. This 'pop-off valve' opened automatically when pressure inside the cell became excessive and then closed when the pressure was relieved.

"The other basic 'button-type' of cell is much smaller so that these cells could be stacked to produce batteries of various voltages. Each cell had a nominal voltage of 1.2 volts, and they are manufactured in current ranges from 80 to 1750 ma./hours and are combined to produce batteries with voltages from 2 to 10 volts. Unlike their big brothers, these button cells are not equipped with pressure relief vents. The cells are termed 'non-gassing,' but I suspect this is a relative term. Quite likely it means that under normal usage not enough gas is liberated inside the small volume of the button cell to require venting, especially since maximum charging current for the largest cell of this type is only 150 ma.

"The maximum recommended charging current for the cell that exploded was 40 ma., and I wondered if possibly something might not have gone wrong with my friend's charger causing it to put out too much current. To double-check on this, I measured the current put out by the repaired charger into the new batteries. It was 37 ma.; so I scratched one perfectly good theory.

"Next my eye caught a short note in the technical literature. It said: 'To prevent possible cell reversals, the battery should not be discharged below .9 volt per cell.' Here was a lead! I wondered how low the voltage of the exploded battery had been when it was put on charge. I remembered that the battery voltage was low enough that the receiver portion of the transceiver would no longer operate; so I borrowed the replacement transceiver and put it on a variable voltage power supply. I had to drop the voltage to 7 volts to make the receiver stop operating. Since each one of the two batteries had 6 button cells in it, that meant the average cell voltage must have been below .6 volt when the transceiver was returned to the owner and placed on charge.

"Armed with this information, I wrote again to the battery manufacturer and gave him all the facts. I asked if he thought it possible one or more of the cells of the exploded battery might have suffered a polarity reversal because of being excessively discharged and that when an attempt was made to charge this reversed cell, a great deal of gas had been liberated inside the hermetically sealed cell, resulting in the explosion.

"He wrote back that it was not only possible; it was probable. He said replacement for 'D' type flashlight cells are expected to undergo considerable abuse, and that is one reason such cells are equipped with automatic relief vents to take care of excessive gassing likely to occur when these large-volume cells are overcharged or discharged at too rapid a rate. The tiny button cells, on the other hand, do not provide room for installing a reliable pressure relief vent. Furthermore, because of their limited volume and current ratings and because they are ordinarily used in services where their charging and discharging can be closely supervised, such vents are not deemed necessary. In most cases the build up of gas would not have been so catastrophic. All that would have happened would have been that the gas pressure would have broken the seal and permitted some of the potassium hydroxide electrolyte to leak out. In this instance, though, no relieving fissure occurred, and the pressure continued to build up until it let go with a bang. I've seen the same dangerous type of explosion happen when a mercury battery is foolishly tossed into a fire.

"Cell reversal can and does happen, however. It is much more likely to take place when the cell is rapidly discharged. For example, discharging a sealed 500 milliampere/hour battery at 2 amperes to 0 volts is more likely to cause a reversal problem than discharging the same battery at .030 ampere to the same voltage. Furthermore, *repeated overdischarge* should be avoided. While a cell reversal is unlikely to take place the first or second time the battery is overdischarged, repeated abuses of this nature are almost certain to damage the cells."

"What does the manufacturer suggest you do to avoid this trouble?"

"He says complete discharge of a nickel cadmium battery should be avoided. It's better to recharge the battery more frequently for shorter periods of time than it is to allow it to become completely discharged and then have to charge it for several hours. Shallow discharges will result in a much greater number of cycles over the useful life of of the battery. Even after shallow cycling it is safe to recharge the battery overnight at the maximum current rate."

Mac lapsed into silence with a faraway look on his face.

"What are you thinking, Boss?" Barney finally asked.

"I was just thinking the recent resurgence of batteries in our work leaves me a little cold. I had it with batteries a long time ago. When I got into this game, all radios were battery-powered. The 'A' battery usually consisted of standard dry cells to warm the filaments of the WD-11 tubes. The standard 45-volt 'B' battery for supplying plate voltage was about the size of a 'giant size' box of soap flakes and a heck of a lot heavier. A console receiver used two and sometimes three of these. On top of all that, we had to use a little tapped 'C' battery to supply bias voltages for the tubes.

"We got away from dry cells by going to storage batteries. A six-volt car battery and trickle charger took over the filament supply for the 01A's and 71A's. For a short while we even tried wet 'B' batteries, believe it or not. Such a battery consisted of a whole rack of test-tube sized cells. If you think a modern housewife gets mad when you scratch her TV set, you should have seen how one reacted to having battery acid spilled on her living room rug!

"With the advent of the two-volt-filament type '30 tubes, along came a battery with matching voltage called an 'air-cell.' I never did know too much about that one. And then *Zenith* provided a roof-mounted 'wind-charger' to keep up a storage battery in rural homes. Lots of us got our first taste of roof-climbing—useful later in TV work—installing and servicing that miniature windmill. Believe me, I was very happy when all-a.c. models began coming on the market and we got away from the danged batteries. Now a service technician has to start learning about batteries all over again. Things certainly do go in cycles in this game. Early radios used batteries, crystal detectors, and loop antennas. Modern radios use batteries, crystal detectors, and loop antennas."

"That kind of reminds me of a joke I read," Barney interrupted, grinning. "A reporter was urging an old man to admit he had seen a lot of progress in his lifetime. 'Oh I dunno,' the old fellow said; 'when I was born there weren't any interurbans, and they aren't any today. Is that progress?' Do you suppose the interurbans will come back, too, Mac?"

"I'd not be a bit surprised!" Mac admitted with a chuckle. "That story makes up a little for the horrible pun you perpetrated earlier. Now let's get to work." ▲

"But if I use a 10k resistor in the pi network filter, then I'll have to use a .02-μf. capacitor to keep the time constant the same."

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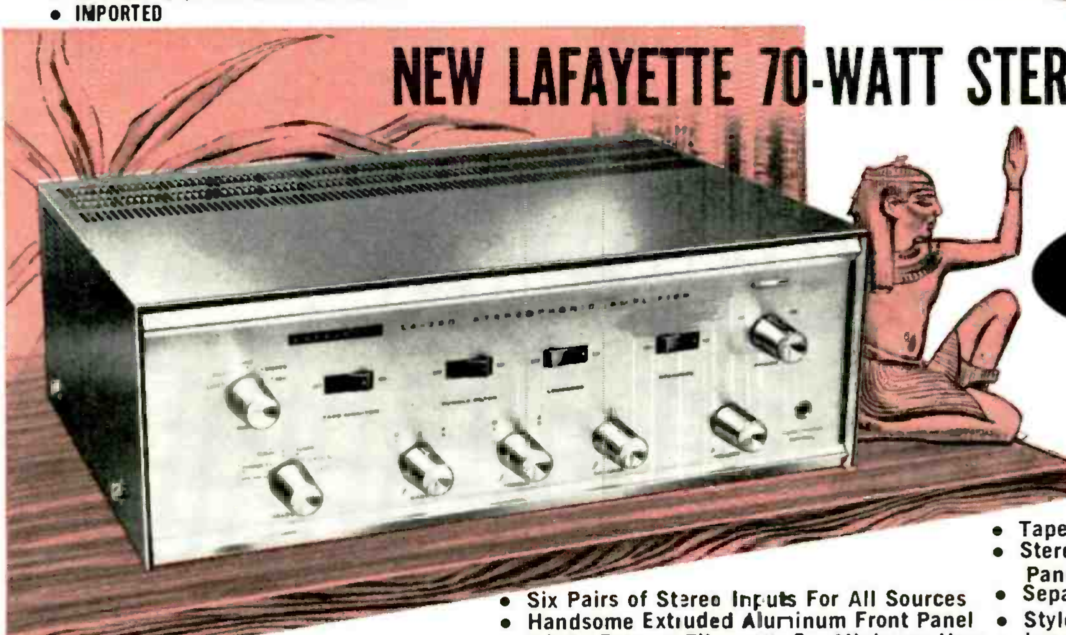

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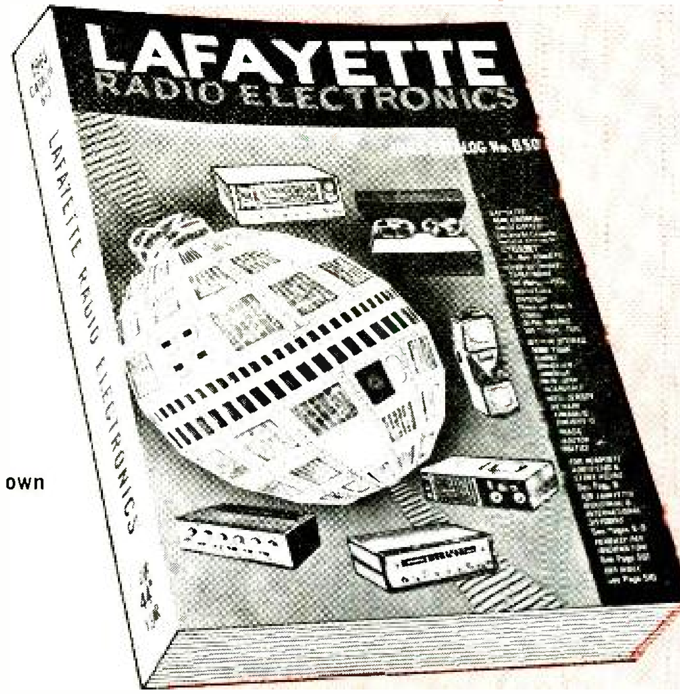

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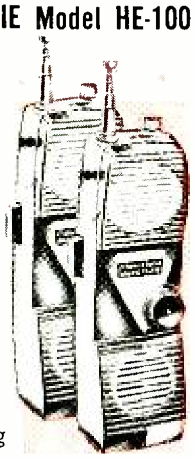

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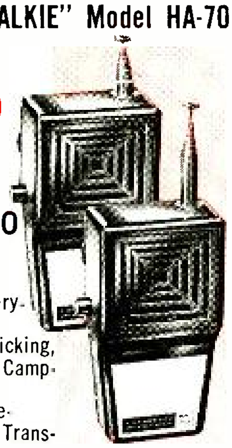

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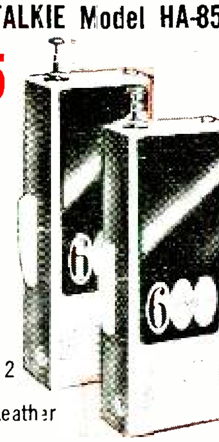

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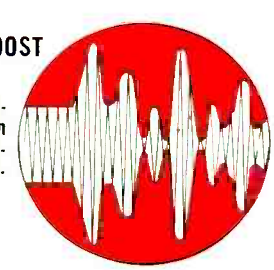

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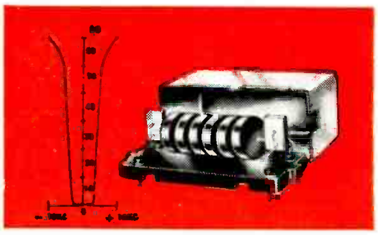

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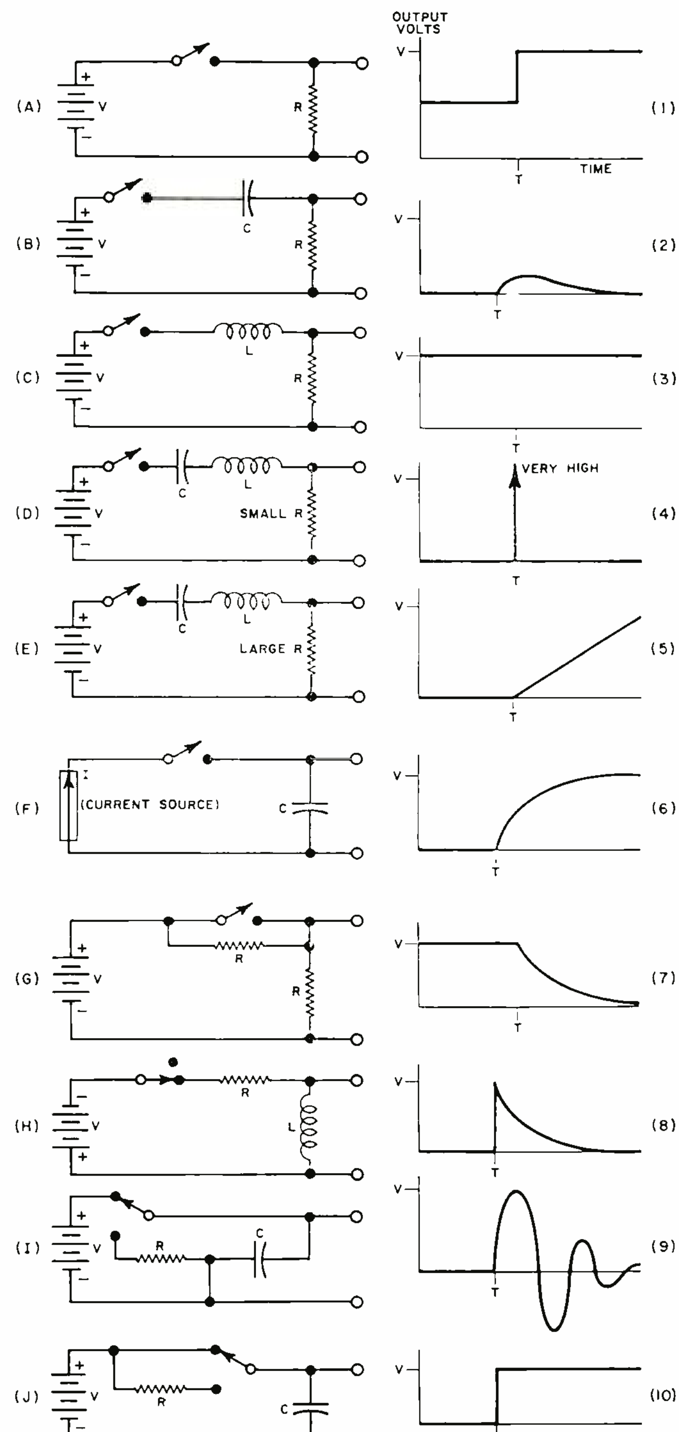
CIRCLE NO. 194 ON READER SERVICE PAGE

TRANSIENTS QUIZ

By DON LANCASTER

SUDDEN changes in an electrical or electronic circuit can be either useful or destructive. These electrical transients may be used for useful waveform generation, or may be the very ones that damage costly circuit components. In each of the circuits below, the switch is changed *from* the position shown to the other position at time *T*. Test your transients knowledge. See if you can match the circuit with the right output voltage transient waveform in the ten circuits below. Assume that the circuit has not been disturbed for a long time before time *T*. (*Answers on page* 118)



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CITIZENS RADIO RULES TIGHTENED

Hobby-type operation of class D stations is expected to be curtailed by stricter interpretation of rules.

EFFECTIVE November 1, the FCC has tightened up the rules governing class D Citizens Band operation. Certain changes have been made to clarify the permissible and prohibited communications and uses of Citizens Radio stations.

The Commission has re-emphasized the fact that CB must not be used for hobby-type operation. Operating the radio station as an activity in and of itself is definitely prohibited. The Commission noted that there has been so much hobby-type operation on the band as to seriously impair the original purpose for which the service was set up. There has been a warning that if there is continued misuse of operating privileges, there is a chance that the service will be discontinued altogether.

Significant Provisions

Some of the significant provisions of the amended rules are:

1. The primary purpose of the class D Citizens authorization as a means of communication between units of a single licensee is emphasized.

2. Communication between units of different class D stations (interstation) is permitted only under certain stated conditions and is restricted to seven designated frequencies (channels 9, 10, 11, 12, 13, 14, and 23).

3. All interstation communications are limited to no more than 5 consecutive minutes with a silent period of at least 5 minutes before another transmission is permitted.

4. Call-sign identification shall be made on each frequency used and it shall include the station being called.

5. All users of Citizens Radio equipment are required to obtain their own licenses and operate under their own call signs.

6. Communications for such organizations as civil defense agencies, volunteer fire departments, and auxiliary police should be conducted under a single station license issued to the organization rather than under licenses issued to individual members of such organizations.

7. The practice of licensees "loaning" their call signs to other persons in order that the latter may operate equipment while awaiting action on their own license applications is prohibited.

8. A new section has been adopted in the rules which spells out various prohibited uses. Some of them are:

(*a*) Activities in violation of law.

(*b*) Carrying communications for hire.

(*c*) Communications containing obscene, indecent or profane words, language, or meaning.

(*d*) Communications in the nature of a broadcast or those not directed to specific persons.

(*e*) Malicious interference.

(*f*) Transmission of music, whistling, sound effects, etc.

(*g*) Communications to stations of other licensees relating to technical performance, capabilities, testing of any transmitter, including transmission concerning signal strength or frequency stability of transmitters.

(*h*) Communications advertising or soliciting the sale of goods or services.

(*i*) Communications to another station over a distance of more than 150 miles. (This new limit is far beyond the ground-wave communications range under normal conditions. Normally the ground-wave range would not exceed 25 miles.)

(*j*) Persons engaged in selling Citizens Radio apparatus shall not allow customers to operate under the seller's station license.

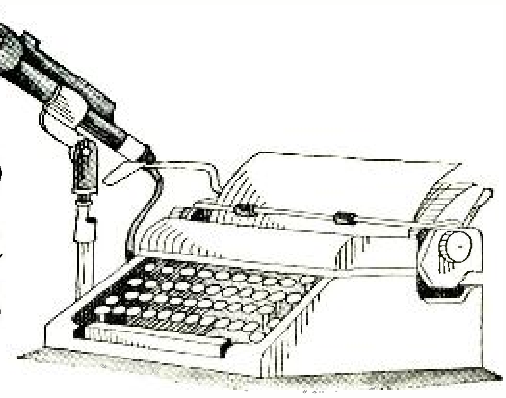
9. An individual whose own radio station license has been revoked or cancelled is prohibited from operating another licensee's station of the same class until he is again issued a license of that class by the Commission.

Availability of Rules

Because there are now approximately 700,000 Citizens Radio stations, the FCC is not able to furnish copies of the revised rules to meet requests of individual licensees. However, all Citizens licensees are now being required to maintain a current copy of Part 95 (formerly Part 19) of the rules covering this service. Hence, the subscription method afforded by the Government Printing Office entitles subscribers to receive a copy of these and subsequent Citizens Radio rules changes as soon as they are issued.

Meanwhile, the text of the new rules will be published in an early issue of the Federal Register, which may be purchased from the Government Printing Office, Washington, D. C. 20402. The Commission will supply a copy of the text to organizations representing Citizens licensees, and reference copies may be consulted at the Commission's Washington offices. ▲

RADIO & TV NEWS



At just about any time you desire, you can walk into a telegraph office and order a telegram by number. For example: number 6 may represent a 10- to 20-word singing-birthday telegram. The clerk has this number, together with the address of the recipient, transmitted to the telegraph office nearest the recipient. At the remote end, the clerk converts the number back into words. In this way it is possible to transmit a considerable number of words, interconnected in different messages, using only a few simple numbers.

This method of coding messages is now being used by *ITT* in their latest military digital encoder/decoder in which 100 different messages are stored, each with a simple numerical identification. A soldier using the device will simply push the appropriate button for the message he desires, and another button for identification. At the remote station, the message will be written out and delivered.

The device also provides a degree of security since only another digital decoder and a code book can be used to receive and decode messages.

It is hoped that this system will come in handy when military commanders using different languages wish to communicate, as messages can be read in or out in any desired tongue.

Tiny Rescue Beacon

An emergency, continent-spanning radio transmitter that uses body heat for frequency control was recently demonstrated by *RCA*.

This tiny shirt-pocket unit weighs 10 ounces including battery, and uses an antenna that tips the scales at one ounce. The crystal-controlled unit has an output of 100 mw. at any frequency between 2 and 30 mc., although it is capable of operating at multiple frequencies simultaneously.

Success of this long-range, low-power transmission concept is based on the fact that if receiver bandwidth is reduced to one-half on a given transmission path, the required transmitter power can be halved and consequently a much lower powered transmitter can be used. In operation, the system uses the stable high-frequency skywave medium and a special modulation technique to transmit three bits of information per minute. Combinations of the three-bit code is used to build up messages.

To maintain the tight frequency control that permits the use of a very narrow bandwidth receiver, the user places a miniature metal container containing frequency determining elements (and linked to the transmitter) under his upper arm where a high degree of temperature stability exists.

Really Low Light Level Camera

During the past several years, there has been a trend in TV camera design to make cameras that will operate at very low light levels. Among other things, it will make it easier to televise football games during the gradually darkening late afternoon hours of fall, as well as greatly reducing the amount of light required in TV studios.

The sensitivity of such cameras has been improving steadily with the years. Recently, *RCA's Astro-Electronic Div.* came up with a camera for use in space research that will be used to detect gaseous clouds having a luminosity of only .0000005 footcandle—less than one millionth of the brightness of a normally lighted room.

For possible compatibility with the Tiros ground stations, the system uses 500 scanning lines with a frame rate of 2 seconds, and has a video bandwidth of 65 kc.

This camera will also be used in an attempt to observe the zodiacal light which is assumed to have the same magnitude of luminosity believed to be found in the faint gaseous regions.

Lightweight Cable

Engineers at *ITT* have come up with a lightweight voice communication cable for use in rugged terrain and eroding climates that weighs in at less than 25 pounds per mile. When rolled out, the cable will be relatively immune to the adverse conditions usually affecting electronic materials in high humidity, temperature, and excessive rainfall of mountainous and jungle environments. ▲

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Dealers have long found that SILVER SCREEN® 85 picture tubes move off the shelves fast. Why? One big reason is the tube's precision-engineered features. Another is that through the years these same features have created the guaranteed acceptance of a *name*—SILVER SCREEN 85. ▪ In picture tubes no brand name approaches the assured recognition of SILVER SCREEN 85 tubes. To your customers, the name means built-in quality and long life dependability. To you, SILVER SCREEN 85 picture tubes mean sales, profits, fewer callbacks, better satisfied customers. ▪ Sylvania values that acceptance and safeguards it by applying every new research and development technique for product improvement. That's why the newest SILVER SCREEN 85 picture tubes have longer life and greater product uniformity. ▪ Stay with the *quality* name in TV picture tubes—SILVER SCREEN 85. See your Sylvania Distributor.

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NEW CAPABILITIES IN: ELECTRONIC TUBES • SEMICONDUCTORS • MICROWAVE DEVICES • SPECIAL COMPONENTS • DISPLAY DEVICES

V.T.V.M. Readings

(*Continued from page* 53)

input impedance of the v.t.v.m. slightly. The voltage dividers provide a discharge path for the capacitors. When voltages above 150 are to be measured the voltage divider made up of *R*1, *R*2, and *R*3 is used. Capacitor *C*3 effectively parallels this voltage divider. If this capacitor becomes "leaky," the voltage divider ratio is changed and a smaller signal is sent to the second voltage divider and to the bridge. The result is a low reading. Although *C*2 is not as critical as *C*3, it is probably best to replace both capacitors. Although insulation resistance is of primary importance, there is merit in using replacement capacitors that have low dielectric absorption as well. In this case, the time to reach full reading and the time to return to zero will both be reduced—the same reasons apply as in the case of *C*1. Again, the capacitor to use is a hermetically sealed (glass- or ceramic-to-metal) type.

Dielectric absorption is a measurable phenomenon and is often stated as the percentage voltage recovery measured with an electrometer after a charged capacitor has been short-circuited for a specified time. Since test techniques vary, the results obtained by one method cannot be exactly compared with those obtained by another. Some procedures call for charging to rated voltage, and others to a lower voltage such as 100 volts. Short-circuit time may vary from 5 to 10 seconds and a small resistor may be specified when short-circuiting from a high voltage—or for a large capacitor.

Actual tests have shown that apparently good oil-impregnated, wax-sealed, paper-tubular capacitors may have a dielectric absorption as large as 15% which easily explains why the v.t.v.m. would not return to zero when such units are used for *C*1 of Fig. 1. In contrast, a random selection of hermetically sealed (glass- or ceramic-to-metal) capacitors showed dielectric absorption less than 1%. Generally speaking, the oil-filled types showed lower dielectric absorption than the wax-filled types. Plastic-case capacitors can only be expected to be marginally better than the wax-sealed, paper-tube units as the plastic case only delays absorption of water—and does not entirely prevent the absorption. It appears that the absorption of small amounts of water in the dielectric can cause a large increase in dielectric absorption. It is interesting to note that such absorption of water in the dielectric may not seriously affect the insulation resistance. This is probably true only when the dielectric is absolutely free of metallic salts.

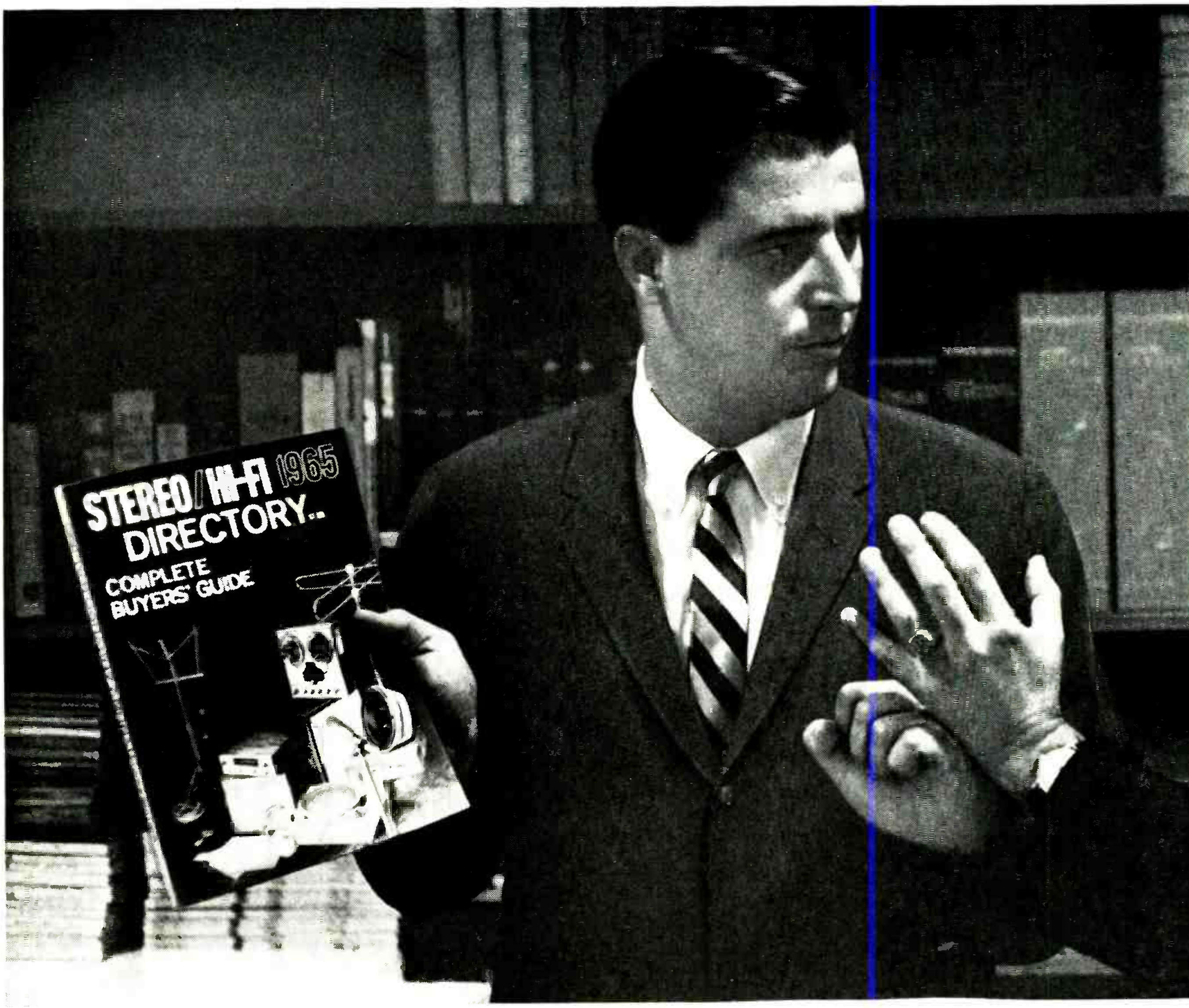
Capacitor manufacturers generally do not rate capacitors on dielectric absorption; in any event such ratings would be meaningless for all except truly hermetically sealed units. The best capacitor from the standpoint of dielectric absorption is one with polystyrene dielectric. These capacitors, which are often used as the zero reference for dielectric absorption, may have a measured factor as low as .02%.

Capacitors can be divided into three groups. Those having the lowest dielectric absorption (in the range of .02% to .1%) have polystyrene, Mylar, Teflon, or polystyrene-Mylar composite dielectric films without impregnant. A second group ranging between about .3% and 1% would be those having a solid dielectric of paper or Mylar or combinations thereof and a filling or impregnation of a natural or synthetic oil. Again, generally speaking, those having solid impregnants would constitute a third group with dielectric absorption ranging from a low of about .8% upwards to several percent.

Measuring Absorption

For those who wish to measure dielectric absorption, a v.t.v.m. may be used as an electrometer. The procedure is to charge the capacitor with a small known voltage, then short circuit it for a moment. The remaining voltage can be measured with an ohmmeter after removing the internal battery. The ohmmeter input is then used as the positive input. This eliminates the voltage divider and the input is directly to the grid of the tube. The time constant of the v.t.v.m. as an electrometer will depend on the grid current drawn by the tube and the total capacitance in the circuit. The writer's v.t.v.m. (an *RCA* WV-97A), has an input capacitance of about 3300 pf., and a grid current of about 10^{-11} ampere. The meter takes about one minute to drift to full scale when the leads are open-circuited. Without further modification of the v.t.v.m., the range is limited to the lowest range of the unit (in the writer's case this is 1.5 volts) which can be adjusted exactly with the "Ohms Adjust" knob. In use, the test leads must be kept shorted except when making a reading, and readings must be made on a momentary contact to avoid charging the capacitor with grid current. In making tests of dielectric absorption with an electrometer having a limited range, it will be necessary to limit initial capacitor charging voltage so that the residual or recovery voltage does not exceed the electrometer range.

The capacitor applications discussed above call for much better capacitors than are required for most bypass or filter tasks. In fact, the insulation resistance required for capacitors *C*2 and *C*3 is higher than that required for many grid coupling capacitors. ▲



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EW104

Optical Scanners

(Continued from page 37)

Other machines hold the document still and supply the vertical movement with a rotating or oscillating mirror. Some devices eliminate the mechanical arrangement altogether and substitute a flying-spot scanner in which the raster is produced electronically (Fig. 10).

In a recently announced *RCA* system, the image is projected onto the face of a vidicon tube and transformed into a video signal by standard TV techniques. In practical machines, the choices are usually determined by desired speed, economy, patent position, and other factors.

One of the most interesting variations of recognition logic is found in a *Sylvania* machine. During scanning, each character, regardless of size, is electronically expanded to fit precisely with a 320-element matrix. This eliminates character size and misalignment problems. The machine has sufficient recognition logic to identify some 2000 different characters—enough for about 20 complete upper and lower case alphabets and symbols.

An experimental *IBM* machine demonstrated in 1962 contained two unusual features. First, it used a coarse scan to determine line position and character size, then a fine scan for actual reading. And second, its logic circuits are programmed to learn to identify new type faces automatically. When a type face the machine has not seen before is fed in, along with an identification of each character, the device automatically analyzes the characters to determine which characteristics of each are important in identification, and which important in avoiding confusion between similar characters. Then, having "taught" itself a new type face and stored the recognition criteria in its memory, it can start to work at once reading the new type.

All current operational reading machines read printed and typewritten characters. But many experiments designed to lay the groundwork for handwriting reading are underway. Leon Harmon of *Bell Telephone Laboratories* has studied several possible approaches, both by building working prototypes and by computer simulation. One of his approaches, for example, involves the use of a captive stylus. As an operator writes on a sheet of paper, two arms attached to the stylus sense its movements. The movements are fed to a logic circuit which analyzes them and attempts to tell, by noting the number and sequence of loops, points, dots, crossings, and other features, the characters that have been written. While a device requiring the use of a captive stylus would have limited usefulness, it would be applicable in certain situations, such as telephone operators noting records of long-distance calls.

A more general approach has been demonstrated with a working prototype machine at *Rabinow Engineering*. Signals developed by sweeping a handwritten number across a row of photocells are computer-analyzed to determine the number's characteristics. If, for example, the logic circuits detect the beginnings of three lines, one above the other, then a split in which the middle line becomes two lines, then these two lines joining the top and bottom lines, the character is identified as a three. Similar characteristics are identified for each of the other numbers. The machine can accurately identify carefully written numerals. Its tolerance for writing variations is fairly large, but it has not yet been determined what percentage of non-specially prepared documents it might be able to read.

Another interesting experimental handwriting reader has been demonstrated by *IBM*. A flying-spot scanner makes use of an unusual moving circular pattern to follow the edges of characters to be recognized. A computer analyzes the characteristics of the numbers and determines their identity.

Although many engineering problems remain, one large-scale test seemed to prove the feasibility of the approach. In September, 1962, 100 students at Tufts College were given 30 minutes of instructions, then put to work writing numbers. Of more than 56,000 numbers written and fed to the machine, it misread or rejected only 120—about one out of 500.

Reading numerals, of course, is far simpler than reading letters. Not only are there fewer numbers, but each one is separate. Letters run together in words. The problem is further complicated by the fact that some people print—and thus separate all letters—while others connect some, put breaks between others within the same word.

While machines capable of reading handwriting are still some distance in the future, those able to read printed and typewritten documents are already at work in many places, and will soon be in operation in hundreds of others.

Says Jacob Rabinow, president of *Rabinow Engineering*: "Every input to computers is eventually going to be on paper. Not punchcards, not tape. Typed paper. Paper is cheap, easy to correct. Everybody has and uses typewriters. Throughout business, we start with information written on pieces of paper so that people can read it. Then we punch it on cards or perform some other extra step so the computer can read it, too. Why not skip the extra step? Fast, accurate, relatively inexpensive optical readers will soon break the last bottleneck and make possible truly automated paper work." ▲

ELECTRONIC CROSSWORDS

By JAMES R. KIMSEY

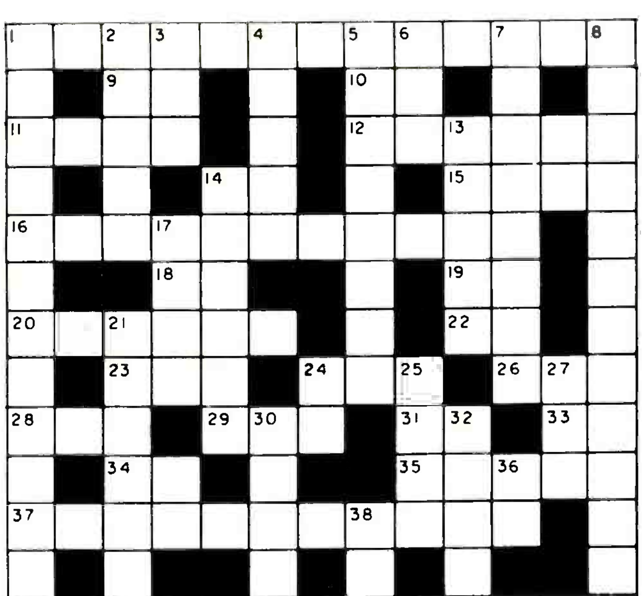
(*Answer on page* 118)

ACROSS

1. The voltage, many times higher than the impressed voltage, produced by the collapsing field in a coil when the current through it is abruptly cut off.
9. Be.
10. Wielder of the blue pencil (colloq.).
11. A radar navigation system of two ground stations which measure the distance to an airborne transponder beacon and relay this information to the aircraft.
12. Conductor connecting antenna to the receiver or transmitter.
14. Specific band modulation (abbr.).
15. Ceremonial act.
16. The polygraph.
18. ___ compensation: a control device that compensates for voltage drop due to current flow.
19. Myself.
20. Recurrent.
22. Type of current (abbr.).
23. Malt beverage.
24. Organ of sight.
26. Junction of component leads.
28. Hot line color.
29. Celestial body.
31. In like manner.
33. Switch position.
34. Amplification factor.
35. Solid non-metallic mineral.
37. A combination of electrical components which prevent extraneous signals from passing into or through an electronic circuit.
39. That property of a color TV system which permits typical, unaltered monochrome sets to receive substantially normal monochrome from the transmitted signal.

DOWN

1. Having the same number of electrons outside the nucleus of the atom.
2. A two-terminal device which will conduct electricity more easily in one direction than in the other.
3. Employ.
4. The progressive rotation of the cross-section of a wave guide about the longitudinal axis.
5. Rate of motion in a given direction.
6. Dutch commune.
7. "_____ wave," also called a sky wave.
8. Energy which a system possesses by virtue of its motion.
13. Pleasant odor.
14. The connection of components end to end in a circuit, to provide a single path for the current.
17. Aromatic seeds used to flavor pickles.
21. A metallic element widely used for plating chassis to improve its appearance and for solderability and to prevent corrosion. Also used in photocells.
24. Printer's measure.
25. Direction.
27. An electrically charged atom.
30. Not worthy.
32. Tough iron alloy.
36. Either.
38. Research building.



Measuring "Sonic Boom"

(*Continued from page* 60)

overpressure. Fig. 4 shows in block diagram form the hookup for response measurements.

Synchronization

All data recorded is synchronized on the recorder as each of the recording oscillographs contains an "interrupter" circuit which establishes a timing track on the photosensitive paper record. These are not necessarily synchronized to each other, however, so the timing tracks in themselves do not supply the answer.

But at test control headquarters, Room 305 of the FAA's Aeronautical Center administration building southwest of Oklahoma City, a telephone line provides round-the-clock hookup between each of the three test sites and the test supervisors. Just prior to each flight pass, an ordinary microphone calibrator (taped to the mouthpiece of an extension phone) is turned on briefly. Its 400-cps tone is recorded on the timing track, and the first half-cycle of this tone provides a synchronized time reference for all recorders. Stability of the internal interrupters is adequate to maintain synchronism throughout the pass.

In addition to the test sites already described, a mobile unit is used for pressure tests only. It operates from a different location at each pass and its equipment is just for such pressure tests. The mobile unit is tied into the communications network by two-way radio, and the influence of CB radio makes itself felt in a label affixed to the microphone of the mobile two-way radio in test control headquarters: "10-4 is the word."

At each test site, all equipment is interlocked in such a manner that pressing a single button starts everything rolling. This reduces the need for technicians to move about during a test—and in the early stages at least, human movement in the house caused more structural response than did the booms. As indications of system sensitivity, the instrumentation engineers report that they are able to tell whether a slight breeze exists—and if there is a breeze, they know from what direction is it blowing—all from their instruments. Similarly, if a technician walks through the house, his location can be pinpointed at any instant. During a flight pass, the technicians must hold their breaths.

Checking the Calibration

Described thus far has been the complete instrumentation system. However, an almost equally elaborate system is used to double-check the calibration. Thermocouples are spotted near each of the instrumentation transducers and their outputs go to separate recorders; this is to allow correction of the record for temperature effects. Each instrument is calibrated every morning. This means that the technician's day begins at 5:30 a.m. although the first flight pass does not occur until 7:00 a.m.

The calibration boxes are virtually the only items of custom equipment in the entire installation. They provide standard sources of voltage, current, resistance, and pressure for each of the transducers, as well as switchable terminations for both transducers and other instruments. Each such box was built at Langley Field and individually calibrated to its matching transducers and oscillographs prior to the test.

Output of all this equipment is a photopaper trace representing the variables being measured. These reels of oscillograph records are then reduced to meaningful data by FAA engineers.

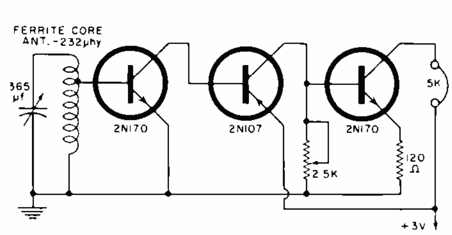
The recording oscillograph, which produces the readout record, is similar to a galvanometer or zero-center microammeter, except that a tiny mirror replaces the needle. Input signal is applied to the coil of the movement. A beam of light is focused on the mirror, from which it reflects to the photopaper; as the coil swings the mirror, the light beam moves on the paper. The paper itself is in motion at a constant rate of speed, similar to that in a direct-writing pen recorder, and the result is a photographic record of the signals applied to the coil.

In these tests, two types of galvanometers are used. In the pressure-measuring instrument chain, frequencies up through 2 kc. must be preserved to accurately reproduce the steep wavefront. For this, a fluid-damped-movement instrument is necessary. For other measurements, frequencies higher than 500 cps are unnecessary, so the simpler, electrically damped instruments are adequate.

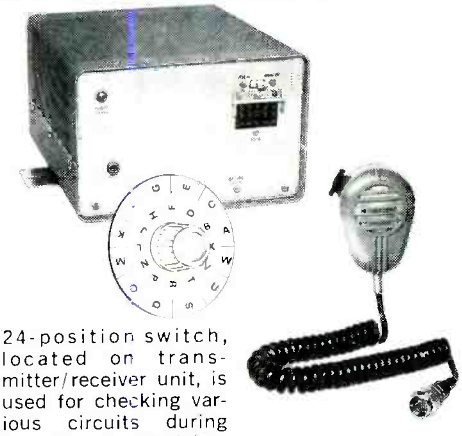
In either case, the output of the recording oscillograph is a roll of exposed photopaper which is then developed into a permanent record. For study purposes, photocopies are made from these primary records. ▲

SIMPLE RADIO

USING a minimum of parts, the three transistor radio shown in the diagram has been suggested by G-E to provide the maximum results for a minimum of parts. Using 3 volts and a 5000-ohm earpiece, the radio can be built into a very small package. ▲



Remote Console



24-position switch, located on transmitter/receiver unit, is used for checking various circuits during tune-up or servicing.

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This "years ahead" built-in test feature has been incorporated into International's two new transceivers. The 750-HB2 with its functionally designed remote console* for desk-top installation, and the 750-HM2 for mobile communication. Both transceivers have 23 crystal controlled channels, and operate on 115 vac, 12 vdc, and 6 vdc.

NEW Built-in test circuits. **NEW** Delayed/Expanded AVC. **NEW** Simplified cabling. **NEW** Built-in S/Meter and Transmit/Meter as standard equipment. **NEW** Microphone with improved characteristics for better "close talk" quality. **NEW** Speech Clipper/Filter Amplifier.

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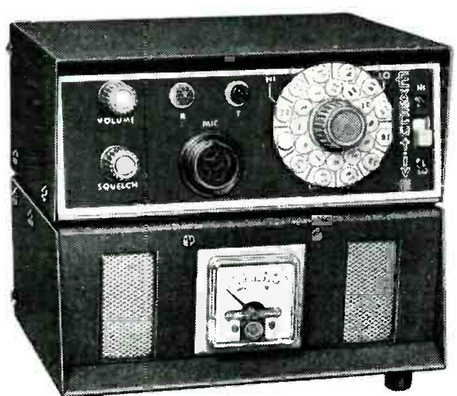


Remote Console and Speaker Console. Two units may be "stacked" or installed separately.

24-position switch, located on transmitter/receiver unit, is used for checking various circuits during tune-up or servicing.

New CB Circuits

(*Continued from page 55*)

of the schematic (*L*1 through *L*4). These coils are interesting in that they excite the reeds into motion with a method significantly different from conventional designs. (In the usual reed relay, audio or a transient is fed to the reed relay's own coil.) The *Cadre* system uses unique reed-exciting coils to pull the reeds down slightly from their rest position. Among other advantages, no separate audio oscillator circuitry is needed to generate accurate tones. Instead, the reeds are magnetically "plucked" to attain their implicit frequency precision.

In our example, coil *L*4 is driven at this moment by "B+" from encoding switch *S*1. The coil pulls down its corresponding reed (4), near the center of the schematic. Coil energy, however, is of short duration: derived from a stored charge on capacitor *C*1. The effect is to momentarily pull, then release, the reed which is then free to vibrate in tuning-fork fashion at the desired audio rate. Two other selected reeds are set into motion, in turn, as the *S*1 wiper sweeps across other contacts of the encoding switch. Reed vibrations set up corresponding sine-wave energy in the reed-relay coil, *RL*2, and the tones couple into the CB transceiver *via* matching transformer *T*1. Tone modulation of the transmitter occurs.

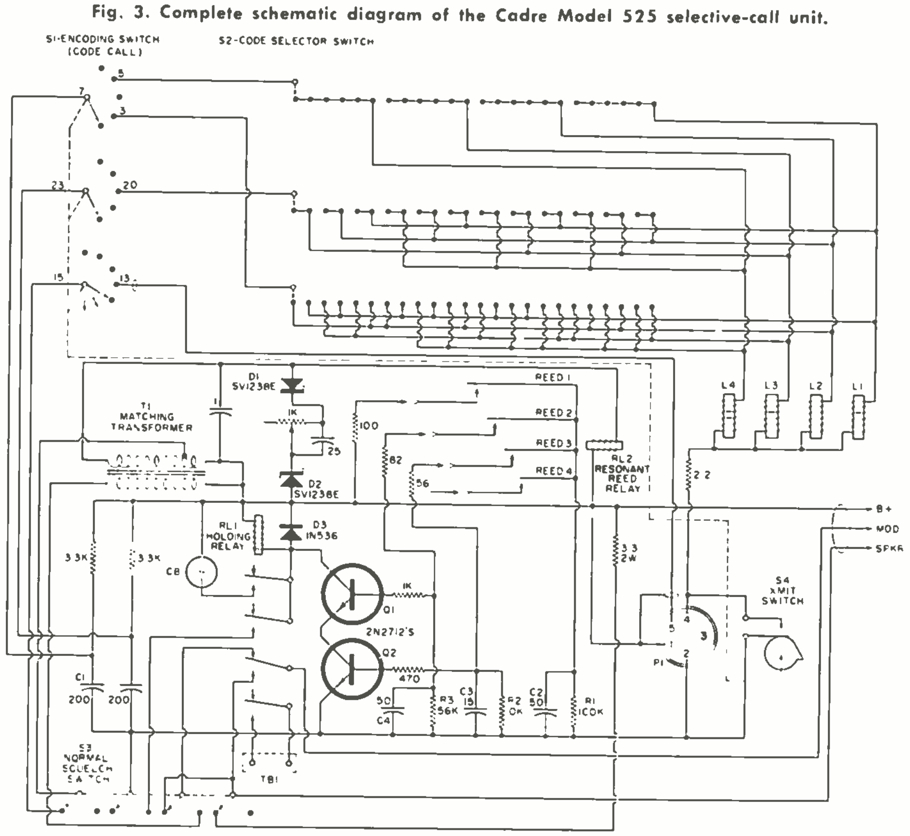
Upon receipt of the tone signal, a similarly equipped CB transceiver processes the three tones for decoding. Tapped from the loudspeaker, audio energy is applied to the reed-relay coil (reed-exciting coils are not used on receive), *RL*2. If the frequencies are correct, three reeds commence to vibrate, in sequence. As the reeds open and close their contacts, *R-C* circuits (near bottom center of the schematic) are activated, *e.g.*, *C*2-*R*1, *C*3-*R*2, and *C*4-*R*3. The net result is controlling the forward bias of transistors *Q*1 and *Q*2. Wired as an "and" gate, the transistors conduct current only when both are properly biased, a condition which occurs only for the correct code. (A more detailed circuit analysis would reveal that the time-constant circuits are charged and discharged by the reeds in rather complex fashion. The result is that only the correct tone frequencies and sequence add up to the desired effect, *i.e.*, forward biasing of both transistors at the same time.) The time-constant circuits are also designed to bleed off incorrect audio frequencies.

Conduction of the transistors energizes holding relay *RL*1 and the CB receiver opens to the the incoming call. The loudspeaker is connected and a lamp illuminates to warn that a desired call has been received. ▲

REFERENCES

1. RCA, Commercial Engineering Dept., 415 S. Fifth St., Harrison, N.J.
2. General Radiotelephone Co., 3501 W. Burbank Blvd., Burbank, Calif.
3. Cadre Industries Corp., Endicott, N.Y.

Fig. 3. Complete schematic diagram of the Cadre Model 525 selective-call unit.

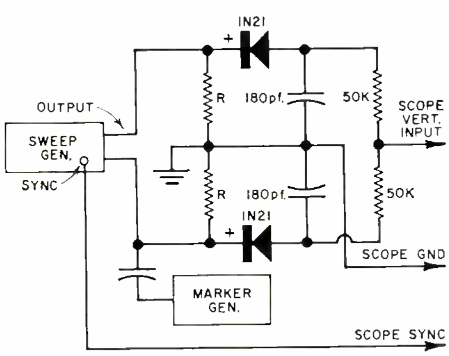


HOW LINEAR IS YOUR SWEEP?

THE fastest way to align a TV or FM set is to use a sweep generator to cover the frequency of interest and then adjust the various tuned circuits for proper responses as suggested by the manufacturer.

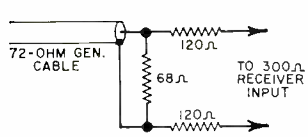
However, a question could arise—in the case of a distorted waveform, what portion of the distortion is due to the circuits being checked and what portion is due to inaccuracies within the sweep generator?

To assure correct frequency response measurements, the output of the sweep generator should be flat over the range of interest and the output impedance of the generator should match the generator cable termination. These



SWEEP GEN. OUTPUT IMPEDANCE	VALUE OF R
53Ω	27Ω
72Ω	39Ω
300Ω	150Ω
OMIT R IF GENERATOR OUTPUT LEAD IS TERMINATED	

(A)



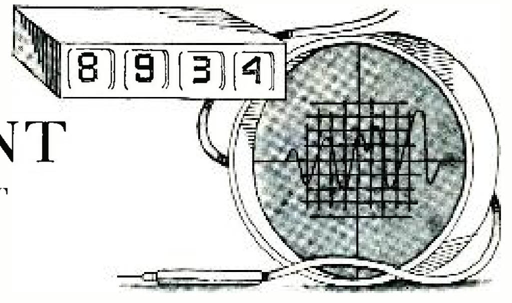
(B)

requirements are necessary and if either one is not satisfied, it could result in a poor response from a properly aligned tuner or i.f. strip.

The flatness of the sweep generator can be checked with a test circuit suggested by *Sylvania* and shown in (A). Set the generator to sweep the frequency of interest and any deviations in generator output over the swept frequency will show up on the trace. The marker generator can be used to spot frequencies of interest.

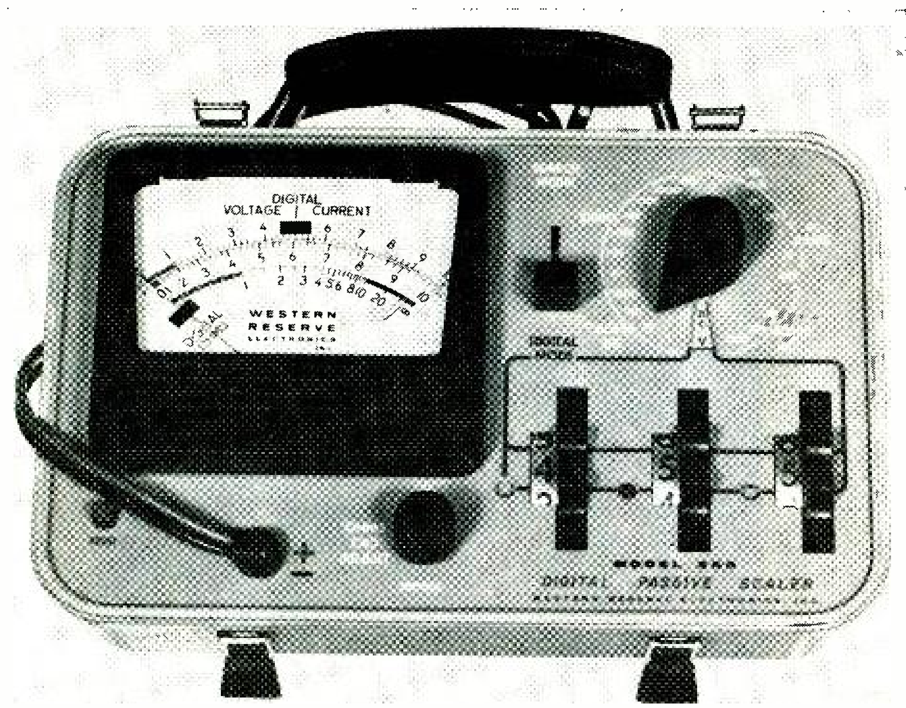
To match the impedance between the commonly used 72-ohm sweep generator output impedance and a typical 300-ohm TV set input impedance, the circuit shown in (B) should be used. ▲

TEST EQUIPMENT
PRODUCT REPORT



Western Reserve Electronics Model 300 Digital V.O.M.

For copy of manufacturer's brochure, circle No. 65 on coupon (page 13).



THE Model 300 is a unique type of portable v.o.m. that is referred to as a "Digital Passive Scaler" by its manufacturer. Across its entire measurement range, values accurate to within 1% of indicated are presented for direct reading from three in-line thumb-wheel knobs. Ranges for the passively measured values are 10 μa. to 10 amps d.c., 100 mv. to 1000 volts a.c. and d.c., and one ohm to one meg resistance.

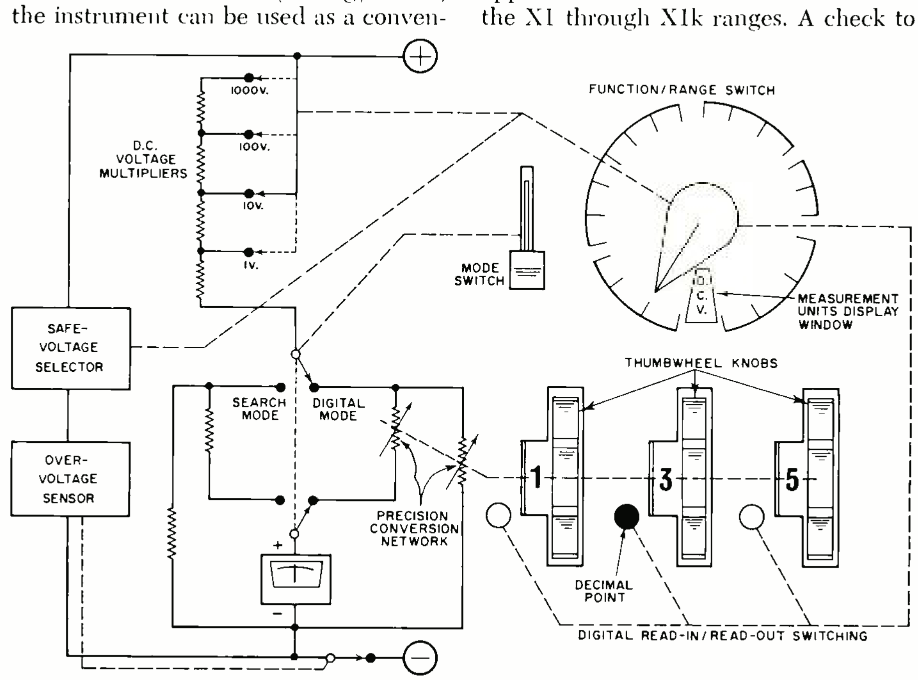
There are two safety features—one for the instrument, the other for the measured circuit. First, the entire instrument is overload-protected by a "fail-safe" resettable system which derives its activation power from the overload. A sensed overload, either a.c. or d.c. voltage or current, internally disconnects the instrument on all functions and ranges until the overload has been removed. Second, the safety of sensitive and semiconductor devices in circuits is assured by virtue of a safe, power-limited shunt ohmmeter. In addition to being safe for all semiconductor circuits, this ohmmeter has an extra feature when applied to resistance measurements in silicon semiconductor circuits. Measurements are the same as those made if the semiconductor devices had been removed from the circuit.

The Model 300 has two operating modes. In its "Search" (analog) mode, the instrument can be used as a conventional v.o.m., but with extended ranges and the additional advantages of the two safety features. In its "Digital" mode, the instrument can be used for precision measurements wherein the accuracy of the indicated value is to within 1%, and the value indicated is easily interpreted by any operator. The extended ranges and two safety features pertain to the "Digital" mode as well.

The 1% accuracy is achieved by an unusual circuit technique. This technique utilizes a precision conversion network which reduces varying values to be measured to a precise value on an accurately calibrated indicator. The indicator is a fixed point on a temperature-compensated, taut-band meter and is used directly for d.c. measurements and in conjunction with a bridge circuit for a.c. measurements. The amount of conversion needed to cause the meter's pointer to reach the fixed point is read directly as the measured value from the set of three in-line thumb-wheel knobs which control the conversion network. The decimal point and measurement units change with function and range selection and are indicated by a unique mechanical arrangement.

The digital-mode resistance measuring circuitry is basically that of a Wheatstone bridge. The proper bridge ratio arms are selected automatically with range selection. Since the readout includes an automatically positioned decimal point and automatically displayed measurement units, the Wheatstone bridge is direct reading.

The characteristics of the power-limited shunt ohmmeter make it useful for locating shorted or opened silicon diodes *in circuit*. The equivalent .05-volt source of the ohmmeter is so low that it causes no noticeable conduction of silicon *p-n* junction; hence, a good diode appears like the resistance across it on the X1 through X1k ranges. A check to



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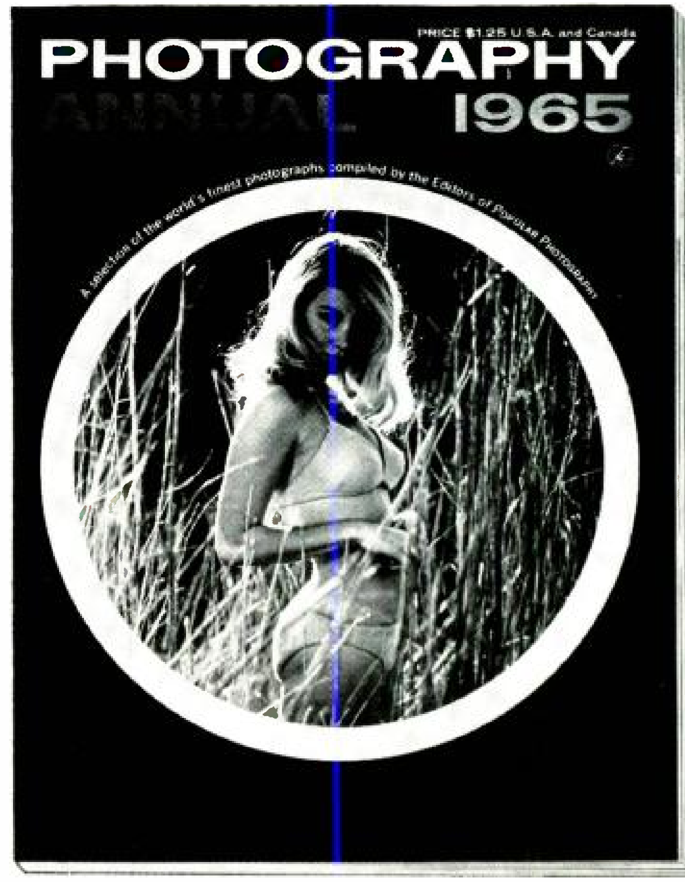

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see that the diode is not open-circuited can be made by selecting the X10k or X100k range and noting an appreciable change in resistance. This technique is not possible with typical conventional ohmmeters. Such meters usually use a 1.5-volt source and are required to supply too much current on their low ohms ranges. Such high current may result in excessive power dissipation in sensitive semiconductor devices. Also, although the current and power are low on the X100k range of the typical ohmmeter, the voltage is high—frequently in excess of many published transistor V_{ceo} absolute maximum ratings.

The Model 300 is compactly enclosed in a rugged fiberglass case which is about the size of a small lunch box and weighs six pounds. Price for the instrument is $350. ▲

Sencore PS127 Oscilloscope

For copy of manufacturer's brochure, circle No. 66 on coupon (page 13).

A FAIRLY recent addition to the *Sencore* line of service-type test equipment is the Model PS127 wide-band 5-inch-CRT oscilloscope. The company has had a 3-inch-CRT model in its line for some time for technicians who require portability for in-home TV servicing. For those who want a larger tube scope for the service bench, the PS127 should fill the bill. The scope should also meet the requirements of many labs and production lines as well as the needs of the technician working on color-TV sets.

The vertical amplifier has a calibrated vertical input attenuator so that rapid direct reading of peak-to-peak input voltages can be made. This amplifier has a response that is within 3 db from 10 cps to 4.7 mc. with a maximum sensitivity of 17 mv. r.m.s. per inch on direct input. An unusual double-ended probe is used with the scope. A connection made to one end of this probe provides direct input, while a connection made to the other end provides low-capacity input. Using the low-*C* input, peak-to-peak voltages of up to 5000 volts can be observed. This permits the scope to be used in fairly high-voltage circuits.

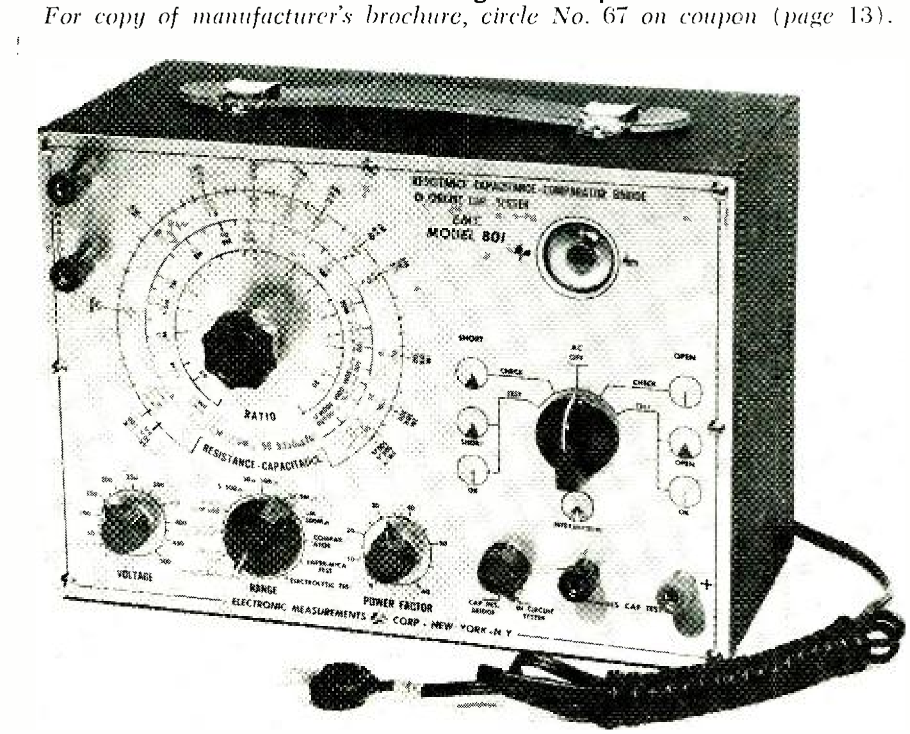
The horizontal section uses a phantastron circuit as the time-base generator. This produces a linear sweep from 5 cps to 500 kc.

The circuit employed in the scope is quite conventional. It uses a total of nine tubes, including the 5UP1 cathode-ray tube, and two rectifiers. The vertical signal is applied to an input cathode follower, then to a pentode amplifier. The output of this stage is applied to a push-pull driver and push-pull output tube to the vertical-deflection plates of the CRT. Horizontal input from the sweep oscillator or from an external source is applied to a cathode follower, then to a triode phase splitter, to a push-pull horizontal output stage, and then to the horizontal-deflection plates of the CRT. A sync-pulse clipper and blanking-pulse clipper are also used in the horizontal section. A half-wave high-voltage rectifier and a full-wave low-voltage rectifier, both using *RC* filtering, complete the circuit.

The Model PS127 is available from the manufacturer's dealers at a price of $169.50. ▲

EMC Model 801 R-C Bridge and Capacitor Checker

For copy of manufacturer's brochure, circle No. 67 on coupon (page 13).



AN instrument that combines two functions in one is the Model 801 resistance-capacitance bridge and in-circuit capacitor checker, made by *Electronic Measurement Corp.* The in-circuit capacitor checker has become invaluable in providing rapid indication as to whether suspected capacitors are open, leaking, or shorted without disconnecting the components for the test and reconnecting them afterwards. However, a suspected capacitor may exhibit none of these faults but cause trouble because it is off value. To determine this, the troubleshooter has had to disconnect his in-circuit checker, get it off the bench, and set up an entirely different instrument, the *R-C* bridge, if he has one. Again, valuable time is lost. With the Model 801, he can conduct the comprehensive range of tests provided by both instruments through the same set of test leads. A switch connects one instrument in place of the other.

For the in-circuit shorts test, an a.c. bias voltage applied to the grid of the self-rectifying tuning-indicator tube causes the eye to close. The component under test is shunted across the grid circuit. A complete short or substantial leakage (an independent leakage test is also provided) will kill the bias, causing the eye to open. The test for open capacitors is provided by an oscillator tuned to about 20 mc. but prevented from oscillating by an overcoupled secondary winding on the oscillator coil. This is the condition with no capacitor (or an open one) shunted across the secondary, *via* the test leads. A good or shorted capacitor loads the secondary, permitting oscillation. Since the oscillator tube is the triode section of the magic eye, bias developed on its grid during oscillation causes the eye to close.

The *R-C* bridge permits precise measurements of capacitance, in 4 ranges,

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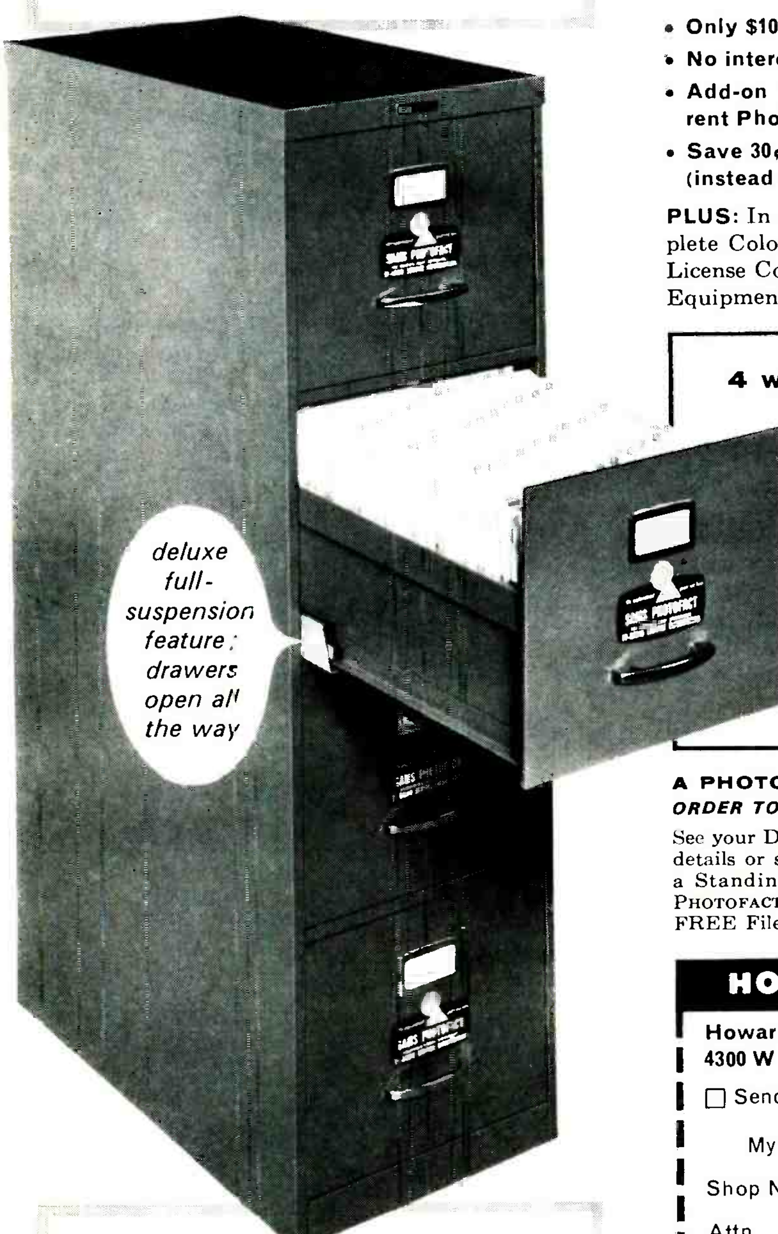

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from 10 pf. to 5000 μf., and resistance, in 4 ranges, from .5 ohm to 500 megohms. Values of inductors—or resistance and capacitance beyond the already comprehensive ranges provided internally—can be determined through a calibrated ratio scale by comparing the unknown component against an easily connected resistor, capacitor, or inductor of known value. Since the range of ratio measurements extends from 1:1 to 100:1, very few known standards would be required for comprehensive coverage. A power-factor test and d.c. leakage test are also provided.

This instrument will solve the problem for many technicians who ask themselves which type of capacitor-testing equipment they ought to have. Aside from the great convenience obtained by combining these functionally related tests, it has been possible to keep the cost down. There is only one power supply, of course. Since the various test functions are never used simultaneously, it is possible to get double duty out of some elements with a well-devised switching arrangement that also makes the instrument easier to use. The tuning-indicator tube, for example, is a common null indicator in bridges of this type. It is also the type of indicator used in separate in-circuit testers, and the same tube serves as combined oscillator-indicator for the open test.

Model 801 is available in kit form at $24.95. The factory-wired version sells for $38.95. ▲

Frequency Calibrator

(*Continued from page 57*)

which should be checked most carefully against the diagram before power is applied to the circuit. With this compact construction, errors are very easy to make and quite hard to correct once made.

Adjustment

When the wiring is checked and found OK, arrange a temporary power supply, with switching as shown in Fig. 2, and connect it to the calibration oscillator. With the crystal and tubes *V1* and *V4* in their sockets and the primary power on, close the "Main Switch" and let the device warm up for some minutes. Tune in a convenient standard-frequency signal (such as WWV or WWVH) on the receiver. Attach a short length of wire temporarily to the junction of *R6* and *R5* and adjust the trimmer *C1* until a harmonic of the calibration oscillator crystal zero beats with the standard.

Next, insert *V2* and *V3* in their sockets, remove the temporary antenna from the junction of *R5* and *R6*, and attach it to the output connector. Turn on the receiver b.f.o. and tune across any band. Calibration signals should now appear at every 10 kc. If an oscilloscope is available, check the output for symmetry. The positive and negative square waves of the calibration output should be of exactly equal lengths. If this is not the case, adjust either *C5* or *C6* until both halves of the square-wave cycle are of equal length.

Finally, insert *V5* in its socket, set the "Audio" control (*R21*) to about mid-range, and check performance again, with the "Tone" switch closed. A clean musical tone should now be heard every 10 kc. across any band. If the tone is ragged and splatters across the dial, back off on the audio volume until a clean tone appears. If an oscilloscope is available, adjust the modulation until it is just a bit under 100 percent. Adjust the audio tone frequency by means of the screw on the back of *L1*. Lowest frequency obtainable with the constants shown is about 580 cycles; highest frequency is slightly above 1200 cycles.

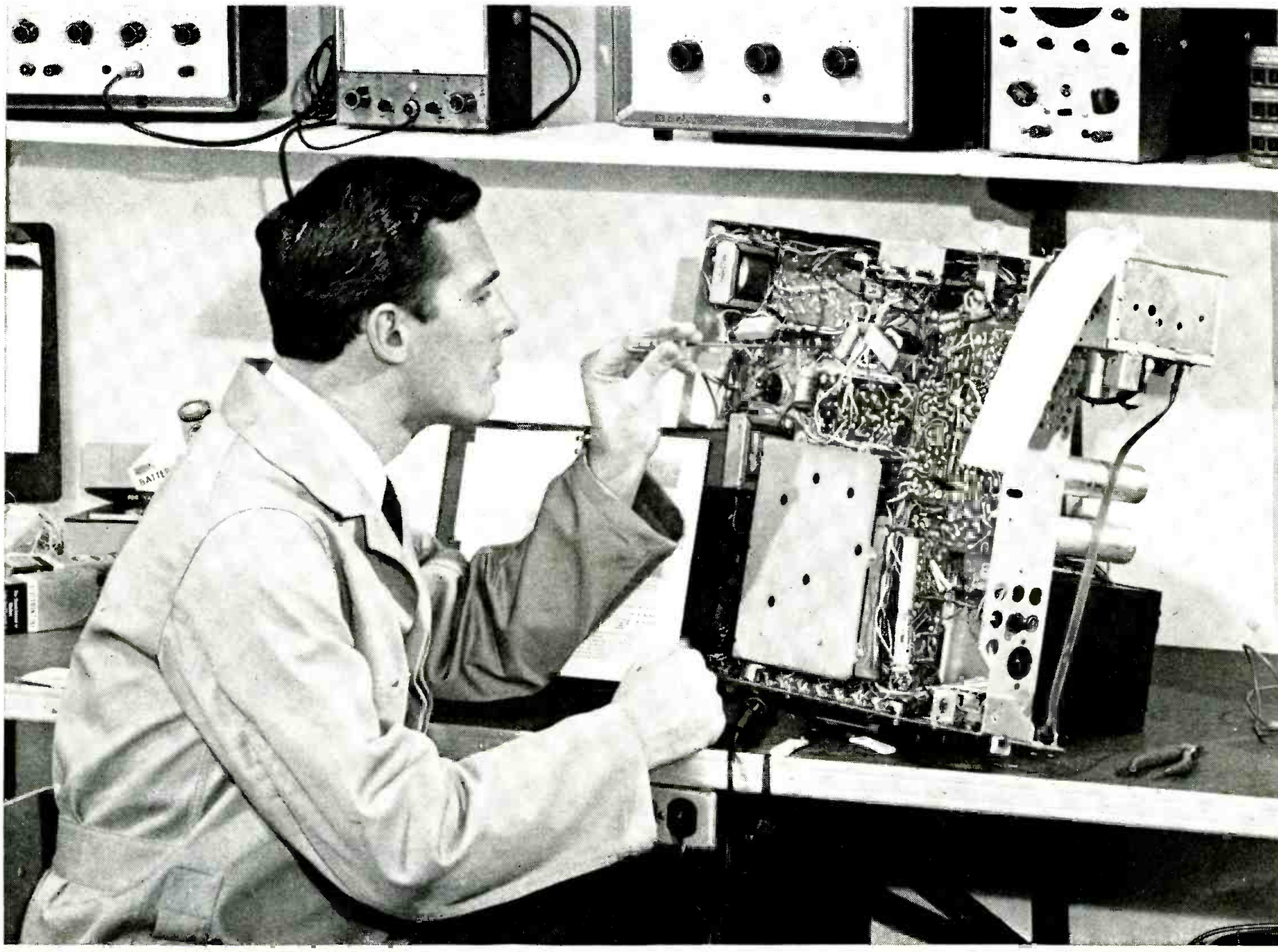
Installation

When the performance of this calibration oscillator is satisfactory, it is ready either for installation in the receiver or as an outboard item. There are no special problems in this installation except that the coupling between the oscillator output and the receiver input must be *very* loose. With the oscillator described, a ½" length of unshielded coaxial cable 1" from the antenna coil gave an "S"-meter reading of 3, which is about right for the purpose. Too close a coupling will result in overloading of the receiver input and, in some instances, "blast through," so that the calibration signal can be heard at all points on the dial. The lead from the oscillator output to the coupling point should be shielded to prevent interference with other services. This shielding is very important when the receiver i.f. is an even multiple of 10 kc.

Performance

Several calibration oscillators on this general design have been built and put into service. Once installed, they work and keep on working and have needed no maintenance of any sort to date. Estimated and recommended maintenance procedure includes checking calibration against a standard (such as WWV or WWVH) every six months, and replacement of all tubes about every 5000 hours.

If the calibration oscillator is used several times each hour, wiring should be such that the filaments are on all the time that the receiver is in operation. If, however, the calibration oscillator is used only a couple of times a month, it will be economical to wire it so that the filaments are turned off when the oscillator is not in use. ▲



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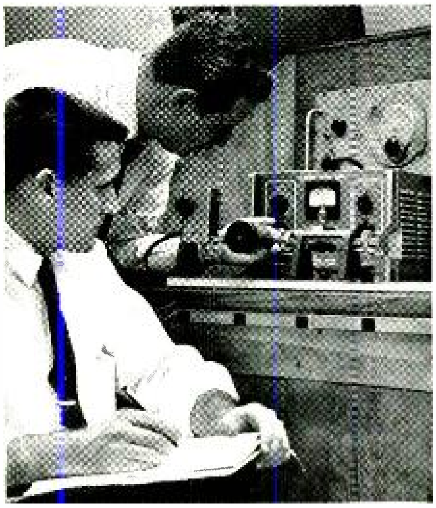

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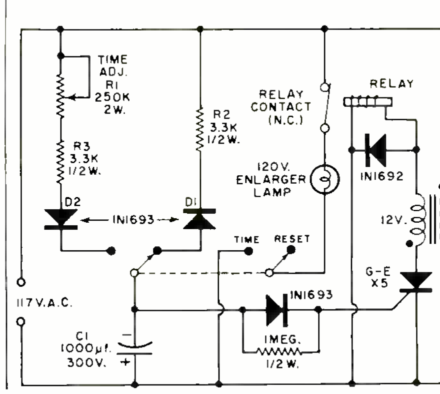
THE solid-state, time-delay relay shown in the sketch can be used to replace clock-operated, or other electromechanical devices used in photo darkrooms. Time delays ranging from a fraction of a second to nearly one minute are attainable with the values of *R1* and *C1* shown. Repeatability is better than 2 percent.

The SCR functions as a very sensitive relay to supply sufficient current to energize the output relay coil. The SCR can be triggered on by a few microamperes of current available from the high-impedance timing circuit consisting of *R1* and *C1*. With the switch in the "Reset" position, *C1* charges to the peak negative value of the supply voltage (about 165 v.) through diode *D1* and resistor *R2*. In this position, the lamp load is off. When the switch is placed in the "Time" position, the lamp comes on and capacitor *C1* starts to discharge towards the positive peak supply voltage value through *D2*, *R1*, and *R3* at a rate determined by the setting of *R1*. Since the time constant associated with this network (*C1*-*R1*) is numerically long, and current flows for a part of each cycle, this process takes many complete cycles of the supply voltage. In practice, the voltage across *C1* never attains its ultimate value since once it becomes positive enough (about 2 v.) to trigger the SCR, the SCR energizes the relay which extinguishes the lamp and terminates the cycle.

The "Time Adj." control *R1* can be calibrated by means of an accurate clock with the resultant time marks scribed on a plastic dial for use by a pointer attached to the rotor of *R1*.

The wattage of the enlarger lamp is a function of the current-carrying capacity of the relay contacts.

This information was supplied by *General Electric*. ▲



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

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ADDING VU METER TO TAPE RECORDER

By JOHN W. HOGAN
Chief Eng., Nortronics Co.

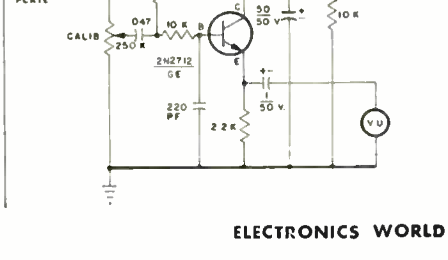
MOST home tape recorders currently in operation do not have meter-type record-level indicators. It is simple to add a vu meter to these machines by using the single transistor emitter-follower circuit shown below. The *n-p-n* transistor requires a positive d.c. supply which is obtained from the "B-plus" of the amplifier in the tape recorder.

The input to the transistor should be coupled to a point on the existing amplifier at or near the plate of the second stage of the microphone preamp. Be certain to choose a point before the high-frequency recording equalization is incorporated. The signal level required across the 250,000-ohm calibration control is approximately 1 v. r.m.s. when the recording head is being driven to a level of 0 vu or "zero level."

The pot should be adjusted so that the meter reads 0 vu while a 400-cps tone is recorded on the tape at 12 db below saturation. This will be about 2% harmonic distortion on playback. If an oscillator and a voltmeter are available, connect the voltmeter to the loudspeaker voice coil and the audio oscillator, set at 400 cps, to the high-level input of the recorder. Turn up the record-level control to a full setting and make a saturation recording on the tape. Then, reduce the record level and make a series of 400-cps tone recordings at various level settings without changing the oscillator output control. Use the microphone to identify the settings for the various recorded levels.

When playing back the above recordings, first set the playback control to give a convenient reading on the voltmeter for the saturated signal—one volt is sufficient. The normal recording which then gives a reading of ¼ volt, or 12 db less, is the one you want. Return the record-level control to the setting which gives this record level, and then adjust the calibration control of the vu meter to read 0 vu in the record position with the same 400-cps input.

A vu meter will insure that recordings are made at the maximum undistorted level. ▲



EW Lab Tested

(*Continued from page* 30)

stylus on its new V-15 cartridge and presumably has developed techniques which assure the precise positioning and dimensional tolerances which are essential to the successful use of this type of stylus.

The frontal radius of the stylus is 0.9 mil, while its edge radius is only 0.2 mil. A shadowgraph measurement of the stylus of our test cartridge on an optical comparator confirmed these dimensions. We tested the cartridge in a *Shure* SME-3012 arm. It tracked the *Cook* Series 60 test record, with its extremely large low-frequency amplitudes, and the 30 cm./sec., 1000-cps bands of the *Fairchild* 101 record, at only ¾ gram tracking force. Its intermodulation distortion, measured with the *RCA* 12-5-39 record, reached 3% at 23 cm./sec. with a 1-gram tracking force. Increasing this to 1.5 grams reduced the IM to 3% at 27.9 cm./sec., which is the highest recorded level on this record. Few cartridges will even approach this low distortion level, even at much higher tracking force. Increasing the force to 2 grams produced no significant improvement at lower levels. A force of 1 gram was used for our other tests.

The frequency response, with *CBS Labs* STR-100 test record, was within ±2 db from 20 cps to 16,000 cps. Channel separation averaged 25 db or better up to 10,000 cps, and better than 10 db up to 20,000 cps. The output was 6.1 mv. per channel at 3.54 cm./sec. velocity (equivalent to 5 cm./sec. lateral velocity). The measured vertical stylus angle, using the *CBS* STR-160 record, was 20 degrees. Hum shielding was very effective. The 1000-cps square-wave response, with the *CBS* STR-110 record, was very good, showing only moderate ringing.

In listening tests, the cartridge sounded as good as it measured. On stereo records, it gave a clean, well-defined sound, with no noticeable coloration. The advantages of the elliptical stylus, which are quite subtle on most records, were clearly audible when playing mono LP records. They had a sparkle and definition which we had never before heard from them, with no trace of the rattling distortion which is produced by playing a mono disc with a conical stylus of very small radius.

The V-15 is a deluxe cartridge, selling for $62.50. It ranks with the very best of today's stereo cartridges with respect to tracking ability and low distortion, and does a superior job of playing mono LP's of any vintage as well as stereo discs. Although it is physically quite bulky, and heavier than most current cartridges, it will fit into practically any standard arm. ▲

NG?

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NEW PRODUCTS & LITERATURE

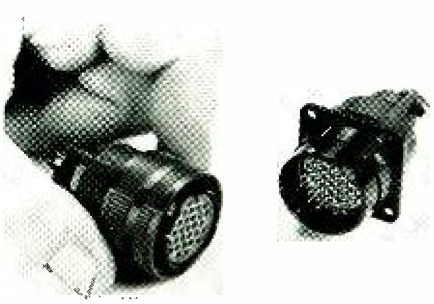
Additional information on the items covered in this section is available from the manufacturers. Each item is identified by a code number. To obtain further details, simply fill in the coupon appearing on page 13.

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

HIGH-RELIABILITY CONNECTORS

1 **Amphenol** has announced a new line of high-reliability connectors, in which not only every part and all the materials going into the construction but complete details on production procedures are coded to insure uniformity and performance.

With the new quality control program, according to the company it will be possible to



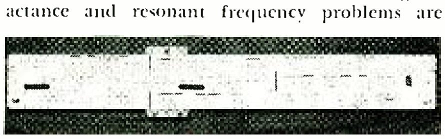
locate connectors manufactured under the same conditions, at the same time, and with the same parts and materials on the same production line as those that went into a specific application. Tests can then be run that will confirm potential difficulties—if this is actually the case.

The new procedure is expected to be extended to the firm's entire connector line including commercial units for communication and electronic data processing applications.

ELECTRONIC SLIDE-RULE

2 **Cleveland Institute of Electronics** is now marketing a new slide-rule which has been developed exclusively for electronic engineers and technicians.

Its special design features are said to facilitate reading the various scales. Scales for solving reactance and resonant frequency problems are



provided. In addition, the slide-rule accurately locates decimal points and provides widely used formulas and conversion factors not found on other scales.

The instrument comes complete with a 123-page instruction manual.

FLUX-CORED WIRE SOLDER

3 **Semi-Alloys, Inc.** has recently developed a new flux-cored wire solder specifically designed for soldering steel assemblies. The solder can be supplied in several alloy compositions and in wire diameters from .005" to .250". The wire can be used in all of the common soldering techniques.

HIGH-GAIN U.H.F. ANTENNA

4 **Winegard Company** has announced a new all-channel u.h.f. antenna which has been named the "Tracker." The antenna uses the "incident wave" principle with a tangent paraboloid reflector system.

The company claims uniform frequency reponse across all u.h.f. channels 14-83 with a measured gain of +13 db. The impedance match into 300 ohms is 1.5:1 or better at all u.h.f. frequencies.

Four feet high, the unit is constructed of anodized aluminum. Snap-lock hardware holds the element securely in place and makes installation easy and quick.

H.F. AMPLIFIER TRANSISTORS

5 **Motorola Semiconductor Products Inc.** has recently introduced a line of high-frequency, small-signal amplifier transistors specifically designed to meet TV and FM applications requiring high-gain, low-noise devices.

The new line includes both "n-p-n" and "p-n-p" types. The "n-p-n" silicon types are numbered 2N3291 through 2N3294 while the "p-n-p" germanium units have been designated 2N3283 through 2N3286. Both series of devices have guaranteed forward a.g.c. characteristics which is an important consideration for r.f. or i.f. amplifier applications.

Typical characteristics for the germanium series include a 2000-mc. maximum frequency of oscillation, power gain of 20 db at 200 mc., and a 5-db noise figure at 200 mc. For the silicon series, the noise figure is 7 db at 200 mc., all other ratings being the same.

PROTOTYPE PRINTED CIRCUITS

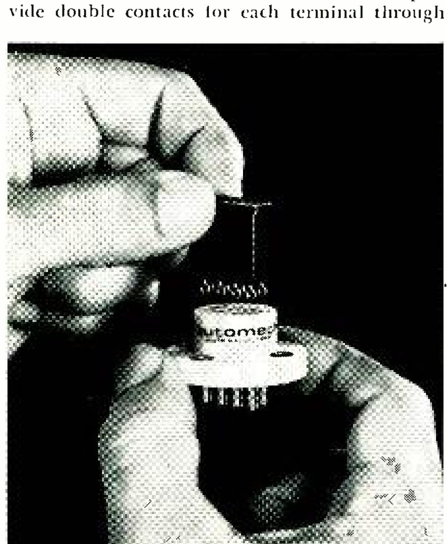
6 **Vero Electronics, Inc.** is now offering a "universal" wiring board for prototype circuit design and assembly. Known as "Veroboard," it combines the advantages of the printed-circuit technique without the cost or delays of custom printed circuits.

The board itself is manufactured from synthetic resin bonded laminate, to which are bonded a number of strips of copper running the full length of the board. The board is pierced with a regular matrix of holes at 0.2", 0.156", or 1". Spacing of the copper conductors and the hole matrix enable a large variety of printed circuit and normal wire-ended components to be used to achieve a compact unit.

The board is reusable and comes complete with assembly aids and accessories.

DUAL-CONTACT TEST SOCKETS

7 **Automech Associates, Inc.** is offering custom test sockets which permit quick and reliable plug-in testing of relays and measurement of contact resistance. Dual-contact test sockets provide double contacts for each terminal through



wiping action of gold-plated phosphor bronze socket pins. The test sockets are made to order to mate with relay headers and will accept straight pin, hook, flattened, pierced, and turret terminals leads.

Test temperatures can range from −100 to +400 degrees F.

WIRE BUNDLE MOUNTING PLATE

8 **The Thomas & Betts Co.** has recently introduced a new adhesive-backed metal mounting plate for holding wire bundles and harnesses. Developed for applications where telephone or communications cables must be supported without drilling, the plates provide excellent holding strength after setting 15 minutes. Pull-off force after 48 hours is 42 pounds.

The plate will accommodate "Ty-Raps" ties up to 3/16" wide. Wire bundles up to 4" in diameter may be mounted with this new clamping device.

NEW SCOPE CAMERA

9 **Beattie-Coleman, Inc.** has introduced a new camera, the MII-565 "Oscillotron," which permits the recording of oscilloscope traces in the nanosecond range.

The camera has an ultra-fast 86 mm., f/1.2 lens and utilizes **Polaroid** 10,000 speed film. Object-to-image ratio is 1:1. Interchangeable backs accept **Polaroid** film packs and 4 x 5 sheet films. It has a synchronous electric shutter. Data recording on the film edge is an optional accessory.

SOLID-STATE VIBRATOR

10 **Forest Electric Company** is now offering the VE-100, a solid-state vibrator eliminator which replaces most non-synchronous vibrators, eliminating "hash" and "sticking" frequently encountered.

The unit is designed to afford direct replacement in 12-volt systems, is hermetically sealed in epoxy resin, weighs 6½ ounces, and measures 1½" dia. x 29/16" high. The mounting is a 5-pin header.

SILICON RECTIFIER DIODES

11 **Westinghouse Semiconductor Division** has added a new line of medium-power silicon rectifier diodes.

Type 402, JEDEC series 1N1183A, are designed for severe industrial service involving cyclic loading and widely varying operating conditions. Principal applications are in d.c. power supplies, inverters, welding controls, converters, motor controls, and frequency changers.

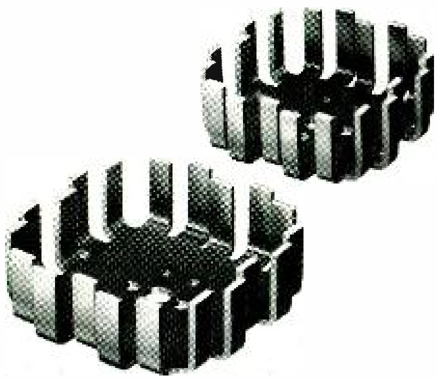
The new diodes are rated 40 amperes with low reverse-leakage current, but can be used at currents up to 70 amps with proper cooling. Maximum one-cycle surge current under load is 1000 amps peak; maximum reverse-voltage ratings are up to 1000 volts peak.

They are hermetically sealed and fused. They have all-welded cases to withstand thermal stresses, eliminate leakage or moisture penetration.

TRANSISTOR HEAT DISSIPATOR

12 **International Electronic Research Corp.** has developed a "staggered-finger" transistor heat dissipator which the company claims is more efficient than other units of up to two-thirds more mass and one-third more volume.

Standard configurations are available in six transistor case hole patterns with other hole pat-



terns available on special order. Heat dissipation of a single unit holding a 2N1899 transistor mounted on an epoxy board shows temperatures held at 69 C at about 10 watts, 101 C at about 20 watts, and 130 C at 30 watts.

The dissipators are fabricated of aluminum and are available with two finishes: black anodized per MIL-A-8625 or Insulube 448 for positive insulation to 500 volts.

SOLID TANTALUM CAPACITOR

13 **Kemet Dept., Linde Division of Union Carbide Corporation** has developed what is said to be the smallest polar solid tantalum capacitor ever made, the "Kemet P-series" unit.

Measuring 0.290" square and 0.095" thick, the new "W" case size is in addition to the firm's line of P-series rectangular capacitors for printed-circuit applications.

The new unit is available in values from 0.33 to 10 μf, in 5, 10, and 20 percent tolerances, with voltage ratings of 6, 10, 15, 25, 35, and 50. Operating temperature range is −55 to +85 degrees C at full rated voltage.

SOLDER CREAM

14 **Alpha Metals, Inc.** has developed a new screenable solder cream which has been especially formulated for micromodule work, including component and substrate soldering. A combination of pre-alloyed solder and rosin flux, it can be applied through silk screens, etched masks, and other similar devices in thicknesses up to .025".

After screening, the cream is easily cured to form a dry, non-tacky, non-flaking coat, ready for use any time after curing. The new cream is being offered in 7 and 14 ounce glass jars and in larger quantities in special plastic-lined steel containers.

PHOTOCONDUCTIVE CELL KIT

15 **Clairex Corporation** is marketing a special kit for design engineers which contains a selection of photoconductive cells plus technical data. Five different types, in both cadmium sulphide and cadmium selenide, are included in the kit.

The CL505, CL603A, CL701L, CL707, and CL902 comprise the selection, which varies sufficiently in sensitivity, spectral response, speed, and size to suit most applications.

VISE FOR ELECTRONICS

16 **Wilton Corporation** has introduced a new specialized vise for electronics work. It is designed for delicate small assemblies and printed-circuit boards.

The unit combines the strength of heavy gauge steel construction, the rigidity of double slide bars, and the gentle yet sure grip of rubber-wrapped jaws. The jaw opening adjusts with a crank handle to accommodate work pieces up to 6½". The rubber jaw faces are 2" wide.

CUSTOM TRANSFER SHEETS

17 **Chart-Pak, Inc.** has announced the availability of "Deca-Dry" custom transfer sheets made from original artwork for logotypes, symbols, designs, headings, captions, trademarks, drawings, original lettering styles, labels, codes,

and any other frequently used printed matter.

Images on the custom sheets transfer simply by lightly rubbing with a medium pencil, burnishing tool, or ball point. A rigid plastic base material prevents image distortion due to heavy pressure or sharp points.

A heat-resistant adhesive and cohesive ink keep transferred images firmly in place. The sheets measure 13¼" x 16½" with a 12½" x 15" printing area and are available in black, red, blue, and white. Artwork may be supplied by the customer or prepared by the manufacturer for a nominal charge.

INDICATING LIGHT LINE

18 **General Electric Company** is now marketing a new line of indicating lights for use on electronic equipment, business machines, materials handling systems, and commercial and industrial machinery.

The lights, designated CR103, Type H, have been designed for quick, easy mounting and installation and offer the user a variety of lens shapes and colors. They can be used wherever oil-tightness is not required.

Types HA and HD require a 1" hole for mounting; Type HB require only a 1/16" mounting hole, while the compact Type HC takes a 13/32" mounting hole.

NEW TRANSISTORS

19 **RCA Electronic Components and Devices** has announced two new series of transistors, each containing four types.

The silicon "n-p-n" high-voltage transistors have been designated 40256, 2N3440, 2N3441, and 2N3442. They are designed for use in power supplies, stable deflection circuits, and high-voltage operational and differential amplifiers.

The second series contains four new silicon "n-p-n" planar transistors, Types 40231, 40232, 40233, and 40234. They have been specifically designed for audio amplifier applications in radios, television sets, phonographs, tape recorders, and other consumer-type audio equipment.

Ratings and characteristics on both series are available from the manufacturer.

IGNITION TUNE-UP

20 **Rite Autotronics Corp.** is offering a tune-up instrument kit which lets a motorist perform all ignition tests on his car. Five high-accuracy instruments are included in the kit: an

idle tach, a cam dwell tester, coil tester, alternator diode and ignition cable tester, and a regulator-generator tester. All of the instruments are housed in an unbreakable fitted carrying case.

HIGH-POWER TRANSISTORS

21 **Delco Radio Division** is now offering two new series of advanced process, germanium high-power transistors, the DTG 1000 and 2000 series. The new devices have current ratings of 15 and 25 amperes with sustaining voltage V_{ce} capabilities ranging as high as 325 volts in selected units. The basic series of five (DTG 2000) devices are characterized by 25-ampere collector current ratings and sustaining voltages from 30 to 120 volts.

The DTG 1000 series are 15-ampere high-voltage devices especially characterized by electrical parameters needed for auto ignition and video horizontal and vertical deflection circuits. Package configuration is the diamond-base TO-3 design.

TRANSISTORIZED TV

22 **Emerson Radio and Phonograph Corporation** has recently introduced an 11-inch television receiver which incorporates 22 germanium and silicon transistors, 13 silicon diodes and recti-

fiers, as well as one silicon gate-controlled switch developed specifically by **Texas Instruments** for TV applications.

DUAL MESSAGE INDICATORS

23 **Leecraft Manufacturing Co., Inc.** is now offering a new line of compact rectangular indicator lights which contain two lamps for the purpose of activating two legends, separately or simultaneously.

A wide variety of lamps is available in a full range of voltages. The units are designed to suit the applied circuit voltage and to insure the required lamp life. Any applicable legend or trademark can be hot-stamped on high-heat plastic lenses which can be furnished in a variety of colors. Housing is nylon and the bezel can be furnished in different finishes.

The units snap into a 1.281 x .395 hole with no additional hardware. Terminations can be either ¼" male tab or wire leads.

1-WATT AVALANCHE DIODES

24 **North American Electronics Division** has introduced a new series of 1-watt avalanche diodes using the polymerized silicon encapsulating technique.

The new series, registered as JEDEC Type 1N4323 through 1N4358, is rated 1 watt at 75 degrees C in the DO-7 size package. The series is available in zener voltages from 6.8 volts to 200 volts with 5, 10, and 20 percent tolerances available. The standard device is supplied with silver leads.

SOLID-STATE COMPONENTS

25 **I.E.H. Manufacturing Company, Inc.** is now marketing a new line of replacement transistors and silicon rectifiers which the company claims will cover approximately 95% of all replacements. The new line consists of 9 transistors, 12 silicon rectifiers, 4 silicon diodes, and 3 dual diodes. Also included are epoxy molded silicon rectifiers in standard or miniature sizes. All units in the line are skin-packed.

REPLACEMENT TIPS

26 **Oryx Company** is now offering four new replacement tips for its miniature precision soldering irons. A new gold-alloy tip material and a special iron-plating close the gap between the company's regular copper-alloy tips and its solid nickel tips.

The "T" and "U" tips are made of a solid gold-alloy and have a diameter of only 40/100th inch. They are intended for the finest microcircuit applications where the joint heat load is negligible. They are designed for use on the firm's model 5 or model 6A soldering instruments.

The types "V" and "W" have diameters of 3/32" and a plated end. The "V" tip is a long-life, iron-coated tip while the "W" type is unplated.

D.C. TUBULAR CAPACITOR

27 **Cornell-Dubilier Electronics** has announced a new d.c. tubular capacitor with polystyrene dielectric film wrap.

The Type WRP is recommended for precision-timing circuits, high-"Q" tuned circuits, long time constant circuits, and similar applications in quality industrial equipment.

Important properties of the new capacitor are: extremely low capacitance change with temperature, low dielectric absorption, and very high insulation resistance.

TRANSISTORIZED INDICATOR

28 **Transitron Electronic Corporation** is now marketing a transistorized neon indicator light which has been tradenamed "The Transindicator."

The unit offers the operational advantages of a single hermetically sealed package containing all the necessary circuit components for positive and negative turn-on and turn-off. It is available in various mechanical configurations including clip-mounted types for printed-circuit boards, front and rear panel mount adapter types, and complete standard or special printed-circuit board assemblies.

The indicator can be mounted on 3/8" centers with maximum height above the circuit card of 0.390" which is compatible with conventional PC board spacing.

INTEGRATED BRIDGE RECTIFIER

29 **Varo Inc.'s** Special Products Division has recently introduced the 1N4437 integrated bridge rectifier, a silicon avalanche rectifier single-phase bridge in an electrically insulated case. It is rated with a minimum avalanche voltage of 150 volts and a maximum of 700 volts.

The output current is rated at 10 amps at 100° C and 18 amps at 50° C. The unit is rated with reverse current equal to 0.1 ma. max at rated voltage and 100° C and 1 volt leg forward voltage drop. Surge current is 100 amps and the maximum junction temperature is 150° C.

HIGH-CAPACITY CAPACITORS

30 **Aerovox Corporation's Hi-Q Division** can supply ceramic capacitors for transistor circuits with capacity requirements from 10 pf. up to 160,000 pf. The new Types MC 51, MC 505, MC 61, and MC 605 are of "Ceralam" construction. They offer flexible designs with a wider than usual selection of values and tolerances. Units are life-tested at twice rated voltage and may be manufactured to high-reliability standards on request.

HI-FI—AUDIO PRODUCTS

FM STEREO ANTENNA

31 **JFD Electronics Corporation** is now offering the LPL-FM 10-cell log-periodic antenna for FM-stereo applications. This new unit provides up to 4.1 db more gain than a 10-element FM yagi, according to the company.

The antenna operates on the full wavelength log-periodic mode. The array of "L" shaped log-periodic dipoles is a back-fire, front-fed type that provides front-to-back ratios up to 26 db. As the impedance match is very high, the "L" dipoles employ transmission line transformers and 180° phased feeder harness to insure precise 300-ohm impedance. Narrow beamwidths and minor lobe levels (less than 21.6 db) help reject distortion-producing reflected signals.

The antenna comes factory pre-assembled. The dipoles are constructed of 1/2" aluminum tubing. Twelve-inch inserts and four-inch inserts reinforce each dipole to provide extra strength against ice and wind loading. The entire antenna is gold alodized for corrosion protection.

Other models in the LPL line are available with 8, 6, and 4 cells.

MATCHED STEREO MODULES

32 **RCA Sales Corporation** has entered the high-fidelity component field with a line of laboratory-balanced stereo sound modules. The new line consists of a "Studiomatic" record changer, a solid-state tuner-amplifier, three sets of speaker systems, and a console tuner-amplifier-changer ensemble.

All of the components are specifically designed to be compatible and capable of being assembled into a complete system without technical know-how. The components are housed in a cabinet of walnut veneers and selected hardwoods.

TRANSISTORIZED CONVERTER

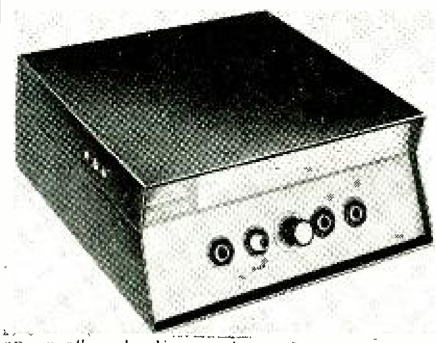
33 **Flite-Tronics Co. Inc.** is now offering a transistorized converter which is designed to operate 12-volt stereo tape equipment in aircraft and boats with 24-volt electrical systems.

Input of the converter is 27.5 volts at 1.3 amps and output is 13.5 volts at 2 amps. Weighing one pound, the PC-12 has no moving parts and measures 2 1/2" wide x 2 3/8" high x 4 1/2" long.

BATTERY-OPERATED AMPLIFIER

34 **Perma-Power Company** has just introduced a portable amplifier that works on flashlight batteries and has a frequency response of 50-15,000 cps.

The "Ampli-Vox" Model S-700 features all-transistor design for instant performance. It offers one-knob operation. A single control turns it



on or off and adjusts volume. It is rated at 25 watts (EIA music power), 40 watts peak. The ten flashlight batteries will provide 200 hours of operation.

The amplifier measures 8⅜" wide x 3¼" high x 8¾" deep and weighs only 7 pounds with batteries installed. It can be adapted to a.c. operation by means of a plug-in power adapter which is available separately.

TRIPLE-PLAY AUDIO TAPE

35 **Eastman Kodak Company** has announced a new music-quality, triple-play audio tape, Type P105.

The tape uses a high-output oxide applied with advanced coating techniques to give a signal-to-noise ratio that is as much as 6 db greater than conventional triple-play tapes, according to the company.

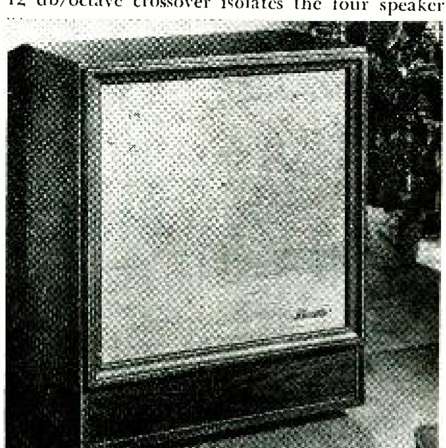
It comes on a 7" reel carrying 3600 feet of tape to provide more than 1½ hours of uninterrupted music at a recorder speed of 7½ ips. Where extended play is important, the 7" reel will give a total of 6 hours four-track stereo or 12 hours four-track mono per reel at 3¾ ips.

The tape is also available on 5", 1800-foot reels and a 3¼", 600-foot reel.

FOUR-WAY SPEAKER SYSTEM

36 **Sherwood Electronic Laboratories, Inc.** is now marketing "The Tanglewood," a four-way speaker system that features six speakers.

Over-all response is 29-17,500 cps ± 2½ db. A 12 db/octave crossover isolates the four speaker



response ranges at 200, 600, and 3500 cps. The system handles 75 watts of program material.

The two 10" woofers have staggered resonances of 17½ and 18½ cps and there is an 8" mid-woofer, an 8" midrange, and two 3½" ring-radiator tweeters. All speakers are individually chambered and rigidly mounted to 1" thick, cross-braced flakeboard baffles.

The enclosure is of 1" thick solid-core walnut veneer with a hand-rubbed finish. The cabinet measures 31" high x 24" wide x 13" deep.

RADIO/INTERCOM UNIT

37 **Fasco Industries Incorporated** is now offering a transistorized radio/intercom for household installation. The system consists of a master control unit which offers complete intercom facilities with gain independent of the radio volume control. Power output is 1½ watts and power input is 16 volts a.c., 12 watts (a class 2 power transformer is included). The radio section covers the standard broadcast band 540-1600 kc. and the FM band. Module construction is used in the receiver. A high-impedance phono jack is included. The receiver uses 10 transistors and 7 diodes. A 5" PM speaker, 45 ohms impedance, is used.

The complete system includes 1 master control unit, 1 door station, and 3 remote-control units plus a complete installation package.

3-WAY SPEAKER SYSTEM

38 **LTV University** has added the "Classic French Provincial" 3-way speaker system to its line.

Housed in a French Provincial cabinet measuring 36" x 29" x 16" deep, the speakers are a heavy-duty, high-compliance 15" woofer; an 8" deluxe direct-radiator mid-range; and a "Sphericon" super tweeter. The system provides virtually uniform response from below 20 cps to 40,000 cps.

COMPACT STEREO PHONO SYSTEM

39 **Shure Brothers, Inc.** has entered the premium-quality, packaged-component market with its "M100 Maximum Performance Phono System," which will be offered initially in two models. One unit is a portable unit completely self-contained in Samsonite luggage-style cases. The second is the "Library Model" which is housed in solid walnut cabinetry.

Both units feature solid-state preamp/amplifier and two ultra-compact speaker systems. Each unit

is equipped with the company's V-15 "Stereo Dynetic" cartridge with Bi-Radial elliptical stylus. The systems' automatic turntable is the **Dual**/Auto Professional Model 1009. Inputs are provided for other program sources such as AM, FM-stereo tuner, and tape recorder.

Operating controls include stereo/mono switch, separate treble and bass controls, speaker balance control, on-off-volume switch, and phono-aux. microphone (p.a.) switch.

BATTERY RECORDER

40 **Superscope Incorporated** has recently introduced the **Sony** Model 905 "Voice Command" battery recorder, a 2-in-1 tape recorder featuring a voice-activated mechanism with transistorized computer-type electronic switching and automatic gain control.

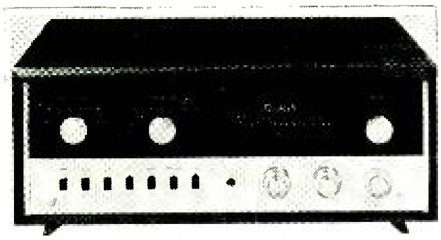
The complete Model 905 consists of two units. The upper part is the actual recording instrument and, when detached from the matching a.c.-powered amplifier/speaker base, serves as an independent battery-operated portable recorder. When placed on the base, the recorder will play back on the hi-fi amplifier/speaker in the base. The base also contains a charger and while the amplifier/speaker is in operation, the batteries are automatically recharged.

Tape speeds are 3¾ and 1⅞ ips. Frequency response is 90-9500 cps. It will handle reel sizes up to 3¼". It comes complete with leather case and lifetime nickel-cadium rechargeable batteries.

SOLID-STATE STEREO PREAMP

41 **McIntosh Laboratory Inc.** has added the C24 solid-state stereo preamp to its line of audio components.

The new unit has frequency response of 20-20,000 cps +0, −0.5 db; distortion is less than .1% at 2.5 volts and less than .3% at 10



volts. The input selector has six positions: aux., tape, tuner, phono 1, phono 2, and tape head. Input sensitivity on aux., tape, tuner, and tape monitor is .20 volt; on phono 1 and phono 2, 2 mv.; and on tape head 2 mv. There is a compensator switch which provides RIAA or LP phono equalization.

18 silicon planar transistors are used in the preamp. Power requirements are 105-125 volts, 60 cycles, 8 watts. The front panel is 16" wide x 5-7/16" high while the chassis is 15" wide x 5" high x 11" deep including connectors. Clearance in front of the mounting panel, including knobs, is 1 1/2 inches.

MINIATURE TAPE RECORDER

42 **Craig-Panorama, Inc.** is now offering the TR-190 "Electronic Notebook," a completely self-contained miniature tape recorder which may be operated by one hand.

The special "M Zone" design combines a built-in microphone and vu meter for monitoring recording level and battery life, with push-button control for starting and stopping the unit.

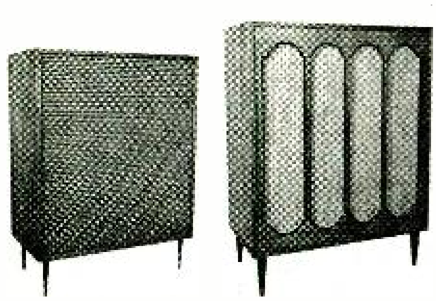
The recorder features a snap-in tape pack for recording up to 30 minutes and is equipped to recharge the nickel cadmium batteries without removing them from the unit. There is a separate pause switch on the mic. plus single-action lever control for play, record, rewind, stop.

The instrument is 6 1/2" long, x 3 3/4" high, x 1 3/8" wide. It comes with a leather carrying case.

HI-FI SPEAKER SYSTEMS

43 **Hartley Products Company** has added the Mark III and Mark IV "Concertmaster" speaker systems to its line of hi-fi components. Both systems are identical in size, measuring 38" high x 29" wide x 16" deep. The Mark III is housed in a modern oiled-walnut enclosure while the Mark IV is in a traditional rubbed oiled-walnut housing.

Both systems use the 218MS 18" wooter with response down to 16 cps. Middle and high frequencies are handled by the new 220MS speaker.



Both speakers employ magnetic suspension and a patented tri-polymer plastic cone construction. The crossover network, which provides a droop of 12 db per octave, has been set at 250 cps to insure optimum blend of bass and midrange.

STEREO TURNTABLE

44 **Weathers Industries** has added the "Townsend" stereo turntable to its line. A 12-pole synchronous hysteresis motor drives the aluminum platter with only .03% wow and flutter. The platter and tonearm are suspended on a delta wing suspension system that produces −50 db rumble. The walnut tonearm will accept any standard cartridge and is adjustable to stylus pressures recommended for each cartridge.

Speed is 33 1/3 rpm. The turntable comes com-

(Continued on page 116)

Your Postmaster Suggests:

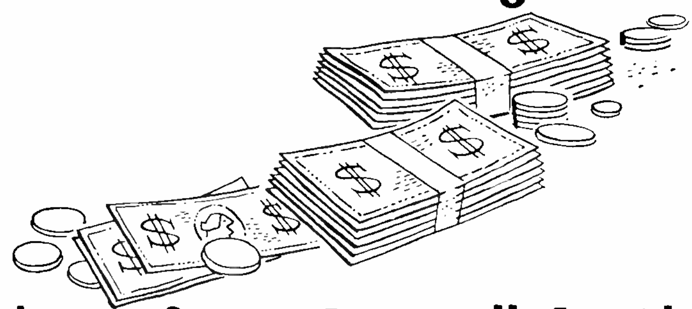
Always Include

Your (ZIP CODE) Number

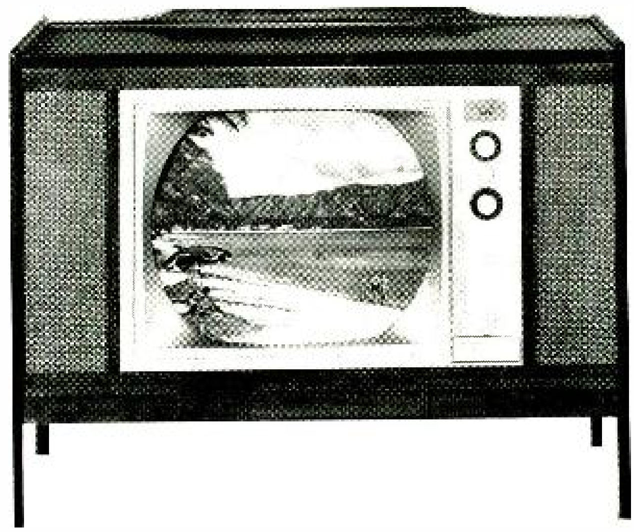
in your

Return Address

Regardless Of What You Pay For Other Color TV



It Can't Perform As Well As This One...



And Yet A Heathkit® Set Costs As Little As $399!

Exclusive Heath Features For Unequalled Performance! That's right. No matter how many of your hard-earned dollars you pay for another brand of color TV, *none* can equal the performance of the Heathkit All-Channel, High Fidelity 21" Color TV! Why? *All* color sets require minor periodic adjustments to maintain peak picture performance. The Heathkit GR-53A is the *only* set with a "built-in service center" that provides the facilities for perfect picture adjustments. Heath's simple-to-follow instructions & detailed color photos show you exactly what to look for and how to achieve it . . . quickly, easily! You become the expert! Result? Beautiful, true-to-life color pictures day in and day out . . . and *no* costly color TV service calls for simple picture alignment!

And since you service & maintain the set yourself, a costly service contract isn't required! Heath warrants the picture tube for 1 year, all other parts for 90 days.

No Trade-In Required!

Keep your present set as a handy "second" set for the den, bedroom, children's room, etc.

Quick & Easy To Assemble!

No special skills or knowledge required. All critical assemblies are factory-built and tested. Simple step-by-step instructions take you from parts to picture in just 25 hours!

Convenient Time-Pay Plan!

Only 10% down, and the rest in easy monthly installments. Get *free* catalog for full details.

Finest Components, Most-Advanced Circuitry

With the Heathkit GR-53A you're assured of the finest parts and most advanced color TV circuitry that money can buy . . . at up to $200 savings. You enjoy rock-steady pictures with no overlap or color fringing.

But Don't Take Our Word For It!

See the special articles on the Heathkit GR-53A in the May issue of *Popular Electronics*, June issue of *Radio-TV Experimenter*, February issue of *Popular Mechanics*, April issue of *Science & Mechanics*, and the August issue of *Radio-Electronics!*

Now Compare The Features . . . . And The Price!

In addition to the ones already mentioned, there's the high definition 70° 21" color tube with anti-glare bonded safety glass; 24,000 volt regulated picture power; 27 tube, 8 diode circuit; deluxe Standard-Kollsman VHF tuner with push-to-tune fine tuning for individual channels and transistorized UHF tuner for all-channel (2-83) reception; automatic color control and gated AGC for peak performance; line thermistor for longer tube life; two hi-fi outputs plus tone control; transformer operation; chassis & tube mounting on sturdy one-piece metal support for easy set-up and servicing; plus a low price of only $399.

Use The Coupon & Order Yours Now!

And be sure to check the appropriate box to get your Free new 1965 Heathkit Catalog with complete descriptions & specifications of the GR-53A as well as over 250 easy-to-build kits!

Kit GR-53A, chassis, tubes, mask, UHF & VHF tuners, mounting kit, and special 6" x 9" speaker, 127 lbs. $399.00

The Only Color TV You Can Install 3 Ways!

1. In New Heathkit Deluxe Walnut Cabinet (Illust. above), model GRA-53-7, 85 lbs. $115.00
2. In Heathkit walnut-finished hardboard cabinet (Illust. below), model GRA-53-6, 52 lbs. . . . $49.00
3. In a wall, bookshelf, or custom cabinet!

FREE! 1965 Heathkit Catalog!

HEATHKIT

HEATH COMPANY, Dept. 15-10-3
Benton Harbor, Michigan 49023

☐ Enclosed is $ ________, plus shipping.

Please send Model(s) ________.

☐ Please send FREE 1965 Heathkit Catalog.

Name ____________________ (Please Print)

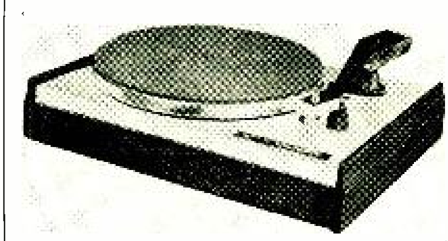
Address ____________________

City ________ State ________ Zip ________

CL-193

Prices & specifications subject to change without notice.

CIRCLE NO. 187 ON READER SERVICE PAGE



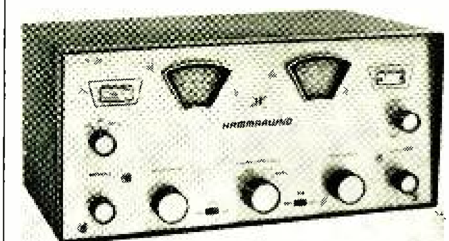
plete with tonearm and walnut base and measures 17½" wide x 14½" deep x 5¼" high, including tonearm.

CB-HAM-COMMUNICATIONS

GENERAL-COVERAGE RECEIVER

45 **Hammarlund Manufacturing Company** is currently introducing a new general-coverage receiver, the HQ-66.

The unit is a ten-tube superhet with electrical bandspread tuning and direct dial calibration. Coverage is 540 kc. to 30 mc. A temperature-



compensated high-frequency oscillator provides excellent stability.

An exclusive "auto-response" circuit permits a complete range of audio output—from the sharp response required in short-wave reception to the broad response necessary for high-fidelity broadcast reception. This function is entirely automatic.

NEW FM TWO-WAY RADIO LINE

46 **General Electric Company** has launched a new generation of transistorized FM two-way radio products which has been tradenamed "MASTR Progress Line."

The line makes extensive use of silicon transistors. The series includes transistorized mobile units and transistorized base stations for all major bands in the mobile radio spectrum, u.h.f.

frequencies as well as low-band, mid-band, and high-band v.h.f. It includes u.h.f. mobile units with r.f. power up to 60 watts. In v.h.f. the mobiles are available up to 100 watts. Base stations range up to 330 watts, depending on the frequency selected.

Details on the complete line, with information on special features, will be supplied by the company.

MARINE ELECTRICAL GROUND

47 **Heath Company** is introducing a corrosion-proof marine electrical ground system that provides 13.8 square feet of grounding surface—which exceeds the 12 foot figure required by the FCC.

The new system, Model MD-14, is designed to be used on both single- and dual-engine craft with a minimum keel length of nine feet. The system consists of two heavy-gauge copper tubes, 8 feet long and 1¼" in diameter, which are strapped to each side of the boat's keel with brass mounting strips and bolts. Only seven holes are required for permanent mounting, with just one hole through the hull.

Because of its design and location, the MD-14 will not catch on rocks, logs, etc. or interfere with normal boat maintenance. Since the weight is distributed equally, it will not affect the balance, steering, or maneuverability of any water craft.

"CONVERTIBLE" CB TRANSCEIVER

48 E. F. Johnson Company has just introduced the "Messenger III," a multi-purpose CB transceiver which can be adapted for use in four different types of two-way radio applications.

The all-transistor unit which measures less than 2¼" high, less than 6¼" wide, and 8¾" deep, can be converted for use as a mobile, under-

dash unit, as a base station, as a self-contained p.a. amplifier, or as a full 5-watt battery-powered portable pack set. Powered by rechargeable nickel-cadmium batteries, in portable use the unit is slid into a high-impact plastic carrying case, the battery and antenna connections are mated, and the unit is ready for field use. As a portable the unit weighs 10 pounds and measures 9½" wide x 9¾" high x 4¾" deep and is equipped with carrying handle and adjustable shoulder strap.

The transceiver will cover any 11 channels in the 23-channel band and permits the instant selection of any one channel by rotating the channel-selector switch on the front panel. The unit comes complete with crystals for one channel and dynamic microphone with coiled cord.

MANUFACTURERS' LITERATURE

WIRE & CABLE CATALOGUE

49 Belden Manufacturing Company has just released a new electronic wire and cable catalogue, No. 864.

Thirty-five new numbers are introduced in the publication including control cables, FEP Teflon cables, paired cables, quads, and miniature precision video cables. The rest of the firm's line is also pictured and described in the catalogue.

CONDENSED GLOSSARY

50 International Resistance Company is offering a "Condensed Glossary of Electronics Terminology" as a service to the industry.

The pocket-sized publication lists a total of 133 terms. Words that in lay language mean other things are included, along with definitions of computer types and various solid-state and other devices.

MICROCIRCUIT KIT DATA

51 Corning Glass Works' Electronic Products Division has issued a four-page technical bulletin which describes a kit of microcircuits specifically designed for evaluation testing.

The kit allows a designer to determine the exact behavior of the company's thin-film tin oxide resistors under his particular conditions of use. Illustrations in the bulletin include photos and the schematic of the microcircuits in the kit. Also shown are a general parameter listing as well as performance charts of typical thin-film resistors.

CONTROL CATALOGUE

52 **Centralab** is offering an 8-page catalogue covering its "Fastatch II" control system. Listed are all controls and accessories necessary for the assembly of exact replacements for single, dual, triple, and quad single-shaft controls, dual concentric controls, and units with switches.

Approximately 98% of all exact-replacement control applications are covered by the items listed.

POWER OUTLET BOXES

53 **Waber Electronics Inc.** has issued an eight-page brochure which lists its complete line of pre-wired master power control outlet boxes. All of the power outlet boxes described in the brochure are rated at 15 amperes, 130 volts and custom units are also available to meet specific requirements.

More than 100 units are described and illustrated in brochure #564.

MICROWAVE DEVICES

54 **Sylvania Electric Products Inc.** is now offering a free booklet containing technical data on all microwave devices produced by the firm's Microwave Device Division.

The catalogue contains information on traveling wave tubes, backward wave oscillators, microwave phototubes, gas lasers, klystrons, magnetrons, microwave diodes, rocket planar triodes, waterloads, and waveguide windows.

A rapid referencing system is used to enable a reader to locate any device readily.

INDUSTRIAL EQUIPMENT LINE

55 **F. W. Bell, Inc.** has issued a short-form, 4-page catalogue covering characteristics of its line of six gaussmeters, three special probes, six models of magnetic testing systems, a full line of miniaturized Hall effect devices, plus Hall effect multipliers and wattmeter transducers.

Complete technical details are supplied on the above product categories.

MINIATURIZED PAGING SYSTEM

56 **Round Hill Associates** has issued a pocket-size brochure describing its miniaturized radio paging system for use in offices, stores, plants, schools, construction sites and other similar applications.

The four-page publication pictures and describes the system in operation and lists advantages of the system.

PRECISION TRIMMERS/INDUCTORS

57 **LRC Electronics, Inc.** has issued a new catalogue illustrating a complete line of precision trimmer capacitors and inductors. Electrical and mechanical specifications along with dimensional diagrams of each unit are included in this 16-page publication.

SEMICONDUCTOR CATALOGUE

58 **General Electric Company** has issued a 40-page catalogue which gives applications and characteristic ratings on the firm's line of more than 1400 semiconductors.

Highlights include new silicon economy transistors, double heatsink diodes, silicon controlled switches and reference amplifiers, active, discrete functional devices, and a complete line of SCR's.

Catalogue 610.10 includes information on integrated circuits and military specifications.

DESIGNERS' DATA SHEETS

59 **Motorola Semiconductor Products Inc.** has announced the availability of several series of silicon switching transistors characterized for "worst-case" design conditions.

The Designers' Data Sheet permits the design engineer to design circuits from information presented on the data sheet. In order to do this, the usual typical curves, which provide some guidance to the engineer, have been supplemented by limit curves which are directly applicable to "worst-case" switching circuit design.

New annular silicon devices which are characterized with designers' data include "n-p-n" types 2N3252, 2N3253 and "p-n-p" types 2N3244 and 2N3245—all high-current, high-speed switching devices; and "n-p-n" types 2N2369, 2N3227 and "p-n-p" types 2N3248 and 2N3249 which are high-speed, low-current switching units.

AUDIO CATALOGUES

60 **Argos Products Company** has issued two new catalogues: the first covers a line of high-fidelity speaker systems while the second, available to dealers and distributors, covers sound-system equipment. This 12-page catalogue gives comprehensive information on portable, transistor battery-powered sound-column p.a. systems; music and voice-range sound columns; as well as baffles with speakers.

TWO-WAY RADIO PRODUCTS

61 **Decibel Products, Inc.** is now offering copies of its catalogue covering two-way radio products. The listing includes omni-directional, bi-directional, and uni-directional antennas in frequency bands from 27 to 470 mc. as well as duplexers, cavity filters, coaxial cable assemblies, and mounting hardware.

The catalogue has been designated No. 12.

CONNECTOR CAPABILITIES

62 **ITT Cannon Electric Inc.** has issued a 12-page brochure detailing its capabilities in the production of microminiature connectors.

The publication illustrates the firm's standard microminiature connectors as well as many special configurations that incorporate the company's "Micropin"/"Microsocket" combination. ▲

PHOTO CREDITS

Page	Credit
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34 (bottom), 54 (top)	RCA
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42, 44, 46	Westinghouse Electric Corp.
47, 48	Ampex Corporation
51	Rosemount Engineering Co.
54 (center)	General Radiotelephone Co.
54 (bottom)	Cadre Industries Corp.
58, 59	Official Photo, FAA

Answers to Transients Quiz

(Appearing on page 76)

(A)	10	(F)	5
(B)	8	(G)	1
(C)	6	(H)	4
(D)	9	(I)	7
(E)	2	(J)	3

Answer to Electronics Crosswords

(Appearing on page 87)

I	N	D	U	C	T	I	V	E	K	I	C	K
S	■	I	S	■	W	■	E	D	■	N	■	I
O	B	O	E	■	I	■	L	E	A	D	I	N
E	■	D	■	S	S	■	O	■	R	I	T	E
L	I	E	D	E	T	E	C	T	O	R	■	T
E	■	■	I	R	■	■	I	■	M	E	■	I
C	Y	C	L	I	C	■	T	■	A	C	■	C
T	■	A	L	E	■	E	Y	E	■	T	I	E
R	E	D	■	S	U	N	■	A	S	■	O	N
O	■	M	U	■	N	■	■	S	T	O	N	E
N	O	I	S	E	F	I	L	T	E	R	■	R
I	■	U	■	■	I	■	A	■	E	■	■	G
C	O	M	P	A	T	I	B	I	L	I	T	Y

ELECTRONICS MARKET PLACE

COMMERCIAL RATE: For firms or individuals offering commercial products or services. 60¢ per word (including name and address). Minimum order $6.00. Payment must accompany copy except when ads are placed by accredited advertising agencies. Frequency discount: 5% for 6 months; 10% for 12 months paid in advance.

READER RATE: For individuals with a personal item to buy or sell. 35¢ per word (including name and address). No Minimum! Payment must accompany copy.

GENERAL INFORMATION: First word in all ads set in bold caps at no extra charge. Additional words may be set in bold caps at 10¢ extra per word. All copy subject to publisher's approval. Closing Date: 5th of the 2nd preceding month (for example, March issue closes January 5th). Send order and remittance to: Martin Lincoln, ELECTRONICS WORLD. One Park Avenue. New York. New York 10016

FOR SALE

TRANSISTOR Ignition coils, components, kits. Advice Free. Anderson Engineering. Wrentham 5, Mass.

JUST starting in TV service? Write for free 32 page catalog of service order books, invoices, job tickets, phone message books, statements and file systems. Oelrich Publications, 6556 W. Higgins Rd. Chicago, Ill. 60656.

GOVERNMENT Surplus Receivers, Transmitters, Snooperscopes, Parabolic Reflectors, Picture Catalog 10¢. Meshna, Nahant, Mass.

TRANSISTORIZED Products importers catalog. $1.00. Intercontinental. CPO 1717, Tokyo, Japan.

DIAGRAMS for repairing Radios $1.00. Television $2.50. Give make model. Diagram Service, Box 1151 E, Manchester, Connecticut 06042.

INVESTIGATORS, free brochure, latest subminiature electronic surveillance equipment. Ace Electronics, 11500-J NW 7th Ave., Miami 50. Fla.

CANADIANS—Giant Surplus Bargain Packed Catalogs. Electronics. Hi-Fi, Shortwave, Amateur, Citizens Radio. Rush $1.00 (Refunded). ETCO. Dept. Z, 464 McGill, Montreal, Canada.

NEW transistor buried treasure, coin detectors. Kits, assembled models. $19.95 up. Free catalog. Relco, A-22, Box 10563, Houston 18, Texas.

WEBBER Labs. Transistorized converter kit $5.00. Two models using car radio 30-50Mc or 100-200Mc, one Mc spread. Easily constructed. Webber, 40 Morris, Lynn, Mass.

COPYRIGHTED theory gravitation caused by pushing radiation from stars. Important spaceage implications. $1.00 refundable. Carnahan, 4407 Ave. H, Austin, Texas.

RESISTORS precision carbon-deposit. Guaranteed 1% accuracy. ½ watt 8¢. 1 watt 12¢ 2 watt 15¢. Rock Distributing Co., 902 Corwin Road, Rochester 10, N.Y.

TRANSISTORS, SCR's, diodes, Nickel Cadmium batteries, meters, crystals, Components. Quality Guaranteed. Send 10¢ for catalog. Electronic Components Co., P.O. Box 2902, Baton Rouge, La. 70821.

CONVERT any television to sensitive, big-screen oscilloscope. Only minor changes required. No electronic experience necessary. Illustrated plans, $2.00. Relco, Box 10563, Houston 18, Texas.

COMPLETE KNIFE catalog 25¢. Hunting, Pocket, Utility. Heartstone, Dept. ZD, Seneca Falls, New York.

TV CAMERAS, transmitters, converters, etc. Lowest factory prices. Catalog 10¢. Vanguard, 190-48 99th Ave., Hollis, N.Y. 11423.

TAPE RECORDER & TELEVISION SALE. Latest models, $10.00 above cost. Arkay Sales, 22-02 Riverside Ave., Medford Mass. 02155.

DIAGRAMS, service material, Radio, Television, $1.00. Supreme Publications. 1760 Balsam, Highland Park, Ill. 60035.

LIGHT control. Dim, bright. Plugs in lamps, outlets. Uses house bulbs. $1.90 + 10¢. Walt. Weiler, Huntingdon, Penna.

HP 205AG audio generator 375 VTVM 256B Dumont scope LCR bridge meters ARC xmitters. WE regulated power supplies GE CFIAC recorder Weston 432 Wattmeter, sonar gear. Sell, trade, want hi-fi equipment. Harry Johnson, 200 Woodmont, Johnstown, Pennsylvania.

RESISTORS, NEWEST TYPE METAL OXIDE FILM, 1/8, 1/4, 1/2, 1 watt $.07-$.12 each, 18-470,000 ohms RESISTOR KITS, COPPER CIRCUIT BOARD, CAPACITORS, BATTERY MOTORS. HIGH BARRIER, TERMINAL BLOCKS, etc. Write: FARNSWORTH ELECTRONIC COMPONENTS, 88 Berkeley St., Rochester 7, New York.

SALVAGE CIRCUIT BOARDS packed with dozens of transistors, diodes, miniature transformers, capacitors, etc. Assortment "A" $5.00, "B" $4 00, "C" $3.00, all different, postpaid. ENGINEERING ASSOCIATES, 434 Paterson Road, Dayton, Ohio 45419

METERS—Surplus, new, used, panel and portable. Send for list. Hanchett, Box 1898, Riverside, California.

RCA BTA-1L 1KW Broadcast Transmitter $650.

BRAND NEW RCA ET-10 Communications Transmitter 2-20MC AM 350W .... $500.

SPECIAL TS-323/UR Freq. Mtr 20-480 MC .002% Accy. .... $195.

COLLINS 231D-20 5KW Auto Tune Transmitter 2-20 MC. with complete sets of spares $LOW

HP 608B Sig. Gen. 10MC.-400Mc, like new. $	595.00
G.R. Unit Oscill's 1211B 5 to 50mc. New .	210.00
HP 650AR Sig. Gen. 10cy to 10mc. Excellent	300.00
HP 175B Tuneable Biolmeter, New	99.00
HP 212A Pulse Generator, Excellent	325.00
HP 205 AG Audio Generator, Excellent ...	295.00
TS 418/U Sig. Gen. 400mc to 100mc. Like new	495.00
Measurements Corp. 31 Intermodulation Monitor, New	150.00
Empire Devices Broadband X-tal mixer type CM-107C. 1120mc to 1700mc. Excellent	90.00
Waveguides HP X370C. New, **$30.00.** HP S370C. New	62.50
Close-out 100 ft of RG-11A/U. PL-259 each end. New	3.50
SPECIAL PRD 1100A 3db. Attenuator	22.50
PRD 390 Adaptor. NEW	22.50
PRD 130B 6db. Attenuator	25.00
H. P. 455A Probe T. Connector	20.00
AN/URM 14 Mike Simulator	Q
AN/UKH-1 100kc Dig Counter	290.00
AN URM 25 Sig. Gen 10Kc-50Mc.	Q
HP 683C 2 to 1 KMC Sweep Oscillator	1800.00
TS-47A APR Sig Generator	75.00
TS-147/D x Band Test Set	675.00
BC-1032B Panadaptor 5.25 mc IF	125.00
Ballentine 300 VTVM	99.00
Hewlett Packard 430B Power Mtr.	120.00
TS-917 Analyzer for TTP	175.00
Dumont 324 Scopes	245.00
SP-600 JX-540 Kc-54mc/s	450.00
Tektronix 514AD	375.00
HP 400D VTVM	160.00
HP 525B	210.00
HP 500B Freq Mtr.	150.00
TS152 B U Sig Gen. 5-100mc, FM Wavemeter 5-100mc	225.00
HP 200D Audio Gen.	95.00
Bird 63A VHF Wattmeter	150.00
HP 415A SW1	130.00

WANTED: BUY OR TRADE: PRC; ARC 27, 34; APR 9; SG-1, 2, 13/ARN; ARM-5; T 368; R-39; BC-610, R-388, etc.

SPACE ELECTRONICS
4178 Park Ave.
Bronx, N. Y.
(212) CY 9-0300

CIRCLE NO. 221 ON READER SERVICE PAGE

"TAB", SILICON 750MA* DIODES

Factory Tested! Gtd.!

**NEWEST TYPE! LOW LEAKAGE*

Piv/Rms 50/35 .05	Piv/Rms 100/70 .09	Piv/Rms 200/140 .12	Piv/Rms 300/210 .16
Piv/Rms 400/280 .20	Piv/Rms 500/350 .24	Piv/Rms 600/420 .32	Piv/Rms 700/490 .40
Piv/Rms 800/560 .48	Piv/Rms 900/630 .55	Piv/Rms 1000/700 .70	Piv/Rms 1100/770 .75

ALL TESTS AC & DC & FWD & LOAD!

D.C. Power Supply: Output 330&165VDC @ 150 Ma. Inpt 115v/60 to 80 cys. **Cased! Special $5**

SILICON POWER DIODES STUDS & P.F.*

DC AMPS	50Piv 35Rms	100Piv 70Rms	150Piv 105Rms	200Piv 140Rms
3	.12	.18	.22	.30
12	.40	.60	.70	.85
18*	.25	.45	.60	.85
35	.85	1.10	1.40	1.60
100	1.75	2.15	2.50	3.10
240	4.50	5.70	6.90	8.40
D.C. AMPS	**300Piv 210Rms**	**400Piv 280Rms**	**500Piv 350Rms**	**600Piv 420Rms**
3	.40	.45	.50	.60
12	1.00	1.25	1.40	1.55
18*	1.00	1.30	Query	Query
35	2.25	2.50	2.85	3.40
100	3.75	4.60	5.65	8.00
240	16.50	24.50	Query	Query

Sil. Pressfit 18A upto 100 Piv ....4 for $1
Micro or MuSwitch CSD 35Amp/AC-DC 3 for $1

"TAB" ★ SCR's ★ TRANSISTORS ★ DIODES!!!

Full Leads Factory Tested & Gtd! U.S.A. Mfg.

PNP 50Watt/15Amp HiPower TO36 Pckg! 2N441, 442, 277, 278, DS501 up to 50 volts/VCBO $1.25 @, 5 for $5
2N278, 443, 174 up to 80v $3 @ 2 for $5.
PNP/10Watt/3A-2N155, 156, 235, 242, 254, 255, 256, 257, 301, 351: ¢35 @, 4 for $1
PNP/Signal up to 350MW TO5, ¢25 @, 6 for $1
NPN/Signal IF, RF, OSC. TO5, OV5, ¢25 @, 6 for $1
PNP 2N670/300MW ¢35 @, 4 for $1
PNP 2N671/1Watt ¢50 @, 3 for $1

Silicon PNP TO5 & TO18, Pckg ¢25 @, 5 for $1
TO36, TO3 Pckg Mica Mtg Kit 5 for $1
Power Heat Sink Finned 80 Sq $1.25 @ 5 for $5
3Amp/TO3/Pwr Transistors Untested! ....10 for $1
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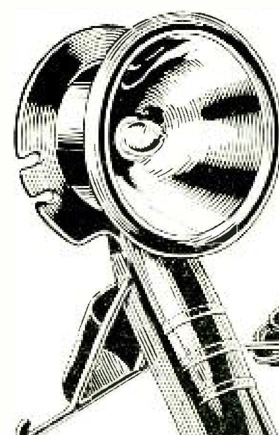

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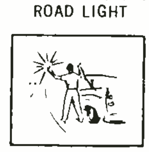

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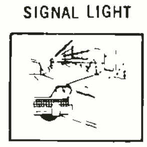

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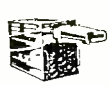

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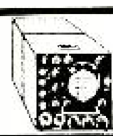

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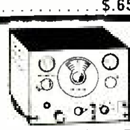

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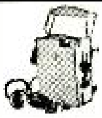

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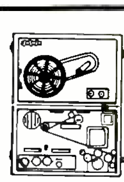

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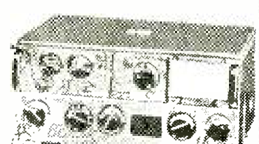
200-1500 Kc
2 to 18.1 Mc
$79.50 EXC. USED
complete with Tubes



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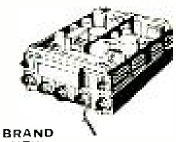
15 Tubes 435 to 500 MC



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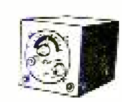

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CIRCLE NO. 183 ON READER SERVICE PAGE

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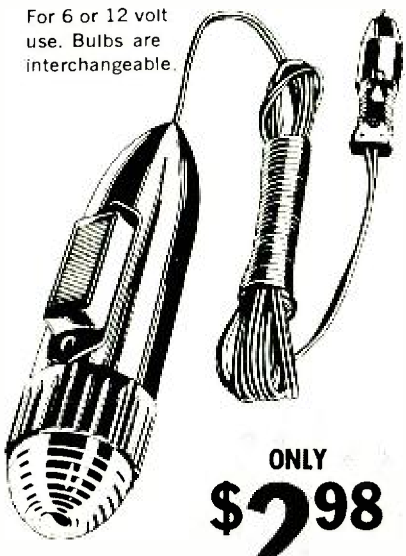

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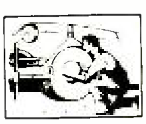

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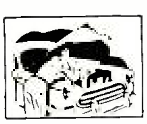
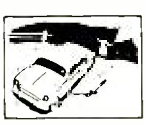
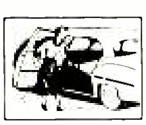


WORK LIGHT



FLASHLIGHT



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ALL-BAND SSB RCVR BARGAIN: Hallicrafters R-45 ARR-7, 550 kc to 43 mc continuous: Voice, CW, MCW: 2 RF's, 2 IF's: S-meter: 455 kc Xtl: 6 select choices. Pwr required 270 v 110 ma dc, 6.3 v 4 A ac. Less pwr sply, w/Handbook, other data, checked, aligned, clean, 100% grtd, fob Los Ang. **149.50**
Same w/60 cy pwr sply, ready to use. **179.50**
(Add $20 for SSB Product Detector installed.)

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ARC-5 Q-5'er Rcvr 190-550 kc w 85 kc IF's. Use as 2nd converter for above or other rcvrs. Checked electrically, w lots of tech. data, w/spline knob 9 lbs fob Los Ang. **14.95**
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AN APR-4 RECEIVING SET: Tune 38 to 1000 mc. Includes TN-16, 17, 18, APR-4: plug: handbook checked, grtd OK, fob Los Angeles. . **179.50**
Add $60 for TN-19, 975-2200 mc; add $125 for TN-54, 2175-4000 mc; add $30 for AM FM version of the rcvr, w 60 cy pwr sply; add $90 for 60 cy Panadapter 30 mc ±1½ mc IP-111; add $125 for RDP Panadapter w 5" CR, 30 mc ±5 mc.

LM FREQ. METER 125 kc to 20 mc is combin. heter. freq meter & signal source, CW or AM, accuracy .01%, xtl calib. Clean, checked, 100% grtd, w/plug, data, 16 lbs fob LA. **57.50**
Add $22 for LM sply w/plugs, data, or $10 for EAO, converts for LM w parts, data, included.

TS-323 UR, 20-400 mc, similar GERTSCH FM-1. Crystal, .001%, W/handbook supplement giving supplementary xtl check points & instruct. to ". . . . closely approach crystal accuracy." W/ schematic, instruct., pwr sply data, clean, checked, 100% grtd, fob Los Ang **199.50**

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Tube	Price
OA2	.80
OA3	.90
OA4G	1.35
OB2	.80
OB3	1.20
OC3	.75
OD3	.73
OG3	2.75
OY4	1.20
OZ4	.77
1A3	.73
1A5	.73
1A6	.73
1A7	1.39
1AB5	.77
1AE4	1.34
1AF4	1.30
1AG4	2.20
1AJ5	.48
1AX2	.60
1B3	.77
1B5	.98
1C5	.73
1C6	.73
1DN5	.53
1D5GP	.98
1D7	.78
1D8	2.20
1E5GP	[illegible]
1E7	.87
1F4	[illegible]
1F5	.73
1F6	[illegible]
1G3	.77
1G4	.69
1G6	.80
1H4	.95
1H5	.87
1H6	.73
1J3	.77
1J5	.98
1J6	.98
1K3	.77
1L4	.66
1LA4	.87
1LA5	2.50
1LA6	.87
1LB4	.87
1LC5	1.05
1LC6	.87
1LD5	1.95
1LE3	.87
1LG5	1.98
1LH4	.87
1LN5	.57
1N5	.87
1P5	.98
1Q5	.98
1R4	.80
1R5	.75
1S4	1.05
1S5	.70
1T4	.70
1T5	.80
1U4	.70
1U5	.63
1V	1.05
1V2	.50
1X2B	[illegible]
2A3	2.50
2A5	1.25
2A6	1.10
2A7	1.50
2AF4A	.93
2AH2	1.23
2AS2	[illegible]
2B1	.98
[illegible]	.70
2BN4	.62
2CY5	[illegible]
[illegible]	.79
2EA5	[illegible]
2EN5	.69
2ER5	1.65
2EH5	.74
[illegible]	[illegible]
[illegible]	[illegible]
2GK5	.59
2CW5	[illegible]
2HK5	[illegible]
2X2	.60
2X2A	1.30
[illegible]	[illegible]
3A3	.74
3A4	[illegible]
3A5	1.10
3AF4	[illegible]
3AL5	[illegible]
3AT2	.71
[illegible]	[illegible]
3AV6	[illegible]
3AW3	.72
[illegible]	3.45
3B7	1.35
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
3BN6	.73
[illegible]	[illegible]
[illegible]	[illegible]
3BZ6	.54
[illegible]	[illegible]
3CE5	.56
3CF6	[illegible]
3CS6	.56
3CY5	[illegible]
3D6	1.48
3DG4	.83

Tube	Price
3DK6	.58
3DT6	.52
3DZ4	.79
3EH7	.60
3EJ7	.60
3ER5	.86
3FH5	.63
3FS5	.74
3GK5	.59
3GW5	.53
3HA5	.99
3HK5	.59
3HS8	1.29
3Q4	.61
3S4	.73
3V4	.61
4AU6	.52
4AV6	.40
4BA6	.85
4BZ5	.56
4BC8	1.00
4BL8	.61
4BN6	.72
4BQ7	.99
4BS8	.96
4BU8	.71
4BZ6	.56
4BZ7	1.00
4CB6	.55
4CS6	.59
4CY5	.70
4DE6	.60
4DK6	.58
4DT6	.53
4EH7	.60
4EJ7	.60
4EM6	.94
4ES8	1.90
4EW6	.56
4GK5	.59
4GM6	.58
4GS8	1.29
4GZ5	1.49
4GZ6	.59
4HC7	.73
4HM6	.56
4HS8	.71
4HT6	.99
4JC6	1.64
4JD6	1.64
5AM8	.77
5AN8	.88
5AQ5	.52
5AR4	1.40
5AS8	1.75
5AT8	.81
5AV8	.98
5AZ4	.73
538	1.30
[illegible]	.60
5BE8	.81
5BK7	.8
5BQ7	.99
5BR8	.81
5BT8	.79
5BW8	1.31
5CG8	.79
5CL8	[illegible]
5CM8	.88
5CQ8	.82
5CZ5	.70
5EB8	.77
5DJ4	.77
5EA8	.78
5ES8	1.11
5EU8	.78
5EW6	.67
5FG7	.67
5FV8	.77
5GH8	.62
5GM6	1.04
5GX6	.54
5HC7	1.49
5HG8	.80
5J6	.70
5KE8	1.24
5T4	.84
5T8	.84
5U4	.58
5U8	.82
5V3	.88
5V4	[illegible]
5V6	.54
5W4	[illegible]
5X4	.90
5X8	.80
5Y3	.4
5Z3	1.00
5Z4	[illegible]
6A3	2.50
6A4	.73
6A5	3.00
6A6	1.50
6A7	1.10
6A8GT	1.10
6A8M	1.15
6AB4	.44
6B5	3.00
6AB7	1.00
6AC5	1.95
6AC7	.93
6AD7	3.25
6AE5	2.50
6AF3	[illegible]
6AF4	.99
6AF4A	.99
6AF5	2.50
6AF11	1.98
6AG5	.68

Tube	Price
6AG7	1.35
6AH4	.79
6AH6	1.05
6AJ5	1.95
6AJ8	1.73
6AK5	.90
6AK6	.80
6AL5	.35
6AL7	2.10
6AL11	1.05
6AM8	.76
6AN4	1.59
6AN5	2.65
6AN6	2.45
6AN8	.91
6AQ5	.52
6AQ6	1.00
6AQ7	1.73
6AQ8	.77
6AR5	.53
6AR6	.87
6AR8	2.00
6AR11	1.70
6AS5	.59
6AS6	.78
6AS7	[illegible]
6AS8	.83
6AS11	1.98
6AT6	.47
6AT8	[illegible]
6AU4	.83
6AU5	.50
6AU6	.50
6AU7	.70
6AU8	.85
6AV5	.89
6AV6	.39
6AV11	1.65
6AW8	.89
6AX3	.93
6AX4	.64
6AX5	.73
6AX7	.67
6AX8	1.45
6AY3	.59
6AZ8	1.30
6B4	3.80
6B5	4.00
6B10	1.39
6BA3	1.15
6BA6	.48
6BA7	.98
6BA8	.88
6BC1	2.10
6BC5	.59
6BC7	.88
6BC8	1.00
6BD5	1.20
6BD6	.5
6BE3	.71
6BE6	[illegible]
6BF5	.88
6BF6	.47
6BF8	1.70
6BG6	1.65
6BH6	[illegible]
6BH8	[illegible]
6BJ6	.63
6BJ7	.77
6BJ8	1.45
[illegible]	[illegible]
6BK5	.91
6BK7	[illegible]
6BL7	1.05
6BL8	.97
6BN4	[illegible]
6BN6	.70
6BN8	.74
6BQ5	.63
6BQ6/6CU6	1.08
6BQ7	.98
6BR8	.80
6BS8	[illegible]
6BU8	[illegible]
6BV8	1.23
6BW8	1.03
6BX7	1.05
6BY5	1.24
6BY6	.60
6BZ6	.54
6BZ7	.99
6BZ8	1.06
6C4	.43
6C5	[illegible]
6C6	.87
6C8	[illegible]
6CA7	1.35
[illegible]	1.35
6CA4	.73
6CA5	.77
6CB5	2.05
6CB6	.53
6CD6	[illegible]
6CF6	.95
6CG7	.59
6CG8	[illegible]
[illegible]	[illegible]
6CL6	[illegible]
6CL8	.77
6CM6	1.45
6CM7	.67
6CM8	1.02
6CN7	.68
6CQ4	1.35
[illegible]	[illegible]
6CQ8	.90
6CR6	.58

Tube	Price
6CS6	.55
6CS7	.67
6CU5	.56
6CU6	1.05
6CU8	.99
6CW4	1.09
6CW5	.78
6CX8	1.82
6CY5	.68
6CY7	.69
6CZ5	1.80
6CZ7	1.95
6D4	1.75
6D6	.67
6D10	1.95
6DA4	.66
6DA5	[illegible]
6DB5	.67
6DC6	1.30
6DC8	1.33
6DE4	.68
6DE6	.59
6DE7	.73
6DG6	.60
6DJ8	1.17
6DK6	.57
6DN6	1.76
6DN7	1.35
6DQ5	1.89
6DQ6	1.05
6DR7	.73
6DS5	1.40
[illegible]	1.30
6DT5	.79
6DT6	.51
6DT8	[illegible]
6DV4	2.65
6DW4	.90
6DW5	.99
6DZ4	.78
6E5	.85
6EA7	.88
6EA8	.77
6EB5	.71
6EB8	.91
6EH5	1.33
6EH7	.59
6EH8	.77
6EJ7	.77
6EM5	.75
6EM7	.80
6EQ7	.70
6ER5	.88
6ES5	.68
6ES8	1.39
6ET7	1.04
6EU7	.66
6EU8	.77
6EV5	.73
6EW6	.55
6EW7	.78
6EY6	.72
[illegible]	.65
[illegible]	.89
[illegible]	.93
[illegible]	1.32
[illegible]	1.83
[illegible]	[illegible]
[illegible]	[illegible]
6F5GT	1.10
6F5M	1.50
6F6	.67
6F6M	1.25
6F7	2.50
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	.67
[illegible]	[illegible]
[illegible]	[illegible]
6FJ5	2.25
6FM7	[illegible]
6FQ7	.56
6FS5	.74
6FV6	.68
6FV8	.77
[illegible]	[illegible]
6FW8	4.25
6FY5	1.25
[illegible]	1.23
6GG6	1.00
[illegible]	[illegible]
[illegible]	1.75
6GH8	.78
[illegible]	.59
[illegible]	.77
6GL7	2.35
6GM5	.78
6GM6	[illegible]
6GN8	.93
6GR7	.78
6GT5	1.00
6GV5	.98
6GV6	.85
[illegible]	1.85
6GW5	[illegible]
6GW8	1.50
[illegible]	.55
6GX8	1.25
6GY5	[illegible]
6GY6	.60
[illegible]	.53
[illegible]	.99
[illegible]	.90
[illegible]	.97
[illegible]	.70
6HJ8	.80
6HL8	.59
6HS8	.71
[illegible]	.79
6HZ6	.56

Tube	Price
6H6	.56
6J4	2.95
6JB6	.98
6JC8	.74
6JE6	2.00
6JE8	.98
6J5	.92
6J6	.69
6J7	1.65
6J8	1.40
6J11	1.83
6JH6	.55
6JH8	1.85
6JK8	.68
6JT8	1.03
6JV8	.68
6JZ8	.83
6K6	.61
6K7	.95
6K7G	.75
6K8GT	.87
6K3M	1.45
6K11	1.50
6KD8	.62
6KT8	.80
6KU8	1.05
6KZ8	.67
6LB8	1.00
6L5	.90
6L6GA	[illegible]
6L6GB	1.50
6L6G	.98
6L6GC	1.65
6L6-M	1.95
6L7	1.05
6M11	1.85
6N6	1.45
6N7	.96
6P5	.95
6Q7GT	1.27
6Q7-M	1.45
6Q11	1.05
6R7	1.25
6S4	.49
6S7	.90
6S8	.74
6SA7GT	.97
6SA7-M	1.25
6SB7Y	1.15
6SC7	1.35
6SD7	.70
6SF5	.75
6SF7	1.00
6SG7	1.10
6SH7	.97
6SJ7GT	.90
6SJ7-M	1.02
6SK7GT	.63
6SK7-M	1.46
6SL7GT	.81
6SN7	.63
6SQ7	.92
6SR7	1.00
6SS7	.95
6SZ7	[illegible]
[illegible]	.96
6T8	.83
6U5	[illegible]
6U8	.81
6V3	1.10
6V6GT	[illegible]
6V6M	2.50
6W4	.60
6W6	.69
6X4	.39
6X5	.51
6X8	.78
6Y6	1.00
7A4	.87
7A5	.87
7A6	1.15
7A7	.87
7A8	.55
7AD7	1.15
7AF7	1.45
7AG7	.87
7AH7	1.25
7AU7	[illegible]
7B4	1.45
7B5	.87
7B6	.87
7B7	.87
7B8	1.25
7C5	[illegible]
7C6	.87
7C7	.89
7E5	.87
7E6	.68
7E7	1.25
7EY6	[illegible]
7F7	1.75
7F8	.88
7G7	1.25
7H7	.95
7HG8	1.67
7J7	1.65
7K7	1.65
7L7	[illegible]
7N7	1.75
7Q7	.87
7R7	.87
7S7	.87
7V7	1.35
7W7	1.60
7X6	.95
[illegible]	1.55
7Y4	.67
7Y7	1.25
7Z4	.87

Tube	Price
8AU8	.88
8AW8	.91
8BH8	.87
8BQ5	.61
8CG7	.61
8CM7	.69
8CN7	.95
8CS7	[illegible]
8CX8	.89
8EB8	.92
8EM5	.84
8ET7	1.08
8FQ7	.54
8GN8	.97
8JV8	.93
8KA8	.84
9A8	.98
9AU7	.67
9BR7	1.32
9CL8	.77
9EA8	.66
9U8	.80
10AL11	1.09
10BQ5	.89
10C8	1.03
10DE7	.73
10EG7	.86
10EM7	1.75
10EW7	.97
10GN8	.93
10HF8	1.12
10JA8	.92
10KU8	1.07
10Y	.73
11CY7	.73
11JE8	.89
11KV8	1.52
12A4	.59
12A5	.95
12A6	.85
12A7	1.45
12A8	3.00
12A11	1.74
12AB5	.58
12AC6	.53
12AD6	[illegible]
12AE6	.48
12AE7	.92
12AF3	[illegible]
12AF6	.65
12AG6	.60
12AJ6	[illegible]
12AL5	.45
12AL8	.93
12AL11	1.05
12AQ5	.58
12AT6	.48
12AT7	.74
12AU6	.49
12AU7	.59
12AV5	.93
12AV6	.39
12AV7	.80
12AW6	.98
12AX3	.63
12AX4	.65
12AX6	.62
12AX7	.6
12AY7	1.42
12AZ7	.84
12B4	.66
12BA6	.49
12BA7	.82
12BD6	.48
12BE3	.67
12BE6	.51
12BF6	.58
12BH7	.75
12BK5	.98
12BL6	.51
12BN6	.97
12BQ6/CU6	1.11
12BR7	.72
12BV7	.74
12BW4	1.09
12BY7	.75
12BZ6	.75
12BZ7	.84
12C5	[illegible]
12CA5	.60
12CN5	[illegible]
12CR6	.65
12CS6	.63
[illegible]	1.60
12CU6/BQ6	1.05
[illegible]	[illegible]
12D4	.67
[illegible]	[illegible]
12DE5	.60
12DE8	.81
[illegible]	[illegible]
12DQ6	1.02
[illegible]	1.33
[illegible]	[illegible]
[illegible]	[illegible]
12DT7	.77
12DT8	.76
[illegible]	[illegible]
12DW8	.87
12DY8	[illegible]
[illegible]	[illegible]
12EA6	.99
12EC8	[illegible]
12ED5	.60
12EG6	.60
12EK6	.60
12EL6	.48

Tube	Price
12EL8	.86
12EZ6	.55
12F5	1.50
12F8	.64
12FA6	.77
12FK6	.48
12FM6	.48
12FQ8	.78
12FR8	.95
12FX5	.64
12FX8	[illegible]
12GA6	.63
12GC6	1.04
12GE5	.93
12GW6	1.02
12J5	.95
12J8	.82
12K5	.73
12K8G	.87
12K8M	2.75
12L6	.71
12L8	.50
12Q7GT	1.35
12Q7M	2.50
12R5	.75
12SA7GT	.87
12SA7M	2.50
12SC7	.78
12SF5GT	.98
12SF5M	1.75
12SF7GT	.65
12SF7M	1.75
12SG7	.95
12SG7M	1.10
12SH7	1.39
12SJ7GT	.99
12SJ7M	1.75
12SK7GT	.93
12SK7-M	2.00
12SL7	.78
12SN7	.65
12SQ7GT	.89
12SR7	.98
12U7	.60
12V6	.62
12W6	.69
12X4	.45
13DE7	.73
13DR7	.72
13EM7	1.22
13FD7	[illegible]
13FM7	.78
13GF7	.78
14A4	1.25
14A5	1.10
14A7	.87
14AF7	1.35
14B6	.87
14B8	[illegible]
14C5	.98
14C7	1.45
14E6	.98
14E7	.98
14F7	.87
14F8	1.45
14GT8	.80
14H7	.95
14J7	1.30
14N7	.98
14Q7	.87
14R7	.87
14S7	1.45
14W7	.98
14X7	.95
14Y4	.95
15AF11	1.95
15CW5	1.15
15FY7	1.29
15HB6	1.28
15KY8	.83
16AQ3	1.42
16GK6	.57
17AX3	.51
17AX4	.65
17AY3	.68
17BE3	.57
17BQ6	1.10
17BS3	.86
17C5	.56
17C9	1.18
17D4	.67
17DE4	[illegible]
17DM4	.78
17DQ6	1.04
17DQ7	1.85
17GE5	1.70
17GJ5	.99
17GV5	.99
17GW6	1.01
17H3	.95
17HC8	1.18
17JB6	1.12
17L6	.56
17JZ8	.93
17LD8	1.20

Tube	Price
17W6	.68
18A5	.99
18FW6	[illegible]
18FX6	.51
18FY6	.84
19	.75
19AU4	.85
19BG6	1.35
19C8	1.05
19CL8	.57
19EA8	.77
19HV8	[illegible]
19JN8	1.20
19Q9	.75
19T8	.83
2050	1.05
21EX6	1.47
21GY5	1.02
22BH3	.74
22BW3	1.43
22DE4	.67
22JG6	1.06
25A7	3.00
25AC5	2.00
25AK4	.66
25AV5	1.00
25AX4	.68
25B8	1.73
25BK5	.89
25BQ6	1.12
25C5	.51
25CA5	[illegible]
25CD6	1.50
25DK	[illegible]
25DN6	1.50
25EH5	.53
25F5	.56
25L6	.55
25W4	.66
25Z5	1.10
25Z6	.73
27GB5	1.59
32ET5	.53
32L7	.85
33GY7	1.40
34DG5	.51
34GD5	.79
35A5	.85
35B5	.95
35C5	.49
35EH5	.55
35L6	.58
35W4	.40
35Y4	1.63
35Z3	1.20
35Z5	.58
50A5	1.49
50B5	.68
50C5	.51
50DC4	.46
50EH5	.53
50HC6	.86
50HK6	.54
50L6	.59
50X6	.67
50Y6	.95
50Y7	1.10
60FX5	.60
70L7	.89
117L7	2.50
117N7	3.95
117P7	3.95
117Z3	.83
22	.95
24A	.95
26	1.10
27	1.50
28D7	1.50
30	1.15
32	1.00
33	.85
34	.79
35-S1	.85
36	.95
37	.70
38	.90
39/44	[illegible]
41	.95
42	1.25
43	1.20
45	2.00
46	.95
47	2.10
48	3.50
50	[illegible]
53	2.98
55	1.90
56	[illegible]
57	1.35
58	1.85
59	2.50
71A	.95
75	1.90
76	1.40
77	1.25
78	1.15
80	1.25
81	1.25
82	1.23
83	2.10
84/6Z4	.95
85	.98
5881	2.95
6336	5.95
6146	3.95
6550	3.75
807	.70

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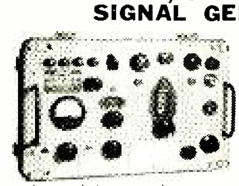
TS-147B/UP MICROWAVE SIGNAL GENERATOR



Portable unit designed for testing and adjusting Radar, Beacon, and Communication systems operating in the frequency range of 8500 to 9600 MC. Provides either F-M or CW test signals of known power level & frequency. This unit contains a direct-reading freq. meter and a power-level meter which measures power referenced to one Milliwatt (DBM). Used to measure both the freq. and power level of the input and output signals. Spectrum width, frequency change, recovery time, and standing wave ratio. Also can be modulated externally. Operates from 115 V. 50-1600 cy.; less cables, plugs, adapter, pick up horn. Size: 11¼ x 18¾ x 12¼".

TS—147B/UP Test Unit, as Photo — Used: $99.50

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Receiver-Transmitter covering freq. range of 950-1150 MC. I.F. Freq. 59.5 1.5 MC. (Can be converted to 1296 and 1220 Bands.) With Tubes (30) 6/6J6, 1 6AS6, 1 5687, 1 3E29, 3 6AL5, 1 5Y3, 2 3B24, 3 6AL5, 2 12AU7, 7 6AK5, 1 2C42, 1 2C46, [illegible] 0, 1 1N-43, 1 1N-25. Digit Counters. Tuners for Trans.-Freq., Rec.-Freq. and LO Freq. Operates from 24 Volts DC & 115 Volts 400 800 cycle. Shpg. Wt.: 45 lbs. Price — Used: $16.95

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BC-348R RECEIVER — AM 6 Bands 200-500 KC and 1.5 to 18 MC. Crystal phasing, antenna align., beat oscillator & audiogain controls, vernier and speed tuning, output jacks for phones and speaker. With Tubes: 3/6K7, 1/6J7, 1/6C5, 1/6K6, 1/6B8, & 1/6F7. Voltage required: 24 Volts 2 A. & 220 VDC 70 MA. Size: 18 x 10½ x 9½". Wt.: 38 lbs. Used $89.50

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400	280	.20 ea	500	350	.24 ea	600	420	.32 ea	700	490	.40 ea
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D.C. AMPS	50 PIV 35 RMS	100 PIV 70 RMS	150 PIV 105 RMS	200 PIV 140 RMS
3	.12	.18	.22	.30
12	.45	.65	.75	.90
35	.90	1.15	1.50	1.70
50	1.60	1.90	2.30	2.80
100	1.75	2.15	2.55	3.15

D.C. AMPS	300 PIV 210 RMS	400 PIV 280 RMS	500 PIV 350 RMS	600 PIV 450 RMS
3	.40	.45	.55	.65
12	1.10	1.35	1.50	1.70
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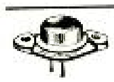

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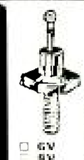

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- 2-500MC PNP MESA TRANSISTORS, TO18 case..........$1
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- 10 PHILCO MAT HI-FREQ. TRANSISTORS, untested....$1
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PRV	7 AMP	15 AMP	25 AMP
50	1.00	1.25	1.50
100	1.50	1.95	2.25
150	1.75	2.25	2.75
200	1.95	2.75	2.95
250	2.25	2.95	3.25
300	2.69	3.19	3.50
350	2.95	3.50	4.25
400	3.25	3.95	4.50

SILICON POWER DIODE STUDS

Amps	Volts	Sale	Amps	Volts	Sale	Amps	Volts	Sale
6	200	37¢	25	200	1.60	50	100	2.95
6	400	59¢	25	300	1.75	50	200	3.75
6	600	69¢	25	400	1.95	100	25	1.50
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6	1000	95¢	35	50	1.05	240	25	4.50
12	50	49¢	35	100	1.29	240	50	4.95
12	100	69¢	35	150	1.50	240	100	5.90
12	200	88¢	35	200	1.75	240	150	6.75
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CIRCLE NO. 206 ON READER SERVICE PAGE

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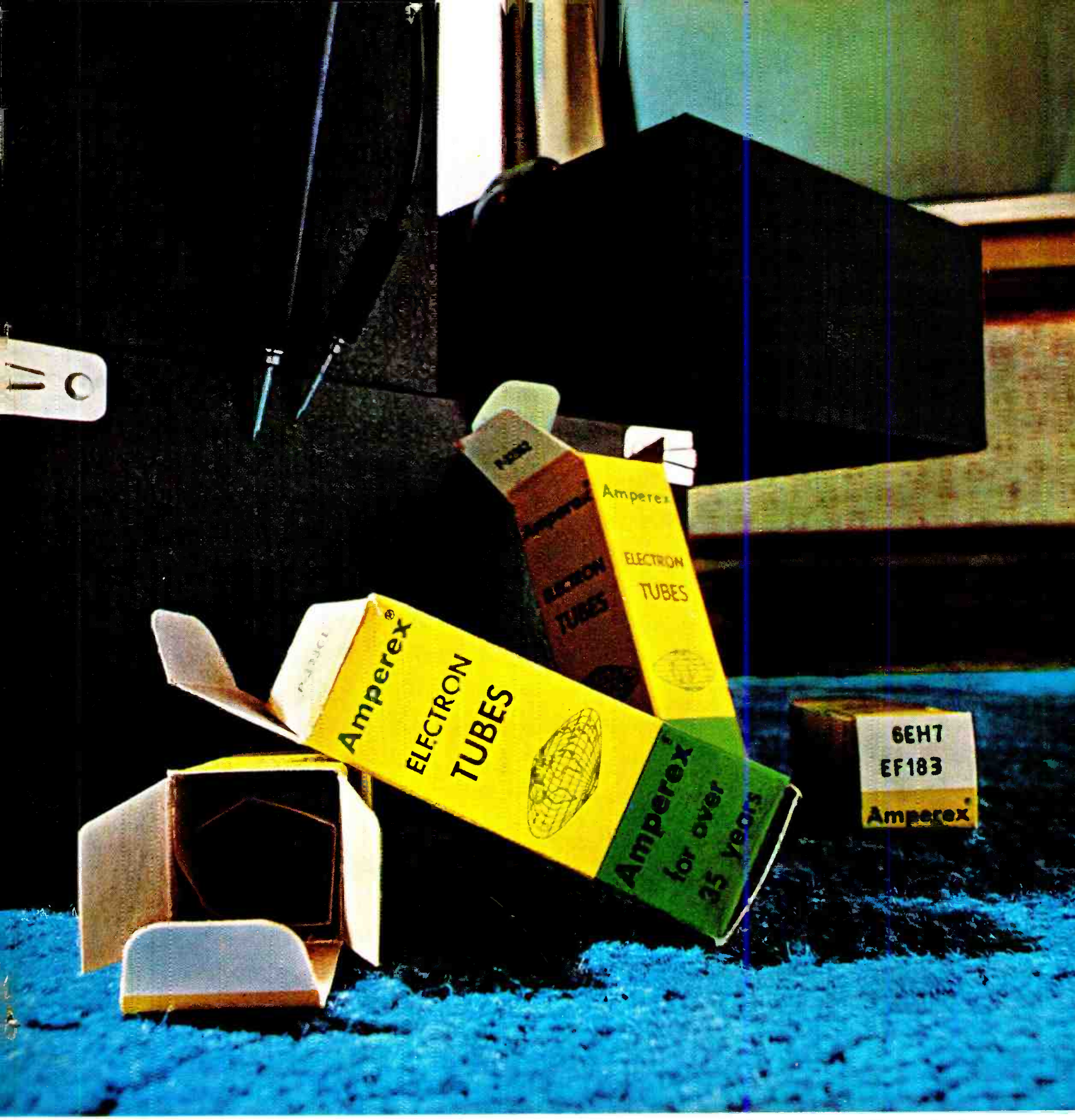

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If your distributor does not yet have all the Amperex types you need, please be patient—in some areas the demand keeps gaining on the supply.

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CIRCLE NO. 248 AN READER SERVICE PAGE

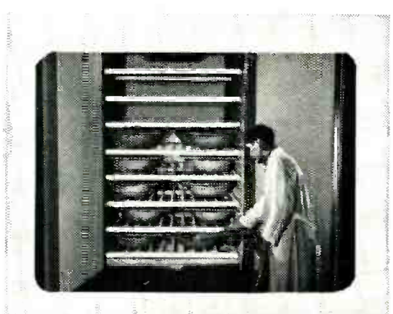
WHERE THE SILVERAMA® SCREEN BEGINS

TV picture quality depends on precise control of phosphors

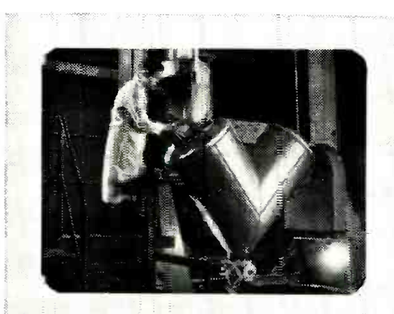
Television picture quality depends on the quality of the phosphor screen inside the faceplate. That's why every RCA Silverama replacement picture tube is completely rescreened—in the same painstaking manner and with the same precision—as RCA picture tubes produced for use in original equipment. Before receiving their new Silverama screens, reused glass envelopes are scrubbed completely clean and given a series of chemical baths internally to restore them to the peak of their optical capabilities.

RCA produces and develops its own screen phosphors. These are formed by reacting solutions of zinc sulfate and zinc and cadmium sulfates with hydrogen-sulfide gas in this complex precipitator, (above). The resulting zinc sulfide and zinc-cadmium sulfide are then activated, fluxed, fired, washed, dried, and screened to form phosphors which emit blue and yellow light, respectively. These are carefully blended to produce phosphors that possess the pleasing "white", high light output, and uniform smoothness, which characterize RCA Silverama picture tube screens.

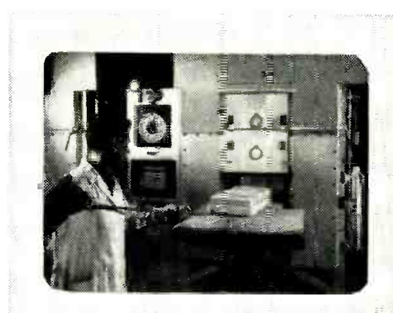
Make RCA Silverama your first choice in picture tubes.



Drying ovens remove moisture from phosphor



Phosphors are blended for best screen quality



Base materials are fired to form the phosphors

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