Electronics World

NOVEMBER, 1965
50 CENTS

117-VOLT TRANSISTORIZED PORTABLE TV

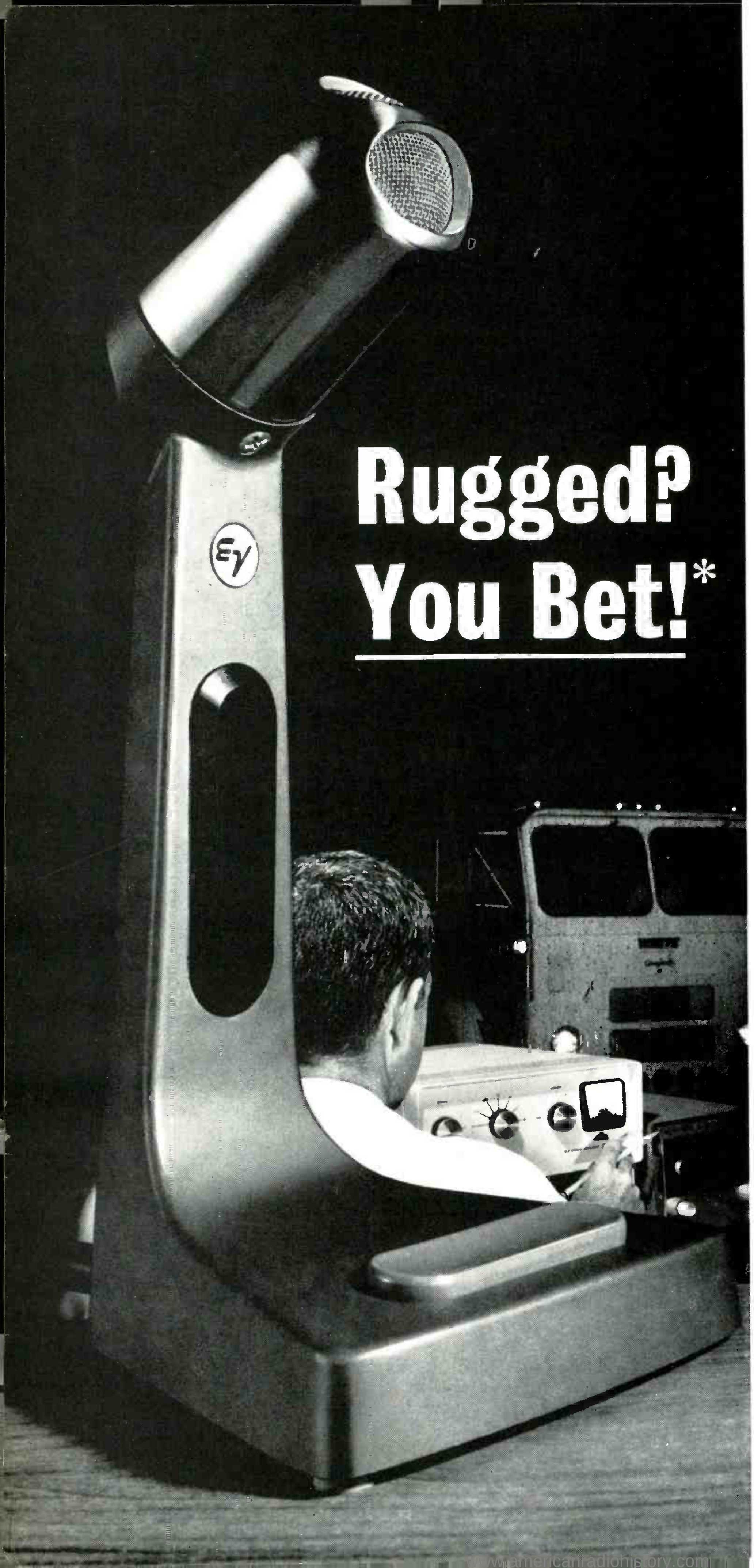
MICROMETEOROID MEASUREMENTS

GLASS FOR ELECTRONICS

CERAMIC I. F. FILTERS

special features on:

INTEGRATED CIRCUITS



TOUCH-TO-TALK
PAGING/COMMUNICATIONS
MICROPHONES

Model 619 Dynamic $47.50 List
Model 719 Ceramic $27.50 List
(Less Normal Trade Discounts)

EV• These new beauties are tough. No flashy, fragile plastic housings. No skimpy, lightweight metal. We use a 400-ton die-casting machine to squeeze molten metal under high pressure into a solid, two-pound chunk that laughs at the bumps and bruises of heavy service. And the long-lasting good looks are guaranteed by deep, gleaming chrome and tough baked enamel.

Behind that big touch-to-talk bar is a telephone type-leaf switch that will last a million calls or more. It latches on with a simple, positive sliding motion. Converts to grip-to-talk position on the stand riser—latching feature and all—in minutes with just a screwdriver. The DPDT switch operates both voice and relay circuits with the option of electronic switching, on the 619 (Hi-Z) and 719, right at the end of the cable . . . no modifications whatsoever.

At E-V, intricate automatic production machines insure almost monotonously perfect Acoustalloy® diaphragms and voice coils in the 619 dynamic models. The result is smooth, peak-free response from 70 to 10,000 cps at —57 db for highest useful modulation. The 619 shrugs off extremes of heat, humidity, and accidental abuse. Both Hi-Z and balanced Lo-Z versions are available.

No less reliable is the more economical Model 719 ceramic version. Response is from 80 to 7,000 cps at —56 db.

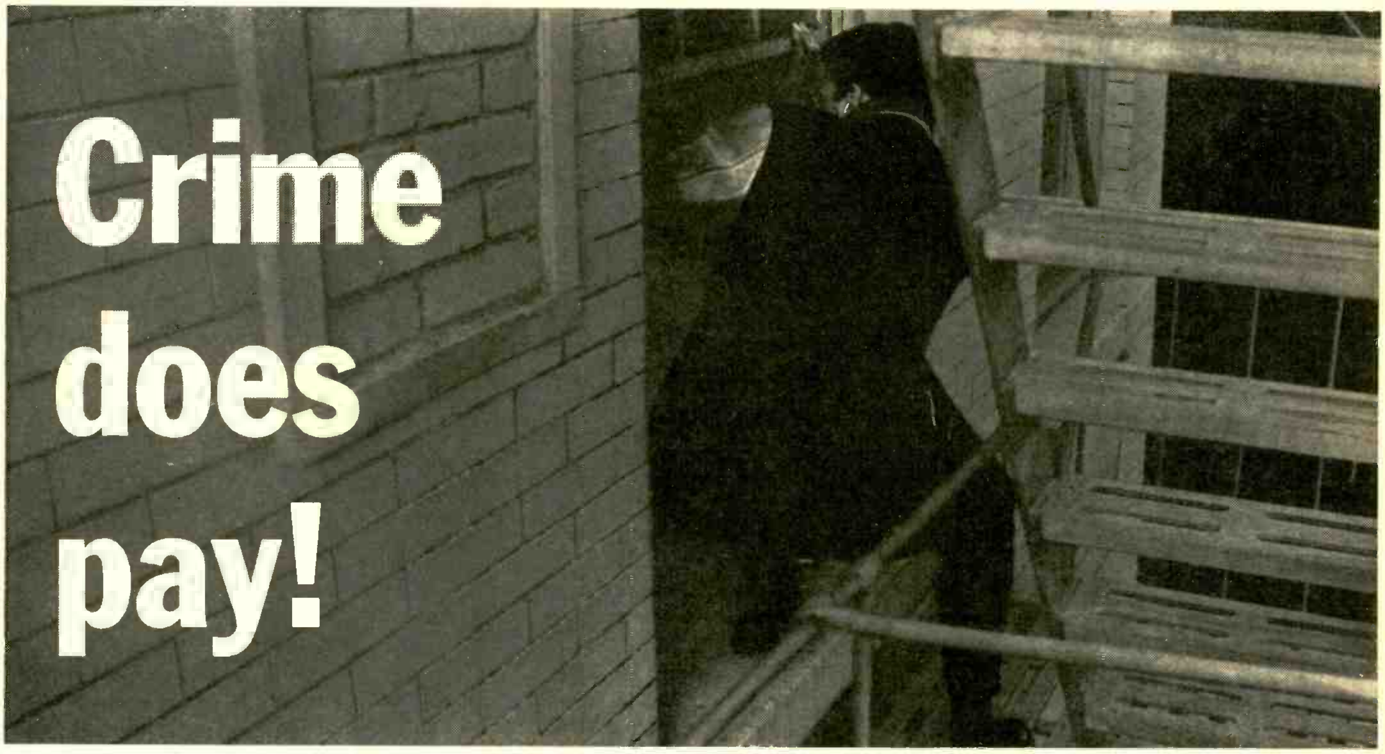
Both models are omnidirectional, are furnished complete with heavy-duty cable. Try one of these rugged new beauties today. You'll find that 2-way radio, paging, and dispatching never sounded — or looked — so good!

ELECTRO-VOICE, INC.,
Dept. 1152N, 629 Cecil Street,
Buchanan, Michigan 49107

Electro-Voice®
SETTING NEW STANDARDS IN SOUND

*We cover our bet with a *lifetime* guarantee. If any 619 or 719 ever fails, just send it to us. We'll repair it at a nominal cost. But if there's even a hint that our workmanship or materials weren't up to par, the repair is on the house — even 30 years from now! Fair enough?

CIRCLE NO. 117 ON READER SERVICE CARD



Every 40 seconds a burglary takes place in the United States.

TECHNICAL INFORMATION

The RADAR SENTRY ALARM is a complete U.H.F. Doppler Radar System which saturates the entire protected area with invisible r.f. microwaves. It provides complete wall to wall—floor to ceiling protection for an area of up to 5,000 square feet. Without human movement in the protected area, the microwave signal remains stable. Any human movement (operation is unaffected by rodents and small animals)in the area causes the doppler signal to change frequency approximately 2 to 4 cps. An ultra-stable low frequency detector senses this small frequency change, amplifies it and triggers the police type siren—which is heard up to a half mile away.

In addition, the RADAR SENTRY ALARM's protection can be extended to other areas with the use of the following optional accessories:

- *remote detectors for extending coverage to over 10,000 sq. ft.*
- *rate of rise fire detector U.L. approved for 2,500 sq. ft. of coverage each (no limit on the number of remote detectors that can be used)*
- *hold-up alarm*
- *central station or police station transmitter and receiver (used with a leased telephone line)*
- *relay unit for activating house lights*
- *battery operated horn or bell which sounds in the event of: powerline failure; equipment malfunction or tampering*

At that rate, it's a multi-million dollar a year business... for burglars.

And an even better business opportunity for you.

Why? Because burglary can be stopped...with an effective alarm system.

In fact, police and insurance officials have proved that an alarm system reduces, and in many cases, eliminates losses—even helps police apprehend the criminal.

Here's where you come in.

Only a small percentage of the more than 100 million buildings—stores, offices, factories, schools, churches and homes are protected by an effective alarm system.

That means virtually every home, every business is a prospect.

You can sell them!

And you don't have to be a super-salesman to sell the best protection available—a Radar Sentry Alarm unit. All you have to do is demonstrate it... it sells itself.

A glance at the technical information shows why.

It's the most unique and effective alarm system ever invented.

And here's the proof.

In the past six years, thousands of RADAR SENTRY ALARM units have been sold in the Detroit, Michigan area alone—sold by men like yourself on a part-time and full-time basis.

Here are just a few customers who are protected by RADAR SENTRY ALARMS:

U.S. Government
U.S. Air Force
Detroit Board of Education
Hundreds of Churches, Banks, Businesses and Homes.

Everyone is a prospect.

So take advantage of your profession. Put your technical knowledge and experience to work for you in a totally new area—an area that will make money for you!

Don't wait!

Let us prove that crime does pay.

Become a distributor.

Write now for free details.

RADAR SENTRY ALARM

Mail to: RADAR DEVICES MANUFACTURING CORP.
22003 Harper Ave., St. Clair Shores. Michigan 48080

Please tell me how I can have a business of my own distributing Radar Sentry Alarm Systems. I understand there is no obligation.

Name__________
SW-11
Address__________
City______ **State & Code**______

CIRCLE NO. 98 ON READER SERVICE CARD

FREE!

From now through December 15, 1965

Get a Color-TV TEST Picture Tube with every RCA WR-64B Color Bar/Dot/Crosshatch Generator you buy

Yes! You read right!

From now through December 15, 1965—with every purchase of an RCA WR-64B Color Bar Generator—you get a FREE color-TV TEST picture tube for use in your color-TV test jig. This is a 21-inch 70° round color-TV TEST picture tube, electrically guaranteed six months from first installation date. These tubes will have minor mechanical (not electrical) defects... they're not quite good enough to go into a new TV set but perfectly adequate for testing purposes.

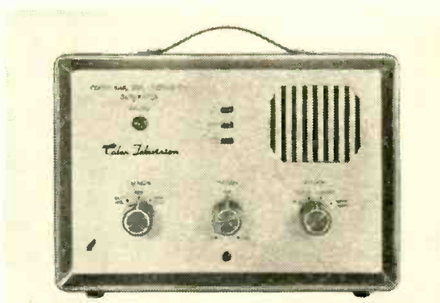
How to get your FREE Color Test Tube

Simply buy an RCA WR-64B Color Bar Generator—*THE* essential color-TV test instrument—between now and December 15, 1965. Fill out your warranty registration card and attach the red identification label on the WR-64B carton. Send them to RCA, Test Equipment Headquarters, Bldg. 17-2, Harrison, N.J. We send you the tube (either from Lancaster, Pa. or Marion, Ind.) freight charges collect. To allow for postal delay, we will honor cards received up until December 31st.

Don't miss out on this never-before offer. You've got to have a color-bar generator anyway—so be sure you buy it now—at the regular price—while you can get a FREE color test tube.

$189.50*

Optional distributor resale price; subject to change without notice. Price may be higher in Alaska, Hawaii and the West.



RCA WR-64B Color Bar/Dot/Crosshatch Generator

RCA ELECTRONIC COMPONENTS AND DEVICES, HARRISON, NEW JERSEY

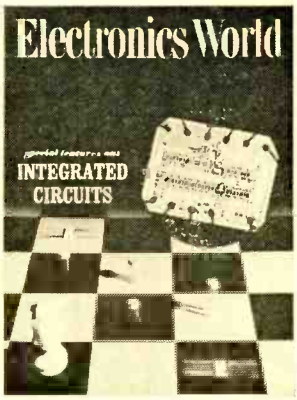
The Most Trusted Name in Electronics

Electronics World

NOVEMBER 1965
VOL. 74, No. 5

CONTENTS

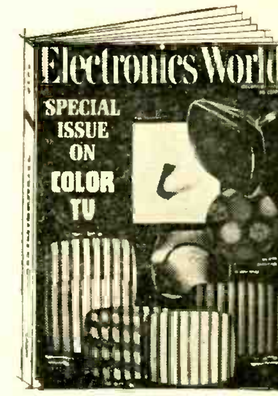
MONTHLY FEATURES



THIS MONTH'S COVER illustrates some of the packaging techniques used for present-day integrated circuits. The physical size of these complex multitransistor devices can be inferred by comparing them to the standard chessman and chessboard shown. The photomicrograph, shown in blue at the upper right, is a 21-bit shift register fabricated by General Instrument Corp., containing 110 transistors of the MOS type and 48 resistors, all on a single chip .07-inch long by .06-inch wide. Operating at a clock rate of 500 kc., this single chip can replace 21 separate microcircuits. The special articles in this issue cover various aspects of linear integrated circuits and developments in this new area of electronics. . . . . (Photo: Bob Rubic)

Electronics World: Published monthly by Ziff-Davis Publishing Company at 307 North Wabash Ave., Chicago, Ill. 60601. One year subscription $5.00. Second Class Postage paid at Chicago, Ill. and at additional mailing offices. Subscription service: Portland Place, Boulder, Colo. 80311

COMING NEXT MONTH



SPECIAL COLOR-TV ISSUE

Six authoritative articles on various aspects of color television will highlight the December issue. J. F. Holahan of RCA discusses the basic principles of colorimetry and color perception as applied to color-TV, while color-TV ghosts, a reception problem, is covered by Walter H. Buchsbaum, along with suggestions for correcting such conditions. A directory of 1966 color-TV chassis provides the basic characteristics of the color sets and picture tubes of 17 manufacturers, along with brief details on their special features. Details on the new rare-earth phosphor are given by Miller and Rychlewski of Sylvania while troubleshooting problems in setting up a color set are outlined by Vic Bell, also of Sylvania. How RCA's color-TV picture tubes are made is the subject of still another story.

CRYOGENICS IN ELECTRONICS
The important uses for equipment producing ultra-low temperatures—including space environment simulation, low-noise amplifiers, and superconducting magnets—are discussed in an authoritative article by William Nelson.

FET'S FOR FM FRONT-ENDS
Because of their almost perfect square-wave characteristic, field-effect transistors make possible a hi-fi tuner with no spurious response or cross-modulation problems. Daniel von Recklinghausen of Scott analyzes such a front-end design.

OPERATION OF A HIGH-QUALITY CCTV CAMERA
Gerald Hansen of Cohu Electronics discusses the operation of this important device. Electromagnetically scanned vidicons, broadcast-type interlaced sync, automatic vidicon target control, and digital-type techniques put such sophisticated closed-circuit cameras almost in the studio class.

*All these and many more interesting and informative articles will be yours in the DECEMBER issue of ELECTRONICS WORLD . . . **on sale November 18th.***

ZIFF-DAVIS PUBLISHING COMPANY

William B. Ziff
Chairman of the Board (1946-1953)

William Ziff
President

W. Bradford Briggs
Executive Vice President

Hershel B. Sarbin
Vice President and General Manager

Philip Sine
Financial Vice President

Walter S. Mills, Jr.
Vice President, Circulation

Stanley R. Greenfield
Vice President, Marketing

Phillip T. Heffernan
Vice President

Frank Pomerantz
Vice President, Creative Services

Arthur W. Butzow
Vice President, Production

Editorial and Executive Offices
(212 ORegon 9-7200)
One Park Avenue, New York, N.Y. 10016

NEW YORK OFFICE (212 ORegon 9-7200)
James J. Sullivan
Joseph E. Halloran

MIDWESTERN OFFICE (312 726-0892)
307 North Michigan Avenue, Chicago, Ill. 60601
Midwestern Advertising Manager, Royce Richard

WESTERN OFFICE (213 CRestview 4-0265)
9025 Wilshire Boulevard, Beverly Hills, Cal. 90211
Western Advertising Manager, Bud Dean

CIRCULATION OFFICE
Portland Place, Boulder, Colorado, 80311

Member Audit Bureau of Circulations

Radio & TV News • Radio News • Radio-Electronic Engineering Trademarks Reg. U.S. Pat. Off.

SUBSCRIPTION SERVICE: All subscription correspondence should be addressed to Electronics World, Circulation Dept., Portland Place, Boulder, Colorado 80311. Please allow at least six weeks for change of address. Include your old address as well as new—enclosing if possible an address label from a recent issue.

EDITORIAL CONTRIBUTIONS must be accompanied by return postage and will be handled with reasonable care; however publisher assumes no responsibility for return or safety of art work, photographs, or manuscripts.

ELECTRONICS WORLD (November 1965, Vol. 74, No. 5) is published monthly by Ziff-Davis Publishing Company at 307 North Michigan Avenue, Chicago, Ill. 60601. (Ziff-Davis also publishes Skiing, Flying, Business/Commercial Aviation, Popular Boating, Car and Driver, Popular Photography, HiFi/Stereo Review, Popular Electronics, Modern Bride, Skiing Trade News and Skiing Area News.) One year subscription rate for U.S., U.S. Possessions and Canada, $5.00; all other Foreign, $6.00. (Schedule for payment in Foreign currencies may be found elsewhere in this issue.) Second class postage paid at Chicago, Illinois and at additional mailing offices. Authorized as second class mail by the Post Office Department, Ottawa, Canada and for payment of postage in cash.

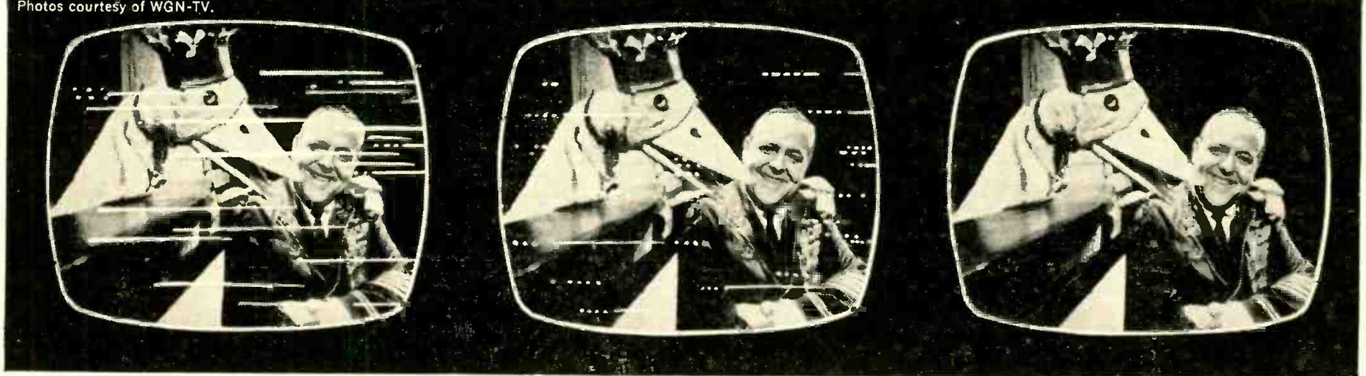
new
8290
Shielded Permohm*
Shown Actual Size

82 Channel TV lead-in

for the strongest, cleanest picture signal and best color... ever!

- Provides 82 channel color reception
- Less installation time and cost
- Eliminates transmission line pick-up of noise and ghost signals
- No expensive matching transformers required
- Can be installed anywhere

Photos courtesy of WGN-TV.



Unshielded twin-lead	Coaxial Cable	* Shielded Permohm
Severe picture disturbance due to ignition noise.	Ignition noise minimized—but not eliminated.	Eliminates automobile ignition noise.

New 8290 Shielded Permohm TV Lead-in combines the strong signal strength of twin-lead with the clean signal protection of shielded cable. Because it is a balanced line for 300 Ohm TV antennas and receivers, *costly matching transformers and connectors are eliminated.*

8290 is specifically designed for superior color reception on all 82 channels. The twin-lead is encapsulated in low-loss cellular polyethylene insulation, Beldfoil** shielded against all outside disturbances, and protected with a weatherproof jacket. A drain wire is provided for grounding the shield to the chassis. The need for stand-offs, twisting or routing of lead-in is eliminated. 8290 can be taped directly to a mast or tower, routed through metal pipe, buried underground, or even installed in rain filled gutters to reduce installation time and cost.

Ask your distributor about 8290 Shielded Permohm TV Lead-in cable, today! Or, write P. O. Box 5070-A for complete information.

*Belden Trademark—Reg. U.S. Pat. Off.

*Belden U.S. Patent 2,782,251
**Belden U.S. Patent 3,032,604

8-9-5

BELDEN MANUFACTURING COMPANY **Belden** P.O. Box 5070-A • Chicago, Illinois 60680

CIRCLE NO. 199 ON READER SERVICE CARD

For the record

WM. A. STOCKLIN, EDITOR

HOME VIDEO TAPE RECORDERS

EVER since 1956 when *Ampex* originally announced the development of its TV broadcast video-tape recorder, engineers in both this country and abroad have been working feverishly to develop a home version simple enough for the consumer to operate and sufficiently low in cost for him to afford.

The market potential is tremendous and the only limitations would be those of cost, quality, and ease of operation. Today's audio tape recorders have the ability to reproduce frequencies from 40 to 16,000 cps. The response required for reasonable fidelity of a black-and-white picture is at least 2 megacycles with one megacycle being absolute minimum. Comparing these with the 2.5- to 3.5-mc. video bandwidth of a TV receiver will give some idea as to the type of picture quality that is obtained.

There are really two main approaches to achieving reasonable performance. The first is to push ¼″ tape past the head at speeds up to 150 ips. This is the simplest technique. The transport mechanism problems, as well as the head wear, become intensified and playing time is limited unless a very large amount of tape is used.

The second, and more professional, approach is to use a helical-scan system where the head itself rotates within a housing across which a wider tape (½″ to 2″) moves. The tape transport would then operate at a more reasonable speed, anywhere from about 4½ to 10 ips.

One hasn't much choice at present. You are limited to a *Westgrove* VKR-500 factory-wired, high-speed design for $794 or the kit version for $392 (which is directed to the qualified electronics technician only) and two helical-scan units from *Norelco* and *Loewe-Opta* at around $4000. But wait until early 1966 and we can expect three new helical-scan designs from *Matsushita* at around $800; *Sony* at $995 (including a miniature TV receiver and monitor); and *Ampex* at $1095.

Are these bargains? They are if you compare these prices with a $50,000 TV broadcast video recorder or the $10,000-$15,000 industrial designs available.

The *Westgrove* recorder is a three-speed version (90, 120, and 150 ips) which can produce an hour recording time per reel on two tracks at 90 ips, using a triple-play tape on an 11½″ reel. The *Loewe-Opta* uses a 1″ tape on an 8″ reel and produces one hour of recording at 6 ips. The *Norelco* EL-3400 also uses a 1″ tape on a 9″ reel for 60 minutes of recording time at 9 ips. The expected *Ampex* Model 6100 will similarly use a 1″ tape on a 9½″ reel and will provide one hour of uninterrupted recording time at 9.6 ips. The tape costs about $65.00. Actually there will be six *Ampex* models ranging upward to $2495. The *Sony* TVC-2010 uses ½″ video tape on a 7″ reel at 7½ ips. It works half as hard in that it records only every other line as compared with a conventional TV picture. Very little is known about the *Matsushita* tape recorder except that it will be designed for ½″ tape on an 8″ reel.

Why all the excitement? They are designed only for black-and-white; they are not compatible (in fact in some cases a recording taped on one machine cannot be re-played on a machine of the same model number); the prices are too high for a true home recorder; quality is fair to excellent depending on the unit, and they are fairly complicated to operate. They are, however, the forerunners of a vast new industry in the making.

No doubt there are many who want to record video programs for later re-play. A timer might be used to turn a set on and off when you're away from home. Some day we can expect a complete video tape library of pre-recorded material much like our present hi-fi/stereo audio tape recordings. By attaching a video camera you convert the system into a home movie system . . . probably not as portable as a conventional movie camera, but with the advantage of being able to be played back immediately, and the tape could be erased and re-used. Certainly it is an ideal medium for observing yourself practicing your golf swing, tennis stroke, or even a speech.

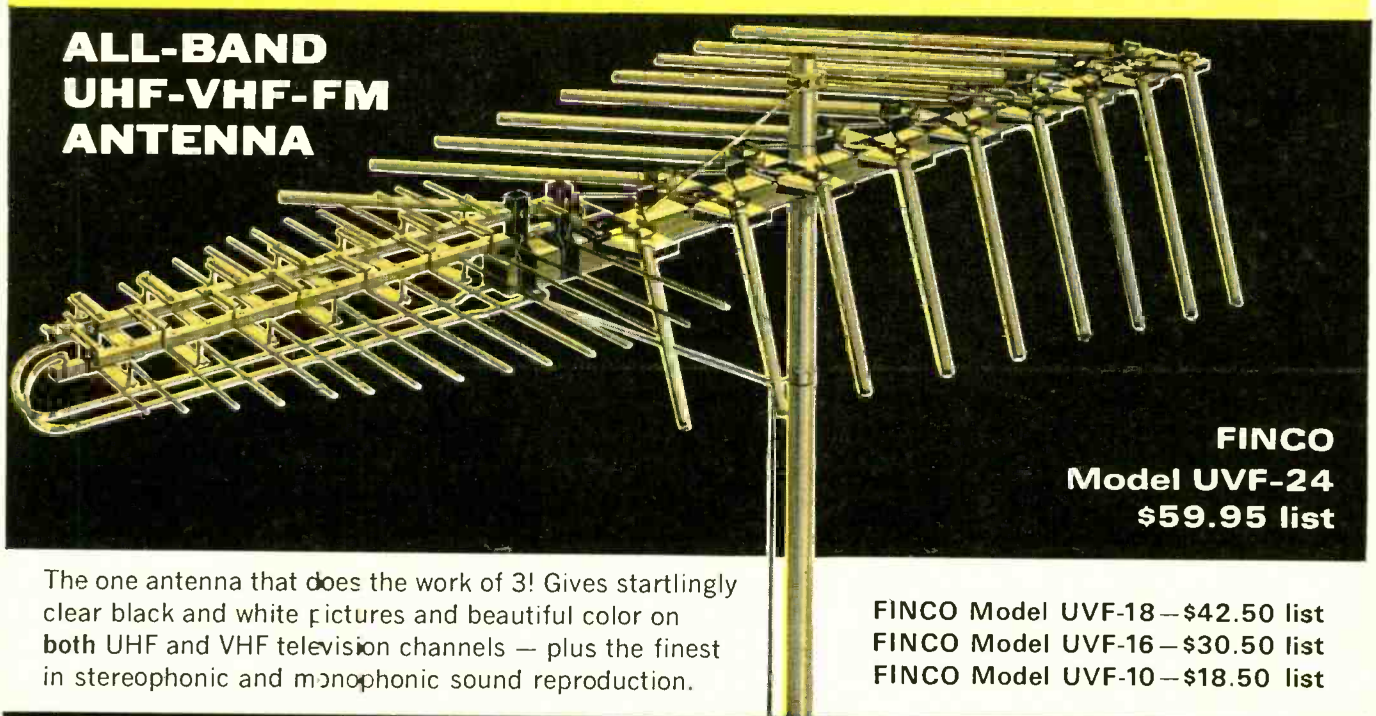
Forgetting the home for the moment, machines of this type at the prices eventually possible could open new markets in industry, offices, and all types of businesses. They might be adapted for closed-circuit TV security checks in banks, plants, supermarkets, restaurants. Also, there are many educational applications and uses for vocational sales training, etc.

Of course new developments are forthcoming quite rapidly. For example, *Par Ltd.*, a New Jersey company under the technical direction of A. Stewart Hegeman, has announced that it has a major innovation on a drive mechanism which permits the use of thin ¼-mil tape. They claim they can reproduce acceptable TV pictures at 60 ips (180 line reproduction) using a longitudinal method. This is somewhat better than 2-mc. bandwidth. Their goal is to produce and market such a machine by mid-1966 for $400-$600. We feel their timing is overly optimistic.

The general reaction within the industry is that a top-quality video recorder will be available for about $500 within the next five years. Add to this $300-$400 for a closed-circuit camera and we will have a new industry—a new consumer product with a tremendous market potential. ▲

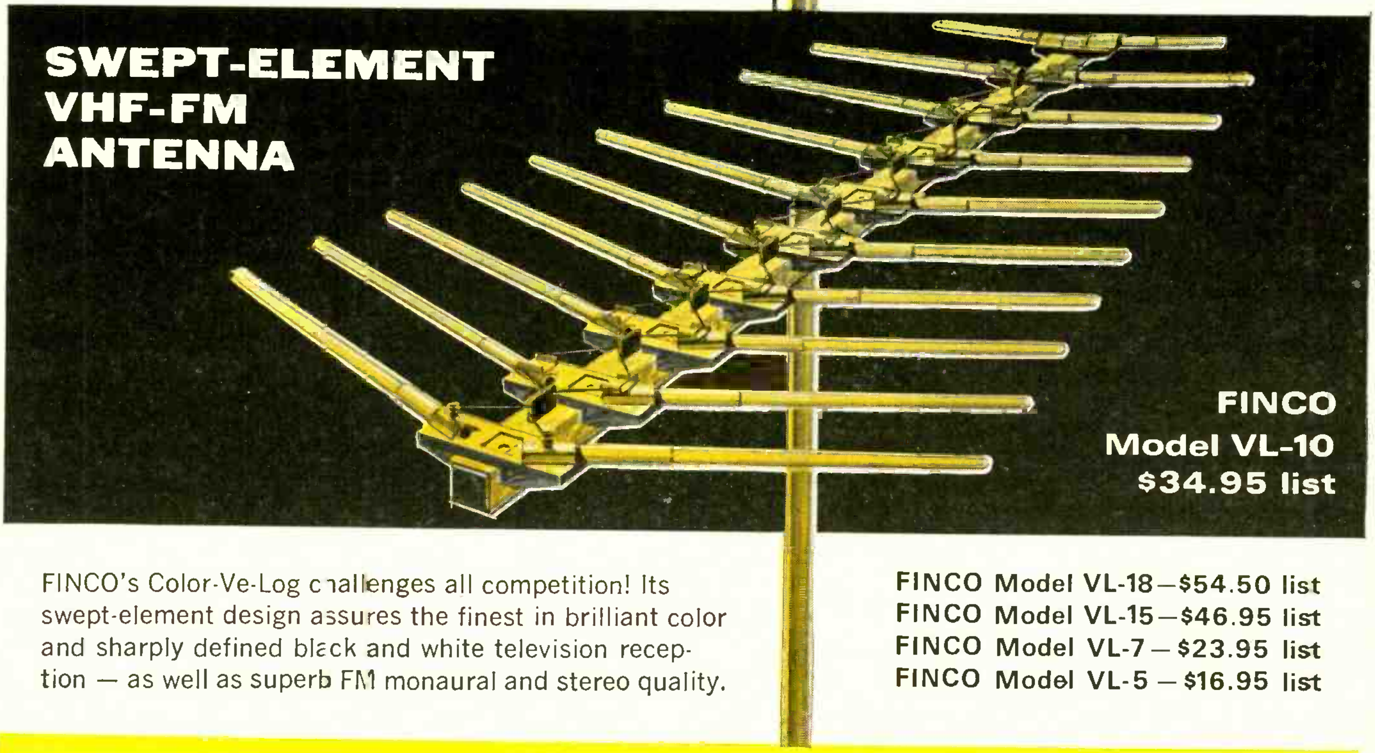
FINCO COLOR-VE-LOG ANTENNAS

FOR UHF, VHF, FM RECEPTION



The one antenna that does the work of 3! Gives startlingly clear black and white pictures and beautiful color on **both** UHF and VHF television channels — plus the finest in stereophonic and monophonic sound reproduction.

FINCO Model UVF-18—$42.50 list
FINCO Model UVF-16—$30.50 list
FINCO Model UVF-10—$18.50 list



FINCO's Color-Ve-Log challenges all competition! Its 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 Model VL-18—$54.50 list
FINCO Model VL-15—$46.95 list
FINCO Model VL-7—$23.95 list
FINCO Model VL-5—$16.95 list

Featuring FINCO's exclusive Gold Corodizing

FINCO COLOR-VE-LOG

Prices and specifications subject to change without notice

THE FINNEY COMPANY • 34 W. Interstate Street • Bedford, Ohio

Write for beautiful color brochures Number 20-322, and 20-307, Dept. 410.

CIRCLE NO. 116 ON READER SERVICE CARD

Discover the ease and excitement of NRI's

3 DIMENSIONAL METHOD

of ELECTRONICS TV-RADIO TRAINING

10 HOME-STUDY PLANS TO CHOOSE FROM

Ask men whose judgment you respect about NRI's three dimensional method of home-study training. Ask about the new, remarkable NRI Achievement Kit. Ask about NRI custom-designed training equipment, programmed for the training of your choice to make Electronics come alive in an exciting, absorbing, practical way. Ask about NRI "bite-size" texts, as direct and easy to read as 50 years of teaching experience can make them. Achievement Kit . . . training equipment . . . bite-size texts . . . the three dimensions of home-study training; the essentials you must have to make learning easier, more interesting, more meaningful. You get them all from NRI.

Whatever your interest . . . whatever your need . . . whatever your education . . . pick the field of your choice from NRI's 10 instruction plans and mail the postage free card today for your free NRI catalog. Discover just how easy and exciting the NRI 3-DIMENSIONAL METHOD of training at home can be. Do it today. NATIONAL RADIO INSTITUTE, Electronics Division, Washington, D.C. 20016.

BEGIN NOW AN ABSORBING ADVENTURE—LEARN ELECTRONICS THE EASY NRI WAY—MAIL CARD TODAY

OUR 50TH YEAR OF LEADERSHIP nri ***IN ELECTRONICS TRAINING***

1 Start Fast with NRI's New Remarkable Achievement Kit

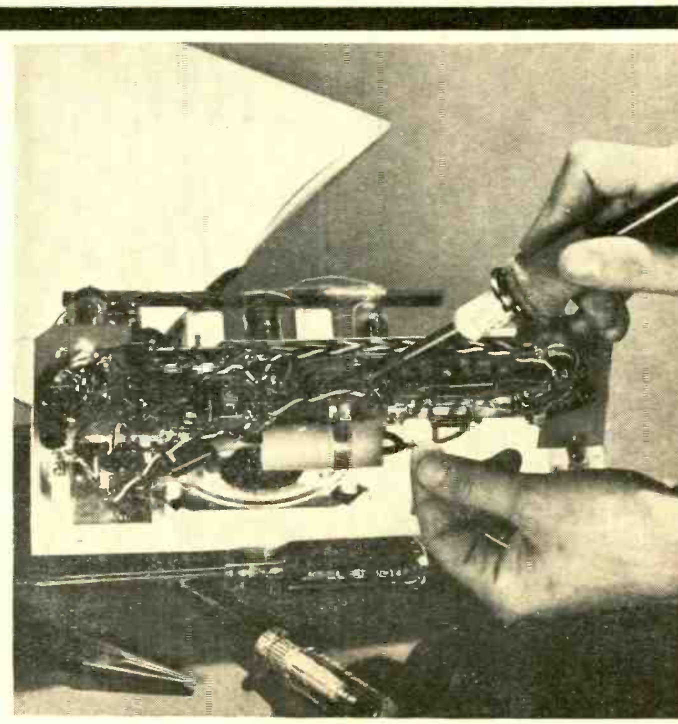
The day you enroll with NRI this new starter kit is on its way to you. Everything you need to make a significant start in the Electronics field of your choice is delivered to your door. It's an outstanding way of introducing you to NRI training methods . . . an unparalleled "first dimension" that opens the way to new discoveries, new knowledge, new opportunity. The Achievement Kit is worth many times the small payment required to start your training. No other school has anything like it. Find out more about the NRI Achievement Kit. Mail the postage-free card today.

2 NRI "Bite-Size" Lesson Texts Program Your Training

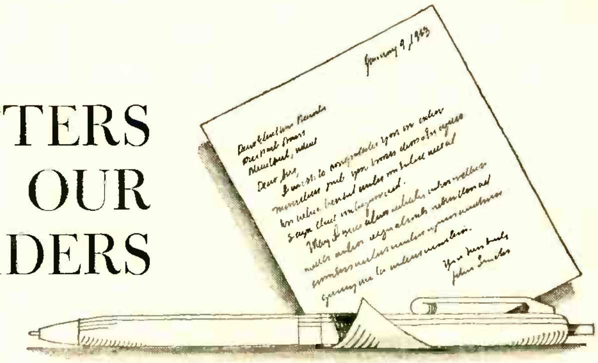
Certainly, lesson texts are a necessary part of any training program . . . but only a part. NRI's "bite-size" texts are simple, direct, well illustrated, and carefully programmed to relate things you read about to training equipment you build. Here is the "second dimension" in NRI's training method. Here are the fundamental laws of electronics, the theory, the training of your choice, presented in a manner you'll appreciate. And in addition to lesson texts, NRI courses include valuable Reference Texts related to the subjects you study, the field of most interest to you.

3 Custom-Designed Training Kits Make Learning Come <u>Alive</u>

Electronics becomes a clear and understandable force under *your* control as you get your hands on actual parts and build, experiment, explore, discover. Here is the "third dimension". . . the practical demonstration of things you read about in NRI texts. NRI pioneered and perfected the use of training kits to aid in learning at home in spare time. *Nothing is as effective as learning by doing.* NRI invites comparison with equipment offered by any other school, at any price. Prove to yourself what three-quarters-of-a-million NRI students could tell you . . . that you get more for your money from NRI than from any other home-study Radio-TV, Electronics school. Mail postage free card for your NRI catalog. (No salesman will call.)



LETTERS FROM OUR READERS



"CHIRP" RADAR

To the Editors:

I recently read with great interest Donald Lancaster's article "'Chirp'—A New Radar Technique" (January, 1965 issue). As a shipmaster with *United States Lines,* I am naturally interested in any new developments in radar, and this article suggested that the development of chirp may lead to a solution of a problem that I and others in my position have a particular interest in.

As you are undoubtedly well aware, the use of radar aboard ship is a factor of tremendous importance for the safe navigation of ships. This is particularly so in thick weather, and in view of the great increase in the volume of ocean traffic in the last few decades, I shudder to think of the hazards we would face without radar.

Of the criticisms offered as to the effectiveness of radar as an anti-collision device, there is one that has a particular importance, especially in coastal and harbor waters. This is the inability of shipboard radars to detect small craft—especially those of wooden construction—at any appreciable distance. This article leads me to believe that chirp radar might solve this problem, as the author mentions that one of its advantages is that it increases range.

R. A. Cahill
Master, SS Pioneer Moor
United States Lines
New York, N.Y.

Our author replies:

Dear Capt. Cahill:

Chirp techniques are theoretically applicable to any radar problem in order to obtain increased range or resolution. As the article pointed out, the chirp technique comes into play only after the ultimate in conventional techniques has been realized. The reason is simply that chirp systems are considerably more expensive than ordinary ones.

This is due to the wider bandwidths required and the higher degree of precision to which all radar signals must be controlled. Particularly important is the transmitted pulse. In ordinary radars, obtaining a brief burst of r.f. energy is all that is required. In chirp, the same level signals must be precisely controlled as to frequency, phase, and amplitude.

As applied to commercial shipping, a chirp system would be considerably more expensive, larger, and more difficult to maintain. If the economics warrant, chirp is an obvious and practical solution to a difficult problem.

A peculiar situation with commercial shipboard radars is the necessity for stocking parts distributors in all main ports of the world. Obviously, more exotic navigational systems suffer badly on this account.

Donald E. Lancaster
Phoenix, Ariz.

OUR CAPACITOR ISSUE

To the Editors:

It was a pleasure to read your excellent July issue surveying the capacitor industry, and I found a commendable lack of commercialism by the various authors. I should like to add the name of our company to your list of manufacturers. *Maxwell,* a newly formed corporation, specializes in energy-storage capacitors, very low impedance pulse lines, and high-energy plasma physics research. I believe that the area of energy storage is an interesting one to the general reader and perhaps could have been expanded upon. Energy-storage capacitors are not just large collections of smaller capacitors.

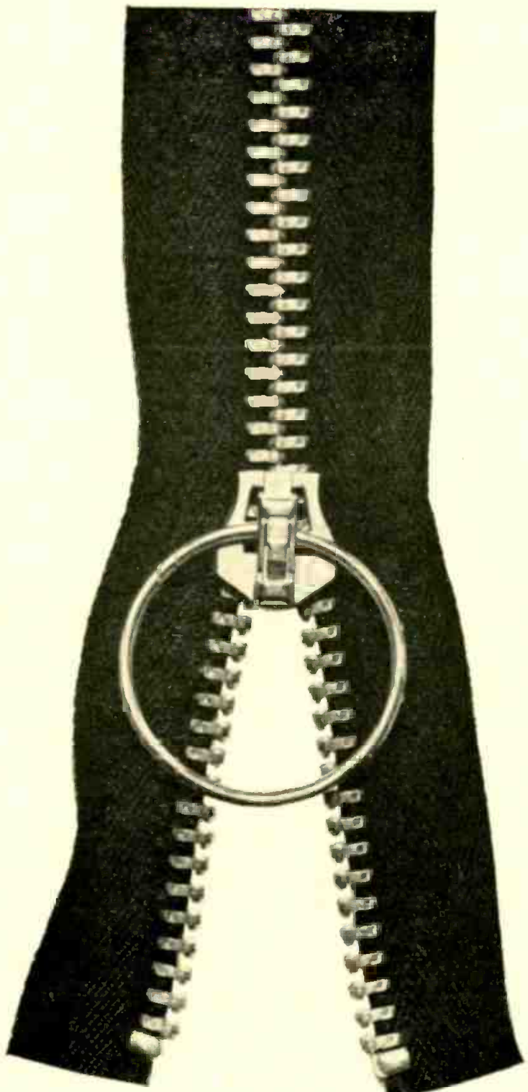
Bruce R. Hayworth, Vice Pres.
Maxwell Laboratories, Inc.
5583 Del Cerro Blvd.
San Diego, Calif. 92120

RECHARGING DRY CELLS

To the Editors:

The letter of Mr. Marc Smith in your July "Letters" column was quite amusing to me. Indeed, every time hot summer days become a nuisance, readers start querying about recharging dry cells.

This subject was rather popular in Great Britain some time ago. The most useful contribution proved to be an article in *Wireless World* (October, 1955 issue) by R. W. Hallows entitled "Dry-Cell Reactivator." There he described an apparatus developed in Holland and named "Electrophoor" which gave astonishing results. Further investigation revealed that the rectifying circuit in the



Zip through Scott's new solid state FM stereo tuner kit in one afternoon

Four to six hours! That's all you need to zip through Scott's new LT-112 solid state FM stereo tuner kit. All you do is complete five simple wiring groups and breeze through an easy new 10-minute alignment. You can actually start after lunch and enjoy superb FM stereo at dinner.

Scott solid state circuitry is the key to the LT-112's superior performance. Costly silicon transistors, three IF stages, and three limiters give the LT-112 a usable sensitivity of 1.9 uv, selectivity of 45 db . . . performance unapproached by any other kit on the market. The LT-112 is actually the kit version of Scott's best-selling 312 solid state factory-wired stereo tuner, of which AUDIO said, ". . . it is one of the finest tuners Scott makes. And that means it is one of the finest tuners anywhere."

All Critical Circuitry Pre-Wired

To insure perfect results, your LT-112 arrives with all critical circuitry pre-wired, pre-tested, pre-aligned, and mounted on heavy-duty printed circuit boards. Wires are all color-coded, pre-cut, and pre-stripped to the proper length. Scott's exclusive life-size, full-color construction book fully details every step . . . makes perfect wiring almost automatic.

You'd never believe a kit so easy to build could be so packed with features. Built right into the LT-112 is a brand-new Scott invention . . . the Tri-modulation Meter. A convenient front panel switch lets you use this Scott exclusive as:

1. A signal-Strength Indicator . . . for proper antenna orientation and coarse tuning.
2. A Zero-Center Indicator . . . for extremely accurate fine tuning of very weak or very strong stations. Accurate tuning is essential to minimum distortion and maximum separation.
3. A precision Alignment Meter that enables you to align your tuner, anytime, with absolute accuracy . . . a procedure that previously required the use of a $500 test instrument.

For your further listening enjoyment, the LT-112 is provided with three stereo outlets . . . one of them conveniently located on the front panel (you can connect a portable tape recorder without disturbing the installation of the tuner). Output level controls on the rear of the unit need be set only once, so you don't have to be bothered about duplication of controls.

Stop in at your Scott dealer's today, and pick up an LT-112 tuner kit . . . $179.95 plus one enjoyable afternoon will net you a lifetime of listening pleasure.

SCOTT®

For complete specifications on the LT-112, write:
H. H. SCOTT, INC., Dept. 160-11 111 POWDERMILL RD., MAYNARD, MASS.
Export: Scott International, Maynard, Mass. Cable HIFI. Prices slightly higher west of Rockies. Prices and specifications subject to change without notice.

CIRCLE NO. 92 ON READER SERVICE CARD

black box did not produce a direct current that was either pure or with a certain content of ripple (but always positive), but rather an alternating current, the current-time area or integrated current of which was positive. In other words, periods of charging were succeeded by periods of discharging at a rate of 50 times a second. A later letter to the editor (December, 1955) showed that this process involving complete reversal of the current direction has been known in the scientific world and in the electroplating industry since 1906 (!) and has been used to reduce the surface roughness and to produce thick deposits without imperfections. This industry used much longer cycles, *e.g.*, 15 secs. in forward and 5 secs. in reverse current flow direction.

In any case, the Dutch circuit gives much better results than any ordinary d.c. or pulsating d.c. reactivator. I have examined it to my entire satisfaction. Eventually, the apparatus I had constructed landed in the garbage can, but the only reason for this was the fact that it's easier to buy a fresh dry cell than to recharge old ones day and night!

By the way, congratulations on your fine magazine.

DR. TOBIAS F. HAFFTER
Baden, Switzerland

According to some battery manufacturers we have contacted, the technique described is known about, but it does not produce significantly better results than the use of pulsating d.c. from an unfiltered full- or half-wave rectifier.—Editors.

* * *

SEALED LEAD-ACID BATTERIES

To the Editors:

While, with space limitations, it is understandable why the entire field of battery technology couldn't be covered in one issue (October) of your magazine, note should be made that the lead-acid battery also has wide application in the electronics field.

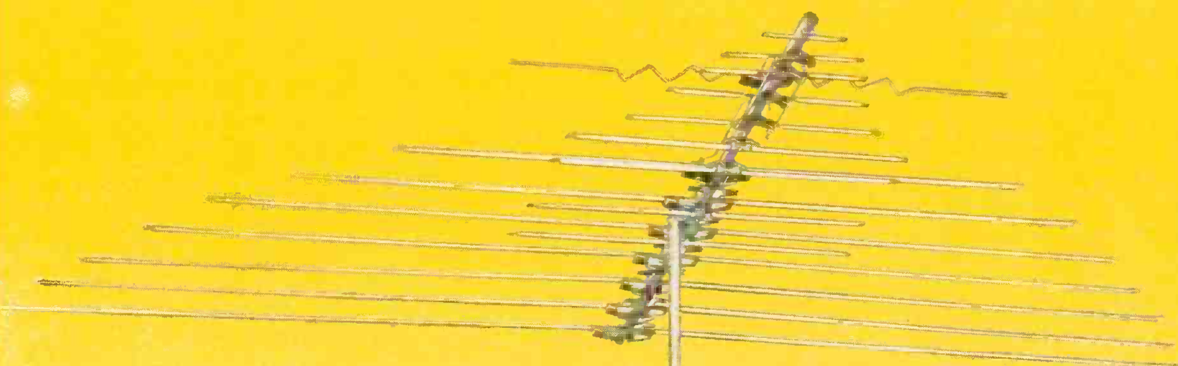
Exide, for example, has a sealed, maintenance-free (MF), lead-acid battery that is being used to power portable tools, TV, lanterns, home appliances, toys, and instruments.

Sealing of lead-acid batteries gives the MF units the combined advantages of high power and rechargeability characteristic of wet-cell batteries, in combination with the handling ease of dry-cell batteries.

Although it is more powerful than most current "in-the-handle" batteries and is capable of operating longer on one charge, the *Exide* MF battery costs only about half as much as the sealed nickel-cadmium units.

MAX L. FRANZEN, Assoc. Dir.
Public Relations Dept.
Gray & Rogers, Inc.
Philadelphia, Pa. ▲

New Winegard Chroma-Tel gives you full size power in a half-size All-Band (UHF-VHF-FM) color antenna



Model CT-80 $27.50

Why are most all-band antennas larger, heavier, more difficult to install and less effective than Winegard's Chroma-Tel? Simply because they're nothing more than VHF antennas with UHF antennas added on.

The Chroma-Tel is *much* more!

It's the first integrated antenna created *especially* for all-band UHF-VHF color operation. And it's super-compact. In fact, it's half the size of other all-band color antennas.

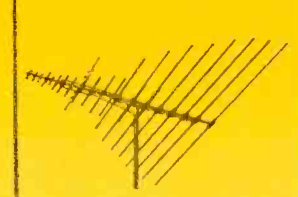
Here's how we did it. Our new Chroma-Lens Director System intermixes both VHF and UHF directors on the same linear plane without sacrificing performance. That's a first! And our Impedance Correlators (special phasing wires that automatically increase the impedance of Chroma-Tel's elements to 300 ohms) are placed only 5¾" apart instead of the usual 10" to 14".

The result? Half the bulk; half the wind loading; half the storage space; half the truck space; and half the weight of other all-band antennas—and at a much lower price!

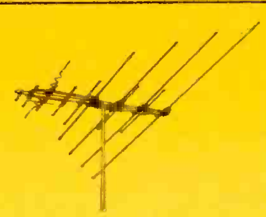
That's Chroma-Tel . . . the most efficient, easiest-to-install (UHF-VHF-FM) high gain antenna ever developed. For complete information, ask your distributor or write for Fact-Finder #242 today.

Winegard Impedance Correlators insure 300 ohm impedance on each element.

All Chroma-Tels include Winegard's model CS-283 UHF-VHF signal splitter. Hangs behind set and separates UHF and VHF signal coming from antenna to the 2 sets of terminals on set. It's FREE

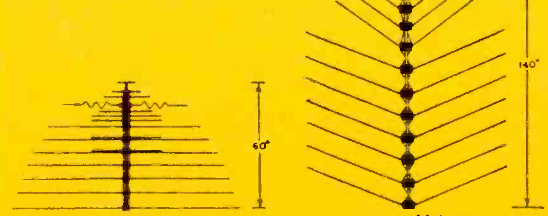


Model CT-90 $37.50



Model CT-40 $17.50

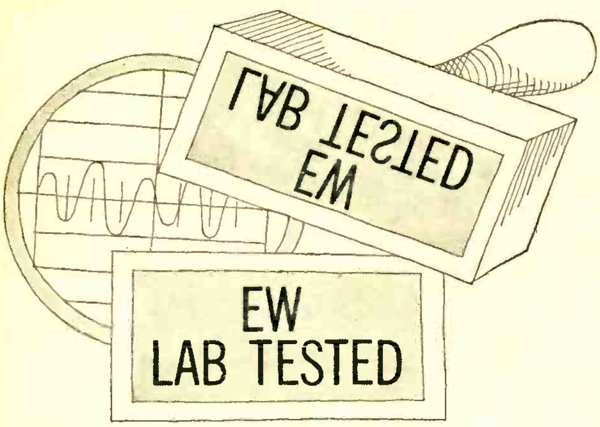
Compare Size and Price:



	Winegard Chroma-Tel	V type (Approximate Figures)
Boom Length:	60"	140"
Total Weight:	5 lbs., 1 oz.	10 lbs., 3 oz.
Carton Size:	.97 cu. ft. (less than 1)	5.8 cu. ft.
Elements:	17	12
List Price:	$27.50	$50.00

Winegard Co.

ANTENNA SYSTEMS
3000 Kirkwood • Burlington, Iowa



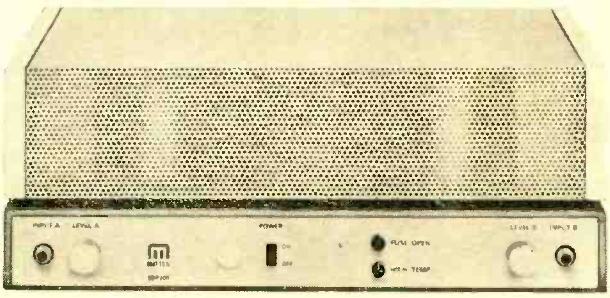
HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

Mattes SSP-200 Basic Stereo Power Amplifier

Mattes SSP-200 Basic Stereo Power Amplifier

For a copy of manufacturer's brochure, circle No. 20 on Reader Service Card.



UNTIL now, all transistor power amplifiers have employed variations of one or two basic circuits. In most cases the designers have had to compromise in their choice of operating conditions for the output transistors. Class-B operation, with its desirable high efficiency, may suffer from "crossover distortion" when the output waveform crosses the zero voltage axis. This is not significant at high power levels, but it may result in relatively high distortion at low power outputs. To some extent, this is a characteristic of all transistor power amplifiers.

As the output stage is operated nearer to class-A, its distortion characteristics improve. Unfortunately, the lower efficiency of class-A operation requires larger transistors, power supplies, and heat sinks and really high-powered class-A amplifiers are not economically feasible.

The *Mattes* SSP-200 power amplifier employs a new, patented circuit which combines the high efficiency of class-B operation with extremely low distortion at all power levels. The driver transistors are coupled to the output stage (and to the speaker load) directly as well as through a transformer, and the output transistors are operated without d.c. bias.

At low output levels, the output transistors do not conduct and only the driver stage supplies power to the load. As the power is increased, both stages contribute to the total output, with a smooth, "kink-free" transfer of load until the output transistors alone provide the output. When the output voltage instantaneously rises above the driver stage supply voltage, a "latching-diode" circuit breaks the direct connection from the drivers to the load and the output stage is driven through the coupling transformer. (Refer to "A 200-Watt Solid-State Stereo Amplifier" in our March, 1965 issue.)

Specifications on the SSP-200 are most impressive. It is rated at 100 watts per channel continuous output (with a 125-volt power line), with IM distortion less than 0.3% at full power or at any lower level. It has an unusually high damping factor of about 250. The amplifier is protected against all hazards of normal use by a thermal cut-out which removes all power should the output transistors become overheated. Lights on the amplifier indicate excessive temperature or a blown line fuse. The output stages are not damaged by short circuits, even at full power.

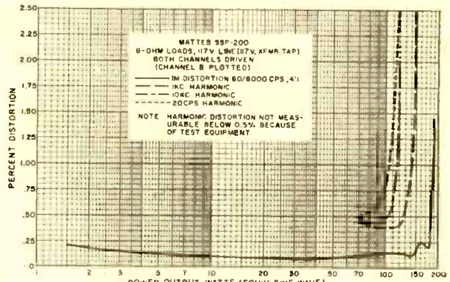
The SSP-200 can be wired for 117-volt operation, even though it is shipped with the tap on its power transformer connected for 125-volt operation. We tested our sample at 117 volts, with the tap set for 117 volts. Although this change can be made by the user or a service technician, we would suggest that the unit be left as originally shipped, since the only effect of using the amplifier on 117 volts when it is wired for 125 volts will be to reduce the maximum power about 15%—and it has plenty of power to spare. What is more, the unit will run a little cooler at high power levels.

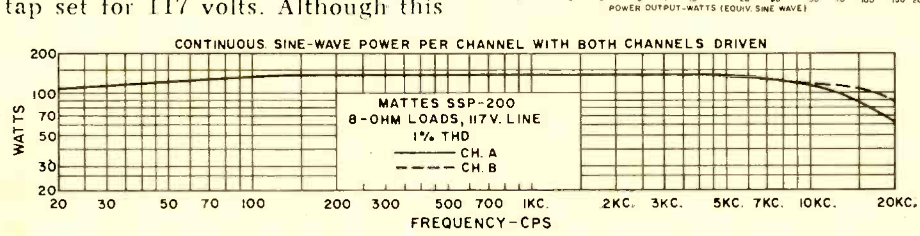
The amplifier required about 0.25 volt to drive it to 10 watts output, or 0.85 volt for full power. Its hum was extremely low, 80 db below 10 watts at full gain and −90 db with gain controls at minimum. The frequency response at all gain settings was better than ±0.6 db from 20 to 20,000 cps.

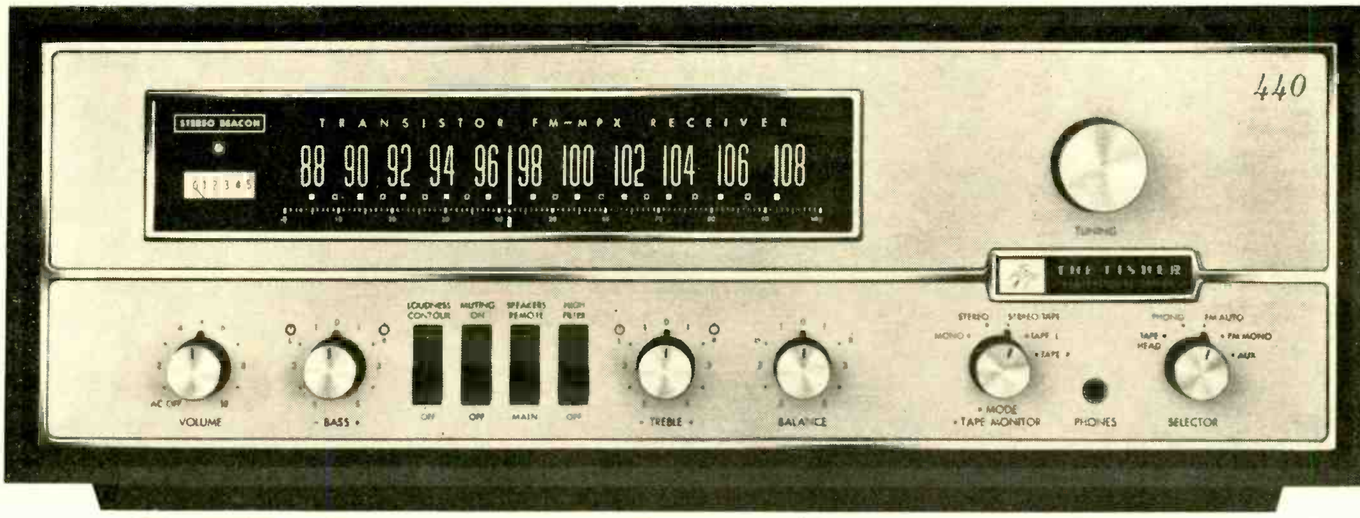
With both channels driven, into 8-ohm loads, the amplifier delivered 140 watts per channel at 1% harmonic distortion, through the middle frequency range. Even at 20 cps, it delivered over 100 watts per channel at 1% distortion, although the high-frequency output showed a slight distortion which limited the output to under 90 watts at 1% distortion. Into 4 ohms, the output is reduced only slightly, while the available power into a 16-ohm load is reduced by about half, when compared to an 8-ohm load.

Although a malfunction in our harmonic distortion set-up prevented our

(*Continued on page* 22)







A Fisher receiver is greater than the sum of its components.

Fisher has always maintained that an all-in-one receiver can equal or surpass the performance of separate components of similar circuitry. And at far lower cost.

The most recent and eloquent proof of this is the new 440-T, the first all-solid-state stereo receiver of Fisher quality under $330.

On a single chassis occupying only 16¾ inches of shelf space and only 11 inches front to back, the 440-T incorporates a sensitive FM-stereo tuner with automatic mono-stereo switching, an extremely versatile stereo control-preamplifier, and a heavy-duty stereo amplifier. All transistorized, all with Fisher reliability.

By eliminating duplication of parts and circuits, such as extra power supplies and the low-impedance circuitry usually associated with connecting cables, the 440-T actually has a *plus* factor of reliability over separate components. Obviously, fewer parts mean fewer trouble spots. But that isn't all. Hum and noise are more easily reduced to imperceptible levels. And critical preamplifier and power circuits operate at their electrical best. Elimination of other unnecessary parts, such as extra chassis, jacks, knobs, etc., clearly means a considerable cost saving.

In the 440-T, Fisher engineering has also achieved a new degree of reliability in transistorized components. Conservatively rated silicon output transistors permit higher undistorted power and long, trouble-free operation. Damaging heat has been designed out. The receiver can be operated at full power, hour after hour, without harm. You can even short the speaker leads without causing damage. Adjustments and alignments have been practically eliminated, so that the 440-T will operate as perfectly after two years as on the first day.

In spite of its technical sophistication (just look at the specs!), the 440-T is so simple to operate that even your wife will enjoy using it from the very first day. Masses and messes of wire are gone; you simply connect a pair of fine speakers and turn on the music.

It is this total approach to integrated design that makes the 440-T more than just the sum of a tuner, an amplifier and a control center. And that is why it is an unprecedented buy at $329.50. (Cabinet, $24.95.)

Features and Specifications

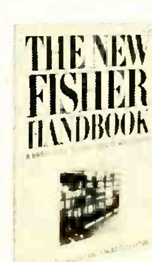
Tuner Section:
4-gang transistor front end; 4 IF stages; 3 limiters; STEREO BEACON*; automatic stereo switching; sensitivity, 2.0 μv (IHF); stereo separation, 35 db; S/N (100% mod.), 68 db; selectivity, 50 db; capture ratio, 2.2 db.

Amplifier Section:
Silicon output transistors; short circuit protection; speaker selector switch (main or aux.); front-panel headphone jack; music power (IHF), 4 ohms, 70 watts; harmonic and IM distortion, 0.8%; frequency response (overall), 20-22,000 cps ± 1.5 db; hum and noise, 80 db; input sensitivity, phono magnetic (low), 4.5 mv; stereo separation, phono magnetic, 50 db.

Size: 16¾" wide x 5⅛" high x 12⅜" deep (including knobs and heat sink).
Weight: 21 pounds.

*PATENT PENDING

The Fisher 440-T



0711

FREE! $2.00 VALUE! Mail this coupon for your free copy of *The New Fisher Handbook.* This entirely new, revised and enlarged edition of the famous Fisher high fidelity reference guide is a magnificent 80-page book. Detailed information on all Fisher components is included.

Fisher Radio Corporation
11-40 45th Road,
Long Island City, N. Y. 11101

Name ______

Address ______

City ______ State ______

CIRCLE NO. 115 ON READER SERVICE CARD

FREE

send today for your ALLIED 1966 CATALOG

world's largest selection

508 VALUE-PACKED PAGES
including exclusive products and special values available only from **ALLIED**

SAVE MOST ON:

Stereo Hi-Fi
Tape Recording
CB 2-Way Radio
FM-AM & AM Radios
Short Wave Radios
Portable TV • Phonographs
Amateur Gear
Intercoms & P.A.
Automotive Electronics
Test Instruments
TV Tubes & Antennas
Power Tools, Hardware
Parts, Tubes, Transistors

MORE OF THE BEST IN ELECTRONICS FOR EVERYONE

EASY TERMS
Use the convenient Allied Credit Fund Plan —over 24 months to pay

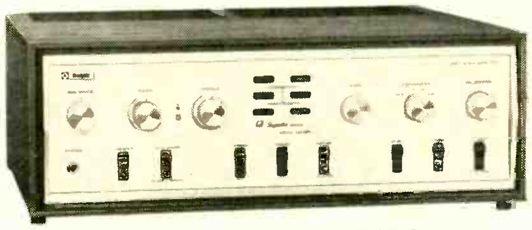
ALLIED RADIO

The World's Largest Electronic Supply House

satisfaction guaranteed or your money back

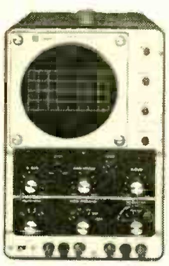
Special in your FREE 1966 ALLIED CATALOG

see what's new in the wonderful world of knight-kits®

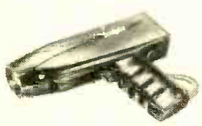


KG-895 Superba Series 120-Watt Solid-State Stereo Amplifier Kit. $149.95 (less case)

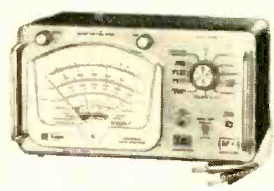
KG-964 Superba Series 64-Watt Solid-State FM-AM Stereo Receiver Kit. $189.95 (less case)



KG-635 5-Inch DC to 5.2 Mc Wide-band Oscilloscope Kit. $99.95



KG-371 Solid-State Auto DC Power Timing Light Kit. $19.95



KG-375 Solid-State Universal Auto Analyzer Kit. $49.95

Safari-I Deluxe 23-Channel Citizens Band Transceiver Kit. $129.95

C-540 Low-Cost 5-Watt Citizens Band Transceiver Kit. $49.95

KG-221 FM Monitor Receiver Kit (police, fire, marine, weather bands, etc.) $39.95

KG-201 Solid-State Motor-Speed/Light Control Kit. $9.95

KG-415 Superba Series Professional Solid-State Stereo Tape Deck Kit. $249.95 (less case)

Knight-Kit GUARANTEE: Buy any Knight-Kit. Build it. Operate it. You must be satisfied or we refund your money.

THERE IS A knight-kit FOR EVERY NEED!

easiest to build—enjoy big savings

- Stereo Hi-Fi
- Hobby Kits
- Intercom
- CB 2-Way Radio
- Test Equipment
- Amateur Gear
- Short-Wave
- Automotive

FREE

Send today for your 508-page Allied 1966 value-packed catalog

send for your 508-page 1966 Allied Catalog

FREE!

ALLIED RADIO, Dept. 1-L
100 N. Western Ave., Chicago, Ill. 60680

☐ Send FREE 1966 Allied Catalog

Name____________________
PLEASE PRINT

Address____________________

City__________ State________ Zip______

ALLIED RADIO

CIRCLE NO. 125 ON READER SERVICE CARD

taking distortion measurements under 0.5%, the power *vs* distortion curve gives an impressive picture of the tremendous capability of this amplifier. At any frequency, the distortion falls to less than 0.5% for all power outputs below 70 watts per channel. At 0.5% distortion, it still delivers 105 watts at 10,000 cps and 128 watts at 1000 cps. The IM distortion is under 0.2% for any power under 155 watts and under 0.25% up to 185 watts. These powers are *per channel*, with both channels driven. Note that the IM figures are based on an equivalent single signal (sine-wave) output with the same peak voltage swing as the combined test tones of the IM measurement. The power outputs, as read on an ordinary average-responding instrument, are multiplied by 1.47 to obtain the equivalent sine-wave powers.

In extensive listening tests, with various types of speakers and program material, the SSP-200 proved to be a superb performer. It ran completely cool at all times. A description of its sound is difficult without resorting to the use of superlatives. It is utterly clean and effortless and somehow made every speaker we used with it sound better than it ever had before. We do not know what, if any, specific characteristic of the amplifier is most responsible for its outstanding listening quality. Probably it is a combination of excellent stability, extremely low distortion, and enormous power reserve. Whatever the reasons, we doubt that any other amplifier we have heard can match it and certainly none can surpass it.

Laboratory measurements are actually unnecessary (and inadequate) to define the character of this amplifier. A few moments (or, preferably a few hours) of listening is all that is needed, and is more convincing than any test data could be.

Because of the very high output power of this amplifer, a special switch is incorporated in the circuit to convert the unit to one with a power of 12 watts per channel. This permits the installation and testing of loudspeaker systems not capable of accepting power levels that might accidentally be delivered were the switch not used.

Speaker connections on the rear panel are made to binding posts, spaced to accept *General Radio* plugs, for convenience and ease of changing connections. Input jacks wired in parallel are provided on both front and rear panels. The input impedance of the unit is 100,000 ohms or more permitting the use of any vacuum-tube or transistor preamplifier. The amplifier is completely stable and will deliver its full power to capacitive loads, such as electrostatic speakers.

The *Mattes* SSP-200, priced at $375.00, is not inexpensive. It is, however, worth every cent of its price. ▲

Why does Arco wind all its tv-replacement capacitors with computer-grade 99.99% pure aluminum foil?

To help cure that pain in your neck.

Impurities in aluminum foil can lead to deterioration, premature failures, lost customer confidence—and call-back time you can't charge for. Big pains in the neck.

So we wind every Arcolytic® electrolytic capacitor with the purest aluminum foil available: 99.99% pure. It meets computer manufacturer standards. And exceeds those of radio-tv manufacturers.

Result: Arcolytic capacitors last longer in your customer's set. In fact, they won't deteriorate even at high operating temperatures of 85° C.

And while we wind them with computer-grade foil, we price them for home-entertainment service. You pay no premium.

You'll find whatever discrete capacitance value you need at your Arco Distributor's. And in your choice of single- and multiple-section tubular, or twist-mount designs. (You'll also find a complete line of equivalent-quality miniature ceramic disc capacitors up to 6000 VDCW.)

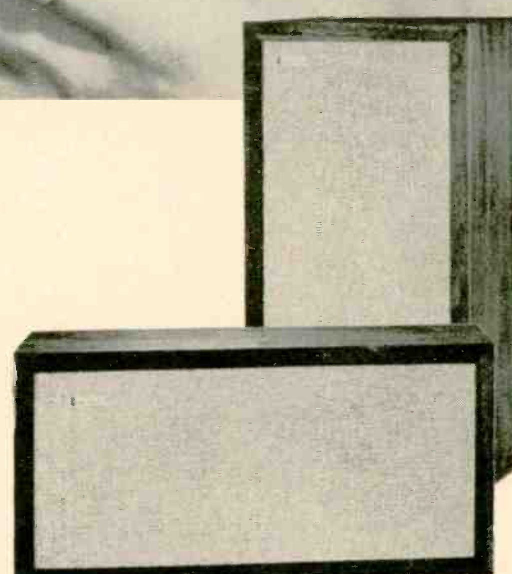
Start using Arcolytic capacitors. And the next call from your customer will be because he likes your kind of reliability, and wants more of your service.

Arco Electronics
A DIVISION OF LORAL CORPORATION
COMMUNITY DRIVE, GREAT NECK, N.Y. DALLAS, TEX. PASADENA, CALIF. WRITE FOR FREE CATALOG.

The lively sound! The more-than-you-pay-for big speaker performance of University's lively new Ultra-D.

Enjoy it — *the lively sound.* Put it anywhere — everywhere! No matter where, the Ultra-D fits!

Enjoy it — listen to *the lively sound* of the Ultra-D at your University dealer today. Bring your favorite record, too! Listen to something you know — you'll agree University *Sounds Better!*



Send for the all-new catalog of the world's largest (and liveliest) selection of high fidelity speakers and systems. It's FREE, and we'll also include details of University's 5-year warranty and our Guide To Component Stereo High Fidelity. Address inquiries to Desk L 55.

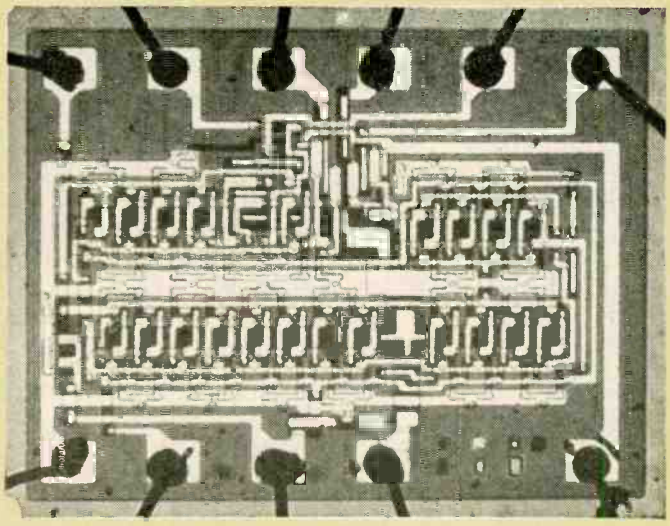
ULTRA-D SPECIFICATIONS: *Components — 10" ultra-linear high compliance woofer, 4" direct radiator mid-range, 3½" direct radiator tweeter.* **Response—35 to 19,000 cps. Size—** *23 13/16" h. x 11⅞" w. x 9¾" d.* ***Finish Oiled walnut.*** *Selling Price — $87.25*

LISTEN—UNIVERSITY SOUNDS BETTER

UNIVERSITY SOUND

A DIVISION OF LTV LING ALTEC, INC.

9500 W. Reno Oklahoma City, Oklahoma



INTEGRATED CIRCUIT TECHNIQUES

By CARL DAVID TODD
Electronics Consultant

With an emphasis on recent developments in the technology, the monolithic, isolated monolithic, the thin- and thick-film, MOS, and the hybrid techniques are examined. Problems in going from discrete to integrated, examples, and testing are included.

THE already wide and yet expanding field of integrated circuits includes several basic approaches for the fabrication of very small electronic circuits and a vast multitude of combination techniques. Each has its own particular characteristics, advantages, and limitations. Just as the various construction methods in building houses are selected according to the end requirements and desires, so must the particular fabrication process for integrated circuits be chosen according to the specific needs and required characteristics.

Since no one integrated circuit technique yet developed can fully satisfy all purposes and required specifications, it is well that we have several from which to choose. In this article we will look at several possible methods for fabricating integrated circuits and discuss their special characteristics with emphasis on their features and limitations. Included will be the monolithic, isolated monolithic, thin-film and thick-film, and MOS techniques with several possible combinations.

This article is directed to the engineer and technician who will be dealing with the finished integrated circuit product either in equipment fabrication, checkout, or repair and will attempt to answer the question "What can I expect of integrated circuits?" Even though your present job has no direct connection with integrated circuits right now, you will want to become familiar with them. It is very likely that you will be seeing a lot of them in the near future.

The integrated-circuit techniques already developed have allowed a fantastic degree of microminiaturization. Going back just a few years to the time before the "semiconductor revolution," the accomplishment seems even greater. Who would have thought that we could contain the circuit function of a dozen or more tubes with associated resistors and capacitors within the size of this letter "O"?

Development of the integrated-circuit techniques has resulted not only in the tremendous reduction of physical size, but has also produced great improvements in the operating reliability of the over-all circuit through the reduction of connecting wires and large, vibrating components.

Let's look at some of the common techniques for making integrated circuits and see just what each method can offer and consider where each might run into trouble.

Monolithic Circuits

Monolithic means "single stone" and a monolithic circuit is one which is fabricated within a single crystal of semiconductor material, usually silicon. The transistors, diodes, resistors, and capacitors are all built right in the semiconductor material. The bulk properties of the material along with the various characteristics of *p-n* junctions are used.

The same basic processes for the fabrication of silicon transistors may be used to make monolithic integrated circuits. The most common ones are the diffusion process, the epitaxial process, or a combination of the two. The transistors, diodes, and passive elements are made at the same time within the body of the silicon by diffusing appropriate impurities through windows cut into an oxide coating by photo-chemical etching.

The monolithic process has the greatest single capability of any of the processes. It is possible to fabricate both active and passive components within a very small volume and with all interconnections made by an aluminum evaporation that is etched to provide the desired paths. The technique is basically that which has been successfully used in the preparation of many transistors and hence is quite well developed.

One of the main limitations on the monolithic technique is the presence of distributed diodes connecting the fabricated components to the silicon substrate material proper. While it is possible to greatly reduce their effect by making sure that they are always reverse-biased, we still have to contend with leakage currents which may flow and with unwanted coupling capacitances which are present in any diode.

Another limitation on the monolithic process is the difficulty in obtaining proper passive components. The range of the resistances which are practical is only about 20 to 20,000 ohms which places a severe restriction on the circuit designer. In addition, the resistors even within the range of practicality have a rather large temperature coefficient (approximately 0.7%/°C).

The capacitors are actually reversed-biased diodes and care

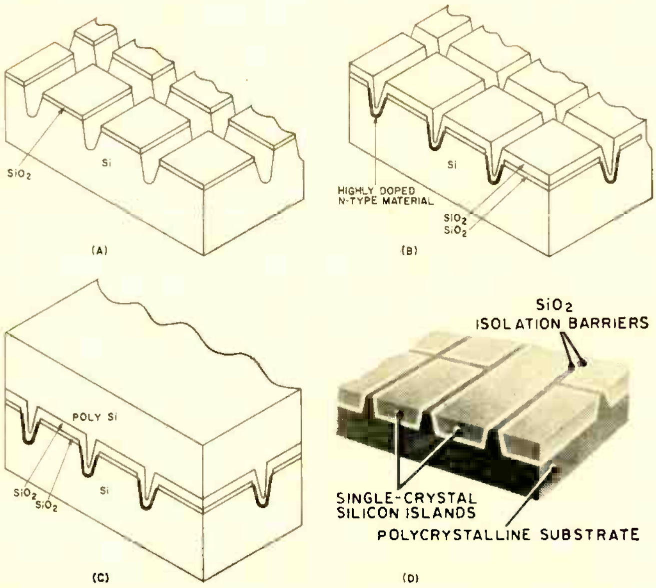


Fig. 1. Isolated monolithic process. (A) Silicon "waffle" wafer showing moats. (B) Oxide grown on moats of wafer. (C) Polycrystalline silicon grown on wafer. (D) Final device.

must be taken to make sure that they stay reverse-biased. Their value, which must be restricted to rather small sizes, will be a function of the applied reverse voltage as is the case with any semiconductor diode.

Still another limitation in producing monolithic circuits is the expense in making the precision masks, several being required for each circuit. This restricts the use of monolithic techniques to those applications where large quantities of the same circuit are required. Even minor changes usually require scrapping the finished integrated circuit and all masks. New masks must be made and the entired process repeated.

Isolated Monolithic Circuits

A variation of the monolithic process which overcomes many problems present with standard monolithic techniques warrants separate consideration. In this approach, portions of the original semiconductor block are isolated from each other either by surrounding sides and bottoms with SiO_2 (glass), a very good insulator.

Let's look at the basic process as currently being used by *Radiation, Inc*. The process starts with a lapped and polished silicon wafer about 0.010 inch thick upon whose surface a thin layer of SiO_2 is formed by heating in an oxidizing atmosphere. Moats or grooves are then etched around the areas which are to be isolated by a normal photo-etching process to produce the results shown in Fig. 1A.

Very highly doped *n*- or *p*-type silicon is epitaxially deposited or grown within the groove and then covered by SiO_2, formed by heating again. The resulting structure is shown in Fig. 1B. Polycrystalline material (not having a carefully arranged lattice structure as the monocrystalline material required for transistors and diodes) is then deposited over the entire surface. The grooves are filled and the entire surface is covered with a thick coating, as shown in Fig. 1C.

The wafer is turned over and the original silicon wafer material is ground off until the polycrystalline material is reached. The surface is then polished and etched to leave small islands of the original silicon wafer from the polycrystalline material. These islands act merely as a structural agent, *via* a thin layer of SiO_2, as shown in the photograph of Fig. 1D. This photo does not show the heavily doped *n*-region which is not always required.

Each of the isolated islands of silicon may then be treated as a separate chip and processed in the same way as in the normal monolithic process. Very careful control of the thickness of the wafer and the deposited coating is required. Let's look at some of the features of this process.

Because of the glass isolation, we no longer have to make sure that we back- or reverse-bias the isolation diodes and we have less than one-tenth the stray capacitances present. Also, the leakage current between elements is greatly reduced, especially if operated at high temperatures. Further, breakdown voltages of 1000 volts between adjacent elements is practical. Another advantage of this technique is the possibility of making both *p-n-p* and *n-p-n* transistors on the same substrate and the capability of selective gold doping to achieve different characteristics for adjacent devices on the same substrate.

A diode matrix, manufactured by *Radiation, Inc.* by the isolated monolithic technique, is shown in the photograph of Fig. 2. The glass isolation region may be seen surrounding each row of diodes in the matrix as well as the heavily doped *n*-regions. The *n*-regions conveniently tie all of the cathodes of the diodes in a given row together.

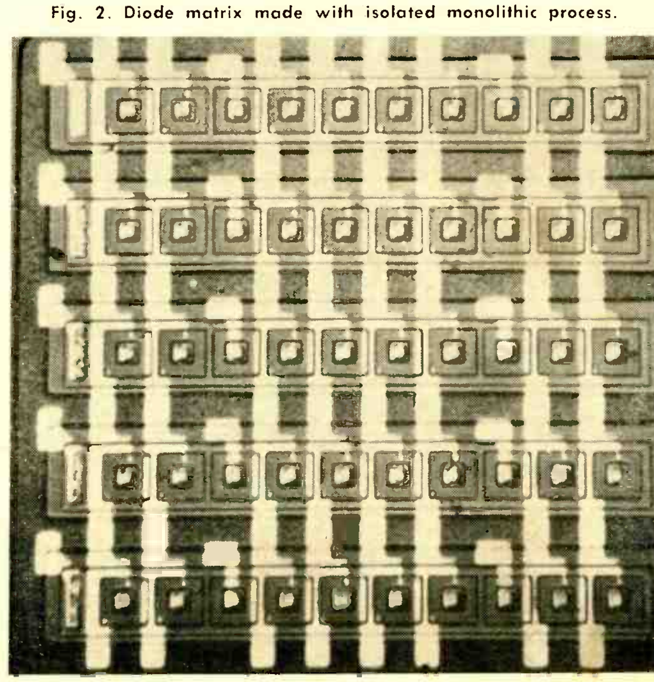
This photograph also shows an interconnection means in which all diodes are connected to the vertical interconnect buses and then disconnected by blowing out a portion of the metallization. This is done by electrical discharge to remove those connectors not needed in the matrix.

Thin-Film Circuits

Another technique which may be used to fabricate integrated circuits is the evaporation and deposition (usually performed in a vacuum) of metals and dielectrics upon a smooth surface, such as glass or vitrified ceramics. The usual method is to raise the temperature of the material to be deposited above its boiling point in a vacuum. The vapor is then allowed to condense upon the substrate through appropriate masks. The resulting depositions are very thin and are measured in microns (millionths of a meter).

Thin-film circuits have the advantage in that higher values of resistance are possible and the temperature coefficient may be held to nearly zero if desired. Because the resistance material is on the surface of the substrate, it is possible to trim a given resistor physically to a precise value. This is achieved by making it a little low in value to begin with and then carefully removing a small portion of the material until the desired value is reached. It is also possible to control the value of the resistance during deposition by monitoring it with a precision bridge. The process is then stopped at an appropriate point and the resistance value "frozen" at that level.

Fig. 2. Diode matrix made with isolated monolithic process.



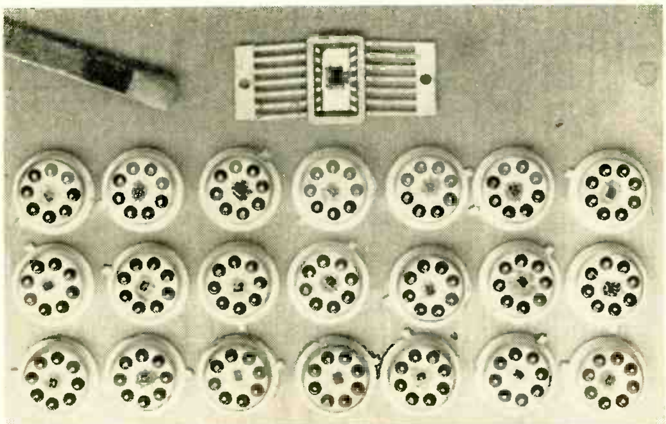


Fig. 3. A 21-bit register (top) whose heart is a microscopic wafer of silicon containing 110 transistors and 48 resistors, replaces 21 separate microcircuits (shown here) in computers.

Capacitors made by the thin-film process are not voltage sensitive as is the case with *p-n* junction capacitance. By careful alternation of metal and dielectric deposition during the fabrication process, a multiple plate capacitor having substantial capacitance is possible. Since the dielectric films must be very thin, breakdown voltage can be a problem if even a very small defect occurs during the deposition of the insulating material (usually silicon dioxide).

Since the deposition is generally made using a substrate of insulating material, isolation between various parts of the circuit is much better than for the monolithic technique. One of the greatest limitations to the use of the thin-film process in its purest form is the lack of quality active devices. Although development transistors and diodes have been made by this method, they have not been found suitable for general use.

The thin-film circuit process has the same problem as the monolithic circuit techniques regarding the requirement for precision masking. If a wide range of resistance values is to be included within a given circuit, the number of masks required is large and the actual number of process steps will almost always be greater than for monolithic techniques. This is especially true if the circuit is complex.

Thick-Film Circuits

It is possible to fabricate circuits utilizing a thick-film technique in which the interconnections and components are applied to a substrate by a silk-screen process. This basic approach has been in use for many years with *RC* networks found in radios, television sets, and hearing aids. The more recent development of the Cermet materials (basically a combination of metal and glass) has improved the basic capabilities of this technique considerably.

Interconnections used in the thick-film process are usually a silver-bearing material and are fired at a rather high temperature. Temperature coefficients for thick-film resistors are not as low as those obtainable with thin-films. Typically, they are much better than those possible with monolithics.

Thick-film capacitors may be quite large in value since the dielectric to be screened can have a large dielectric constant (300 to 500). Breakdown voltages can be made as high as needed by increasing the thickness of the dielectric. This, however, will decrease the capacitance.

No thick-film active devices are currently in use. We must therefore combine thick-films with active devices made by another process, as discussed later in this article.

MOS Technique

The metal-oxide-semiconductor (MOS—a field-effect device) process had been applied to monolithic integrated circuits with notable success. Because the active components on the chip are essentially insulated from each other, isolation

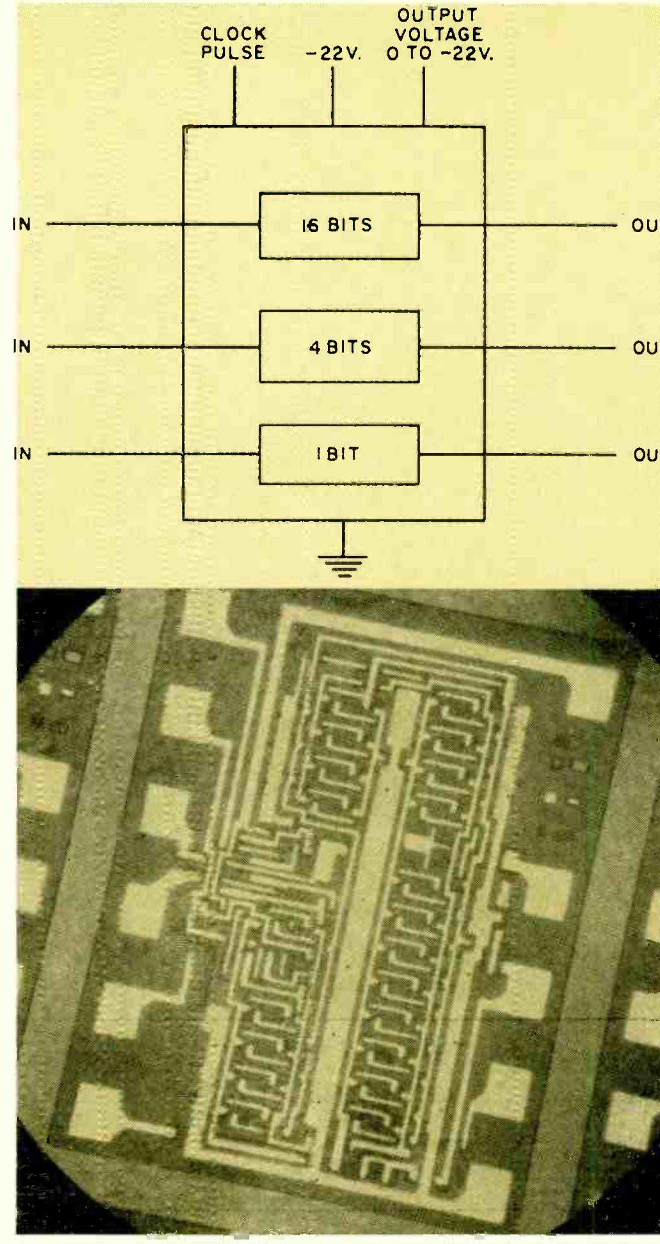
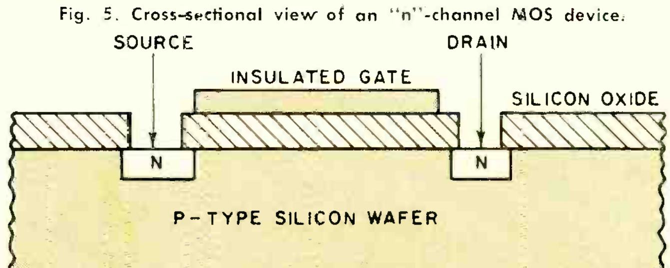


Fig. 4. A 21-bit shift register. The functional block diagram and a photomicrograph of the actual structure used.

gimmicks are not required. The technique lends itself to low-cost, high-density digital integrated circuits. These devices have a lower frequency response than other devices and consequently clock rates for digital functions are limited to a few megacycles.

An example of the use of this new process is a 21-bit shift register developed by *General Instrument Corp.* (Fig. 3). The silicon wafer measures 0.07 inch long and 0.06 inch wide and contains 110 transistors and 48 resistors. Clock rate is 500 kc. and the unit replaces 21 separate microcircuits. Fig. 4 is a block diagram and a photomicrograph of the circuit.

Fig. 5. Cross-sectional view of an "n"-channel MOS device.



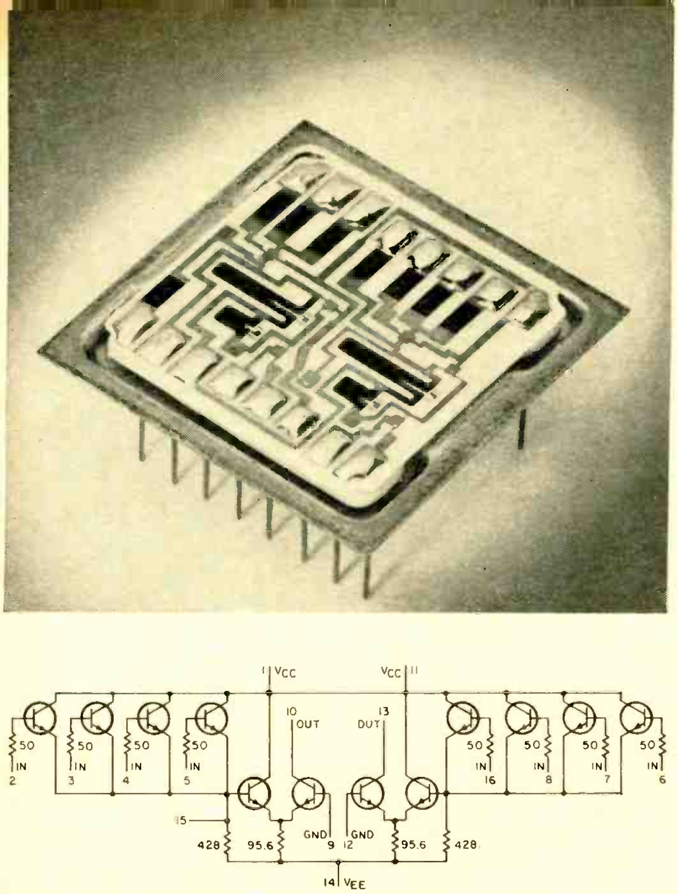


Fig. 6. Photo and schematic of hybrid 4-input gate.

(Also refer to the cover illlustration.) The register is actually three shift registers in one package sharing a common supply and clock pulses. The three can be used either independently or connected in series to give a total of 21 bits of delay to an arbitrary data stream. By letting the output voltage be just a few volts, it is possible to have the register drive other types of low-voltage *n-p-n* logic.

Fig. 5 provides a cross-sectional view of an *n*-channel MOS. The two *n*-regions labeled "source" and "drain" are diffused into the *p*-wafer by such methods as used in the planar process (*e.g.*, photo resist and oxide masking). The source and drain are analogous to the cathode and plate of a vacuum tube, respectively. The third element, the gate (analogous to the grid of a vacuum tube), is evaporated over the silicon oxide between the two *n*-regions. The gate is insulated from the silicon wafer and exhibits a resistance on the order of 10^{10} or more ohms.

In a type called the *n*-channel *depletion* MOS, drain current will flow even if the drain-source (input) circuit is zero biased. For integrated digital circuits, however, the *n*-channel enhancement MOS which exhibits zero drain current for zero bias, is preferred. A significant characteristic of the enhancement type is its low saturation voltage. This permits the design of simple direct-coupled transistor logic (DCTL).

Hybrid Circuits

Each of the basic techniques described has limitations which might restrict their use in many areas for one reason or another. However, each technique has certain advantages. There are many possible combinations of portions of the basic techniques which will result in an expansion of the capability of any of the single processes with many of the desirable features retained. This approach leads to the hybrid circuit.

One of the simplest forms of hybrid fabrication is the combination of several "chips" or discrete monolithic blocks within a single package. This allows more complicated circuitry to be fabricated than might be possible if the entire circuit were to be made as a single monolith. In some cases, it is either impossible or at least impractical to make certain combinations of *p-n-p* and *n-p-n* transistors on a single chip. For example, if matching is required for one reason or another, it is much easier to perform the matching before assembly than to try to obtain a perfect match with two devices on a single chip.

Isolation can be improved by the use of multiple chips and the circuit components contained on each chip may be optimized independently. This becomes especially important where it is necessary to include many active and passive components of different types within a single circuit. Since the interconnections must be made by small wires bonded to the individual connection terminals on each chip, assembly labor can become relatively high. Each extra connection will also decrease the over-all reliability of the device.

The multiple chip arrangement is also useful in developing prototype circuits or configurations which are subject to change. It is possible to alter the design of one chip without affecting any of the others and to add small discrete components to the circuit.

Another hybrid form is the combination of thin-film passive components with monolithic circuits. This is especially useful in the fabrication of circuits requiring large resistances or low temperature coefficients. The monolithic portion is made in the usual manner and then the thin-film portions of the circuit are deposited on top of an insulation layer formed on the surface of the monolithic block. In a sense, most monolithic circuits are in this category of hybrid because the final interconnection is usually a thin-film deposition of aluminum.

Thick-films may also be combined with monolithic blocks in just about the same manner as described for the thin-film combination. However, this is not as common. A more usual combination of monolithic and thick-film circuits is the addition of monolithic active devices or circuit chips to the substrate on which the thick-film circuit has been screened. This combination allows all of the passive components to be fabricated independently from the active components and can result in a very workable arrangement.

An interesting hybrid combination is shown in the photograph of Fig. 6. This particular circuit is for a four-input gate also shown in Fig. 6. The technique, developed by *Corning Glass Works*, combines monolithic circuit chips with thin-film resistors and thick-film interconnections and capacitors. The capacitors, if required, are fabricated on top of the substrate first by silk screening a sandwich of gold paste, niobate glass frit, another layer of gold paste, and finally a layer of protective glass. A portion of each of the gold paste layers is left exposed to allow connection to be made to the electrodes.

The substrate containing all the required capacitors, whose values may be controlled by varying the physical area of the electrodes or the thickness of the dielectric layer, is then placed in an oven and "fired" at a very high temperature. This permits the binding of all layers together, devitrification of the glass dielectric, and provides a hermetic seal over the finished capacitor. The dielectric constant of the glass used for the dielectric is around 400 and the thickness may be a little more than one-thousandth of an inch. This means that capacitance values up to 3000 pf. are practical.

If interconnection crossovers are required (or if they might greatly simplify the circuit layout), they are easily made at the same time as the capacitors. When the first layer of gold paste is screened, a small stripe of gold paste is placed where the crossover is desired. During the screening of the sealing glass, the mid portion of this crossover stripe is covered with a glass seal. This allows another interconnection path to pass over the gold stripe without shorting and with very little coupling capacitance. The dielectric constant of the sealing glass is only around 5 or 6.

The substrate containing the capacitors and crossover stripes is then covered with a thin film of tin oxide deposited without requiring a vacuum. The tin oxide is etched away except where a resistor or interconnection line is required, employing a photoresist technique. Places where a resistor is required are masked off by vinyl (*Continued on page* 86)

TRANSFORMER TURNS RATIO NOMOGRAM

By MAX H. APPLEBAUM
Warwick Electronic Inc., Pacific Mercury Div.

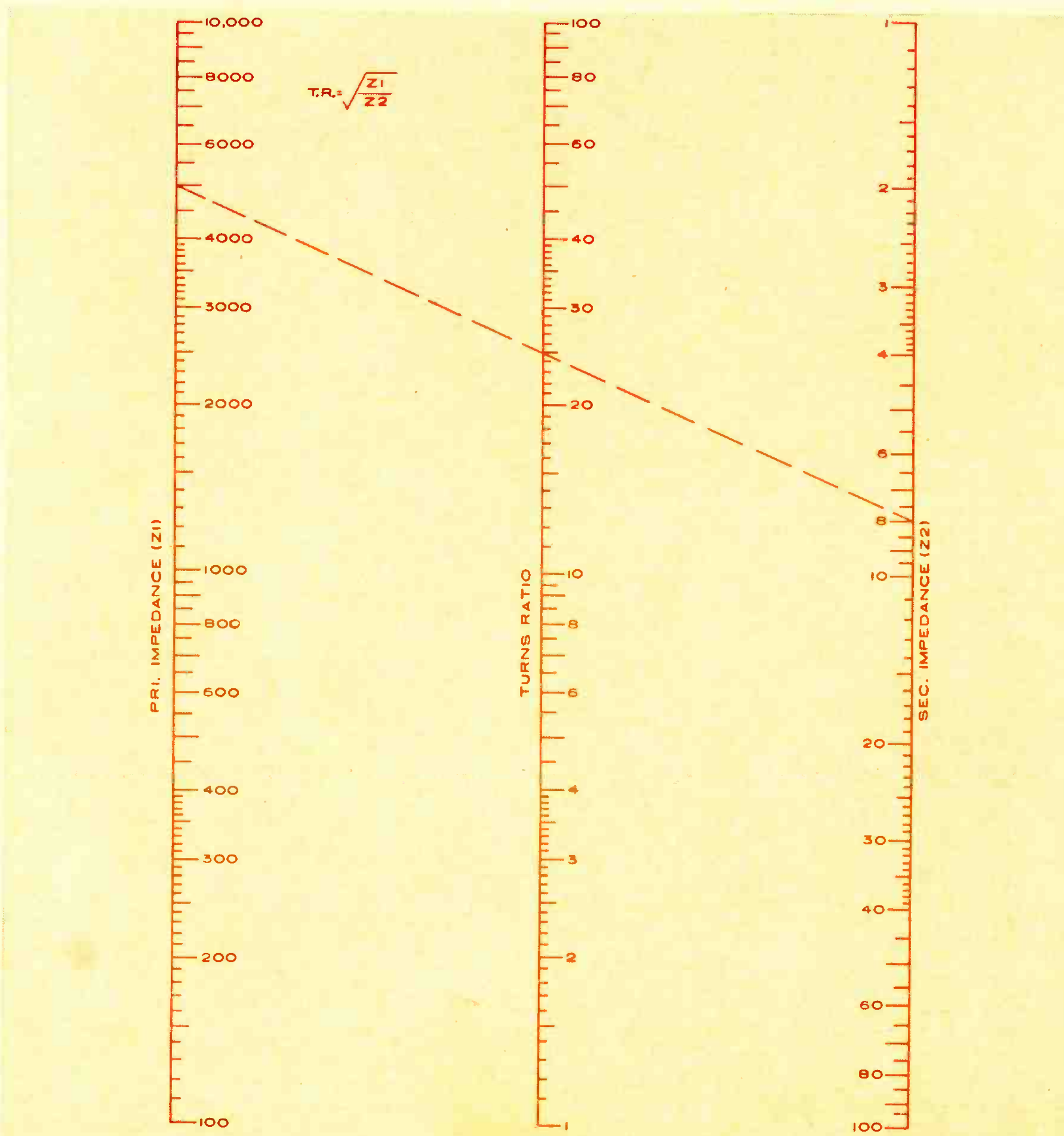
Simple method of determining the turns ratio for transformers employed for impedance matching.

THIS nomogram aids in the computation of the turns ratio for transformers used for impedance matching. The basic equation for the turns ratio is $T.R. = \sqrt{Z1/Z2}$, where Z1 is the primary impedance, Z2 is the secondary impedance, and *T.R.* is the turns ratio $N1/N2$.

The method of solution is illustrated in the example below. Values other than those shown on the scales may be used by multiplying them by 10^n where n may be positive or negative. If Z1 and Z2 are both multiplied by 10^n, then *T.R.* remains unchanged. If only Z1 is multiplied by 10^n, then *T.R.* is multiplied by $10^{n/2}$. If only Z2 is multiplied by 10^n, then *T.R.* is multiplied by $10^{-n/2}$. Using even values of n will simplify the conversion of scales.

Example: Find the turns ratio required for an audio output transformer to match a plate impedance of 500,000 ohms to a speaker whose impedance is 8 ohms.

Solution: Draw a straight line from 5000 on the Z1 scale to 8 on the Z2 scale. The line crosses the *T.R.* scale at 25. Since Z1 was multiplied by 100 then *T.R.* must be multiplied by 10. The turns ratio is therefore 250/1. ▲



LOW-NOISE TV AND FM SIGNAL BOOSTER

By ROBERT B. COOPER

A new pentode vacuum tube allows maximum gain with lowest noise figure for improving borderline color-TV or FM-stereo reception.

DEVELOPMENT of a new tube (*Amperex* 7788/E810F) has enabled the design of a very low-noise signal preamplifier that will produce acceptable color-TV pictures in weak signal areas. The same amplifier can be tuned for improving the operation of FM-stereo receivers in low signal strength areas. *(Editor's Note: This tube costs approximately $10.)*

Commercially available broadband amplifiers (TV channels 2 through 13) are claimed to have low-band (channels 2 through 6) noise figures of 4 to 5 db and high-band (channels 7 through 13) noise figures of 6 to 8 db. In most fringe areas, these signal boosters will not greatly reduce multi-colored snow on color-TV sets or improve FM-stereo reception.

Table 1 shows the characteristics of the low-noise signal booster using the new tube. The circuit has been in operation for over two years in difficult signal reception areas and has produced excellent results. Fig. 1 shows the circuit.

The 7788 is housed in a miniature nine-pin envelope. Operating voltages may seem strange in that the plate requires 120 volts while the screen requires 150 volts for proper operation. Because screen dissipation is limited to one watt, while the plate will dissipate five watts, a variable bias control has to be used to keep the plate current within 35 ma. which, in turn, will keep the screen current safely at 5 ma.

Conventional high-frequency construction techniques must be used when building this amplifier to avoid parasitic oscillations. This means the use of adequate bypassing, short leads, and common ground connections directly to the chassis. Shielding between the input and output portions is important and low-inductance capacitors are used for bypassing.

The amplifier is designed to match a 72-ohm coaxial transmission line in the interests of best color reception and reduction of local electrical interference.

In practice, it has been found that the low-band version produces maximum gain, lowest noise, and maximum rejection of local low-band adjacent channels.

Actual measurements have shown that a 100,000-μv. signal on channel 4 is reduced more than 60 db at the output terminals of an amplifier that is tuned to operate on channel 2.

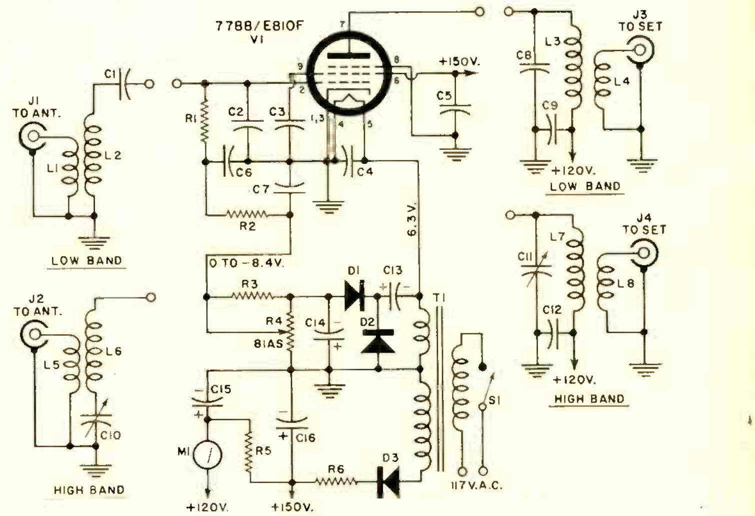
Frequency	Calculated Noise Figure	Measured Signal for 6-db Signal Plus Noise to Noise Ratio	Variation Gain Over 6-mc. Channel	Gain Figure
Channel 2	2.4 db	4 μv.	.1 db	38 db
88—108 mc. (FM band)	2.5 db	.05 μv.	.1 db	40 db
Channel 7	2.9 db	8 μv.	.05 db	35 db
Channel 13	3.0 db	10 μv.	.05 db	33 db

Table 1. Characteristics of the low-noise signal booster.

Table 2. Coil data to be used with the low-noise booster.

Channel	Low Band and FM* L2 (turns)	L3	Channel	High Band** L6 (turns)	L7
2	3	5	7	5.5	4
3	2.5	4	8	5	4
4	2	4	9	4.5	3
5	1.5	3	10	4	3
6	1	3	11	3.5	2
FM	.75	2	12	3	2
			13	2.5	2

*#24 enamel wire, c.w. on Miller 20A0000RB1 slug-tuned form (¼-in. diameter). L1 and L4 are 2 turns #24 enamel wire, c.w. on upper portion of form. **#18 enamel wire, self-supporting (air-wound), ¼-in. diameter, spaced one wire diameter. L5 is 2 turns of #22 hook-up wire, interwound at cold end of L6; L8 is 2 turns of #22 hook-up wire, interwound at cold end of L7.



R1—47,000 ohm, 1 w. res.
R2—27,000 ohm, 1 w. res.
R3—2700 ohm, ½ w. res.
R4—250 ohm potentiometer
R5—1000 ohm, 5 w. res.
R6—100 ohm, 1 w. res.
C1, C4, C6, C7, C9—.001 μf. ceramic cap.
C2, C8—30 pf. ceramic capacitor
C3, C5, C12—.001 μf. stud-mounted cap.
C10—2-9 pf. variable cap. (E. F. Johnson 160-104 or equiv.)
C11—3-11 pf. variable cap. (E. F. Johnson 160-107 or equiv.)
C13—50 μf., 25 v. elect. cap.
C14—250 μf., 15 v. elect. cap.
C15, C16—30/30 μf., 150 v. elect. cap.
L1 through L8—See Table 2 and text
J1 through J4—R.f. jacks (Switchcraft 3505F or equiv.)
D1, D2, D3—400 p.i.v. silicon rect.
M1—0-100 ma. milliammeter
T1—Power trans., 150 v. @ 50 ma., 6.3 v. @ .4a.
S1—S.p.s.t. switch
V1—Amperex 7788/E810F

Fig. 1. Schematic and parts list for the low-noise amplifier.

The high-band channels (7 through 13) can be covered singly, in pairs, or as an entire broadband group. Broadbanding of the high band is not recommended if there is a local station delivering 2000 μv. or more at the receiving antenna.

Coil Data

Low-band (channels 2 through 6 and FM) coils are wound on slug-tuned forms as shown in Table 2, while the high-band coils are self-supporting air-wound. After completion of coil winding, a grid-dip meter can be used to set the coils to the desired operating frequency.

The high-band coils can be spread apart between turns for broadbanding if desired.

Tuning

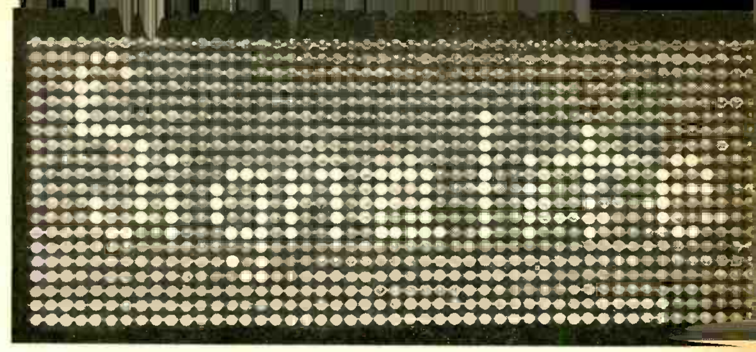
With the desired channel coils plugged in, place bias control *R4* full on and turn on the power. Using a v.t.v.m., pin 2 of *V1* socket should indicate −8.4 volts. Rotate *R4* until this voltage reduces to about −4 volts. Meter *M1* should just be off the zero-current mark.

Carefully advance *R4* until the plate current meter *M1* indicates 35 ma. This is the maximum value for correct operation and exceeding it may burn out the vacuum tube. At the point of 35 ma. plate current, the screen current will be about 5 ma., a safe value. Control grid voltage will be just under −1v.

The 75-ohm coaxial cable from the antenna can be plugged into the amplifier input jack, and a short length of the same cable can be used in conjunction with a 75- to 300-ohm impedance-matching transformer to the TV set.

The coil form slugs (on the low band), or variable capacitors *C10* and *C11* on the high-band coils, are then adjusted for the best picture and sound. ▲

Description of an interesting technique for writing a semi-permanent message by employing small penlight source of light.



The message to be displayed is written with a small flashlight "pencil" on a glass plate. The display itself, shown here, consists of a bank of 1000 special neon glow lamps.

By JACOB G. RABINOWITZ

Chief Engineer, Clairex Corp.

Writing With Light

A UNIQUE application of solid-state photocells and neon glow lamps has been developed in order to demonstrate one of the many uses for cadmium sulfide and cadmium selenide photocells. The device, whose readout portion is shown in the photo, is an interesting technique for writing a semi-permanent message with nothing more than a small flashlight.

The unit is based on the principle of changing resistance in individual photocells with a beam of light so that they, in turn, ignite a corresponding neon glow lamp on a display panel. The lamps on the panel remain lighted until it is desired to change the message. Any message can be written as long as it fits within the physical geometry of the panel.

The system may also be used to project repetitive messages simply by cutting a perforated stencil which is laid over the writing plate. Light from a lamp over the stencil would be projected through the holes to the proper photocells which again would light the corresponding neon lamps. A moving message could be projected in the same manner with a minor modification in the circuit.

The device, called the "Lite-Writer" was developed by *Clairex* not as a product, but rather as a demonstration tool showing the versatility of photocells and neon lamps. It uses a bank of 1000 *Clairex* CL903 cadmium selenide photocells. These photocells have a dark resistance in excess of 10^9 ohms and a light resistance of 133,000 ohms at two foot-candles, maximum voltage rating of 250 volts, and a power rating of 50 mw. They are miniature photoconductive cells and are supplied in a TO-18 case which is .21" dia. x .15" long.

Each of these photocells is individually connected to the trigger element of a three-element neon glow lamp, Type LTG-27-2 produced by *Signalite, Inc.*, Neptune, N.J. The LTG-27-2 lamp is a high-brightness neon glow lamp which was chosen because once ignited (on d.c. operation) it will stay on until a reset button is pushed.

As opposed to the more conventional two-element lamp, the LTG-27-2 is what is commonly called a "trigger tube." This means that while it has all of the electrical and light characteristics of two-element lamps, it has an auxiliary trigger so it can be turned on by a circuit not necessarily connected to the circuit which supplies power for operating the lamp.

Another reason for the selection of neon glow lamps is their low power requirements. Design current for the LTG-27-2 is only 3 ma. A previous model of this demonstrator had used incandescent bulbs, but the power drain for even a relatively short message was so high that the power line was overloaded, repeatedly popping the circuit breaker.

For an installation such as this, lifetime of the neon lamps is an important factor. Since the lamps are soldered in place, replacements would be both time consuming and costly. The rated life for the LTG-27-2 is 5000 hours of continuous operation. Since no one lamp is on all of the time, actual life for any lamp is well in excess of this figure.

A schematic diagram of the writing system is shown in Fig. 1. The light source is turned on when the probe touches the conductively coated glass plate. The beam from the subminiature lamp is passed through an optical lens to a mirror where it is reflected to the bank of CL903 photocells.

Output from each photocell is taken through the circuit shown in Fig. 2 to the corresponding glow lamp on the display panel. Each neon lamp so activated will remain on until the reset button is pushed which extinguishes all lamps at once. The power source is 140 to 145 volts d.c.

The "Lite-Writer" is but one of many interesting devices which utilize solid-state photocells to perform a variety of tasks. They have been used, as has been described here, to light neon lamps, and have also been used in applications where they are activated by neon lamps. Neon lamps are a good source of light to operate both cadmium sulfide and cadmium selenide photocells since the spectral response of these materials peaks at between 5150 and 7350 Å. The light from neon glow lamps falls in the spectrum between 5200 and 7500 Å. ▲

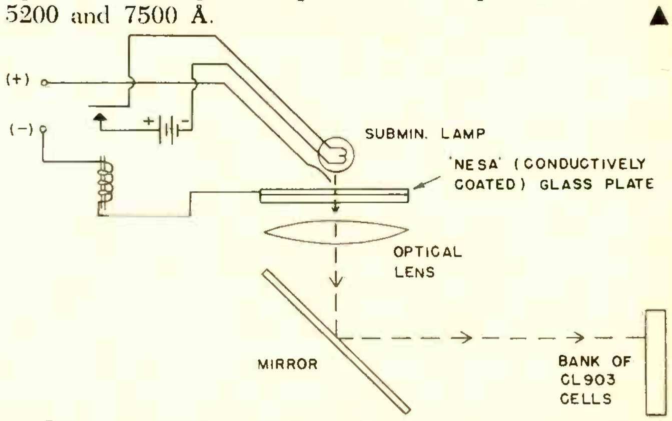
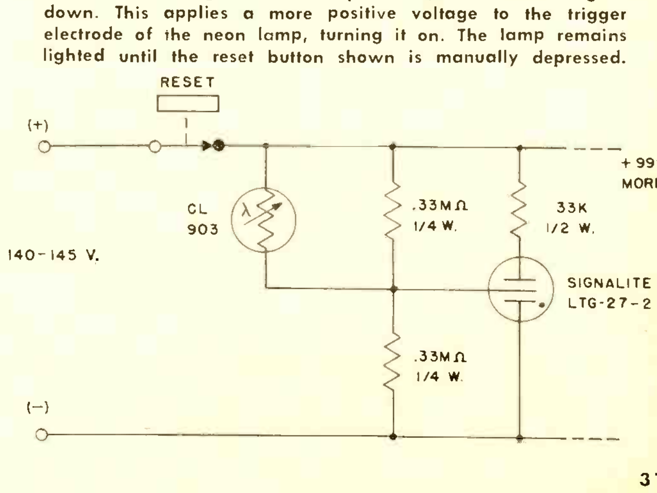


Fig. 1. When the flashlight "pencil" is touched to the glass plate, the relay is energized and the subminiature lamp is turned on. The light travels down and over to the photocells.

Fig. 2. When light strikes a photocell, its resistance goes down. This applies a more positive voltage to the trigger electrode of the neon lamp, turning it on. The lamp remains lighted until the reset button shown is manually depressed.



Line-Operated Transistor TV Sets: *RCA*

By WALTER H. BUCHSBAUM

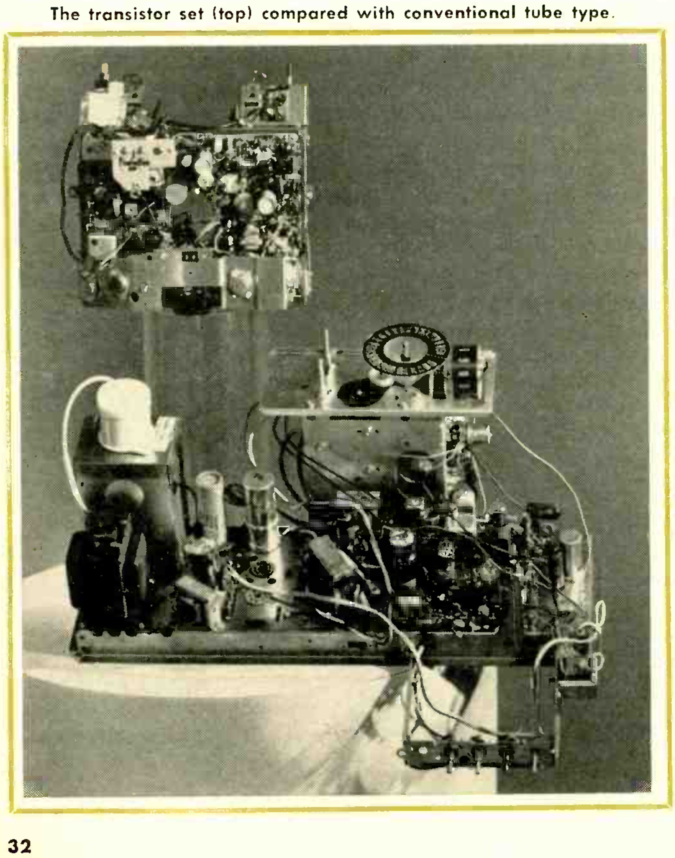
First of a series of articles covering unique circuit details on line-operated, large-screen transistor TV sets. This first article covers the 12-inch RCA sets using the KCS153 chassis.

The RCA "Gamin" 12-inch line-operated transistor TV set. The KCS153 chassis uses 27 transistors, 22 diodes, and one tube.

THE *RCA* Models "Gamin" and "Dapper" 12-inch transistor TV sets use the same chassis and circuitry, but the "Dapper" is furnished with an earphone and muting jack for the loudspeaker. One of the major differences between these receivers and earlier import models is that these sets are intended for straight a.c. service and do not contain a battery or battery charger. Both receivers use the KCS153 chassis, a v.h.f. and u.h.f. tuner, and the new 12BNP4 electrostatic fixed-focus picture tube. Power consumption is about 70 watts.

The KCS153 chassis uses a total of 27 transistors, 18 diodes, four power rectifier diodes, and a single high-voltage rectifier tube. The chassis is isolated from the power line by a power transformer and the circuits are protected by a fast-acting circuit breaker located in the set's "B+" power supply.

The transistor set (top) compared with conventional tube type.



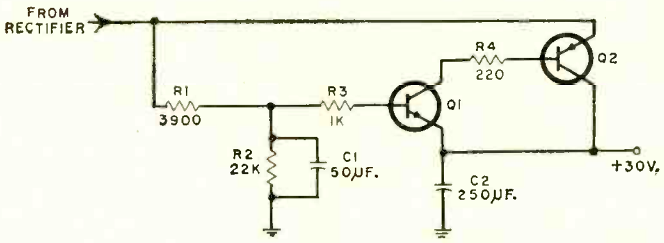


Fig. 1. Two-transistor ripple filter replaces filter choke.

Operating controls are located on the top, with an integral handle, and the three-inch loudspeaker is mounted below. For v.h.f., a telescoping monopole antenna is provided, while a ring antenna is available for u.h.f. A switch on the antenna terminal board selects either the monopole or an external antenna.

Practically all of the circuitry is contained on a single printed wiring board which is mounted parallel with the face of the picture tube. In this manner, all of the components and test points are accessible when the back cover is removed. Five power transistors and the damper diode are mounted on a metal bracket that serves as a heat sink. All other transistors are contained on the printed wiring board. The video output transistor, with a possibility of dissipating slightly more than its minimum power rating, has a separate, free-air type of heat sink mounted to it.

The over-all circuit arrangement of the KCS153 chassis is conventional and, in many cases, transistor circuits serve as direct replacements for their vacuum-tube equivalents. A three-transistor v.h.f. tuner and a separate one-transistor, one-diode u.h.f. tuner each use their own independent tuning mechanisms. Three transformer-coupled i.f. stages deliver video and audio i.f. to separate detectors, while two audio i.f. stages amplify the 4.5-mc. intercarrier signal to the proper level for the two-diode ratio detector. A single audio driver and a single-ended audio output stage complete the audio portion. In the video section, two transistors are used with the output stage having its own heat sink. The sync separator, noise-canceling circuit, and the keyed a.g.c. section each require one transistor with relatively conventional circuitry. Only the "B+" filter and the horizontal and vertical sweep sections represent circuitry which is radically different from their vacuum-tube equivalents.

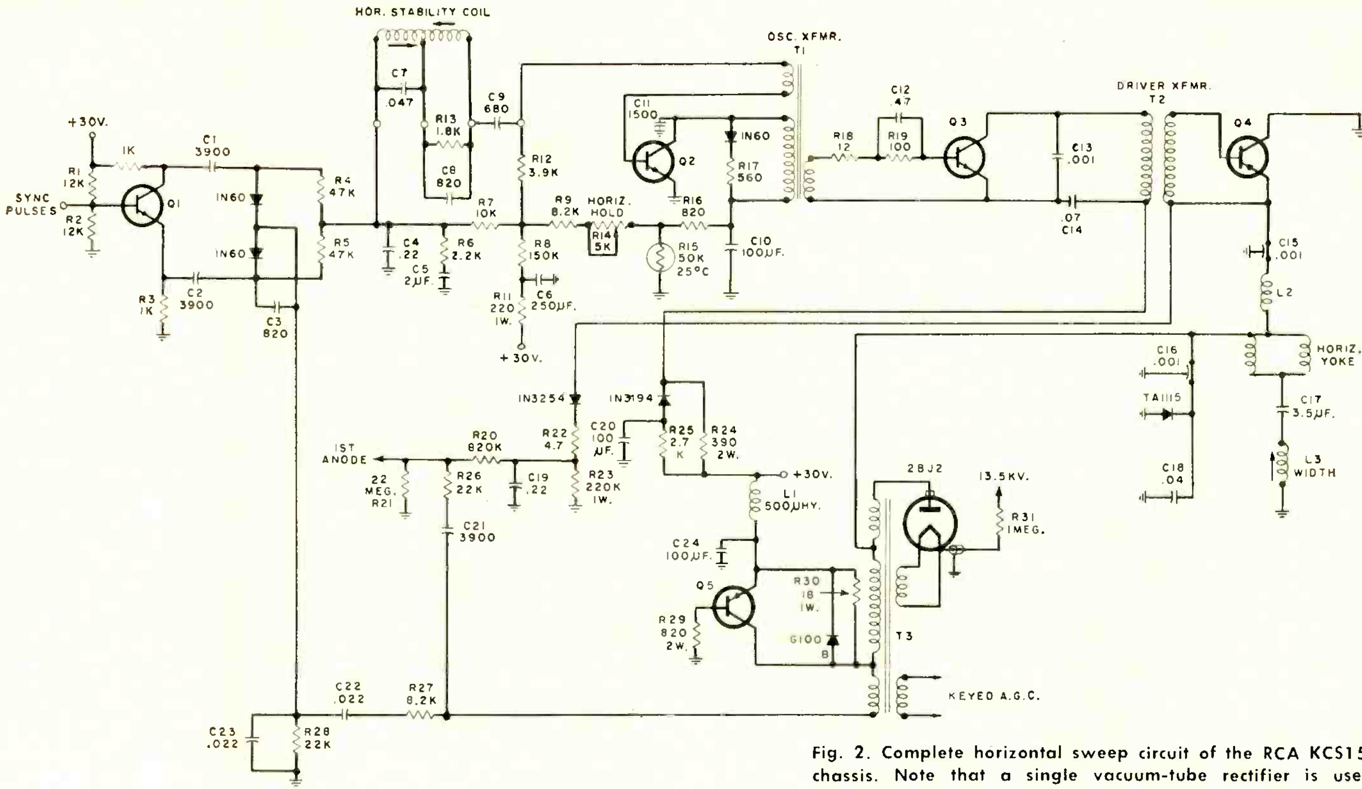


Fig. 2. Complete horizontal sweep circuit of the RCA KCS153 chassis. Note that a single vacuum-tube rectifier is used.

Four transistors are used in the vertical sweep section. One acts as the vertical oscillator, the second as pre-driver, the third as driver, and the fourth actually provides the vertical output signal. It is interesting to note that in the vertical output section the two portions of the vertical deflection yoke are in series, just as in a vacuum-tube circuit. A thermistor connected in series between the two vertical deflection yoke coils maintains a constant height. Another thermistor is used across the vertical output transistor, and one more thermistor is employed in the vertical linearity circuit. In the vertical oscillator stage, a voltage-dependent resistor is used to control the current to the height circuit and thereby helps stabilize the vertical oscillator output amplitude. The purpose of these thermistors is to stabilize the currents in the various transistor stages as the temperature of the chassis varies.

Power-supply filtering is accomplished by two transistors connected as voltage regulators as shown in Fig. 1. Power transistor *Q*2, mounted on the chassis shelf for heat dissipation, acts as a series current regulator whose gain is controlled by its base current, which is a function of *Q*1.

By filtering the relatively low current into the base of *Q*1 with *R*1, *R*2, *C*1, and *R*3, the much greater current passing through *Q*2 is controlled by a low-ripple signal. This technique eliminates the need for bulky iron-core filter chokes while providing excellent regulation.

The most interesting portion of the KCS153, from the viewpoint of novel and complex circuitry, is the horizontal sweep section shown in detail in Fig. 2. A total of five transistors, seven diodes, one vacuum tube, and one thermistor is used to go from the separated horizontal sync pulses to the deflection yoke, and the 13.5-kv. second anode voltage.

The horizontal a.f.c. circuit starts out conventionally using a phase splitter *Q*1 and phase detector consisting of two 1N60 diodes. In this circuit, the incoming sync pulses are compared with a portion of the sweep voltage which is fed back from the bottom of the flyback transformer. The output of the phase detector is an error voltage which is fed to the horizontal blocking oscillator circuit *Q*2. If we omit, for a moment, the horizontal stability coil, it is apparent that the error voltage from the phase detector is filtered by *C*4, *R*6, *R*7, and *C*5 and is then applied, together with a small portion of the fixed 30-volt "B+," to *Q*2. Potentiometer *R*14, controlling the voltage on the collector of the oscillator transistor *Q*2, is the horizontal hold control. Note that *R*15, a resistor used as part of the voltage divider, is a thermistor which changes its resistance according to the temperature. This provides stabilization of the oscillator frequency with temperature variations.

The use of the 1N60 diode and *R*17 across the collector primary winding of the oscillator transformer serves to limit ringing, similar to the damping action in a horizontal output stage. The unusual aspect of the horizontal oscillator circuit is the use and connection of the horizontal stability coil. According to the manufacturer's explanation, the portion of the horizontal oscillator coil which has *R*13 shunted across it controls the *off* time of the oscillator, while the conduction of the transistor, or *on* time, is controlled by the section of the coil shunted by *C*7. In adjusting the horizontal oscillator, it is essential that the horizontal stabilizing coil be set with a calibrated scope to provide an *on* time of 18 microseconds and an *off* time of approximately 40 microseconds.

The output of the horizontal oscillator is a pulse which is amplified by the horizontal driver *Q*3 and changed into a combination pulse and saw-tooth voltage. Transistor *Q*3 acts as a current driver to provide sufficient power through *T*2 to *Q*4, which is the actual horizontal power output transistor. This power transistor is mounted on a metal shelf for heat dissipation. Through a feedthrough capacitor *C*15 and a fixed tuned coil *L*2, the emitter of *Q*4 drives the two portions of the horizontal deflection coil connected in parallel. Another feedthrough capacitor, *C*16, brings the signal to the horizontal damper diode, which is also mounted on the metal shelf for heat dissipation.

Flyback transformer *T*3 provides the high voltage, rectified by the 2BJ2 vacuum tube; a pulse to the a.g.c.; and the feedback signals to the horizontal phase detector. The 30-volt "B+" reaches the emitter of *Q*4 through decoupling circuit *L*1 and *C*24 and the series regulator *Q*5.

In this receiver, "B+" boost voltage is obtained by a separate rectifier and filter network, the 1N3254 and *R*22, *C*19, and *R*20. With the boost voltage, a portion of the flyback pulse is applied to the first anode through *C*21 and *R*26 to blank out the horizontal retrace. Resistor *R*21 is a special 22-megohm device that serves as an arc suppressor. ▲

A ceramic ladder filter along with a ceramic "Transfilter."

Operating principles and applications of fixed-tuned, frequency-selective piezoelectric ceramic i.f. devices.

Ceramic I.F. Filters

By DAVID L. PIPPEN

PIEZOELECTRIC devices have been in use since 1880 when the Curie brothers discovered that application of pressure on sections of certain crystals resulted in their becoming charged with electricity. However, the crystals used have been limited mainly to those of quartz, Rochelle salt, and tourmaline. The demand for a miniaturized i.f. transformer or filter with excellent selectivity, free from magnetic effects, and suited for transistorized equipment has led to the development of certain ceramics for such applications. In the past few years ceramic filters have been developed to the state of being considered as reliable, frequency-selective devices with excellent temperature characteristics.

Operation & Construction

The ceramic device operates much like the conventional crystal filter. When the ceramic element is energized at its mechanical resonant frequency, vibrations occur and very little insertion loss is presented. At other frequencies, a high insertion loss occurs.

The basic ceramic filter is constructed of a rounded disc of specially formulated ceramic. This ceramic has electrode arrangements on each face. The disc shape of the ceramic element allows operation in the radial mode. The configuration of the electrode, dimensions of the ceramic element, and dielectric constant of the ceramic material determine the impedance and resonance characteristics of the ceramic radial resonator.

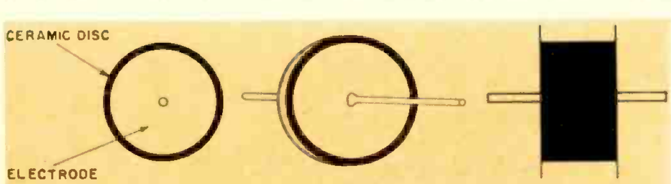
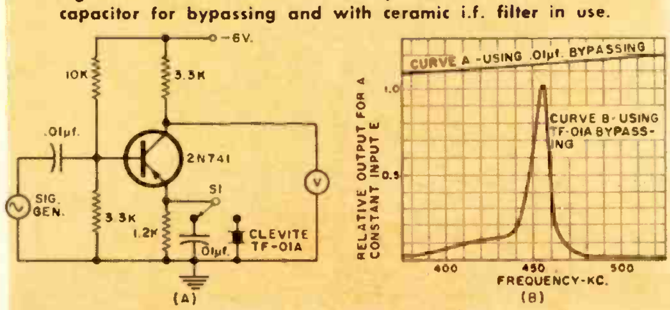


Fig. 1. A fundamental radial resonator and its circuit symbol.

Fig. 2. (A) Test circuit and (B) response with conventional capacitor for bypassing and with ceramic i.f. filter in use.



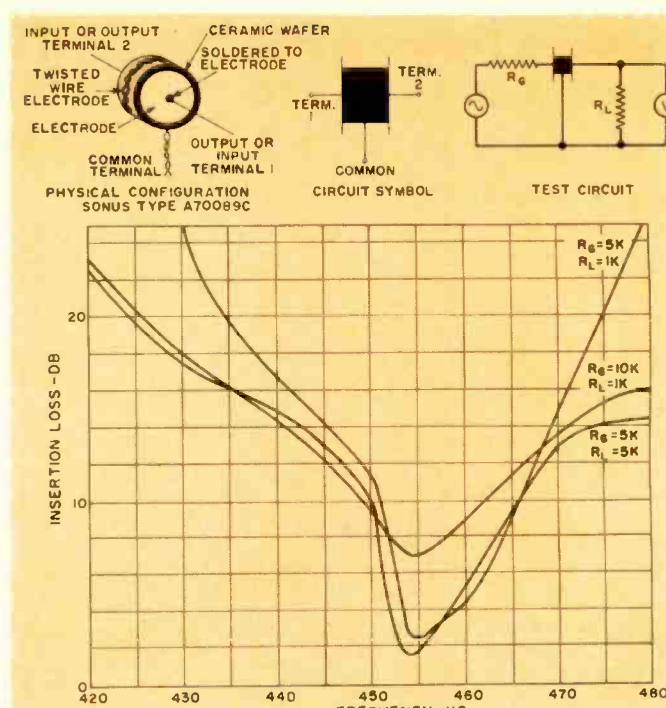


Fig. 3. Construction and response of 3-terminal i.f. filter.

If a ceramic disc has an electrode plated on each face as shown in Fig. 1, then the device is termed a "fundamental radial resonator." This arrangement operates efficiently as a two-terminal device at its fundamental frequency.

Such devices are used in series-resonant filter applications such as for bypassing where they provide much more selectivity than the conventional bypass capacitor. They are also used in place of the conventional i.f. transformer. The device operates in the series-resonant mode and offers a very high impedance at frequencies other than resonance. At resonance it has approximately 15 ohms impedance.

When inserted into a transistor amplifier circuit such as in Fig. 2A, the filter allows maximum negative feedback from the emitter resistor at all frequencies other than the center frequency. At the center frequency, the low impedance of the fundamental radial resonator effectively shorts out the emitter resistor and results in maximum gain. Fig. 2B shows the response of the circuit with a conventional bypass capacitor and with a fundamental radial resonator. Variable bandwidth can be obtained by placing a low ohmage potentiometer in series with this ceramic filter. This type of ceramic filter is offered by one manufacturer (*Clevite Corp.*, Piezoelectric Div., 232 Forbes Rd., Bedford, Ohio 44014) with center frequencies of 455 kc., 465 kc., and 500 kc. for i.f. applications.

The physical construction of a radial resonator used as a three-terminal device for 455-kc. interstage i.f. coupling is shown in Fig. 3. A disc of ceramic is used with electrodes placed on each face. The common terminal consists of a conductor wrapped around the outer periphery of the disc. This configuration (employed by *Sonus Corp.*, 199 Alewife Brook Parkway, Cambridge, Mass. 02138) allows the input and output to be interchangeable since the impedance is the same for the input and output. A range of input-to-output ratios from 1 to 1 to about 10 to 1 can be used with this device.

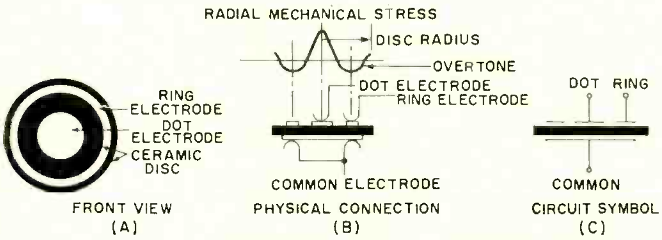


Fig. 4. Electrode arrangement in ring and dot overtone resonator.

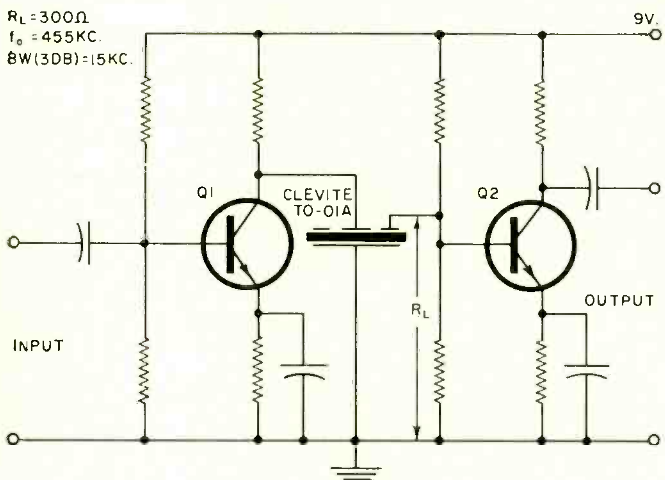


Fig. 5. A two-stage amplifier which employs a ceramic filter unit.

Ring & Dot Resonators

By arranging the electrodes on the ceramic disc as shown in Fig. 4, a radial resonator can be made to operate efficiently in an overtone mode. One face of the ceramic disc has a single electrode and the other face has a "dot" (or small circular area) of electrode in the center as well as a "ring" of electrode around the outer face of the disc. This device is appropriately named a "ring and dot overtone radial resonator." The ring is placed at the exact physical location of the maximum overtone radial mechanical stress, as shown in Fig. 4B.

The ring and dot resonators can be constructed to obtain either *L*- or pi-filter operation. Since the output capacitance should be small for *L* operation and large for *pi* operation, one device cannot fill both needs. The *L*-tuned filter is constructed thicker and requires different impedance-matching techniques than the *pi*-tuned resonator. The *pi* design can provide higher impedances and higher impedance transformation ratios than the *L* design. For operation with the maximum degree of efficiency, both the input and output impedances of these particular devices should be matched.

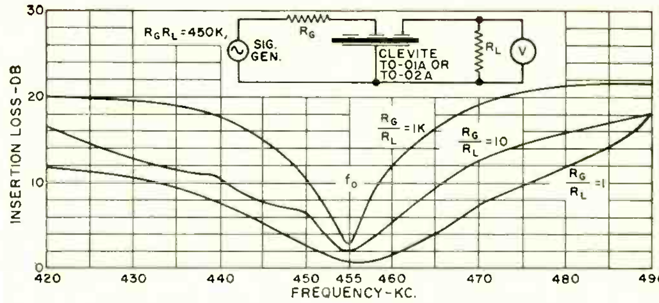


Fig. 6. Effect of circuit loading on response of the filter.

Fig. 5 shows the method of connecting one of these filters (called "Transfilters" by their manufacturer) into a two-stage transistor i.f. amplifier. Fig. 6 shows the effect of changes in circuit parameters on the i.f. response.

Alignment oscillators at the common i.f. frequencies may be easily constructed using ceramic i.f. filters. Fig. 7 is a circuit that oscillates at 455 kc. The ceramic filter used oscillates slightly higher than its nominal frequency of 455 kc., therefore capacitor *C*1 is used as a padder to adjust for the exact frequency. The ring and dot electrodes can be interchanged and oscillations will still occur. It was found, however, that the connection shown provided a cleaner sine-wave output but the output was less. Changes in biasing as well as changing the value of *C*1 will slightly affect the frequency of oscillations. Bias changes on several different filters used in this particular circuit produced frequency changes of approximately 5 kilocycles maximum.

Ladder Filters

Ceramic ladder filters that possess bandpass characteristics very similar to mechanical filters are also available. These filters are about the diameter of a pencil and are up to about 1½ inches long. The ladder filters are constructed by stacking the ceramic radial resonators in a cylindrical package as shown in Fig. 8. This method of packaging permits small sizes that are ideal for miniaturized equipment. Each ceramic disc is held in position by a pair of dished spring connectors with insulators between those springs requiring isolation. These springs function as the electrical connection between elements and eliminate many of the spurious output problems encountered when soldering techniques are used. The springs supply sufficient contact pressure to hold the discs intact for axial loads in excess of 100 g's. Electrical connections between those discs that are physically separate are made by foil jumpers. The entire assembly (*Continued on page* 56)

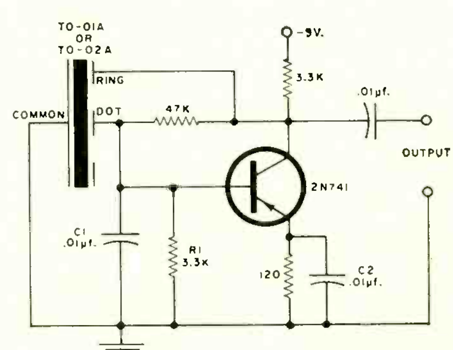
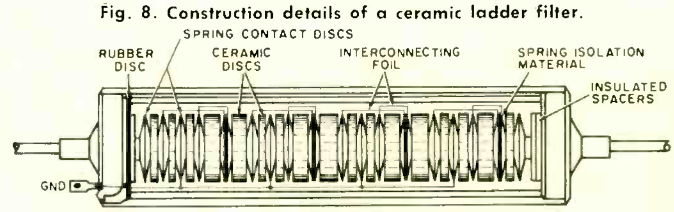
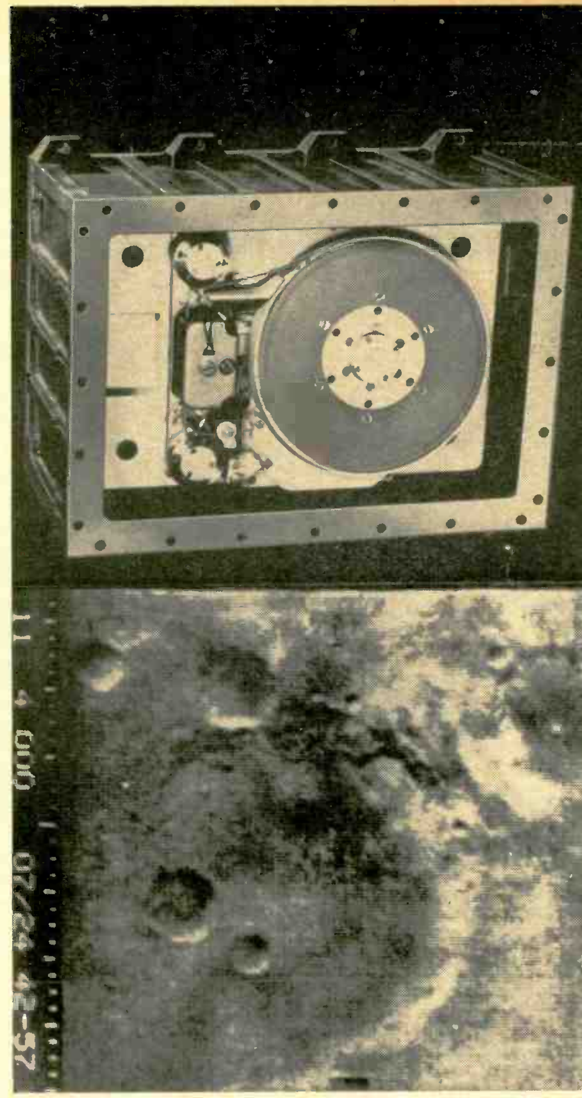


Fig. 7. Circuit diagram showing use of filter in oscillator.

Fig. 8. Construction details of a ceramic ladder filter.

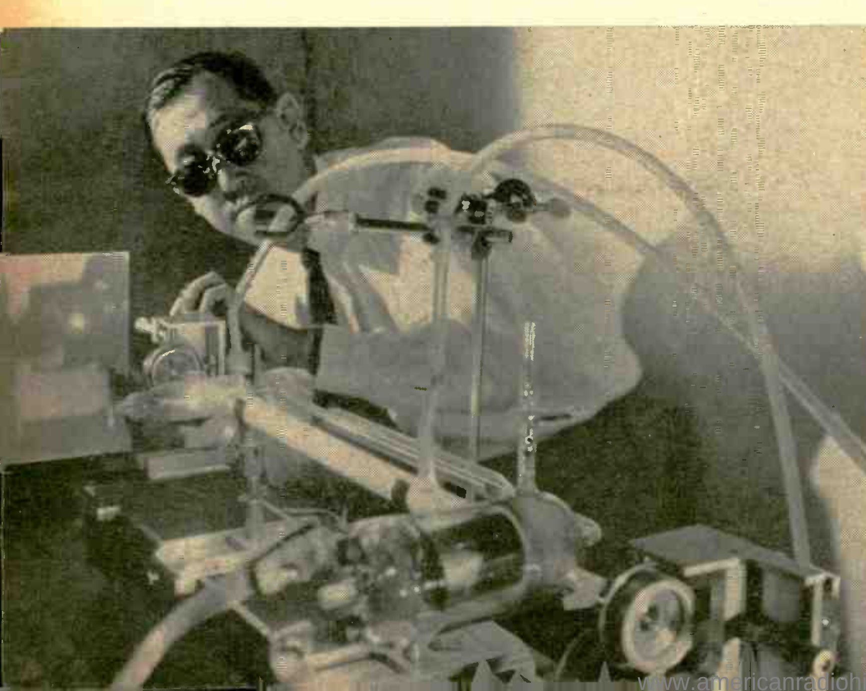


Fuel-Cell Oxygen Maker. (Above) This experimental fuel-cell system can generate pure oxygen from the two waste products given off in breathing. A fuel cell normally is used to generate electricity by reacting a fuel, such as hydrogen, with oxygen. (A fuel cell was used in our recent Gemini 5 flight.) For making oxygen, the cell's operation is reversed by using electric power to generate pure oxygen instead of burning it up. The Westinghouse-designed unit shown here actually uses about 100 small tile-like fuel cells to make up the system.

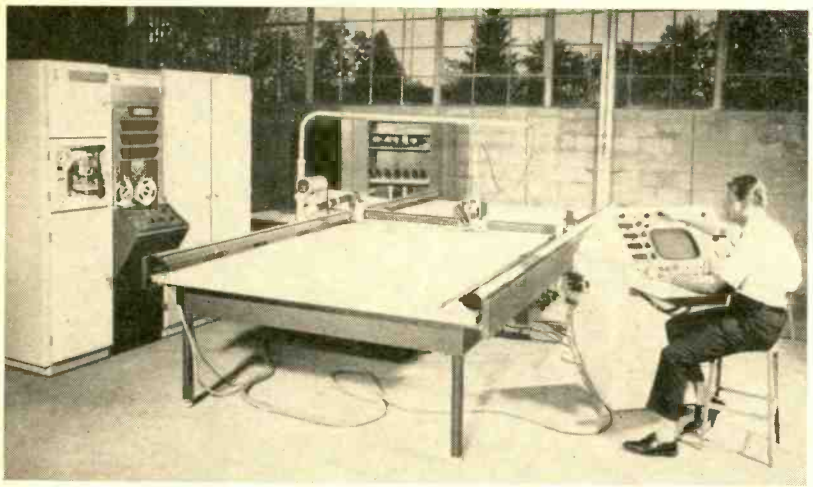


Tape Recorder for Mars Photos. (Above) The photo shown here was taken by Mariner 4 when it was some 7800 miles away from the planet. The success of the program depended on the tape recorder shown which recorded the photo on special Scotch instrumentation tape. Tape length was held to 330 feet by the recorder's ability to operate at the extremely slow speed of one/one-hundredth of one inch per second. The tape was subjected to severe quality-control tests because each photograph consisted of some 250,000 bits of information that had to be retained. In addition to the photographic information, other scientific data was recorded on the same tape.

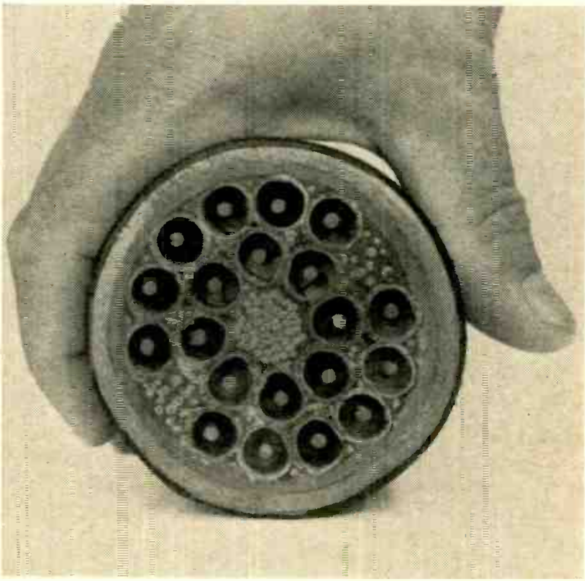
RECENT DEVELOPMENTS in ELECTRONICS



Hologram Laser. (Left) The scientist is adjusting an ionized argon gas laser which is the main component of a new light camera that projects three-dimensional images. This unique laser makes hologram film exposures ten times faster than previously possible. The argon oscillator provides radiation in the blue-green portion of the spectrum and thus decreases film exposure times. The laser has a power output of 1 watt, and it permits film exposure times of 10 seconds compared to 10-15 minutes with helium-neon lasers used previously. The system was developed by Electro-Optical Systems, Inc.

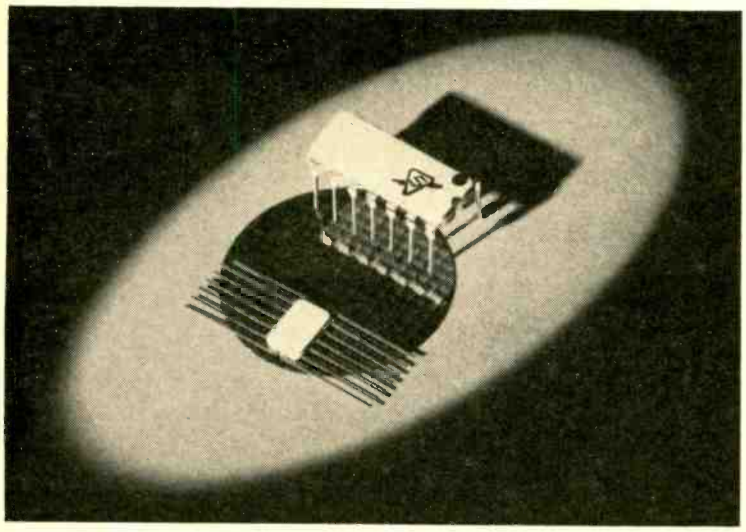


Automatic Drafting Machine. (Left) This new system translates complex mathematical formulas within minutes into precise engineering drawings. The operator sits at the typewriter keyboard and directly controls the alphanumeric operation of the drafting machine. The same keyboard permits the operator to change programs, revise operating subroutines, and insert additional commands into the control memory. Punched paper tape, punched cards, or high-speed magnetic tape can be used to supply input data to the system. Flexibility of operation is further enhanced by the ability of the Expandable Stored Program (ESP) control to accommodate almost any input format. The system was developed by Universal Drafting Machine Corporation and the AIL.

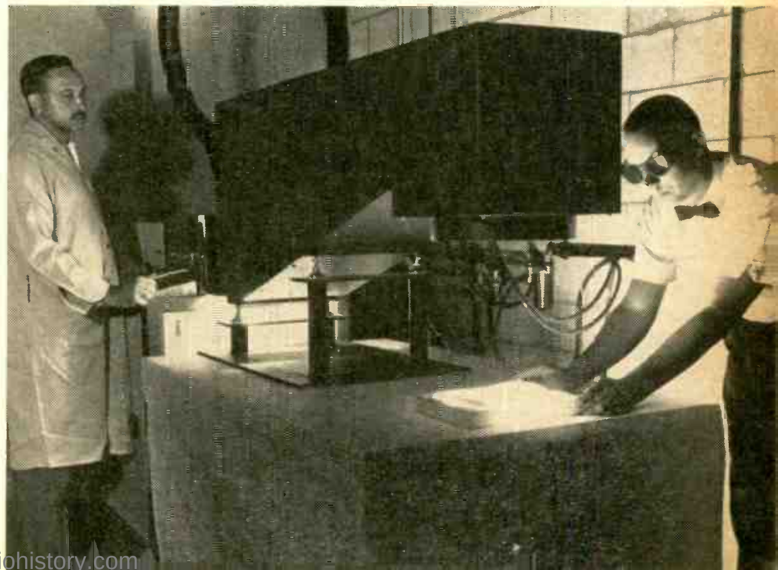


Twenty-Tube Coax. (Above) This is a cross-sectional view of a sample length of a new 20-tube coaxial cable. The cable, approximately three inches in diameter, handles 32,400 voice channels simultaneously when used in the new Bell Labs L-4 system. This link, to be used starting in 1967, has nearly twice the capacity of any long-distance broadband system now in commercial use, including microwave radio. Transistor repeaters are inserted into the line at two-mile intervals. The new cable can be used in a "hardened" communications route—that will withstand natural disasters, floods, hurricanes, and even nuclear blasts short of a direct hit.

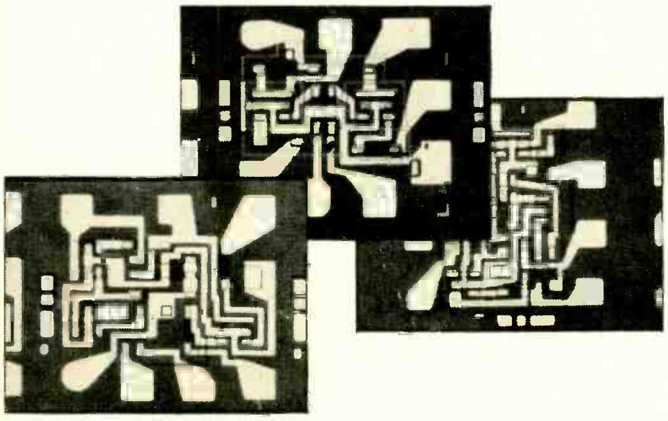
Plug-in Integrated Circuits. (Below) New "plug-in" integrated circuits containing what is said to be the fastest saturated logic in the industry have been announced by Sylvania. The new package is hermetically sealed to facilitate high-speed, low-cost assembly in military, industrial, and commercial computers. The package (the upper unit shown in the photo below) is designed for manual or automatic insertion into double-sided printed-circuit boards. The conventional flat packaging arrangement is also available for the new units.



Simulator Tests Solar Cells. (Right) The electronics technician at the left is operating the controls on a sophisticated solar simulator that is being used here to test the performance of a batch of solar cells. This solar simulator, designed by RCA for laboratory and production-line use, accurately reproduces the sun's spectrum over long periods of continuous operation. Scientists are hopeful that these man-made suns will enable them to perform accelerated tests to determine how materials will "weather." The unit is capable of very stable solar irradiance of up to two solar constants (twice the radiation outside the earth's atmosphere).



The INTEGRATED-CIRCUIT INDUSTRY



A special EW report on the business outlook and direction that will be taken by this new technology. Effects on the technician, engineer, the discrete-component manufacturer, as well as the electronic parts distributor are surveyed.

(Editor's Note: This article is based on a questionnaire sent to manufacturers in the integrated circuit industry and, in some cases, personal interviews with their top management.)

WITH nearly a quarter million individual components used in some of our sophisticated space and missile systems, space and military agencies have been concentrating on ways of reducing size and weight while increasing the reliability of electronic equipment. The semiconductor industry had already made a notable contribution with the development of transistors, diodes, and other solid-state devices. Some of the processes of transistor technology were extended to the fabrication of resistors and capacitors. This led the government to subsidize such giants as *Texas Instruments* for the development of integrated circuits for space and military applications.

Since their appearance in the early 1960's, sales of integrated circuits leaped from $18 million in 1963 to $40 million in 1964. In 1964 *Texas Instruments* and *Fairchild* shared 50% of the market. *Motorola* and *Westinghouse* accounted for close to 20% of the business while about twenty other firms competed for the remaining 30%.

Initially, the government was the sole customer for integrated circuits. Prices for many components were in excess of $100, thus discouraging their use in industrial and consumer products. Now such circuits as flip-flops for industrial applications can be purchased for a dollar, making the integrated circuit attractive for use in both industrial and consumer products. Based on figures compiled by the industry at large, average sales in 1964 for the military market was about 65%, for industrial use, 33%, and less than 2% for the consumer market. A few companies, such as *Varo,* listed their sales as 90% military; *Stewart-Warner,* on the other hand, marketed 90% of its output to industry.

Business Outlook

Integrated circuits have made a notable impact on the whole electronics industry and, in the future, sales will be divided 50-50 between military and industrial/consumer uses (Fig. 1).

The volume of integrated circuit sales is on the rise in all areas. The *Autonetics Division* of *North American Aviation* has purchased $16 million worth of integrated circuits this year for the Minuteman II control and guidance systems. Integrated circuits will also find greater application in non-military equipment—not necessarily because of their small size and lighter weight, but because of their lower cost and greater reliability when compared to discrete components. Lower cost will result from greater yield and improved manufacturing "know-how." Reliability is already high and this particular characteristic will be considered a little later in this article.

Our estimate is, and this is shared by such people as Alvin B. Phillips, general manager of integrated circuits at *Sylvania,* that 1965 should bring a gross volume sales of about $60 million. On an even more optimistic note, Herman Fialkov, vice-president of *General Instrument Corp.,* had this to say:

"For the semiconductor industry, microelectronics holds a truly explosive potential. It took industry 10 years to reach a semiconductor volume (in 1964) of $685 million, excluding microcircuits. But microcircuit sales alone, which were approximately $41 million last year, are projected by competent independent authorities, to more than double, to $80 or $90 million this year, and to leap upward to an estimated $400 million by 1968."

For industrial applications, the integrated circuit has the greatest potential in systems where a number of basic circuits are used repeatedly. Examples are digital computers, desk calculators, counters, and digital voltmeters. Prospects are good that a low-cost integrated-circuit computer will be developed for small firms who can't afford the larger machines. In some cases, companies such as *IBM* make their own (hybrid) circuits for use in their computers. *RCA,* on the other hand, purchases about a half-million dollars worth of integrated circuits from outside sources for its Spectra-70 computer.

The minute size of an integrated circuit makes it especially attractive for hearing-aid applications. This industry is currently the most important user of integrated circuits in equipment offered to the consumer. Some limited use of integrated circuits in medical electronics equipment is under way. This is an area which can derive many benefits from these tiny wonders and greater activity along these lines is expected in the future.

For practical reasons, other consumer products such as AM-FM radios and TV sets, have not been affected to any great extent by integrated circuits. After all, it is impractical to use these tiny components when a 5-inch speaker or a 19-inch picture tube will govern, to a large degree, the ultimate size of the product. The situation will change, however, when integrated circuits become competitive with present techniques of printed-circuit boards and discrete components used in many of these products. In some quarters of the TV industry efforts are being directed toward replacing the conventional discrete i.f. strip with an integrated version for greater cost savings.

The general trend in recent years has been to go from vacuum tubes to transistors in electronics equipment. This has occurred in home receivers, hi-fi sets, and other products. There is a good chance, however, that transistors will be bypassed by a few manufacturers in the TV field. When TV sets are ready for complete "transistorization," integrated circuits may be used exclusively because they will be less costly than transistors and other discrete components.

There are some novel possibilities for consumer radios of the future. Bob Schultz (Manager of the Monolithic Department) and Jerry Fishel (Manager of the Multi-chip Department) of *General Instrument* have some engaging thoughts on this matter. Schultz envisions an ear plug-in radio with a remote tuning unit attached to the wrist. The earpiece would contain all the receiver circuitry and a miniature loudspeaker. The wrist unit would be a flea-power transmitter for selecting the desired station in the earpiece unit. No concealed wires connecting the earpiece to the wrist unit would be needed.

Jerry Fishel has a different slant on what the future integrated-circuit radio may look like. He feels that a receiver based on pulse-code modulation (PCM) would be most compatible with integrated circuits. Digital circuits would be used in this type of receiver since it is easy to make integrated circuits for digital functions. When these circuits become inexpensive, such a receiver may become a reality.

Future applications of the integrated circuit in consumer products will be limited only by the manufacturer's imagination and ingenuity. Some designs that may be practical from both an economic and technical standpoint include a car radio that fits into the cigarette lighter socket, an intercom the size of a 3-watt lamp that plugs directly into the wall, a personal paging system, and automatic switching circuits that will eliminate home wall switches.

Technical Picture

In broad terms, there are two basic processes used in making integrated circuits, the monolithic and hybrid. Monolithic circuits are fabricated from a single crystal of material, usually silicon. Passive components, such as resistors and capacitors, are formed by the same processes that are used for making transistors and diodes. Typical methods employed are diffusion, epitaxial diffusion, and the metal-oxide semiconductor (MOS) technique.

In the hybrid or multi-chip integrated circuit, the transistors and diodes may be made by the diffusion process, but the passive components are fabricated by other methods, *e.g.* thin film. There are many variations to be found in the two general technologies. These details are covered fully in other articles in this issue and will not be discussed further here.

The hybrid technology is well suited for special items and small production runs. The monolithic unit lends itself to mass production of circuits and, in terms of cost, will prove to be the most economical. Consequently, there is little doubt that the integrated-circuit industry will probably concentrate on the monolithic circuits for its high-production items.

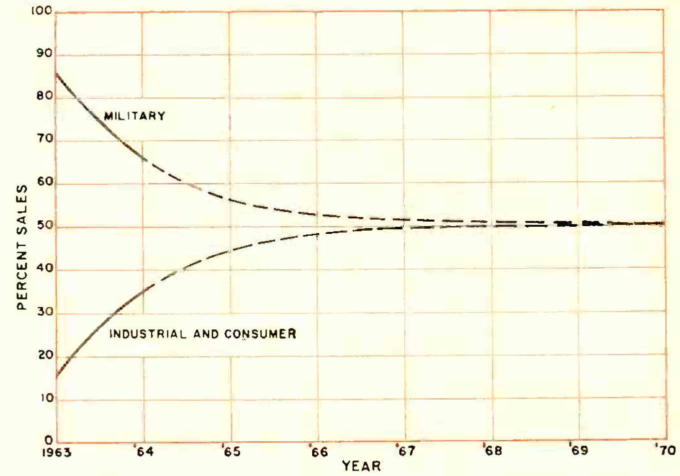


Fig. 1. Projected division of sales between the military and industrial consumer markets for integrated circuits.

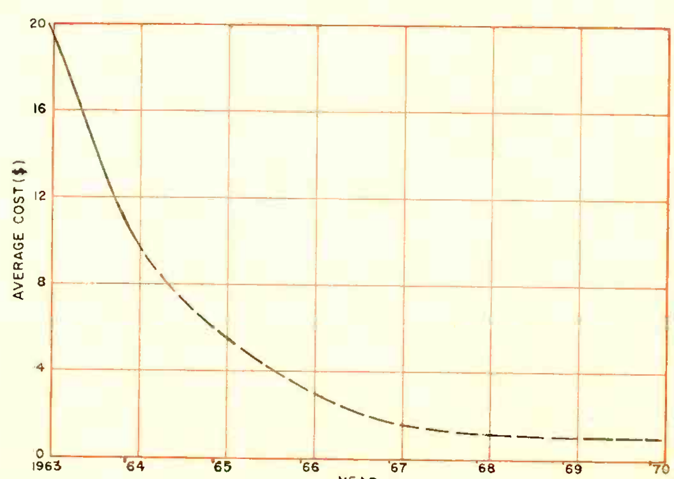
Nearly every manufacturer has off-the-shelf integrated circuits that meet military and industrial (commercial) specifications. Prices are declining steadily (Fig. 2) so that what may have cost $4 a year ago can often be purchased today for a dollar. Delivery can be anywhere from "immediate" to a few months. A large variety of digital circuits and some analog circuits are available off-the-shelf. In the future, one will find more video, audio, and power amplifiers and other analog circuits available in integrated form.

Component for component, integrated circuits often cost less than their discrete cousins. One specific example is the *Fairchild* μL914 dual two-input gate which sells to manufacturers for 99 cents (Fig. 3). The circuit contains 4 transistors and 6 resistors. Assuming you can buy reasonably good transistors at 30 cents and resistors at 5 cents each, the cost of discrete components alone comes to $1.50. Add to this the expense of wiring and packaging the individual components, the actual price of the finished item will be more like $6. *Fairchild* believe that generally a 5 to 1 reduction in manufacturer's cost is possible when going over to integrated circuits.

The cost of converting from an original discrete circuit function to an integrated one can be quite high. The many skills required, such as mask making, photography, and etching can often bring the "tooling" cost to $10,000 or more. If a large production run is scheduled, however, the initial investment is rapidly amortized and the cost per unit item will generally be less than for the discrete circuit.

When a manufacturer switches his product over to the

Fig. 2. Projected trend of integrated-circuit average cost.



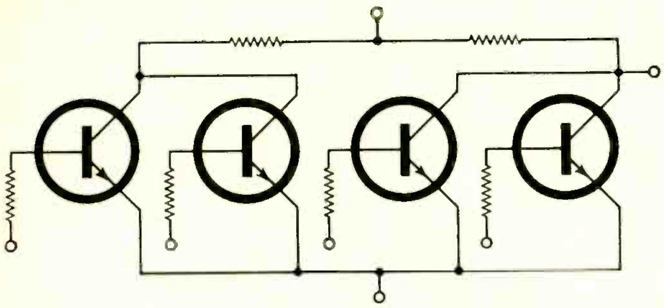


Fig. 3. The Fairchild μL914 dual two-input gate sells for 99¢. An equivalent number of discrete components at 30¢ a transistor and 5¢ per resistor, add up to $1.50. The expense of labor in wiring and packaging the finished discrete-component circuit may result in a total circuit cost of $6.00.

integrated circuit he will find himself restricted when it comes to modifying his product. He has lost the previous flexibility of replacing a resistor here or a capacitor there in order to improve performance. With integrated circuits, new masks, etching, and a host of other steps are required to alter a circuit. This becomes a very costly process and will discourage the OEM from making changes.

To gain the flexibility he once enjoyed with discrete technology, the future OEM may decide to make his own integrated circuits. One approach would be to purchase wafers containing a number of unconnected active and passive components. The OEM would then proceed to do his own masking and etching thus fabricating the desired circuit and making the necessary modifications on the circuit as required for his particular application.

Impact of Integrated-Circuit Industry

Besides influencing the form electronic products will assume in the future, the integrated circuit will also affect the people who earn their livings in the electronics industry. The technician, engineer, discrete-component manufacturer, and the parts distributor may have to discard some old practices and adapt to new conditions in order to remain in the running.

The technician working with discrete circuits spends a good deal of his time troubleshooting for a defective component. In the course of hunting for the culprit, the technician usually refers to schematics for key voltage and resistance values at the pins of a vacuum tube or leads of a transistor. Once the defective part is isolated it is replaced and the job is considered complete. The major cost to the consumer is troubleshooting time; the cost of replacement parts is generally negligible.

With the widespread use of integrated circuits, this concept of servicing will vanish. The future technician will not be able to measure voltages at the pins of a vacuum tube or the leads of a transistor. Further, in most cases he will be unable to replace resistors, capacitors, or other discrete components. Instead of replacing individual parts, he will find himself replacing particular circuit functions. If the trouble is in the mixer circuit, the entire integrated mixer will be removed and replaced. Troubleshooting time will be reduced, thus cutting the service charge. This should enhance the image of the technician and also make it pay for the consumer to have his set repaired rather than discarding it and purchasing new equipment.

The future technician will have to become "system oriented." His training must emphasize functional relationships among the various building blocks that make up a system. His test equipment will be essentially the same; however, he will need fixtures or jigs for checking out a suspected integrated circuit. These jigs are similar to the ones used on the production line for testing integrated circuits.

Based on past experience with vacuum tubes and transistors, it is doubtful whether the integrated-circuit industry will standardize on a limited number of types, sizes, and shapes of integrated circuits. This will mean that the fixtures required for servicing will be numerous. The technician may make them himself or be supplied by the vendor who once produced transistor sockets and has now switched over to making fixtures to hold integrated circuits.

The circuit engineer will also have to become more systems oriented. His design philosophy will be radically different from what it is today. The engineer will be designing with integrated-circuit functions to fit into some over-all system. His approach will be governed by the "black box" concept.

In some cases it may be cheaper to use digital functions rather than analog circuits. This will necessitate a redesign from an analog configuration to one that uses switching circuits. For example, an FM discriminator may become a counter using many integrated digital circuits.

Another reason why digital circuits may be more attractive than the analog type is component tolerance. In a digital or switching circuit, the active device is either "on" or "off." Tolerances on the passive components can be as wide as ±25% and reliable circuit operation is still obtained. In many amplifiers, because of biasing and other considerations, resistance tolerances have to be held much closer than ±25%. The yield of integrated analog circuits with good tolerance usually decreases appreciably, thus upping the cost.

Another possible chore for the design engineer will be the laying out of integrated circuits. Even today, companies like *General Instrument* have some of their customers lay out the masking design for special integrated circuits. Coupled with this, a greater understanding of the physical processes of integrated-circuit operation will become essential. In terms of the engineering curriculum, all these factors should accelerate new course offerings in system design, solid-state physics, integrated-circuit fabrication, and digital switching circuits.

The discrete-component manufacturer will be faced with some serious problems. The increased use of integrated circuits will generally reduce the demand for many low-power passive and active devices. This view is echoed by *Westinghouse*, *Fairchild*, and many others who foresee a decline in growth rate for most discrete-component manufacturers and the obsolescence of many discrete components. A shift in emphasis will probably occur and discrete-device manufacturers will concentrate on high-power and special discrete components. Some may enter the integrated-circuit field while others may switch over to supplying parts which are compatible in size with the integrated circuit.

All is not bleak, however. The foresighted component manufacturer may see his sales keep step with the increasing use of integrated circuits. These tiny devices are going to open up many new markets and generate new products. In addition to integrated circuits, many discrete components will be required for the complete product. The discrete-component manufacturer who has adapted to new conditions will be in an excellent position to get a sizable chunk of the market.

Integrated circuits should simplify parts stocking and purchasing procedures for the parts distributor. In some instances, distributors may specialize and handle either integrated circuits or discrete components. There is also a possibility that the distributor will have to carry the products of fewer companies in order to offer a complete line.

One company, *Philco*, asserts that percent of component sales through distributors will decrease substantially. In our opinion, this can only occur if there is a radical change in the concept of the position the distributor holds in the electronics community. This is an unlikely occurrence.

Reliability of Integrated Circuits

The transistor has been established as a more reliable component than the vacuum tube. (*Continued on page* 78)

LINEAR INTEGRATED CIRCUITS

Commercial linear integrated circuits can be adapted for use in consumer electronics equipment. However, two major roadblocks lie in the way: one is the device cost, and the other is the total lack of inductive elements.

A LINEAR integrated circuit is one whose output varies linearly with its input, just like a conventional amplifier using vacuum tubes or transistors. It will do everything that its big brothers will do, with some important differences. It is extremely tiny (an entire multi-transistor circuit can be contained within a TO-5 transistor case), and it requires far less operating power (in many cases measured in microwatts rather than the milliwatts of conventional circuitry). However, it delivers a somewhat smaller output power.

In one type of linear integrated circuit, all circuit components and interconnections are created by carefully controlled molecular diffusion; they have the desired electrical characteristics and are molecularly bonded together to form a monolithic structure. Circuit reproducibility and reliability are thus greatly increased over a similar circuit fabricated from conventional broader tolerance components soldered or welded to a circuit board.

Most linear integrateds presently being fabricated are used in analog computers. Since most consumer electronic circuitry is analog in operation, the question naturally arises, "Why can't linear integrated circuits be used in radio or TV sets?" The answer is—they can, if the obstacles of high unit price and lack of frequency-selective elements can be overcome.

Several companies have fabricated integrated circuit receivers and transceivers for the military, and one manufacturer has a hearing aid which uses a linear integrated circuit amplifier. However, although there are some prototype consumer applications, the present cost of these items is prohibitive in the price-conscious consumer area.

A glance at Table 1 shows the electrical characteristics of a small sampling of available linear IC's. A directory of some integrated circuit manufacturers is included in the article on page 49 of this issue. All presently available linear IC's are forms of untuned amplifiers having various bandwidths. No units in themselves are capable of being tuned to a particular r.f. or i.f. frequency.

One company is considering the use of a broadband linear IC in an oscilloscope probe so as to create a variable gain device. At present, most scope and v.t.v.m. probes either have no gain or are loss types, as vacuum-tube or transistor circuits are too bulky to be mounted within a hand-held probe.

In another area, development is under way to fabricate a broadband booster that can be used within a CCTV cable. This will eliminate the bulky line amplifiers and their mounts presently being used. It is even possible to mount a broadband amplifier within a dipole receiving antenna so as to create a high-gain receiving antenna without using valuable chassis space for vacuum-tube or transistor signal boosters.

Linear IC's for use as r.f. or i.f. amplifiers (with external tuning components) are presently available for use to 300 mc., with gains up to 30 db, while oscillator-mixer combinations that can operate from the broadcast band to the u.h.f. region are obtainable. This has led several companies to consider using linear IC's along with outboard miniature tuned circuits together on a small printed board. Another company recently announced an integrated audio amplifier having a one-watt power output. Industry engineers claim that when the cost of such composite circuits comes down to present circuit costs, then there is a very good probability that these new devices will find their way into consumer products.

The major reduction in consumer electronics equipment dimensions came with the introduction of the transistor. At this point, size reduction was considerable, as the components used in conjunction with transistors had also undergone a great size reduction. However, some components do not readily lend themselves to miniaturization. The CRT in scopes and TV sets, meters, switches, loudspeakers, batteries, and operating controls, such as potentiometers and knobs, are already near their lowest practical physical limits for efficient operation. Hence, the use of linear IC's in a circuit will not necessarily mean an automatic over-all size reduction of most devices. All they could contribute is an increase in circuit reliability because of the reduced number of circuit interconnections.

There is another, often overlooked, limit to size reduction. Some semiconductor integrated circuit packages, each occupying typically one thousandth of a cubic inch, can dissipate 100 mw. In a practical system, a group of these tiny circuits could realize a density of 200 per cubic inch. This produces a power density of 20 watts per cubic inch, meaning that air cooling is not sufficient and either liquid or thermoelectric cooling must be used. This will tend to offset the size advantage of the small circuit dimensions.

Tuning Problem

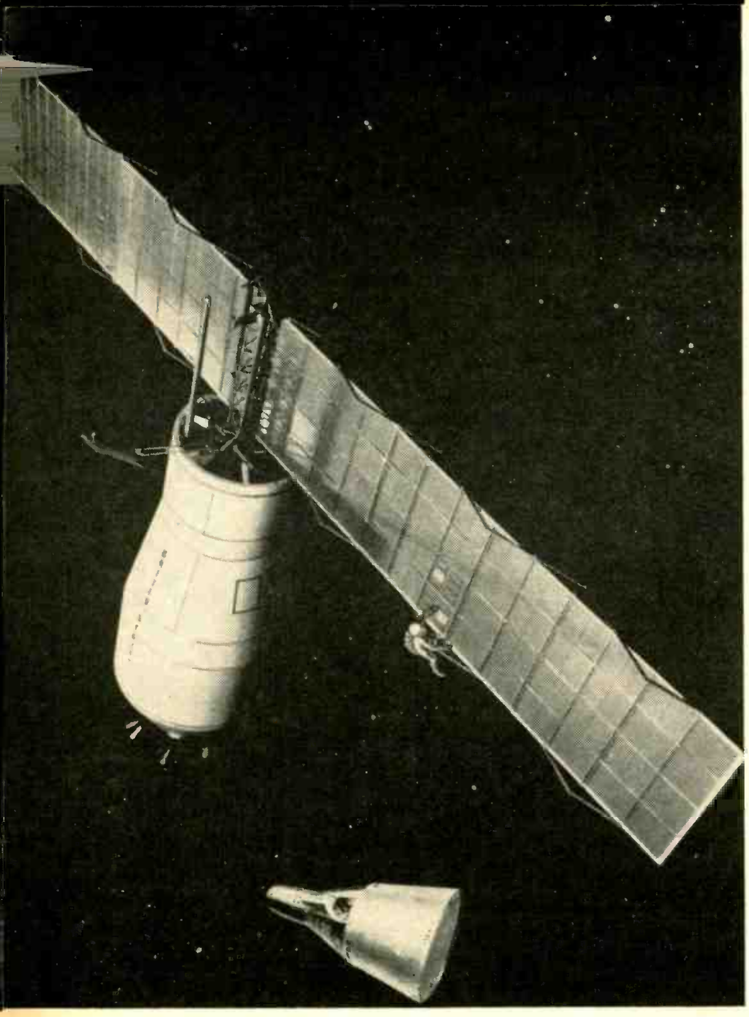
The lack of frequency-selective elements within linear IC's has been mentioned several times. The basic problem is that when an inductor is scaled down in physical size (so that it can be included within the TO-5 can), the "Q" decreases as the square of the scaling factor. Even with relatively large thin-film substrates, it is not possible, at this time, to obtain useful values of inductance without expensive special techniques. Simple ¼-inch special thin-film inductors of 1 to 2 μhy. have been fabricated, but they are not usable below v.h.f. where "Q's" up to 25 are realized.

Many other techniques for creating frequency-selective circuits without the use of inductors have been tested. These include passive feedback using piezoelectric resonators, active feedback with parallel-T or distributed *RC* null networks, and the principle of the reactance tube. None of these has proven feasible, however, and the search for a relatively high-"Q," relatively low operating frequency inductor, or inductance simulator, is still high on the list of integrated circuit research goals.

At the present time, engineers researching consumer applications of linear IC's have (*Continued on page* 71)

Table 1. Characteristics of a small sampling of linear IC's.

Mfr.	Type No.	Frequency Range	Gain (db)	Input Z (kilohms)	Output Z (ohms)
G-E	12X207	10 cps - 100 kc.	56	10	10^6
Gen. Inst.	NC/PC101	d.c. - 20 mc.	25	1.2	500
Motorola	MC1524	d.c. - 770 kc.	(1 w. out.)	8.5	.5
Sprague	UC1507A	10 cps - 10 mc.	34	47	150
Texas Inst.	SN350A	d.c. - 190 kc.	45	34	2000
Varo	8502	10 cps - 100 kc.	46	10	1000



If future manned flight programs in space permit, Gemini astronauts may rendezvous their spacecraft with the giant Pegasus 3. They would then detach small removable panels for later study on Earth. Forty-eight such panels have been attached to eight of the 416 detector panels that are employed on the Pegasus 3.

MICROMETEOROID MEASUREMENTS

By JOSEPH H. WUJEK, Jr.

Description of techniques used in satellites and space probes to learn more about these small particles that may make space travel hazardous.

IN an earlier article ("Experiments in Space," July 1965), we mentioned the importance of micrometeoroid measurements. Particles of space matter which are smaller than about 40/1000th of an inch (40 mils) in diameter are generally classified as *micrometeoroids*. For some perspective, note that the human hair is about 2 to 3 mils in diameter. Particles of a diameter greater than about 40 mils are generally classed as *meteoroids*, while the still larger particles are termed *meteors*. We shall discuss the measurement of the smallest of these particles, and restrict our discussion to particles having appreciable mass relative to an atom.

Beyond determining the hazard level that micrometeoroids may present to a manned or unmanned space vehicle, other reasons exist for these measurements. In particular, the origin and mechanism of creation of these particles are not understood. Until measurements are made to characterize these particles, astronomers can only speculate. It is thus hoped that the results of these measurements will be of value in gaining a better understanding of the universe.

Parameters Measured

Before we can develop an instrumentation system to perform our measurements, we must have a clear understanding of what parameters we are attempting to measure. Ideally, a micrometeoroid instrumentation system would perform the following measurements:

1. *Flux*. How many particles of a given size and speed are there in a particular region of space?
2. *Direction*. What is the direction of these particles? Is their motion random, or are most particles headed on a particular course?
3. *Speed*. How fast are these particles traveling? What is the range of velocities?
4. *Size*. How much variation in size exists among particles?
5. *Composition*. What elements of nature constitute these particles? Are any of these particles radioactive? Do any of the particles have an electronic charge, and of what type, associated with them?
6. *Penetrating Ability*. How far will the particles penetrate into a given material? What "sandblasting" effect will they have on materials?

As we shall see, some of these particular questions are readily answered, while others are not.

Instrumentation Systems

Most micrometeoroid measuring experiments may be reduced to the functional block diagram shown here in Fig. 1.

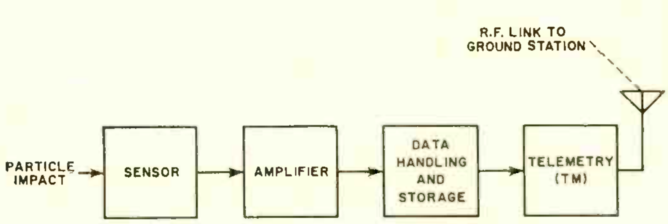


Fig. 1. Generalized micrometeoroid measurement system described.

A *sensor* or *transducer* converts the variable to be measured into an electrical signal. In our case, the variable to be measured has the properties just listed.

The first sensors used were simply *piezoelectric microphones* which listened to the impact of particles against the skin of the spacecraft, as one might listen to rain or hail on a tin roof. These microphones are constructed by bonding a piezoelectric crystal to a thin metallic sheet, such as the spacecraft skin. In using the spacecraft skin a large surface is available for detection, but vibration and noise from the spacecraft itself masked much of the signal and hence reduced the sensitivity. In order to solve this problem, this type of sensor is now fabricated apart from the spacecraft and mechanically damped and decoupled. This type of sensor is

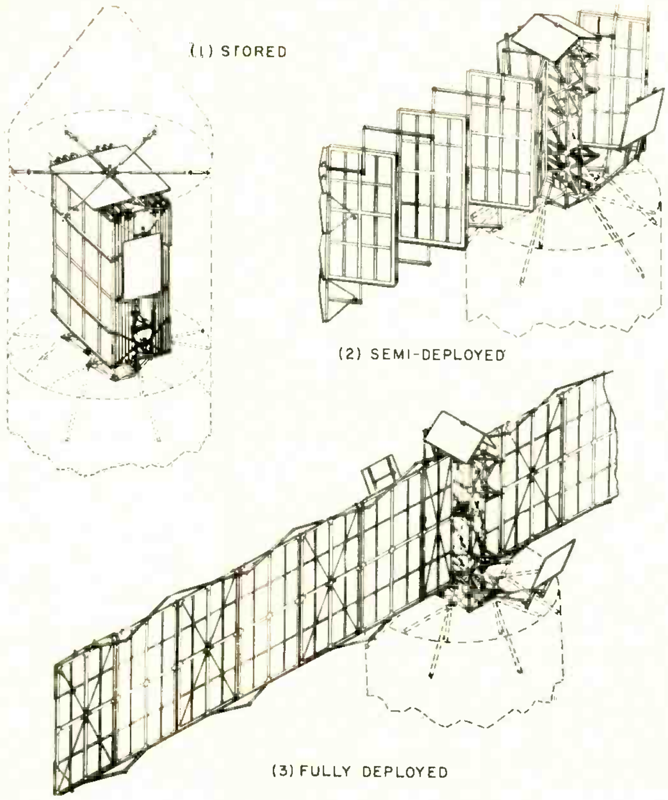
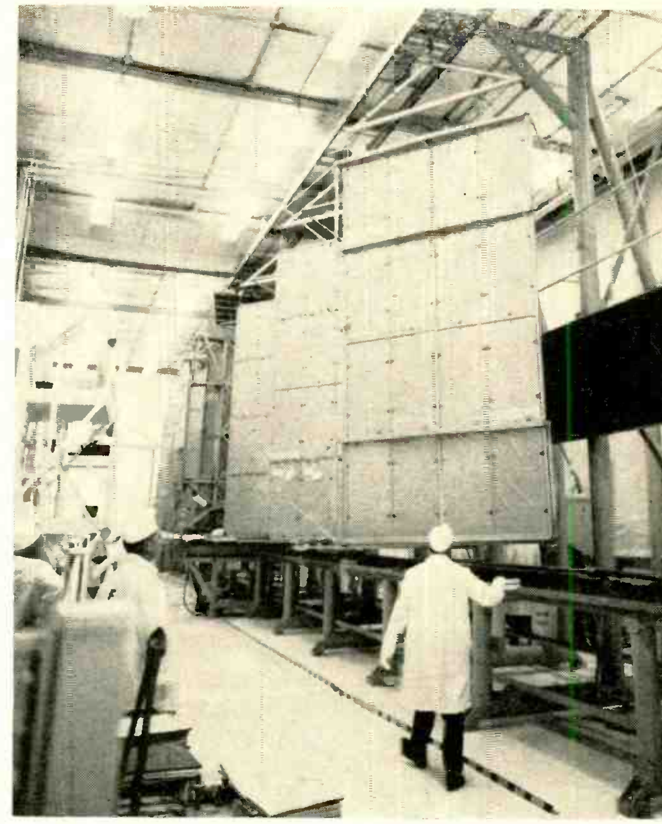


Fig. 2. During launch the micrometeoroid-detecting wings of Pegasus are completely folded. Afterward the wings are unfolded for their entire 96-foot span. The two smaller panels at the sides contain solar cells used to recharge batteries. The electronics equipment is mounted in a cannister in center.



Pegasus weight requirements were so stringent that Fairchild Hiller engineers had to design a wind deployment structure that would not support itself in the earth's gravitational field, but does function in the weightlessness of space. The special test fixture shown here removes gravity loads from the wings.

probably the most commonly used device for these measurements.

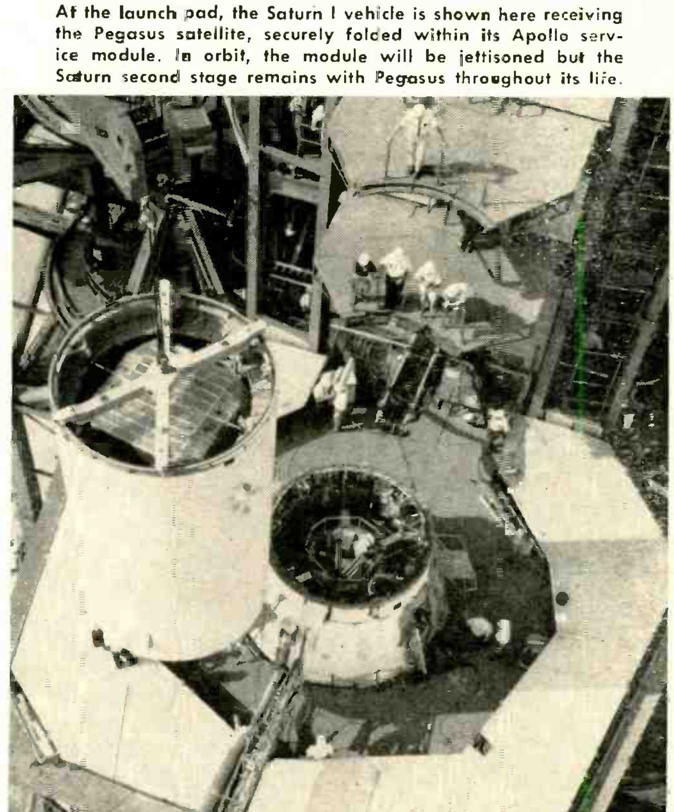
A second kind of sensor is the *capacitor* type. Such a sensor can be fabricated by depositing a thin film of conducting material on either side of a dielectric. A particle striking the outer conductor then penetrates through the dielectric and momentarily discharges the capacitor, giving rise to an electrical pulse. By applying different thicknesses of materials and counting the number of pulses generated within sensors of different thicknesses, a measure of the momentum (mv, where m is mass and v is velocity) or energy ($\frac{1}{2}mv^2$) may be obtained. It was this type of sensor which is in use on the Pegasus satellite, and which we will discuss later in this article. The photo at the end of this article shows a combination microphone/capacitor sensor which was aboard the Mariner 4 spacecraft and staged a "fly-by" of Mars in mid-July of this year. This sensor was built by combining the techniques described above.

Other schemes of sensors exist or are in development, and while not as yet used as frequently as the microphone or capacitor, deserve some comment. The *piezoelectric ballistic pendulum* type uses the property of bending a crystal to produce a signal. The *light-flash* sensor makes use of the fact that certain materials (scintillators) emit a flash of light when struck by a particle. A photomultiplier tube then converts the light-flash to an electrical signal. The amplitude of these flashes is proportional to the energy of the incident particle.

A *pressurized container* and pressure indicator can also be used. While somewhat crude, and good for only one penetration, the sensor is relatively simple to build. The particle punctures the container and, by monitoring pressure, some idea as to the size of the puncture is obtained. A *wire grid* can be used as a sensor. A particle striking a fine-mesh screen open-circuits a wire or wires, and the change in resistance is observed.

Problems common to all sensors are noise, calibration, and interpretation of data. Noise is caused by other components aboard the spacecraft; relays, telemetry equipment, servos, etc., as well as the spacecraft itself. Calibration and interpretation of data are related (*Continued on page* 76)

At the launch pad, the Saturn I vehicle is shown here receiving the Pegasus satellite, securely folded within its Apollo service module. In orbit, the module will be jettisoned but the Saturn second stage remains with Pegasus throughout its life.



GLASS for electronics

By JOHN R. COLLINS

New types of glass are playing an increasingly important role in electronics. They are finding use in delay lines, precision resistors and capacitors, radomes, and CRT's used for readout.

FROM the time of the first pioneer efforts in electronics, glass has been prominent as an insulator, an enclosure, and a dielectric. Special glasses created in recent years have provided greatly improved electronic products and, in many instances, have made simplified manufacturing techniques possible.

The variety of glasses now available is staggering. Practically every element has been utilized in glass-making, and some glasses contain 20 to 30 distinct ingredients. *Corning Glass Works* alone reports that it has more than 100,000 different glass formulas.

Despite this variety, about 90% of all glass produced in the United States is a type called "soda lime," which is made from approximately 70% silica sand (silicon oxide) mixed with oxides of sodium and calcium. The alkali oxides act as fluxing agents and form, with the silica, a mixture that softens and flows at a lower temperature than pure silica. As the glass cools from the temperature at which it is a true fluid, its viscosity increases rapidly. The resulting decrease in atomic mobility is sufficient to prevent the formation of an orderly atomic pattern, and normally glass does not form a crystalline structure. Instead, a random pattern is frozen into the glass, a fact which accounts for many of its properties. Since the transition from a solid to a liquid takes place over a temperature range, glass has no definite melting point. It is customary, therefore, to refer to the softening temperature of glass rather than its melting point.

Soda-lime glass is widely used for windows, bottles, drinking glasses, and lamp bulbs, but its applications in electronics are limited. With a relatively low softening temperature, it cannot be used where excessive heat is encountered. Surface conductivity, an important consideration for many applications, is low because glass with high alkali content tends to absorb moisture. Under conditions of high humidity, the resistivity of soda-lime glass is only about 10^7 ohms/square, compared with 10^{10} ohms/square for glass with low alkali content. This restricts its electronic usage.

Hard Glass

The terms "hard" and "soft" as applied to glass refer to service temperature rather than mechanical hardness, the dividing point being about 400°C. Aluminosilicate glass, which has low sodium content and contains a high proportion of aluminum oxide, has a softening temperature over 900°C and will give useful service up to 650°C. It has good electrical and chemical properties and is often used as an envelope for high-performance power tubes and traveling-wave tubes. When melted in optical quality, it is virtually free of defects and is then useful for faceplaces for cathode-ray tubes.

The hardest glasses are those containing the highest percentage of silica. A glass of about 96% silica is made by chemically removing almost all elements except silica from borosilicate glass. This leaves a porous structure, so it is then necessary to fire the glass again—a process that adds to the expense. Nevertheless, such glass does not begin to soften below 1000°C and can be used regularly at 800°C. It can be heated to a cherry red, then plunged into ice water without ill effect. Glass of this kind has excellent infrared transmission properties and has been used for windows in heat-seeking missiles.

An even harder glass is made by fusing pure silica in which impurity levels are held to less than one part-per-million. This product is the most transparent glass ever made and is used in the finest telescopes. It is also used for laser-beam mirrors and for infrared and ultraviolet windows. Because it has a service temperature from 900 to 1100°C, it is used for crucibles needed to grow silicon crystals for diodes and transistors.

Fused silica glass will transmit an ultrasonic signal with practically no attenuation or scattering, and this has led to its use in ultrasonic delay lines for radars and computers. The electronic signal is converted by a transducer into an ultrasonic signal which travels through the glass until it is picked up by a second transducer and converted back into electrical energy. Relatively long delay times—150 microseconds or more—are achieved by means of a folded path whereby the energy is reflected from facet to facet of a precisely ground polygon. Delay times up to several thousand microseconds are thus possible in a relatively small physical space.

The advantages of very low acoustical attenuation are offset where temperature varies widely by the fact that the coefficient of time delay in fused silica amounts to about 80 PPM/°C. To eliminate the need for temperature control, a special glass was developed with a coefficient of time delay of only 0.5 PPM/°C. This material was used in the delay lines (Fig. 1) in the shift registers of the digital guidance computer for the Gemini manned spacecraft. An important consideration in the selection of this glass was its insensitivity to vibration and other mechanical forces encountered in space flight.

Glass-Ceramics

Even tougher than fused silica glass is glass-ceramic, which is so hard that it can be used to make ball bearings for machinery. Glass-ceramic devices are first formed by ordinary techniques from a special glass batch to which nucleating agents have been added to promote crystal growth. After the device has been cooled, it is reheated and subjected to treatment that causes the crystallization of billions of invisible crystallites throughout the glass body.

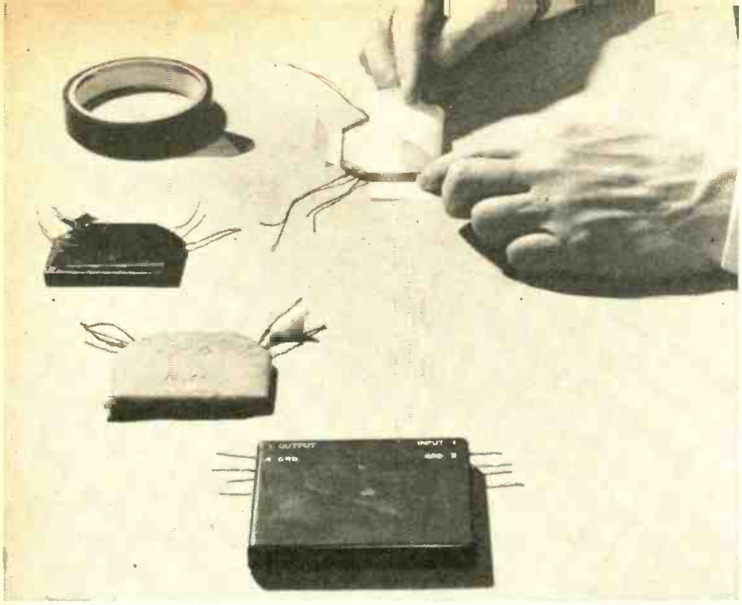


Fig. 1. Delay lines used in radar, computers, and other electronic devices can be made from precise polygon of hard glass.

Glass-ceramic produced by heat treatment is opaque and far stronger and harder than the parent glass. It has greater impact and abrasion resistance and improved thermal and electrical properties. Types have been developed with excellent dielectric properties at microwave frequencies, and these have proved useful for missile radomes. A radome (Fig. 2) permits passage of radio waves for guidance of the missile and at the same time protects the internal guidance system from its environment. Such glass-ceramic radomes have nearly constant dielectric properties over a range from 25 to 500°C; the dissipation and loss factors are nominal.

Photosensitive Glass

One of the most interesting and useful recent developments is a type of glass that is sensitive to ultraviolet light. The discovery grew out of the observation that the windows of old houses sometimes take on a violet coloration. Further investigation led to the finding that certain types of glass, under the influence of ultraviolet radiation, form nucleated crystals. Finally, it was determined that such crystals could be further developed by heat treatment and that they are then 20 times more susceptible to attack by hydrofluoric acid than glass that has not been exposed to such radiation.

Fig. 2. High-temperature, high-strength glass-ceramics are used as combination nose cone/radome in many guided missiles.

When exposed to ultraviolet light and heat, photosensitive glass behaves much like photographic film. An image is formed that is a permanent part of the glass and which extends in depth throughout the body of the glass. Exposed areas turn an opalescent white after heat treatment, while unexposed areas remain clear. Because of the marked difference in sensitivity of the exposed portion, the pattern produced by photographic means can be etched out with hydrofluoric acid, leaving an exact copy of the negative through which the exposure was made.

The process of chemically etching or machining glass has proved a most useful discovery, since glass is difficult to machine by conventional techniques. Fig. 3 shows how photosensitive glass can be chemically machined to form the intricate pattern needed for a fluid amplifier. Developed by the *Diamond Ordnance Fuze Laboratories*, these devices utilize fluids to perform logic functions normally accomplished with electronic circuits. Other applications for photosensitive-glass etching include printed-circuit boards, solid-state substrates, optical coding discs, and various laminated structures. Fine glass screens, containing more than 350,000 precisely located holes per square inch, are utilized for aperture masks in the manufacture of color-television picture tubes.

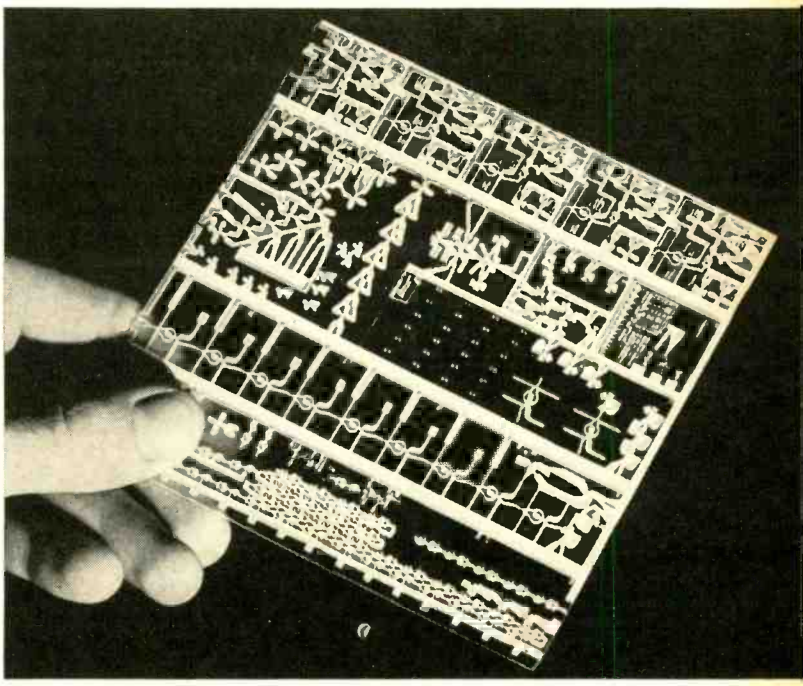


Fig. 3. Glass can be fabricated in a number of intricate patterns as shown by this arrangement of fluid amplifier components.

Coated Glass

Glass itself is an excellent insulator, but it can be made to conduct electricity by firing a metallic-oxide film onto its surface. Although such films are usually less than 0.1 mil thick, they are durable, stable, and—in most cases—transparent. Through selection of the metallic oxides to be used and control of thickness, electrical resistance may be obtained anywhere in a range from about 10 to 10^6 ohms/square.

Coated glass was initially used for residential and industrial heating panels, self-defrosting windshields and rear-view mirrors, and similar devices. Since the metallic surface reflects about 50% of the infrared radiation which strikes it, while letting most of the visible light through, coated glass is also used for windows that permit viewing of industrial processes involving great heat without discomfort to the viewer.

If coated glass panels are grounded, they can be used to shield delicate electronic instruments against r.f. radiation. Used in fluorescent lighting fixtures, they ground interference

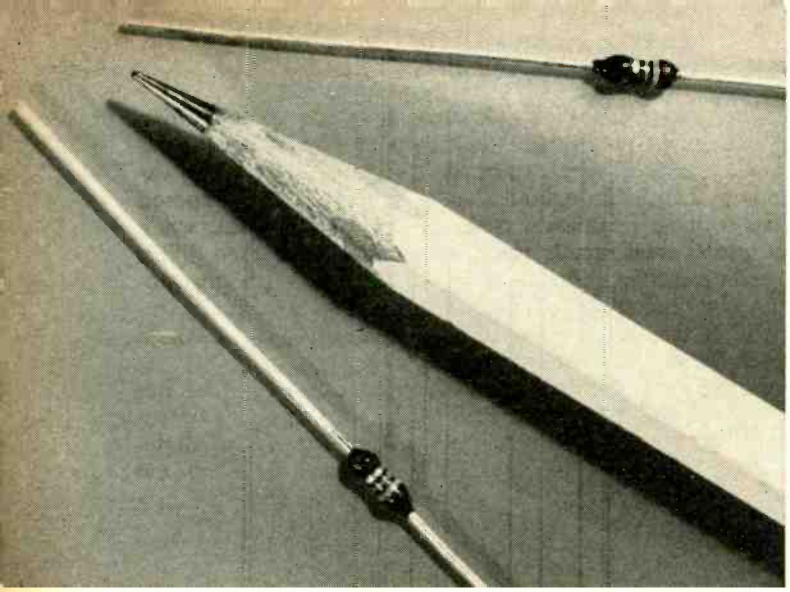


Fig. 4. These precision quarter-watt metal-oxide film resistors use glass bases and can dissipate one-tenth of a watt.

but will permit light rays to pass relatively unobstructed.

Tin oxide fired on a glass substrate that matches its coefficient of expansion forms the basis for a tough resistor with excellent stability under adverse conditions. Such resistors may vary from tiny devices, shown in Fig. 4, to massive units four feet long and five inches in diameter which are used as dummy antenna loads for testing transmitters. They have low noise characteristics and may be hermetically sealed in glass envelopes for protection against moisture and contaminants.

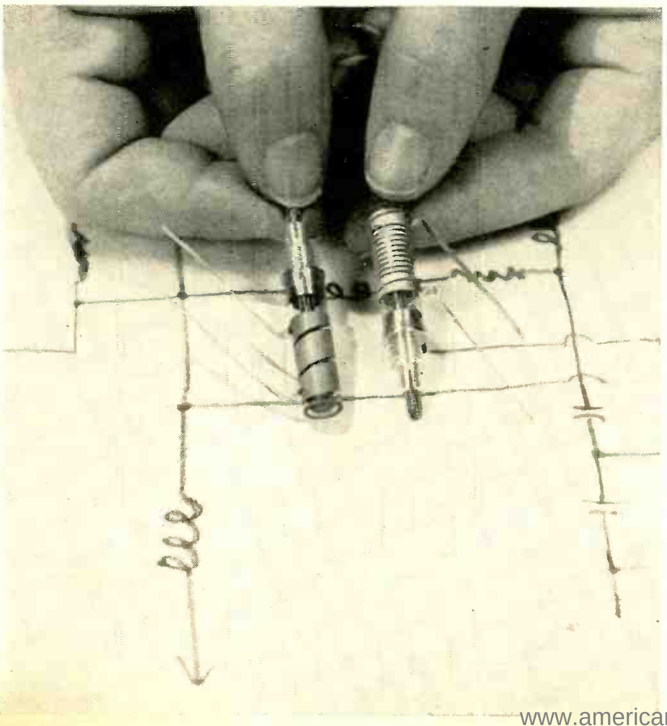
A related application of the same technique is the production of inductors by firing metalized silver conductors into special glass coil forms. The thin metal coatings have almost zero turn-to-turn capacitance, and the inductors can be used at frequencies to 250 mc. (Fig. 5).

Conducting Mosaics

Mosaics consisting of a large number of microminiature conductors, precisely aligned and hermetically sealed in glass, are now being produced, and this has led to the development of a system of electronic printing. A typical array consists of conductors one mil in diameter spaced at intervals of four mils, providing a density of 62,500 conductors per square inch. The mosaics are sealed into the face of cathode-ray tubes. Some of the tubes presently available are shown in Fig. 6.

One of the first applications of conducting mosaics was for the printing of address labels for magazines. Television-type signals were fed to the cathode-ray tube by a character generator, and electrostatic patterns of the characters were formed on a continuous paper web as it passed before the tube. The charged paper was first processed to make the images permanent and was then cut into individual labels. This system made it possible to print 36 labels each second.

Fig. 5. Precision variable inductors are fired on glass bases.



Similar tubes are used in an arrangement for keeping track of individual railroad cars. As trains enter a yard and pass by a scanner, images are taken sequentially of each car in each train. The car numbers showing in the electrostatic print-outs enable fast pinpointing of the location of any car of any train in the yard.

Cathode-ray tubes with conducting mosaics are also used in certain facsimile systems.

Glass for Capacitors

Although servicable capacitors were made many years ago from window glass, it has since been possible to improve the product considerably by careful selection of the best glass for the dielectric. A number of factors enter into the choice.

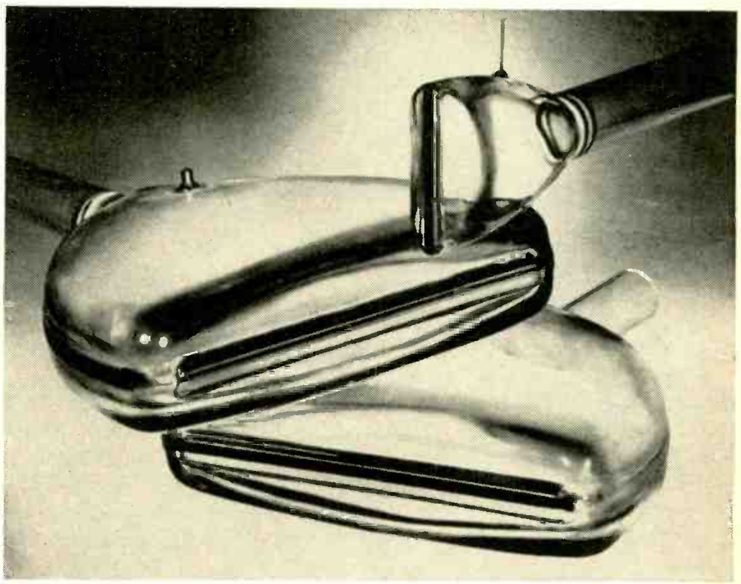


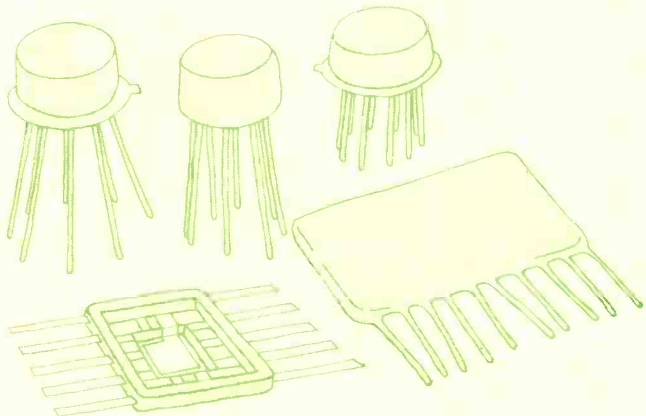
Fig. 6. Cathode-ray tubes with conducting mosaic faceplates are often used in high-speed electrostatic printing equipment.

Pure silica glass has the lowest dielectric constant—about 3.8. The dielectric constant is increased by the addition of fluxing agents to the glass mixture, the largest increases resulting from the heavier ions. Glass containing a high percentage of lead, for example, has a dielectric constant of 15 to 17. However, such glass has high power factor and loss and is therefore not used for capacitors.

Even more important than dielectric constant is dielectric strength. This follows from the fact that the amount of energy that can be stored in a capacitor varies in direct proportion to the dielectric constant, but also in proportion to the square of the dielectric strength. Therefore, a glass with twice the dielectric strength is as effective as one with four times the dielectric constant.

It has already been pointed out that soda-lime glass has relatively low resistivity and hence would not be the best choice for capacitors. Instead, a potash-lead glass is often used. It has a dielectric constant of about 8.8, high dielectric strength, and low power factor and loss. It can be drawn in the form of a thin, flexible ribbon about one mil thick, free from holes, cracks, or other imperfections. Furthermore, it matches the coefficient of expansion of the aluminum foil to which it is mated. Alternate layers of ribbon and aluminum foil are sealed together at high (*Continued on page* 88)

INTEGRATED CIRCUITS: *What's Available?*



By DONALD LANCASTER

Integrated circuits, some at low prices, are starting to appear on distributors' shelves. Here is a brief description of typical units, some practical circuits, and a directory of manufacturers.

ADVANCING technology and fierce competition in the integrated circuits field have resulted in a large number of readily available, low-cost, distributor-stock circuits that can outperform, out-price, and outlast conventional discrete circuitry. These devices are no longer dream components of the aerospace industry but are here now, ready for immediate application.

On the distributors' shelves today are entire logic circuits, including memory and counting flip-flops, gates, adders, expanders, bias sources, and shift registers. And what amazing devices they are. One shift register in a single TO-5 type can is able to count to 100, contains over 600 transistors, and sells for a tiny fraction of the cost of conventional circuitry. For decoding and indicating, low-cost dual latches are available. For counting, single-can decade counters are available for less than $25 each. Dual-decade counters that count to 100 and indicate each number in between are also available. For level detecting and comparing, differential comparators that readily become variable-threshold Schmitt triggers are now in stock.

The amplifiers are even more impressive. One operates from d.c. to 30 mc. with a voltage gain of 2500. A second unit gives 26 db of power gain at 100 mc. A third produces a full watt of audio output into a speaker with very low distortion and consumes very little standby power.

And this is only the bare beginning, the results of a few short months' work in a new technology. The impact on space electronics has already been huge. Give integrateds several more years, and totally undreamed of electronic circuitry will be commonplace. Circuits now impossible or extremely complex will soon become common through microminiaturization techniques. We can soon anticipate desk computers priced lower than mechanical adding machines, picture-on-the-wall TV, truly portable communications, vehicular anticollision devices, precision counters, clocks, and controls. And with these, an entire new era of consumer electronic devices will begin. Table 1 lists most integrated-circuit manufacturers.

How Much Do They Cost?

The pricing of some integrateds is genuinely low. One manufacturer (*Fairchild*) recently announced the feasibility of counting flip-flops in epoxy cases for less than a dollar in quantity. Today you can buy a counting flip-flop for under $4, a five-input logic gate for $3.55, and a bias driver for only $2.25. And these are single-quantity prices that radically drop as the numbers increase.

Other integrateds are expensive, ranging between $15 and $75 each, but when total system costs, including labor and assembly, are considered, they are usually substantially less than the cost required to design, evaluate, and produce similar discrete circuitry. These circuits offer decided performance advantages, notably in regard to wide temperature operation, stability, balance, and frequency response.

How Valuable?

One might inquire what value integrated circuits are where space, weight, and supply power are not acute design problems. To these obvious advantages, we can now add a lower per-circuit cost. Reliability is considerably enhanced since there are fewer soldered joints and fewer interconnections to contend with. Connections, particularly supply runs, are much simpler. Smaller sizes and fewer components result in low mechanical inertia and high shock resistance.

Integrated circuits constitute a total silicon technology and are potentially useful over a −55 to +125°C temperature range, while many newer forms are highly radiation resistant. Each integrated circuit has a guaranteed and specified temperature range, input loading, output capability, and noise immunity. This largely eliminates the temperature tests, environmental checks, loading tests, etc., that commonly plague the discrete circuit designer, for all these tests have already been performed at the can level.

All the transistors in many integrateds are built up out of the same slice of silicon. This means inherent temperature tracking, greatly minimizing drift and offset problems in low-level circuits. Furthermore, integrateds are inherently faster and operate higher in frequency because of their shorter interconnecting leads and the smaller junction sizes. Finally, the locked-in circuit configuration provides precise control of parasitic capacitance and inductance, giving easily reproducible results in high-gain or high-frequency work.

What Types Are Available?

The three most common integrated packages are the flat pack, the TO-5 modified can with 8, 10, or 12 leads, and the dipped-substrate package. The flat pack usually measures 250 mils square by 60 mils or so thick and is accompanied by eight or more leads out the sides of the package. This design represents the most rugged and most compact package but is usually much harder to work with. This is particularly true for technicians used to the much larger discrete circuitry. A premium price is placed on this package by some manufacturers.

The TO-5 can, cut down to 180 mils high, looks like an ordinary transistor with a few extra leads. Good sockets are available, allowing breadboard circuits quite similar to older discrete ones. A closer look reveals two types, a metal can with a glass header and a lower cost, solid epoxy unit. These newer epoxy devices will eventually displace the metal units for all but the most critical applications.

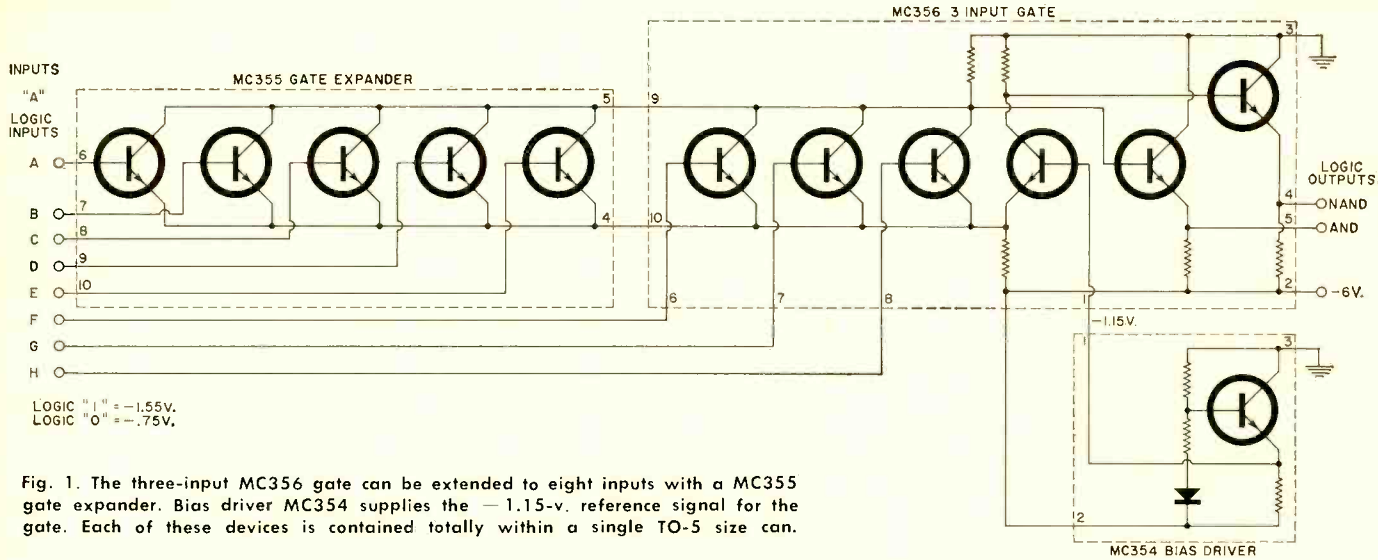


Fig. 1. The three-input MC356 gate can be extended to eight inputs with a MC355 gate expander. Bias driver MC354 supplies the −1.15-v. reference signal for the gate. Each of these devices is contained totally within a single TO-5 size can.

The dipped-substrate package is very similar in appearance to the older printed-circuit networks often used as audio-coupling and vertical integrators in radio and TV applications. This new type takes the form of a postage-stamp-sized ceramic wafer that has both active and passive elements deposited on it. This package is primarily used for latches, decoders, and readout circuitry associated with counters. It is usually self-supporting on its own leads and solders directly onto a printed board.

Most manufacturers sell two lines, a military one and a commercial one. The commercial line is cheaper and consists of "fallout" from the military line. Usually, the primary difference is the operating temperature range. Military units are typically guaranteed from −55 to +125°C, while the commercial ones are only guaranteed to meet specifications over a 0° to 75°C temperature range.

Construction

There are two basic types of integrateds from a circuit-function standpoint. *Digital* circuits are those that perform logic functions and operate between discrete *yes-no* or *A-B-C-D* states. Typical are gates, flip-flops, monostables, etc. *Linear* circuits perform analog functions, and applications include r.f. amplifiers, audio circuits, and differential amplifiers.

The innards of integrateds take one of several basic forms. *Monolithic* integrateds are built up out of a single chip of silicon by various diffusion and doping processes. *Hybrid* circuits consist of a ceramic substrate with deposited capacitors, inductors, and resistors. The active elements are ordinary discrete ones, without cases, bonded directly to the substrate, usually by ultrasonic welding. This technique is useful for high-power levels and circuits where large capacitors are required.

A third type is the *thin-film*. Here, both active and passive components consist of thin films of silicon, nichrome, dopants, and silicon dioxide, all built up on a ceramic or glass substrate. Advantages are good component density and high radiation resistance.

There is a total lack of standardization among integrated circuit manufacturers. Supply voltages, test procedures, and even the location of the can index tab vary greatly. Thus, one must be extremely cautious about connections, power supplies, and the various test procedures.

Specific Devices

Looking first at digital circuits, the *Motorola* MECL line is quite interesting. The MC350 series is a family of ten TO-5 cans comprising a monolithic, all-silicon, high-speed, emitter-coupled logic system. Operation is in the unsaturated current mode rather than in the more familiar voltage mode. This means the "1" and "0" states consist of low- and high-current outputs instead of the low- and high-voltage outputs normally encountered. The MECL line is extremely fast. It easily operates at 30 mc. and the gates in the series have a propagation delay of only six nanoseconds.

Fig. 1 shows how some of the circuits might be connected. Perhaps the most basic circuit is the MC356, a three-input logic gate. This device will provide an *or/nor* or an *and/nand* output depending upon the coincidence of input signals. The actual chip measures only 50 mils square and contains six transistors and five resistors. The transistors are similar to type 2N918. Seven milliamperes of supply power are required from a single −6 volt supply.

The gates in this series all require a precision −1.15-volt reference to compare against the input signals. A resistive divider could be used for this, but for stable, wide temperature operation, an MC354 bias driver should be used. This can holds two diodes, a transistor, and three resistors. Only a single bias source is required for many gates.

Sometimes more than three inputs are required for a single gate. If so, the MC355 gate expander comes into play. This can consists of five transistors with emitters and collectors commonly connected. Its purpose is to provide five extra gate inputs. Any reasonable number of gate expanders can be connected together, and each adds five more inputs. In Fig. 1, these three cans are connected to produce an eight-input *and/nand* circuit.

If only two inputs are required, the MC359 provides two independent, unconnected, two-input gates in a single can. This dual function reduces both the can count and the per-function logic cost. Operation is identical to the three-input gate, except that the MC359 is non-expandable.

Although these gates are primarily intended for logic operation, they make excellent amplifiers, differential amplifiers, and discriminators. This is possible because the normal operation is always in the active region with no transistor ever being completely *off* or *on*.

There are two flip-flops in the series, the MC352, a set-reset model, and the MC358, a J-K counting unit. The MC352 is expandable but will not count by itself. It is easily made into a monostable by the addition of an external resistor and capacitor. The MC358 will count and divide by two as well as perform the normal memory and latching functions.

Another interesting counting flip-flop is the *Fairchild* μL923. This low-cost J-K bistable is in an eight-pin TO-5 epoxy package, contains 15 transistors and 17 resistors, and will count at a 1-mc. rate. A single +3.6-volt supply is needed. This unit is intended for industrial shift-register and binary-counting applications.

Another approach to the set-reset flip-flop is provided by

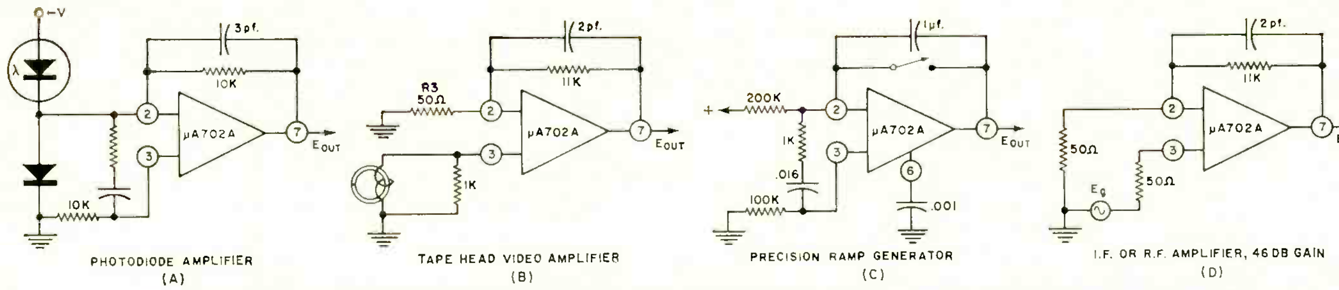


Fig. 2. Possible uses for a typical linear integrated circuit. (A) As a photodiode amplifier. (B) Tape head amplifier. (C) A precision ramp generator. (D) As an i.f. or r.f. amplifier having 46 db gain. Many other circuit variations are possible.

Burroughs in its BIP-6002 dual latch. This dipped substrate contains two silicon-controlled latching switches and suitable gating resistors and provides two independent set-reset latches. This low-cost microcircuit finds most use in decoders and memory and latch circuitry, particularly in those circuits associated with "Nixie" indicators that must operate from a coded input.

Somewhat more expensive is the *Fairchild* CμL958 decade counter. This TO-5 can will singlehandedly count to ten and provide a logic output that is easily decoded to produce all the numbers in between. Inside the can are four counting flip-flops, a logic gate to provide feedback, and an input gate. The can may be reset at any time or at any count, allowing division by any number. Applications are in precision clocks, frequency dividers, industrial counters, and process controls. The units are ideal for predetermined counters.

A second decade device is the *General Microelectronics* PL5050 dual-decade counter. This one has two complete decade counters inside a single TO-5 can, allowing any decodable count from one to one hundred.

Shift Registers

A shift register is essentially a memory circuit consisting of a string of latches or flip-flops. Upon command, the state of each stage is transferred to the next immediate stage. This circuit is extremely useful for word storage in computers and for delaying digital information. It also counts, simply by connecting the output to the input. A single "1" entered into the register will transfer one step for each clock pulse. A ten-element-long register will require ten clock pulses before the "1" returns to the initial state.

A typical unit is the *General Instruments* MEM501 which consists of three independent registers in a single TO-5 can that can be connected to either or both of the others for a register length of 21 bits. This little can contains 110 transistors and 48 resistors. About 100 mw. of power are required from a single-ended, 22-volt supply. Nearly the full supply swing is available as an output. The max. clock rate is 500 kc.

The most impressive shift register currently available is undoubtedly the *General Microelectronics* PL-5100 monolithic, 100-bit, serial-entry shift register. The device contains 612 transistors and counts to 100. Taps are available at shorter lengths. And, as usual, the whole circuit fits nicely inside a TO-5 can with plenty of room to spare.

Linear Circuits

Of the linear integrateds now available, the *Fairchild* μA702A is rather impressive. This is essentially a very-high-gain amplifier with a frequency response from d.c. to 30 mc. It takes the form of a 45-mil square silicon die inside either a TO-5 eight-pin can or the .250-inch square flat pack. The circuit consists of nine transistors and eleven resistors. The input stage consists of a differential amplifier with both sides available as inputs. This allows the μA702A to serve simultaneously as an inverting and a non-inverting amplifier. This is most useful for fixed-gain amplification where the gain is precisely set by external feedback while retaining a high input impedance for the signal.

This amplifier requires two supplies, usually +12 and −6 volts. Internal power dissipation is normally 70 mw. Open-loop voltage gain is 2500 with an input impedance of 25,000 ohms. Since the entire amplifier is on one chip of silicon, both the input transistors are nearly identical. This results in an extremely small differential offset voltage and current. So small, in fact, that discrete component operational amplifiers in the same price range cannot even approach the performance of this integrated design.

Any amplifier operated in a closed-loop feedback mode that performs some mathematically defined operation is called an operational amplifier. These (*Continued on page* 66)

Table 1. A directory of integrated circuit manufacturers.

C.T.S. Corporation
1142 West Beardsley, Elkhart, Ind. 46514

Fairchild Semiconductor
313 Fairchild Drive, Mountain View, California

General Electric Semiconductor Products Div.
Electronics Park, Syracuse, N.Y.

General Instruments Semiconductor Products
600 West John St., Hicksville, L.I., New York

General Microelectronics Inc.
2920 San Ysidro Way, Santa Clara, California

Hoffman Electronics Corp.
Hoffman Electronics Park, El Monte, California

I.T.T. Semiconductors
500 Broadway, Lawrence, Massachusetts

Intellux, Inc.
Box 929, Santa Barbara, California

Motorola Inc.
Box 955, Phoenix, Arizona 85001

National Semiconductor
Box 443, Danbury, Connecticut

Philco Microelectronics
Lansdale Div., Lansdale, Pennsylvania

Radiation, Incorporated
Melbourne, Florida 32902

Raytheon Company
Department 2011, Lexington, Mass. 02173

Sperry Semiconductor
Norwalk, Connecticut 06852

Sprague Electric Company
North Adams, Massachusetts

Signetics Corporation
1675 Stierlin Road, Mountain View, California

Stewart Warner Microcircuits
700 E. Evelyn Avenue, Sunnyvale, California

Sylvania Electronic Components Group
1100 Main Street, Buffalo, N.Y. 14209

Texas Instruments Inc.
Box 5012, Dallas 22, Texas

Transitron Electronic Corp.
168 Albion Street, Wakefield, Mass.

Varo, Inc.
2201 Garland Street, Dallas, Texas

Westinghouse Molecular Electronics
Baltimore, Maryland 21203

LASER MEASUREMENTS

By WARREN GRONER / Sr. Engineer, Electro-Optics Group, Sperry Gyroscope Co.

Equipment and procedures for testing laser performance. Measurement of pulse power, laser spectrum, and modulation are included along with discussion of safety considerations.

THE emergence of the laser and its many applications has made this device extremely important. Commercial lasers and associated instruments have appeared in many engineering firms as well as in a variety of research laboratories. Consequently, laser specifications and the evaluation of laser performance is fast becoming a subject of interest to technicians and engineers. A result of this new technology is the introduction of new concepts and terminology in the electronics laboratory. The description and measurement of laser light is often surrounded by terms and instruments which are unfamiliar to the worker in electronics. For example, some concepts from the field of optics have become increasingly important to the electronics technician.

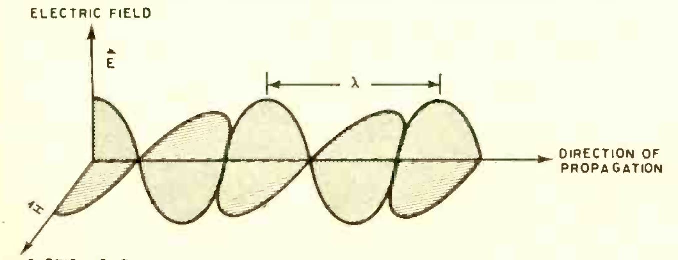
In the following paragraphs the subject of laser performance criteria, their definitions, and their measurement will be discussed. To begin, we will define the quantities which must be determined, and then proceed to describe the apparatus and techniques that are used to measure them. The emphasis will be placed on those quantities and measurement techniques which are unfamiliar to the electronics technician. The need for precautions in working with lasers will also be examined at the conclusion of the article.

Description of Laser Output

Radiation from the laser consists of light, *i.e.*, electromagnetic waves. The electromagnetic wave consists of electric and magnetic fields perpendicular to each other and to the direction of propagation. If the direction of the electric field is perpendicular to the ground, the wave is said to be vertically polarized.

Ordinary (incoherent) light sources produce waves of many different frequencies, phases, and polarizations simultaneously. A description of the output of a noncoherent source in terms of waves is very difficult to visualize. The laser output is coherent, however, and in many cases quite simply described in terms of propagating waves. Fig. 1 shows some features of a single-frequency wave for a given polarization.

Fig. 1. Features of vertically polarized electromagnetic wave.



Consider such a wave at the surface of a transparent solid, such as glass. Fig. 2 summarizes the results for the case where the electric field is parallel and perpendicular to the plane of incidence. (This is the plane that includes the incident ray, the reflected ray, and the normal or perpendicular direction.) Three important features emerge from an examination of the graphs. First, notice that even for normal or perpendicular incidence ($\theta=0$) some light, called Fresnel reflection, is reflected from the surface (4% for glass). Secondly, for one polarization (parallel to plane of incidence) the reflected light intensity is zero for a particular angle, called the Brewster angle. (This is about 57 degrees for an air-to-glass interface.) Finally, for light going from glass to air, there exists an incident angle (about 44 degrees) above which all light is reflected. This phenomenon is known as total internal reflection.

Observation of these three significant results frequently influences the design of lasers and of optical measuring equipment. For instance, in the design of gas lasers, the mirrors which form the resonant laser cavity often cannot be placed in direct contact with the gaseous discharge. Using windows, placed at the Brewster angle to the optical axis, allows the laser light to pass into and out of the discharge tube without loss due to Fresnel reflection. This method also serves to restrict the laser oscillation to a single polarization direction.

These concepts are also used in solid lasers. Fig. 3 shows an example of the design of a high-power ruby laser cavity based on the Brewster angle and internal reflection.

Measurement of Radiant Power

The properties of laser light cannot be determined directly from a measurement of the electric field of the wave. Unfortunately, no detection schemes exist which respond uniquely to this quantity. Photodetectors which are used in the measurement of laser emission (visible or infrared), are sensitive only to the *power* which is radiated. The detector of radiant power is the most important component of the measurement apparatus.

Measurement of radiant power may be accomplished with either of two fundamental detector types: *thermal* detectors or *photon* detectors. Thermal detectors measure the temperature rise of a small sensor element when exposed to radiation. Photon detectors "count" the photons in the radiation beam. Performance of a detector as a measure of laser radiation is described by the following quality factors: 1. sensitivity—the change in output per unit change in input; 2. detectivity—minimum detectable radiant power; 3. response time—the time in which the output rises to 63% of its final value for a step input; and 4. spectral response—the wavelength range over which the detector operates.

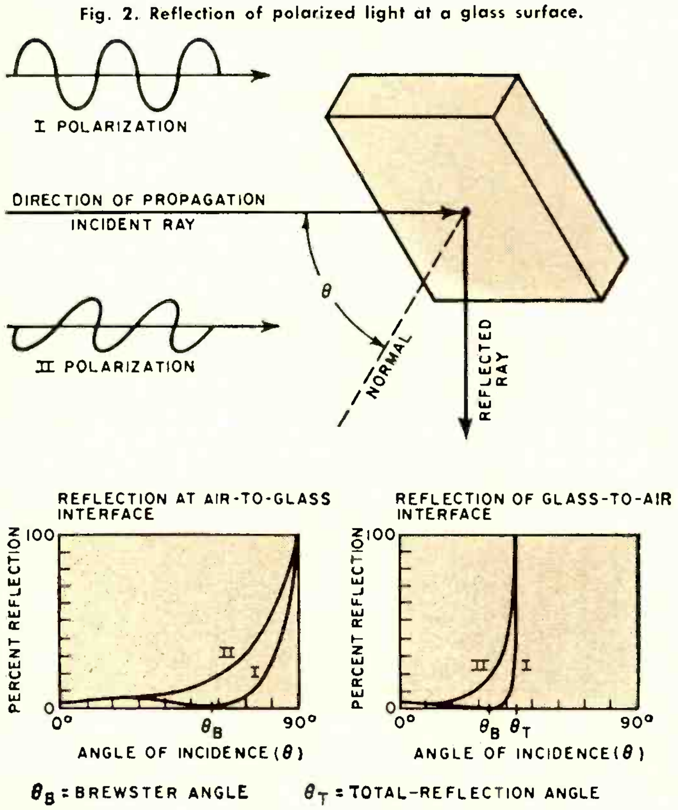
To obtain an accurate measure of laser output, it is important to carefully choose a detector whose characteristics are compatible with the intended measurement.

Thermal detectors are constructed by carefully thermally insulating the sensor (usually a blackened metal) element against heat loss by conduction and convection. Thermocouples or resistance wire temperature probes are attached to the sensor. Because only radiant heating is measured, the sensor element is made to approximate a black body (which absorbs all incident radiant energy). Thermal detectors are consequently characterized by a wide flat spectral response. Since the response of thermocouples and resistance wires is well known, reasonably accurate determination of the absolute power (within about 1%) may be achieved with carefully calibrated thermal detectors.

The detectivity and sensitivity of these devices is mainly determined by construction, which is a well developed art with several commercial manufacturers. Minimum detectable powers as low as 10^{-9} watt are easily obtainable. The sensitivity of these units, which are called *thermopiles*, is generally about 0.1 volt/watt.

The major drawback to thermal detectors is their slow response. Although much attention has been paid to this problem, it seems that detectivity and response time compete in the manufacture of thermal detectors, and even the fastest available units cannot respond in less than 10^{-3} second. Thus, although thermal detectors are useful for accurate absolute measurement of the total output power of c.w. lasers, they are totally unsuitable for detection of the modulation information of a laser beam or the shape of a laser pulse.

Fig. 2. Reflection of polarized light at a glass surface.



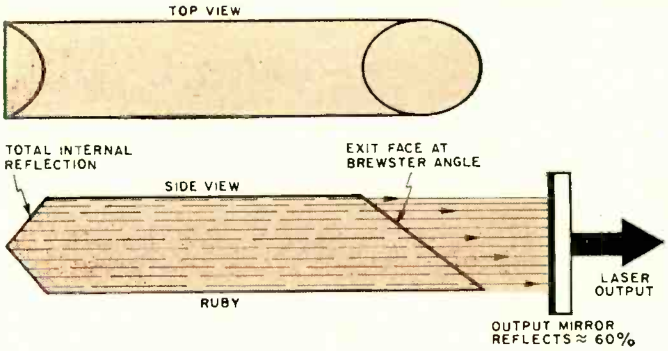


Fig. 3. Ruby laser cavity design using total internal reflection at one end and a Brewster angle surface along with a partially reflecting glass mirror at the other end.

Photon detectors are made of special material which shows a photoelectric or photoconductive effect. Examples include semiconductor diodes and metal cathodes in vacuum tubes. Individual photons are absorbed in the bulk of the semiconductor or on the surface of the metal, creating free charges (electrons or holes). These free charges are collected and form the photocurrent which serves as the output. The response of these devices is entirely characterized by the number of carriers created per incident photon, called the quantum efficiency. The quantum efficiency is in no case much greater than one. Therefore, an estimate of the magnitude of the photocurrent can be made from a knowledge of the number of photons impinging on the detector.

The minimum detectable radiant power for these devices is generally less than 10^{-8} watt. For a quantum efficiency of one, the net photocurrent is only 5×10^{-9} amp. Consequently, it is almost always necessary to feed the output of the detector to an extremely low noise preamp before observing the detected signal on a scope or other convenient display.

The quantum efficiency shows a pronounced peak at a particular wavelength which is a function of the detector material used. This plus other problems prevent the use of photon detectors for absolute measurement of radiant power in any but the most carefully calibrated and controlled systems. However, the speed of response obtainable more than compensates for these difficulties. The response time of a photon detector is limited basically by the time taken for a free carrier to pass between electrodes.

Most common of the photon detectors is the photomultiplier tube. This device consists of a photo-emissive cathode (a surface which ejects electrons when photons strike it) plus a series of dynodes (secondary electron emitters) which serve as a low noise amplifier for the primary photocurrent. The output is developed as voltage across an external load resistor in series with this amplified photocurrent.

Typical photomultiplier tubes show detectivities of less than 10^{-9} watt and photocathode sensitivities of greater than .05 μamp/μwatt at the peak response. The current gain obtained in the dynodes is sufficient to allow the output to be observed directly on a scope, thus avoiding the use of sensitive low-noise preamps. In general, the response time of these devices is under about 0.1 μsec.

Spectrum of Emission

The radiation detector forms the core of most measurements of the properties of laser radiation. A standard method for measuring the spectrum of the emitted radiation is accomplished by placing a dispersing element, such as a prism or diffraction grating, between the laser and the detector. The dispersing element effects a separation of the incident light into its frequency components (see Fig. 4). By rotating the dispersing element with respect to the fixed incident

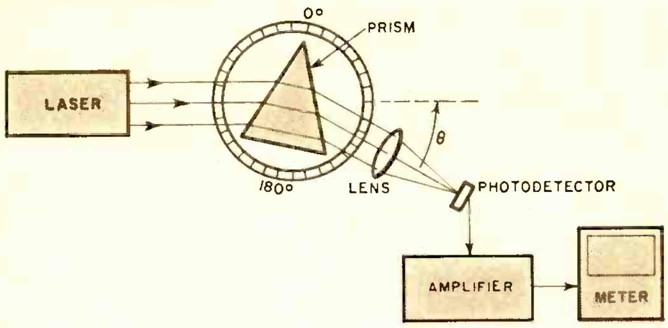


Fig. 4. Determining spectrum of laser by means of a prism.

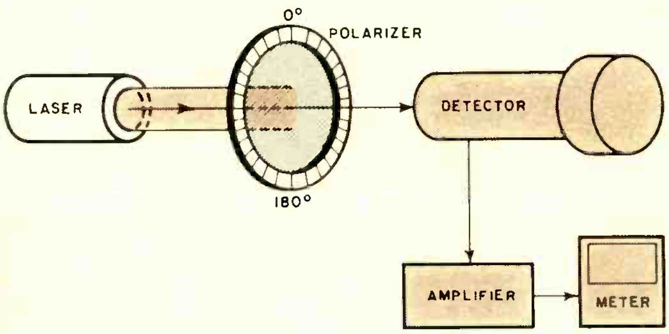


Fig. 5. Measuring the polarization of the laser output.

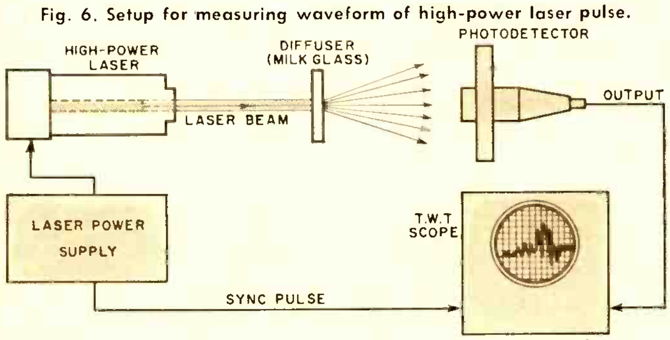
beam direction and the detector, the different frequency components are made to fall consecutively on the detector. By plotting the detector output as a function of rotation angle, the spectrum is obtained.

Calibration of the device is accomplished by passing lights of known spectra through the instrument. The angular positions of the dispersing element which yield output for the known lines is recorded. By superposing this information on the spectrum plot of the unknown emitter (laser), the frequency of the laser emission may be determined.

Commercial instruments, called spectrometers, have been highly developed for this purpose. This method is useful for determining the center frequency of laser emission. The width of the laser spectrum, however, is frequently narrower than the minimum detectable frequency spread of even the finest spectrometer. Consequently, to obtain an accurate and detailed picture of the laser spectrum, a more sophisticated method is necessary.

The laser spectrum often consists of individual fine lines of discrete frequency and small separation. The beat frequency between these lines is several megacycles. This beat is observable with a square-law detector, such as a photomultiplier tube. By directing the laser on to a photomultiplier tube and measuring the detector output with a frequency analyzer, the fine structure of the laser spectrum may be inferred. This method is limited, of course, by the frequency response of the detector. With a good photomultiplier tube it is just enough to cover the range of uncertainty in a high-quality spectrometer. The exact spectrum may be obtained with a combination of these methods.

Fig. 6. Setup for measuring waveform of high-power laser pulse.



The measurement of the polarization of the laser wave is done by analyzing the output with a linear polarizer. This device transmits an amount of polarized light depending on its orientation.

The direction of polarization may be determined by rotating a polarizer between the laser and a suitable detector (see Fig. 5). The detector output will show a pronounced minimum when the polarization of the polarizer is 90 degrees with respect to that of the laser beam, thus indicating the direction of polarization. Sheets of Polaroid plastic material serve well as analyzers in many cases. However, they are effective only in a restricted spectrum, and are often not capable of withstanding the high peak powers of pulsed laser outputs.

These difficulties may be avoided, and a convenient polarizer constructed, by using the properties of the Brewster angle. A stack of 4 or 5 thin glass plates (microscope slides) oriented at the Brewster angle (incident laser beam 57° from the normal), will transmit almost all the light polarized in the plane of incidence, and will reflect much of the light polarized perpendicular to the plane of incidence.

Measuring Pulse Energy

The extremely high radiant power densities obtained from pulsed lasers make the accurate measurement of their output a difficult task. Firing a pulsed laser directly into a blackened thermopile will, in general, give inaccurate results, and may even damage the sensor surface.

Thermal detectors, called ballistic thermopiles, have been especially developed for the measurement of pulsed laser outputs. The sensor is designed to provide a multiple reflection path for the input light. The incident radiation becomes effectively trapped, bouncing back and forth until it is completely absorbed. The individual absorbing surfaces are smooth and shiny, removing (*Continued on page* 67)

GUIDELINES FOR LASER SAFETY

1. **The laser beam should be discharged into a background that is non-reflective and fire-resistant.**
2. **An area should be cleared of personnel for a reasonable distance on all sides of the anticipated path of the laser beam.**
3. **Looking into the primary beam must be avoided at all times, and equal care should be exerted to avoid looking at specular reflections of the beam.**
4. **Avoid aiming the laser with the eye.**
5. **Work with lasers should be done in areas of high general illumination to keep pupils contracted, thus limiting the energy which might inadvertently enter the eyes.**
6. **Caution must be exercised to avoid accidental pulsing of the laser and to avoid electrical shock. Systems should be designed to prevent this hazard and to establish a "fail-safe" condition.**
7. **Individuals working in laser test procedures and others frequently exposed to laser discharges, should be included in an occupational vision program which encompasses thorough general ophthalmologic examinations at regular intervals.**
8. **Safety eyewear designed to filter out the specific frequencies characteristic of the system affords protection, but it may be only partial.**

FREE!

LAFAYETTE

1966 Catalog 660

Now BETTER THAN EVER

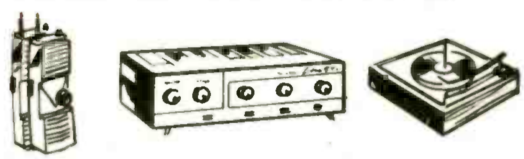
Over 500 Pages

Featuring Everything in Electronics for

- HOME
- INDUSTRY
- LABORATORY

from the

"World's Hi-Fi & Electronics Center"



Use Lafayette's Easy-Pay Budget Plan

No Money Down... Up to 24 Months to Pay

Satisfaction Guaranteed or Money Refunded

STORE LOCATIONS

NEW YORK
Brooklyn
Syosset
Manhattan
Jamaica
Scarsdale
Bronx

NEW JERSEY
Newark
Paramus
Plainfield

MASSACHUSETTS
Boston
Natick

MARYLAND
Mt. Rainier
(Wash. D.C. Area)

Mail the Coupon Today for Your FREE 1966 Lafayette Catalog 660

LAFAYETTE Radio ELECTRONICS
Dept. RK-5 P.O. Box 10
Syosset, L.I., N.Y. 11791
Send me the Free 1966 Lafayette Catalog 660

Name ....

Address ....

City .... State ....

Zip ....
(Please Give Your Zip Code No.)

Mail This Card Today For Your

FREE!

1966 Lafayette Catalog 660

Name

Address

City

State

Zip

Dept. RK-5

(Please Give Your Zip Code No.)

Mail This Card Today for Your Friend's

FREE!

1966 Lafayette Catalog 660

Friend's Name

Address

City

State

Zip

Dept. RK-5

(Please Give His Zip Code No.)

Dept. RK-5

LAFAYETTE RADIO ELECTRONICS
P.O. BOX 10
SYOSSET, L.I., N.Y. 11791

PLACE
STAMP
HERE

Dept. RK-5

LAFAYETTE RADIO ELECTRONICS
P.O. BOX 10
SYOSSET, L.I., N.Y. 11791

PLACE
STAMP
HERE

Live Better Electronically With

LAFAYETTE RADIO ELECTRONICS

Mail The Card Today for Your

FREE!

1966 Catalog 660

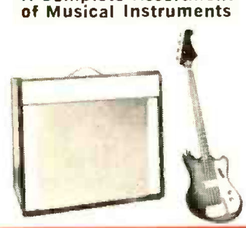
Shop At The
"World's Hi-Fi & Electronics Center"
For Widest Selection, Low Prices

Stereo Hi-Fi • Citizens Band • Ham Gear • Tape Recorders • Test Equipment • TV and Radio Tubes and Parts • Cameras • Auto Accessories • Musical Instruments • Tools • Books

Everything In Electronics for Home • Industry • Laboratory

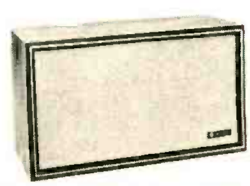
Exclusively Yours at Lafayette

A Complete Assortment of Musical Instruments



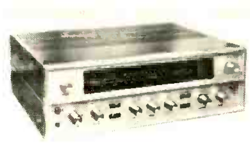
New! 25-Channel, Solid-State C.B. Transceiver Model HB-600

New! Criterion Hi-Fi Bookshelf Speakers



No Money Down • Up to 24 Months to Pay

70-Watt AM-FM Stereo Receiver, Model LR-800



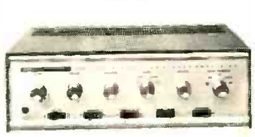
New! Lafayette U. S. Army-Look-a-Like 2-Way Radio, Model GT-3

New! Criterion 1000B — Pushbutton 4-Track Stereo Tape Recorder in Teak Case

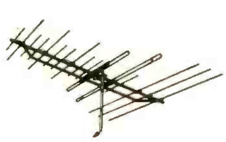
Satisfaction Guaranteed or Money Refunded

New! Lafayette Mobil-Ade™ 12-Channel Solid-State CB Transceiver, Model HB-555

50-Watt Solid-State Stereo Amplifier, Model LA-248



New! Complete Line of Lafayette TV Antennas



Do A Friend A Favor...

Have a friend interested in hi-fi or electronics? Send us his name and address and we will send him his own personal copy of the 1966 Lafayette Catalog 660.

FREE *Mail The Card Today*

JOHN FRYE

The installation of CATV in a fringe-reception community has brought a number of unforeseen problems in its wake.

TWO YEARS OF CATV

BARNEY glanced up from the TV set he was aligning just in time to catch Mac, his employer, smothering a yawn. "Out doing the Watusi last night?" the youth asked with a grin.

"Of course not; you know I do nothing more ancient than the Frug or the Jerk. Actually, though, it was after one this morning when I climbed into bed. We had a service-dealers meeting at the Ambers last night to discuss CATV-connected problems. Several fellows from other towns with CATV systems or proposed systems were there, as were representatives of the local CATV company. Our system, after being in use for two years, has had time to work out the initial bugs; so we felt we had a legitimate right to air any gripes we may still have with the cable operation. At the same time, it was only fair to give the CATV people a chance to answer those complaints."

"Sounds like an interesting confrontation."

"It was. The first question brought up was, 'Has CATV helped sales?' Most dealers admitted the cable substantially boosted sales, especially of color sets, during the past two years. Previously you needed a good high-gain antenna seventy to eighty feet in the air here to pull in a decent color picture a high percentage of the time. That meant spending almost as much for antenna, tower, and rotator as you did for the color set. This put a real crimp in color sales, especially among tenants who were not about to erect an expensive tower on rented property. The advent of cable really brought these people into the color market and permitted us, in this ultra-fringe area, to keep pace with the swing to color that is sweeping the rest of the country.

"Several dealers, on the other hand, questioned whether profit from these increased set sales offset the loss of revenue formerly secured from the sale and maintenance of antennas, towers, and rotators. Individual opinion varied, understandably, with how deeply involved the dealer had been in the antenna business before CATV came along. One dealer said the cable had actually cost him receiver sales, and he gave a logical explanation. The set he sells is a quality one designed for the difficult-reception market. It is noted for its high sensitivity and immunity to noise. Because of these features, this set has always been very popular here in spite of its higher cost. Now, on the cable, sensitivity and noise immunity are of little importance. A poor set in this regard will perform just as well with the strong cable signal as will the higher priced set, and this dealer has lost much of his selling advantage."

"I'll bet his plight brought big crocodile tears to the eyes of the other dealers," Barney added.

"You know it! But this dealer's experience suggests that the spread of CATV may well shift the accent in TV receiver design away from 'hot' front-ends and wide-range a.g.c. systems to circuitry showing up to better advantage on the cable—say improved adjacent-channel rejection or perfection of i.f. and video amplifiers."

"What else was bugging the dealers?"

"They thought the cable company ought to make a special effort to provide consistently good pictures to all dealers' showrooms. This would be to the advantage of the cable company as well as the dealer because a good demonstration picture would sell both the set and the cable. On the other hand, if a good picture could not be shown on any of the brand-new sets on the dealer's floor, obviously something was wrong with the cable or the distribution system installed by the cable company; but just try to explain this to a prospective customer! If dealer X down the street happened to be getting a better picture from the cable, that is where the customer very likely would buy his set. Ghosts in color sets were the most common complaint.

"Another gripe was that cable company employees, called on a poor-reception complaint, would first 'prove' the fault was not in the cable by showing the picture on a portable receiver; then they would go ahead to 'diagnose' the receiver trouble. The dealers argued that many cable faults, such as fine cross-hatching, smearing, or ringing, would not show up nearly as well on the portable as on the large-screen receiver. And guessing that the receiver had tuner trouble, perhaps right after a new tuner had been installed, did little to add to customer-dealer relations.

"By far the most common complaint, though, was that dealers had to make too many 'no-charge' calls because of the cable. Some such calls were to identify cable-signal radiation into the receivers of non-subscribers. Others were to confirm that the poor reception was caused by trouble on the cable or by service-interrupting work on the cable. In either case, since no trouble was found in the receiver, the dealer felt he could not make a charge without alienating the customer; yet estimates of the cost-per-dealer of these calls ranged from $1500 to $2500 per year."

"Did anyone admit service work on cable-connected sets is easier than work on sets connected to fringe-area antennas? With cable receivers, you get away from those maddening borderline poor-reception complaints where it is hard to be sure if the trouble lies in the set, the antenna, or simply changing conditions."

"Yes, this was admitted, but it was argued that since a set will work after a fashion on the cable even though sensitivity and other characteristics are way down, the net result is still a loss of revenue. Before cable, a set in this town had to be working very near top performance to bring in a suitable picture at all. A weak i.f., r.f., or sync amplifier tube was all that was needed to seriously degrade reception and generate a service call. On the cable, a receiver can be half-dead and still perform reasonably well. The local distributor said that the result of this situation was reflected in a loss of replacement part sales."

"They weren't pulling any punches, were they? What did the cable people have to say about all this?"

"Quite a bit. They admitted their service was not perfect, but they pleaded they were still suffering from growing pains. While better than 52% of all the houses in town are already on the cable, this figure is expected to go over 60% in three or four months. Adding a stream of new customers to a cable system means constant readjustment and rebalancing. And during the past year a new TV station and a new 24-hour-a-day Weather Scan channel has been added for customer convenience.

"As for the complaint about poor pictures at the dealers' showrooms, the spokesman humorously suggested he might employ the same question the man used when someone inquired how his wife was: 'Compared to what?' Surely cable pix must not be inferior to those secured from the old antennas or the dealers would go back to those old antennas. Seriously, he agreed every effort should be made to furnish the best possible signal to showrooms and promised that effort would be made.

"Even now, he revealed, the company was engaged in a major, expensive effort to improve cable service by changing all trunk-line cable to a new and improved aluminum-jacketed type designed to boost picture quality and reduce signal radiation—although most of the latter, he hastened to say, was caused by illegal connections to the cable inside the customers' homes. Ghosts always haunt a cable system since cable imperfections, abrupt changes in cable temperature, or amplifier defects can produce these; but the spokesman felt confident the installation of the new cable would reduce ghosts to a minimum. He pointed out that a cable was capable of near-perfect picture transmission as proved by the fact that most network programs were relayed through coaxial cable before being telecast locally.

"Finally, he said every effort was being made by the cable management to discourage their service people from 'diagnosing' set troubles. Cable technicians are instructed to find out if reception difficulty is caused by the cable or the receiver. In the latter case, a suggestion can be made that a technician be called —and nothing more. Cable customers are encouraged to call the company *first* in case of trouble. Furthermore, the bulletin board of the Weather Scan channel is used, whenever possible, to give advance warning of the area and hours where service interruptions may be caused by work on the cable.

"Before he sat down, the spokesman pointed out the cable company had a limited number of technicians to make new installations, answer service calls, carry out constant preventative maintenance, and put in new cable and equipment. They could do a better job with more people; but, like every business, they tried to do the best they could with what they had."

"I think they do pretty well," Barney offered. "I know cable service outages are fewer and shorter than they used to be, and most of these are caused by power failure supplied to the amplifiers rather than any trouble with the CATV equipment itself. What do you think?"

"I agree they are doing a good job, but I feel they must constantly be trying to do better. CATV is on trial in the eyes of the people. It is not enough that a cable system furnish a good black-and-white picture. It must be designed and maintained to furnish excellent color reception. If that takes more expensive cable, better amplifiers, better head-end equipment, and more and better trained technicians, so be it. Let the cable company plow back enough of its profits to accomplish this. They have said, 'Take down your antennas; we have a better way.' They must keep faith with the people who believed them."

"You're right," Barney agreed. "Practicing pinch-penny tactics now when CATV is starting to roll is actually giving aid, comfort, and ammunition to the enemy. By the way, did you see where some CATV systems are starting to use the new teletypewriter service worked out between *Telemation* and the *AP*?"

"No, how does it work?"

"A TV camera simply watches a teletypewriter machine, and the output is fed into an empty channel on the cable system. Copy will be fed to the machine at the usual 60 words per minute speed, or it can be rolled past the camera at three times that speed. Any time a CATV subscriber wants the news 'hot off the wire,' all he has to do is tune to the 'news channel' and read the latest. When the news is breaking fast, the CATV customer can get the news at the same time the newspapers and newscasters do."

"Well, considering that most urgent news is bad news, I'm not sure if this is an advantage or not," Mac said dourly. ▲

Ceramic I.F. Filters

(*Continued from page* 35)

is then packaged in a cylindrical case.

These ceramic ladder filters can be designed to cover the frequency range from 200 kc. to over 1 mc., with a bandwidth of 1 to 10% of the center frequency. The upper frequency should be increased significantly in the near future. The filter center frequency, bandwidth, and selectiveness depend upon the ceramic disc characteristics, spacing between discs, and the number of discs used. The "*Q*'s" of these units vary from 50 to 2000 and have insertion loss ranges of 0.5 to 15 db (depending on the "*Q*" and bandwidth of a particular filter).

The various types of ceramic filter units described are shock resistant, highly stable, and insensitive to magnetic fields. Their small size allows miniaturization without sacrificing selectivity. In addition, no tuning or alignment adjustments are required. These factors all indicate that ceramic-filter applications will increase in military, commercial, and consumer electronic devices. ▲

Be super-critical.

Whether you're looking for the fun and economy of building quality kits or you want ready-to-use factory-wired equipment — before you buy, examine carefully. Compare EICO with anybody else — feature for feature, chassis for chassis, part for part. The more critical you are, the more you'll see for yourself that your best buy is EICO.

EICO

Over 3,000,000 EICO instruments now in use! Preferred by engineers, scientists, technicians and students. EICO equipment is available nation-wide through 2500 EICO dealers.

New Model 435 — DC Wideband Scope. Top-quality DC 4.5mc scope with 3" flat-face CRT. Zener calibrator. Outperforms 5" scopes three times its size, facilitates on-location color TV and other servicing. **$99.95 kit, $149.95 wired.**

New Model 342 — FM Multiplex Signal Generator. Design lab quality. Both composite audio and FM RF outputs. Inputs for stereo audio source for store demonstrations, critical A/B listening tests. **$149.95 wired.**

New Model 965 — FaradOhm Bridge/Analyzer. 9-range, low-voltage capacitance-resistance bridge safely measures even 1-volt electrolytics. Metered bridge balance, leakage test voltage (6 DC VTVM ranges 1.5-500V), leakage current (11 DC VTAM ranges 0.15ua-15ma). DC VTVM & VTAM externally usable. **$129.95 wired.**

New Model 1030 — Regulated Power Supply. Speeds troubleshooting, design work, production line testing, electronics teaching. Variable bias and plate sources regulated to 1/3 of 1%: 0-150V @ 2ma; 0-400V @ up to 150ma. Ripple less than 3mv rms. Unregulated fil. volts of 6.3V & 12.6V, @ 3A. Switchable, monitoring milliammeter and voltmeter. **$59.95 kit, $99.95 wired.**

New Model 378 Audio Generator. Near-distortionless sine wave generator ($<$ 0.1% 20-20,000c) providing fast, convenient, switch-selection of frequencies from 1c to 1,000c (1c steps 10c-100c, 10c steps 100c-1kc, 100c steps 1kc-10kc, 1kc steps 10kc-100kc). 8-pos. 10db/step output attenuator & fine attenuator. Output meter (4½" 200ua) with 8 voltage ranges & db scale. **$49.95 kit, $69.95 wired.**

New Model 440 Scope. Lowest-priced quality oscilloscope available. Excellent for electronics teaching and home workshop. Flat 2c-500kc. 3" flat-face new CRT. Compact, light, rugged. **$49.95 kit, $69.95 wired.**

New Model 779 — Sentinel 23 CB Transceiver. 23-channel frequency synthesizer provides crystal-controlled transmit and receive on all 23 channels. No additional crystals to buy ever! Features include dual conversion, illuminated S/RF meter, adjustable squelch and noise limiter, TVI filter, 117VAC and 12VDC transistorized dual power supply. Also serves as 3.5 watt P.A. system. **$169.95 wired.**

New Model 712 — Sentinel 12 Dual Conversion 5-watt CB Transceiver. Permits 12-channel crystal-controlled transmit and receive, plus 23-channel tunable receive. Incorporates adjustable squelch & noise limiter, & switches for 3.5 watt P.A. use, spotting, & Part 15 operation. Transistorized 12VDC & 117VAC dual power supply. **$99.95 wired only.**

New Model 753 — The one and only SSB/AM/CW Tri-Band Transceiver Kit. 200 watts PEP on 80, 40 and 20 meters. Receiver offset tuning, built-in VOX, high level dynamic ALC. Unequalled performance, features and appearance. Sensationally priced at **$179.95 kit, $299.95 wired.**

New Model 3566 — All Solid-State Automatic FM MPX Stereo Tuner/Amplifier. No tubes, not even nuvistors. Delivers 112 watts IHF total to 4 ohms, 75 watts to 8 ohms. Completely pre-wired and pre-aligned RF, IF and MPX circuitry, plus plug-in transistor sockets. **$219.95 kit** (optional walnut cabinet $14.95), **$325.00 wired including walnut cabinet.** UL approved.

Model ST70 70-Watt Integrated Stereo Amplifier. Best buy of highest ranked stereo amplifiers according to independent testing. **$99.95 kit, $149.95 wired. ST40** 40-Watt Integrated Stereo Amplifier, **$79.95 kit, $129.95 wired. ST97** Matching FM MPX Stereo Tuner, **$89.95 kit, $139.95 wired.**

EICO Electronic Instrument Co., Inc.
131-01 39th Ave., Flushing, N. Y. 11352

Send for **FREE** catalog describing the full EICO line of 200 best buys and name of nearest dealer.
I'm interested in:

- ☐ test equipment
- ☐ hi-fi
- ☐ ham radio
- ☐ CB

Name__________

Address__________

City__________

State__________ Zip______

EW-11

1945-1965: TWENTY YEARS OF LEADERSHIP IN CREATIVE ELECTRONICS

New Ideas For Christmas Giving . . .

A Gift For Everyone . . . In This Vast Heathkit® Selection!

Kit GR-43
$159.95

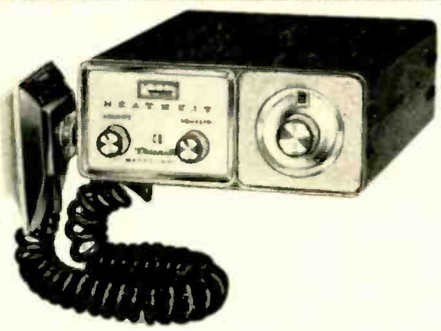
New Heathkit 10-Band Transistor Portable!

10 bands tune Longwave, Standard Broadcast, FM and 2-22.5 mc Shortwave. 16 transistors, 6 diodes, and 44 factory assembled and pretuned circuits. Two separate AM & FM tuners and IF strips. FM tuner & IF strip are same components used in deluxe Heathkit FM stereo gear. 2 built-in antennas. Battery saver switch cuts current drain up to 35%. Rotating tuning dial. Dial light. 4 simple controls for tuning, volume, tone, AFC and band switching. 4" x 6" PM speaker. Earphone & built-in jack. Optional 117 v. AC converter/battery charger available @ $6.95. Time zone map & "listener's guide." Man size: 13½" W x 5⅛" D x 10 9/16" H. 17 lbs.

Kit GD-983
Now Only
$799.00

Ideal Gift For The Whole Family . . . Heathkit®/Thomas Organs!

The Heathkit/Thomas "Coronado" Transistor Organ, (illust.) boasts 17 organ voices, two 44-note keyboards, Leslie plus 2-unit main speaker system, 28 notes of chimes, 13-note heel & toe pedalboard, color-tone attack & repeat percussion, matching bench, plus many more professional features. 242 lbs. Also the Heathkit/Thomas "Artiste" Transistor Organ with 10 voices, two 37-note keyboards, repeat percussion, etc. now at only $332. 154 lbs. . . . Both organs have all genuine Thomas factory fabricated components.



Kit GW-14
$89.95

Assembled GWW-14
$124.95

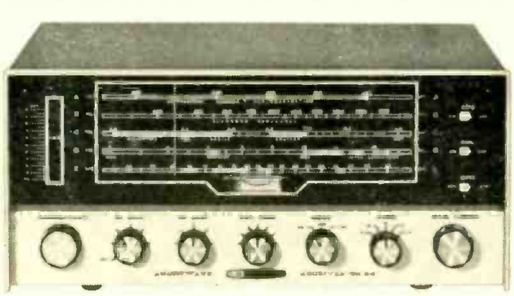
New 23-Channel, 5-Watt Transistor CB Transceiver!

23 crystal-controlled transmit & receive channels for the utmost reliability . . . at competitive prices! All-transistor circuit for instant operation, low battery drain . . . only .75 A transmit, .12 A receive. Only 2⅞" H x 7" W x 10½" D . . . ideal for car, boat, any 12 v. neg. gnd. mobile use. "S" meter, adjustable squelch, ANL, built-in speaker, ceramic PTT mike, aluminum cabinet. 8 lbs. Kit GWA-14-1, optional AC power supply, 5 lbs., $14.95.

Kit SB-110
$320.00

New 6-Meter SSB Ham Transceiver

Full SSB-CW transceive operation on 6 meters. 180 watts PEP SSB—150 watts CW. Operates fixed or mobile; PTT and VOX. Switch-selection of upper sideband, lower sideband, and CW. Covers 50-52 mc with crystals supplied, total coverage 49.5—54 mc. Famous Heath SB series Linear Master Oscillator for true linear tuning. Built-in 100 kc calibrator and antenna switching. Accessory mobile mount SBA-100-1 . . . $14.95. 23 lbs.



New Deluxe Shortwave Radio

Kit GR-54
$84.95

Compare it to sets costing $150 and more! 5 bands cover 200-400 kc, AM, and 2-30 mc. Tuned RF stage, crystal filter for greater selectivity, 2 detectors for AM and SSB, tuning meter, bandspread tuning, code practice monitor, automatic noise limiter, automatic volume control, antenna trimmer, built-in 4" x 6" speaker, headphone jack, gray metal cabinet, and free SWL antenna. 25 lbs.

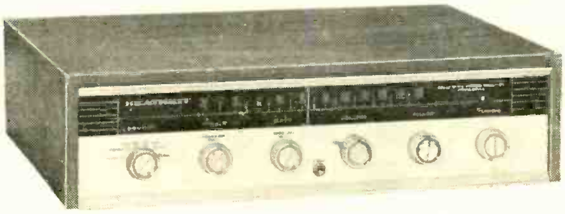
Kit HD-10
$39.95

New Heathkit Solid-State Electronic Keyer

All solid-state circuitry. Speed range—15 to 60 words per minute. Solid-state switching—no relays to stick or clatter. Adaptable to either right or left handed operators. Convertible to semi-automatic operation. Variable dot-space ratio. Self-completing dashes. Sealed switches on paddle—no exposed contacts to clean or adjust. Built-in paddle—"feel" is adjustable to your fist during assembly. "Hold" switch for transmitter tuning. Transformer-operated power supply isolates keyer from line power. Fused for protection. 6 lbs.

..."Do-It-Yourself" Heathgifts!

Now Choose From 2 Heathkit® Transistor Stereo Receivers!



New 30-Watt Transistor FM Stereo Receiver . . . Less Than $100!

Features 31 transistors, 11 diodes for cool, natural transistor sound; 20 watts RMS, 30 watts IHF music power @ ±1 db, 15 to 60,000 cps; wideband FM/FM stereo tuner plus two preamplifiers & two power amplifiers; front panel stereo headphone jack; compact 3⅞" H x 15¼" W x 12" D size. Assembles in 20 hours or less. Custom mount it in a wall, or optional Heath cabinets (walnut $9.95, beige metal $3.95) 16 lbs.

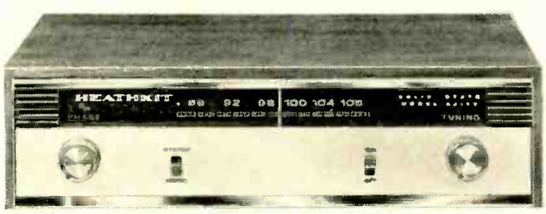
Kit AR-14
$99.95
(less cabinet)

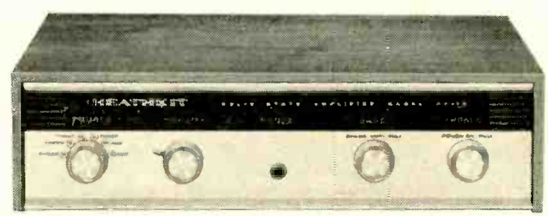
66-Watt Transistor AM/FM Stereo Receiver

Just add 2 speakers for a complete stereo system. Boasts AM/FM/FM Stereo tuning; 46-transistor, 17-diode circuit for cool, instant operation and natural transistor sound; 66 watts IHF music power (40 watts RMS) at ±1 db from 15 to 30,000 cps; automatic switching to stereo; preassembled & aligned "front-end" & AM-FM IF strip; walnut cab. 35 lbs.

Kit AR-13A
Now Only
$184.00

Best Hi-Fi News Of '65 . . . New Low-Cost Transistor Stereo Twins!





New Transistor FM/FM Stereo Tuner

Heath's easiest to build stereo/hi-fi kit . . . takes only 4 to 6 hours! 14 transistor, 5 diode circuit for cool instant operation, transparent transistor sound. Phase control assures best stereo performance. 3 transistor "front-end" plus 4-stage IF section. Filtered outputs for direct stereo recording. Automatic stereo indicator light. Preassembled & aligned "front-end." Install in a wall or either Heath cabinet (walnut $7.95, beige metal $3.50). 6 lbs.

Kit AJ-14
$49.95
(less cabinet)

Matching 30-Watt Transistor Stereo Amplifier

Assembles in 10 hours or less! 17 transistors, 6 diodes. 20 watts RMS, 30 watts IHF music power @ ±1 db, 15 to 60,000 cps. No audio transformers . . . assures minimum phase shift, extended response, lower distortion. Solid-state power supply plus electronic filter for regulation within 10%. Accommodates phono, tuner, auxiliary . . . 4, 8, 16 ohm speaker impedances. Lighted panel. Installs in wall, or Heath cabinets (walnut $7.95, metal $3.50). 10 lbs.

Kit AA-14
$59.95
(less cabinet)

Buy Now—Use This Order Blank

NEW
1966 CATALOG!

Free! 108 pages . . . many in full color . . . describe these and over 250 easy-to-build Heathkits. Save up to 50%. Mail coupon for your free copy.

Heath Company, Dept. 15-11
Benton Harbor, Michigan 49023

HEATHKIT

☐ Please send FREE Heathkit Catalog

Model	Description	Weight	Price

Name ______________________
(Please Print)
Address ______________________
City ____________ State ____________ Zip ____________

SHIP VIA:
☐ Parcel Post ☐ Express Collect ☐ Freight ☐ 20% Included, C.O.D. ☐ Best Way

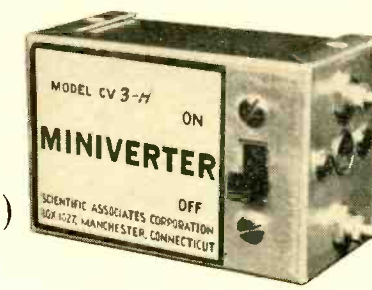
All prices & specifications subject to change without notice.

(A)

NEW CITIZENS BAND CIRCUITS

By LEN BUCKWALTER

(B)



(C)

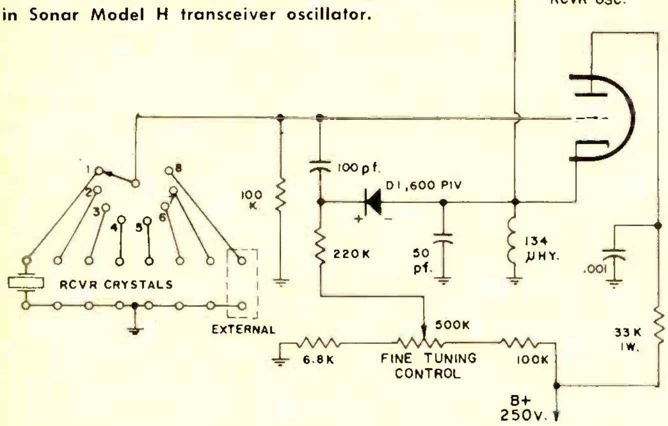
Silicon diode fine-tuning circuit
Transceiver with mechanical filter
CB-to-broadcast-band converter

THE three circuits described this month all bear in some way on receiver tuning. In the *Sonar* Model H transceiver there is a fine-tuning circuit which employs a novel semiconductor circuit. It permits an operator to make small tuning adjustments in a crystal-controlled receiver. Next is a component familiar to many hams, but only recently introduced to circuits in CB radio. It is a mechanical filter now used in a transceiver produced by *United Scientific Labs*. The final tuning circuit occurs in a device known as the "Miniverter" (*Scientific Associates Corp.*). Connected to any standard AM receiver, this accessory converts the 27-mc. Citizens Band signals to the broadcast band.

Sonar Model H Fine Tuning

The transmitting frequency tolerance assigned to the CB service—.005%—is a relative rating. Stated in actual frequencies, it represents an acceptable carrier drift of about 1300 cps above or below the nominal channel. This is narrow enough to keep adjacent-channel signals from overlapping. Yet, this small amount of frequency shift could affect signal intelligibility during reception. Such a situation might occur, for example, if a transmitter generated a carrier somewhat on the high side and a receiver's local oscillator added to the error. The net effect could be an i.f. signal which exists partially outside the receiver's passband. Some sideband cutting would cause a drop in intelligibility.

Fig. 1. A standard silicon diode acts as a variable capacitance fine-tuning device in Sonar Model H transceiver oscillator.



One solution to the problem is in the *Sonar* Model H transceiver (photo A). It provides a method of fine-tuning the receiver local oscillator with a front-panel control. This is not the first receiver to provide such an operating feature. What is significant is *Sonar's* circuit approach. The Model H uses no variable-capacitor trimmer in the oscillator section. Instead it relies on a simple diode arrangement which approximates the action of a voltage variable capacitance diode (like the "Varicap," for example). The component, however, is a standard silicon diode originally intended as a power rectifier. Through suitable selection for proper "Q" and capacity range, the diode can provide the desired action; converting voltage into capacitance variations. In this circuit, it provides a fine-tuning range of ± 2 kc.

Operation of the circuit can be seen in the schematic of Fig. 1, the receiver's local oscillator. It is basically a crystal-controlled Colpitts circuit. The crystals depart somewhat from usual CB practice, where third-overtone types are generally used. Here, crystals are 13-mc. fundamental with second-harmonic output providing the local-oscillator frequency in the 26-mc. range. This small design difference, however, is not crucial to the tuning action which follows. Consider next diode *D1*. Its effective position in the circuit is across the receiver crystal. And, as mentioned earlier, the component is a standard silicon power rectifier; albeit chosen for desirable properties of "Q" and capacity.

Operating potential for the diode is taken from the 250-volt "B+" source. This is dropped across a voltage divider with a potentiometer serving as the fine-tuning control. In this arrangement, it is possible to bias the diode from about 10 to 200 volts d.c. As voltage varies, the diode effectively varies its capacitance from about 4 to 30 pf. This change in shunt capacitance across the crystal produces a change in crystal frequency of a total of about 4 kc. In this fashion, the receiver local oscillator—and the incoming signal—can be compensated for frequency drift.

Voltage regulation is not required to keep fine-tuning stable at a given pot setting. It has been found that "B+" variations as high as 10% will not disturb tuning. Since the diode requires nearly a 200-volt change to produce a total frequency shift of only 4 kc., small power-supply fluctuations introduce entirely negligible effects.

For a copy of the manufacturer's brochure, circle No. 21 on Reader Service Card.

USL Transceiver Mechanical Filter

With CB frequencies spaced only 10 or 20 kc. apart, adjacent-channel interference is a problem in receivers with poor selectivity. If tuned to channel 11, for example, strong signals on channel 10 or 12 may also be heard. To narrow down receiver selectivity, designers have resorted to several techniques. One is dual-conversion, which lowers signal frequency to a point where the i.f. transformers are capable of relatively sharper tuning. Another is the crystal filter which depends on the high "Q" of crystals for obtaining selectivity. Also, there is the "Q" multiplier—a high-gain amplifier using feedback to narrow the i.f. passband. Now a technique is introduced that is new to CB radio—it is the mechanical filter, used effectively in ham, commercial, and military two-way radio. *United Scientific Labs* utilizes such a device in its "Contact 25" transceiver (photo B). Positioned in an i.f. stage, it contributes a rated 40-db rejection of adjacent-channel interference.

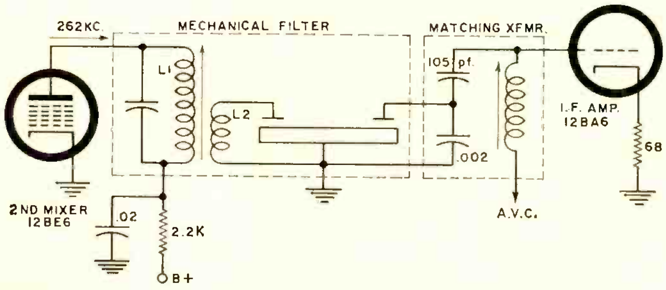
The concept of the mechanical filter is based on the fact that certain metal alloys driven into mechanical resonance will display extremely high "Q". By adding suitable transducers it is possible to transfer the selectivity of the vibrating alloy to a signal voltage. The device is also termed an "H" filter due to its physical arrangement. It begins with a small piece of metal alloy about ¼" square. Two notches cut into the metal give it the "H" shape. On two opposite legs are cemented pieces of barium titanate; ceramic transducer material which converts mechanical movement into a voltage or *vice versa*. The mechanical filter in the *USL* transceiver is shown schematically in Fig. 2. There is a horizontal bar, representing the vibrating metal element, and two barium titanate transducers above it. Let's trace circuit actions surrounding this section.

The filter is inserted between the receiver's second mixer and i.f. amplifier, where i.f. signals are 262 kc. To introduce the mixer signal into the mechanical filter it is first necessary to match impedances. This is effected by matching transformer *L1-L2*; it transforms high impedance at the plate of the mixer down to the low characteristic impedance of the barium titanate on the input side of the filter. Signal voltage now drives the barium titanate into corresponding mechanical movement. The metal bar is thus driven into mechanical resonance. (During manufacture the bar is ground precisely to resonate mechanically at 262 kc.) Due to the high "Q" of the bar, any adjacent-channel interference (which generates a slightly different i.f. frequency) is attenuated.

Mechanical vibration is now applied to the second transducer. The barium titanate element converts movement into voltage and feeds the processed signal to the grid of the receiver's i.f. amplifier. A network at the output of the filter provides the necessary match between low-impedance output of the filter to high-impedance input at the tube grid.

For a copy of the manufacturer's brochure, circle No. 22 on Reader Service Card.

Fig. 2. A mechanical filter in this USL "Contact 23" Citizens Band transceiver unit results in a high degree of selectivity.



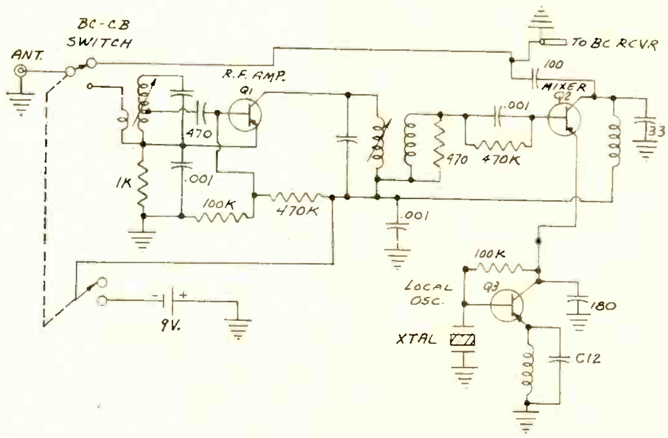


Fig. 3. Converter circuit in Scientific Associates "Miniverter."

Scientific Associates "Miniverter"

Here is an accessory device which adapts a standard car radio for reception of CB frequencies. It is intended for casual listening or monitoring in vehicles not already CB-equipped. In the interests of simplicity, the "Miniverter" (see photo C) utilizes the front-end of the car radio as a variable i.f. amplifier. This technique eliminates a manual tuning capacitor on the converter; channel selection is done with the car radio's regular tuning dial.

The circuit of the unit is shown in Fig. 3. It is a 3-transistor device which closely resembles the front-end of a standard superheterodyne receiver. Signals from the car's regular whip antenna are introduced to the input switch. (This selector diverts signals to converter or BC set.) The first transistor, Q1, is an r.f. amplifier broadly tuned in the 27-mc. band. After amplification, signals reach mixer Q2 where they heterodyne with the local oscillator signal from Q3. The crystal frequency is 27 mc. plus approximately 600 kc. An incoming signal on 27 mc. is therefore converted down to the band during the mixing process. Output appears across the mixer collector choke and the signal is introduced to the BC receiver through an interconnecting cable. At this time, signals throughout the CB band may be present in the converter output.

Selecting a particular channel is done by varying the BC set's tuning dial. Each incoming CB channel, in beating with the fixed crystal frequency, falls on a different BC frequency. (The BC band, about 1-mc. wide, easily contains the 290-kc. width of the CB band.) Thus manual tuning of the BC set can tune any desired channel as it performs as a variable i.f. amplifier.

A byproduct of this type operation is that converter-plus-BC set form a dual-conversion receiver. The first conversion occurs in the converter—from 27 mc. to BC frequency—followed by a second conversion during the normal superheterodyne action of the BC set, where signals are converted down to 455 kc. or some other standard i.f. value. ▲

For a copy of the manufacturer's brochure, circle No. 23 on Reader Service Card.

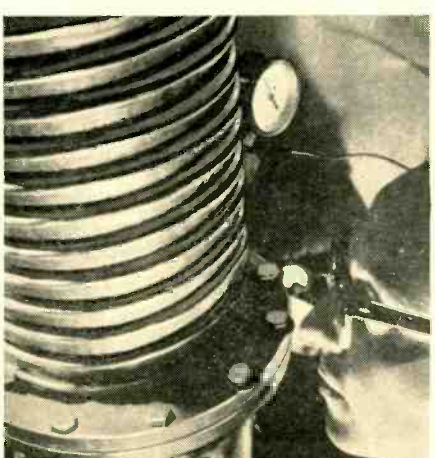
696,000 TECHNICIANS NEEDED BY 1970!

Government Report* Points Out Rapidly Growing Job Opportunities: Need for Trained Electronics Technicians An Important Factor

By Bill Gordon, RCA Institutes, Inc.

President Johnson Emphasizes Need. In his 1964 annual manpower report, President Johnson indicated that the demands for manpower are expanding most in, among other fields, service and technical (including technician) occupations. This expansion is the result of a handful of causes underlying today's big changes in the occupational picture: (1) increasing complexity of modern technology, (2) trend toward automation of industrial processes, (3) growth of new areas of work, such as in the field of atomic energy, earth satellites and other space programs, and (4) data systems analysis and data processing. Indicative also of the growing importance of the use of technicians is a recent revision of the "List of Critical Occupations" published by the U.S. Department of Labor in which technicians are listed for the first time by the U.S. Government.

Salary Levels for Trained Technicians Rising Fast. Beginning salaries for graduates of top level technician education programs have continued to go up during the past five years, at a faster rate than salaries of similar types of jobs. In fact, a U.S. Labor Department projection based on the figures shows that by 1970, technician salaries will average an all-time high.

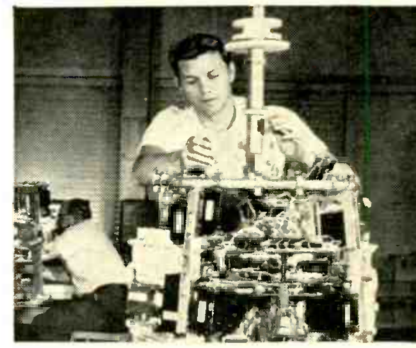


Nuclear Instrumentation

Technical Education is One of Today's Best Investments. Today, a person interested in becoming a technician can choose Home Training or Classroom Training to begin building his career. One of the nation's largest schools devoted to training electronics technicians, RCA Institutes, offers a wide variety of courses in both categories. In addition, the RCA "AUTOTEXT" Programmed Instruction Method is helping people learn faster and easier so they can get started on their careers in the shortest possible time. Dramatic proof comes from the success stories of countless graduates who find profitable positions in government, industry, or in their own businesses.

Of the total 696,000 technicians needed by 1970, it can be estimated that electronics technicians at all levels will form a vital core in today's major job picture.

*"Scientists, Engineers, and Technicians in the 1960's" U.S. Department of Labor, Bureau of Labor Statistics.



Space Electronics

RCA DEVELOPS AN EASY WAY TO LEARN ELECTRONICS AT HOME

New "Career Programs" Help Train You For Expanding Job Opportunities. RCA "AUTOTEXT" Instruction Method Speeds Learning

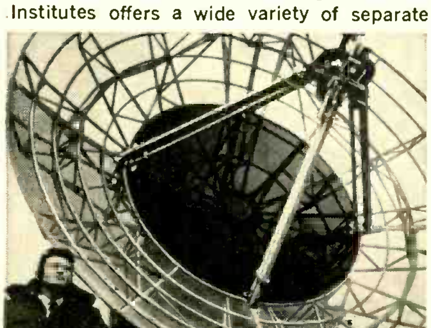
Choose an RCA "Career Program" that will train you for the job you want in Electronics! No time wasted learning things you'll never get to use. "Career Programs" answer the need for today's growing job opportunities for trained Electronics Technicians. They can help you get the job you want faster and easier than you ever dreamed possible!

And each "Career Program" starts with the amazing "AUTOTEXT" Programmed Instruction Method—the scientific way to learn that's almost automatic! "AUTOTEXT" helps even those who have had trouble with ordinary methods of home training in the past. This is the "Space Age" way to learn everything you need to know with the least amount of time and effort!

Choose a "Career Program" now. Each one is designed to train you for a specific, rewarding career in one of the following exciting fields:

- TELEVISION SERVICING
- FCC LICENSE PREPARATION
- AUTOMATION ELECTRONICS
- AUTOMATIC CONTROLS
- DIGITAL TECHNIQUES
- TELECOMMUNICATIONS
- INDUSTRIAL ELECTRONICS
- NUCLEAR INSTRUMENTATION
- SOLID STATE ELECTRONICS
- ELECTRONICS DRAFTING

In addition to these "Career Programs" RCA Institutes offers a wide variety of separate courses on many subjects—from Electronics Fundamentals to Computer Programming.



Radar Microwave

VALUABLE EQUIPMENT INCLUDED

And, with your RCA Training, you receive top-quality equipment to keep and use on the job. When you train with RCA Institutes, you never have to take apart one piece to build another. You'll get the new Programmed Electronics Breadboard which provides limitless experimentation...and, with which you construct a working signal generator and a superheterodyne AM Receiver.

SPECIAL BONUS— OSCILLOSCOPE and METER KITS

Valuable Oscilloscope and Multimeter Kits are yours at no additional cost when you enroll in any one of the RCA Career Programs..."must" equipment for electronics technicians in almost all jobs.

LIBERAL TUITION PLAN

Only RCA offers you this most economical way to learn. You pay for lessons only as you order them. No long term contracts. You may stop your training at any time without owing a cent.

CLASSROOM TRAINING ALSO AVAILABLE

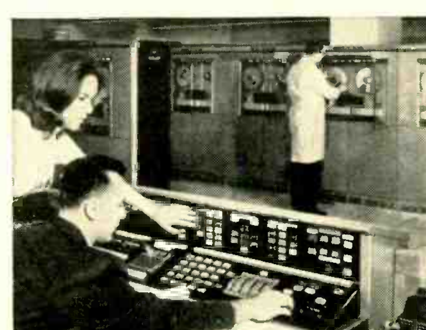
If you prefer to learn in a classroom, RCA Institutes maintains one of the largest schools of its kind where the latest classroom and laboratory training is available in day or evening sessions. You may be admitted without any previous technical training.

Preparatory courses are available if you haven't completed high school. Coeducational classes start four times a year.

FREE PLACEMENT SERVICE

RCA Institutes records prove that in a recent class 9 out of 10 Resident School students who used the Free Placement Service had their jobs waiting for them when they graduated. And, many of these jobs were with top companies in the field—IBM, Bell Telephone Labs, General Electric, RCA, and radio and TV stations, and other communications systems throughout the world.

SEND THE ATTACHED POSTAGE PAID CARD FOR COMPLETE INFORMATION WITHOUT OBLIGATION. NO SALESMAN WILL CALL. VALUABLE FREE BOOK INCLUDED. CHECK HOME STUDY OR CLASSROOM TRAINING.



Computer Programming

RCA INSTITUTES, Inc., Dept. EW-N5
A Service of Radio Corporation of America
350 West 4th St., New York, N. Y. 10014

THE MOST TRUSTED NAME IN ELECTRONICS

"AUTOTEXT"—An RCA Trademark

Integrated Circuits

(*Continued from page* 49)

devices are key components in analog computers, as they readily multiply, add, integrate, and perform other operations. Several units together can generate trigonometric functions, precision ramps, and other exacting waveforms. The μA702A is extremely well suited for these applications. A few typical circuits are shown in Fig. 2.

Sometimes it is desirable to start with an analog signal and produce a discrete *yes-no* output. One form of this device is called a Schmitt trigger. Amplitudes below a critical level leave the trigger in the *off* stage; above a second critical level, the trigger snaps into an *on* state. A related problem is to compare two arbitrary signals and ask, "Which one is bigger?", then derive an *off-on* output as an answer.

Both these tasks are admirably accomplished by another *Fairchild* unit, the μA710 differential comparator. A 2-mv. difference between two input signals is enough to drive the output from *on* to *off* or *vice-versa*. The frequency response is good to 5 mc. and usable at 70. Important applications are Schmitt triggers, *go, no-go* gauges, analog-to-digital converters, window detectors, and certain alarm circuits. Unlike ordinary Schmitt triggers, the *Fairchild* unit may have completely variable and easily adjusted trip points simply by the addition of a pot to the basic circuit.

The *Motorola* MC1110 is an emitter-coupled amplifier for i.f. and r.f. applications and is useful to 300 mc. It can provide 26 db of power gain at 100 mc. with a noise figure of 6 db. Two transistors, a resistor, and a capacitor are housed in a five-terminal TO-5 type can. Gain is easily varied from +30 to −6 db by varying the emitter current. This amplifier readily matches 50-ohm sources and loads.

How about an audio amplifier? The *Motorola* MC1524 is an audio amplifier that will deliver one watt into a 16-ohm speaker over a frequency range of d.c. to 500 kc. In this device, 230 mv. of input signal are needed for full output. The output impedance is very low, providing good damping. Total harmonic distortion is less than 0.5% at the 50-mw. level.

An important advantage of this unit is the low standby current, very important in compact circuitry. The circuit is new, militarily oriented, and expensive. It is not feasible to integrate a portable phonograph with one of these, at least not yet. These units are ideal for portable communications systems, commercial and military transceivers, and other similar compact battery-operated equipment. ▲

Laser Measurements
(Continued from page 52)

only a little energy at each reflection, thus keeping the surface temperature low.

The sensing elements themselves are deliberately made rather massive and are thermally isolated from their surroundings. In this way the element stores the absorbed energy during the total duration of the pulse. The final temperature which the sensor reaches after being exposed to a pulse of radiation, is proportional to the total energy in the pulse. This temperature is sensed by a thermocouple whose output is applied to a microvoltmeter.

In general, a pulsed laser is described by the total energy it can deliver (joules), and the peak power obtainable. The total energy is measured in the manner just described and the peak power is obtained by determining the pulse width on a scope and dividing this value into the total energy. No particular attention is paid to the absolute value of the radiant power in determining the pulse width. The problem of inaccuracy and possible damage to the photodetector are avoided by intercepting only a small fraction of the laser beam.

The measurement is still difficult however, due to the extremely short pulses (<50 nanosec.) delivered by high-power lasers. In order to measure pulse width accurately, the response time of the photodetector must be less than 5 nsec. Also, the oscilloscope used to observe the pulse must be capable of writing speeds compatible with nanosecond pulses. Sampling scopes cannot be used because the pulse repetition rate is very low. One is therefore forced to use traveling-wave scopes. Such scopes are designed specifically for recording high-speed transient events. They have low input impedances and require considerable current for deflection (see Fig. 6).

Coherent Detection of Modulation

Among the most impressive measurements which have been associated with lasers is the coherent detection of a modulated laser beam. Such methods depend upon the coherence of the carrier itself. In this method modulation is detected by mixing the local oscillator and received signal at the detector. Such mixing may only be used to demodulate the received signal if a consistent phase relation is maintained between the local oscillator and the center frequency of the received signal, that is, both the local oscillator and transmitter must be coherent and frequency locked.

This technique is only feasible in the optical frequency range if both local oscillator and transmitter are c.w. lasers. It must also be noted that in this case the photodetector is functioning as a demodulator. This operation is possible because the photodetectors respond to the light power, or the square of the electric field. In this manner an output is developed proportional to the difference frequency of the modulation.

The detector frequency response must be greater than the modulation frequency bandwidth. However, a laser may, in theory, be modulated up to one half its center frequency (about 10^{14} cps). It is therefore necessary to consider coherent wideband systems. At present, the development of detectors with the necessary frequency response is a subject of great interest to researchers in the field of laser technology. Efforts have produced prototypes whose frequency response extends well up in the gigacycle range.

In order to obtain sufficient power in the beat-frequency signal, the local oscillator and incoming signal must be carefully superimposed. The dimensional misalignment that is allowable is a fraction of a wavelength. However, at optical frequencies, ¼ wavelength is only a couple of millionths of an inch. Thus spurious building vibrations and even sound waves affect the measurement. Hence, appropriate fixturing must be developed to isolate the apparatus from the influence of unwanted vibrations and noise.

Safety Considerations

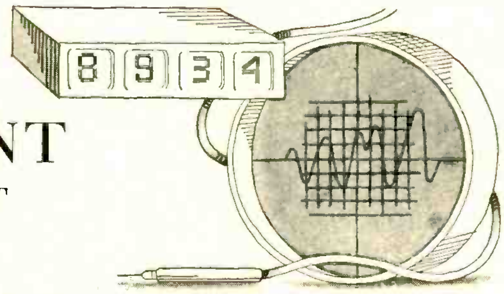
The extremely high radiant powers considered as a problem in measurement, also create a safety hazard to the engineer and technician performing the measurement and to those in the immediate vicinity. It is quite important to consider safety as an essential part of all laser work. Laser beams, pulsed or c.w., are sufficiently intense to cause burns on the retina. Thus direct viewing of a laser output can never be safely accomplished. Due to the slow spreading of the laser output beam, this hazard persists for great distances. Further, it is not minimized by interruption of the beam with any material which specularly reflects the light. For this reason, it is important to consider eye hazard not only at the measurement site, but in any area which may be exposed to direct or specular reflection of the laser beam.

Difficulty may be minimized by intercepting the laser beam completely by a diffuse reflecting or absorbing surface. In this way, the range of the eye hazard area may be reduced. Safety glasses have been developed specifically for workers in the laser field. However, even this simple precaution must not be applied casually.

In working with high peak power pulsed lasers, additional safety precautions must be exercised. In the first place, these devices must store large amounts of power prior to pulsing, making the electrical shock hazard an important consideration. Careful regard to interlock switches and other normal electrical safety measures is mandatory when the circuits involved store thousands of joules in large banks of capacitors. Adequate wiring is more than just a catchword when peak currents of thousands of amps will flow upon discharge. In the second place, the radiant powers which these devices are capable of, may be well up in the gigawatt range. This type of power, even unfocused, will raise the temperature of surfaces it impinges upon by tens and even hundreds of degrees. Focused, it is capable of vaporizing even the most refractory materials, and of ionizing the air. Danger of skin burns is then an additional problem.

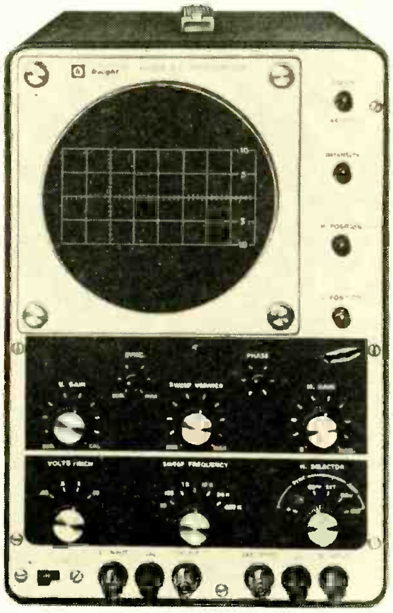
Concern for the safety of personnel who become directly involved with the construction and application of lasers has prompted the Occupational Health Branch of the Office of the U. S. Surgeon General and the Department of the Army to formulate guidelines for handling lasers in laboratories. Some of their recommendations are summarized elsewhere in this article. It would be a good idea to post these precautions conspicuously in the laser laboratory. ▲

TEST EQUIPMENT
PRODUCT REPORT



"Knight-Kit" Model KG-635 Oscilloscope

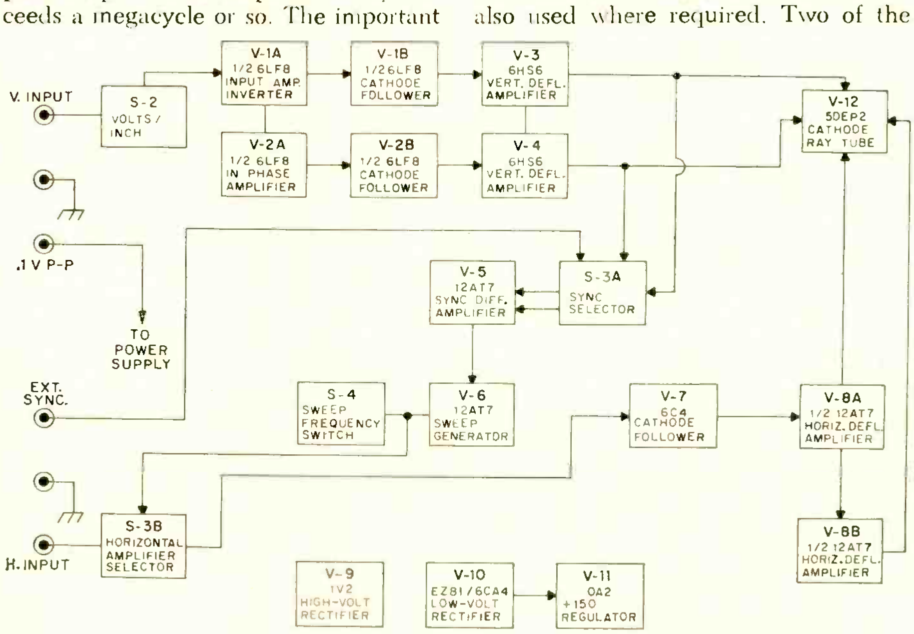
For copy of manufacturer's brochure, circle No. 24 on Reader Service Card.



MIDWAY between the low-cost, simple, general-purpose scope and the expensive, elaborate laboratory scope lies a class of instrument called a "wide-band service scope." This instrument is not as wide in bandwidth as a lab scope, which may cover from d.c. to 20, 50, or 100 or more megacycles, but it does go beyond the general-purpose scope whose response rarely exceeds a megacycle or so. The important frequency seems to be 3.58 mc., which is the frequency of the color-TV subcarrier. In order to respond to such signals in a color set, the scope must have a response higher than this figure. The scopes that have evolved, then, based on color-TV receiver requirements, are wide-band service scopes, with response from d.c. to about 5 mc. These instruments must be more elaborate in circuitry and more costly than the narrow-band general-purpose scope, but are far less elaborate than a lab scope. What is more, these units do not usually use calibrated, or driven sweeps, as do the lab instruments.

The new "Knight-Kit" KG-635 is just such an instrument. It uses fairly conventional circuitry (see block diagram) to achieve a calibrated sensitivity of 50 mv.(p-p)/inch and a frequency response rated at ±1.5 db from d.c. to 5.2 mc. Actually, our own measurements showed a response of ±1 db up to 5 mc. and ±3 db up to 7.5 mc.

A sync limiter circuit keeps the trace steady at just about any input signal level that the scope can handle. Also contributing to the stability of the waveforms on the 5-inch CRT is the use of the new polystyrene and Mylar capacitors in the sweep-generating circuits. Non-inductive metal-film resistors are also used where required. Two of the power-supply potentials are voltage-regulated so that line-voltage changes do not affect the pattern being viewed.



A useful 100-mv. (p-p) signal is available at a binding post on the front panel to double-check the accuracy of the four-position frequency-compensated vertical input attenuator.

The KG-635 is smaller than the usual 5-inch bench scope. Although it is not as portable as a 3-inch instrument would be, it is quite easy to handle. At the same time, of course, it displays a larger waveform than the 3-inch tube.

The scope does not use any printed circuits so that the construction time of the kit version is not short. For example, it took us a total of 24 hours for complete construction and adjustments. The construction manual is excellent and is letter-perfect as well. All in all, the instrument is well-engineered and a very worthwhile addition to the bench.

The KG-635 is sold by *Allied Radio* for $99.95 in kit form or for $149.95 for the factory-assembled instrument. ▲

EMC Model 100 Tachometer & Dwell Meter

For copy of manufacturer's brochure, circle No. 25 on Reader Service Card.

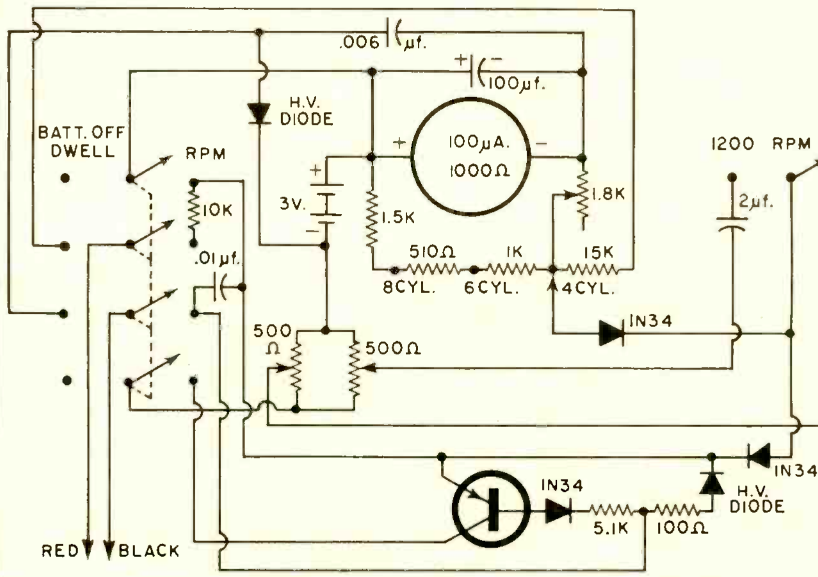
TWO extremely important auto-engine characteristics are engine speed and breaker points dwell-angle setting. Dwell angle is the time the ignition points are closed, as compared with the time of the complete ignition cycle. The *EMC* Model 100 tachometer and dwell-angle meter is an electronic instrument that will measure these characteristics easily and accurately. Only two connections are required for all measurements; no changing of leads is needed in transferring from dwell to r.p.m. The instrument covers the requirements for all foreign and domestic cars whether 4-, 6-, or 8-cylinder, and for either positive- or negative-ground electrical systems.

A complete schematic of the instrument is shown here. Automotive connections are made *via* the red and black input leads: the red lead is connected to the junction of the breaker points and the ignition-coil primary; the black lead connects to the car chassis.

When the switch is thrown to the "RPM" position, the Model 100 is being used as a tachometer. The red input lead samples the chain of pulses generated by the points' opening and closing. The number of electrical pulses is directly related to the engine speed. The input pulses are fed through an r.f. filter to a transistor amplifier stage driven to saturation, producing a cleaner, uniform series of output pulses. These pulses are passed through two 1N34 diodes to an *RC* integrating circuit and meter. This meter responds to average current flowing and is calibrated in rpm.

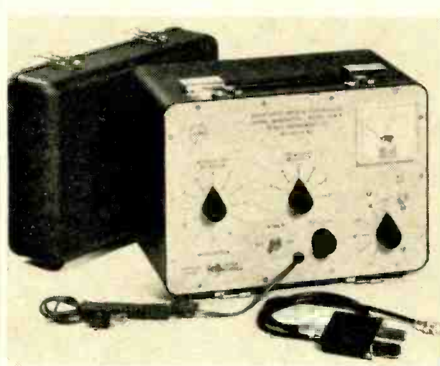
When the meter switch is thrown to measure dwell angle, the transistor is removed and all that remains in the circuit is the meter, the batteries, and a high-voltage isolating diode. Of interest here is the time duration of point closure. If the points are open all the time, the current is zero. If the points are closed all the time, the meter reads full scale as set by the series variable resistor. This would be a dwell angle of 45° for an 8-cylinder car, 60° for a 6-cylinder car, or 90° for a 4-cylinder car. The meter reading is directly calibrated in terms of dwell angle.

The *EMC* Model 100 costs $29.95 factory-assembled. It also comes as a kit for $24.95. The instrument's instruction book contains a chart of rpm and dwell-angle data for all cars. In addition, the instrument functions as an electronic ohmmeter and so can also be used as a continuity checker and diode tester. ▲



Ferris 500 Series Signal Generators

For copy of manufacturer's brochure, circle No. 159 on Reader Service Card.



THE *Ferris Instrument Co.*, long known for its high-quality, laboratory-type r.f. signal generators ("Microvolters"), has just completed the engineering of a new 500 Series of solid-state, crystal-controlled signal generators. This line of instruments is custom-designed for the specific needs of the user so that unneeded features, which would add to the cost of the unit, are eliminated. For example, one manufacturer of garage-door openers is using the generator with twelve fixed frequencies in the 27-mc. band. Another radio manufacturer is using the instrument with fixed frequencies at 455 kc., 535 kc., 600 kc., 1400 kc., 1620 kc., 1630 kc., and 10.7 mc. for production-line and laboratory alignment of AM-FM sets.

The instruments are designed for laboratory and production testing as well as repair-shop and field servicing of all receivers operating from 100 kc. to 54 mc.

A basic unit contains four transistors operating as a crystal oscillator, an r.f. amplifier, audio oscillator, and modulator. These are powered either by a solid-state, zener-regulated a.c. power supply or by a 9-volt rechargeable battery. A highly accurate five-step metered attenuator is used in the generator, so that a metered output from 1 to 100,000 microvolts into 50 ohms can be obtained.

Prices for the standard models start at $300. ▲

Linear Integrateds

(*Continued from page* 41)

to make do with "outboard" microminiature tuned circuits coupled to existing active-element IC's.

There is no doubt in the minds of consumer equipment engineers that linear IC's will come to the consumer field. Within the next year or so, some radio, TV, or audio systems will use some integrated circuits, once the barrier of unit cost has been removed or reduced to the point where the price differential is not as great as at present. The lack of suitable tuning elements will not deter this introduction. As previously mentioned, equipment size is limited by other components within the system.

In the area of research, development is now under way on a "device on a slice." In this approach, instead of a large number of identical circuits being formed on a slice of silicon, one over-all interconnected system, such as a complete radio except for non-electronic items, or a TV set except for the high-power circuits, can be laid down on a single one-inch diameter silicon slice.

The development of entirely new circuit elements may change the design of future consumer electronics equipment. One laboratory is presently experimenting with an acoustic-resonant transistor that is theoretically capable of producing power at its resonant frequency without the need for frequency-selective components. This particular device lends itself admirably to local oscillator use in receivers and to use in low-power r.f. stages in transmitters. ▲

NEW FCC RULING ON GARAGE-DOOR OPENERS

PART 15 of the FCC Rules and Regulations pertaining to the operation of garage-door openers above 70 mc. was recently amended in two important respects. First, the transmitters need no longer automatically transmit for a second and then have a 30-second silent period. If the transmitter has a spring-loaded switch that turns the unit off when the switch is released, then it is exempted from the duty-cycle limitation previously in force.

Second, in view of the interference problem and the need to protect the aeronautical radio navigation and radio-astronomy bands and the safety frequencies, the Commission specifically prohibits radiation from the transmitter and receiver from certain frequency bands. These are: 73—75.4 mc., 108—118 mc., 121.4—121.6 mc., 242.8—243.2 mc., 265—285 mc., 328.6—335.4 mc., 404—406 mc., 608—614 mc., 960—1215 mc., 1400—1427 mc., 1535—1670 mc., 2690—2700 mc., 4200—4400 mc., 4990—5250 mc., 10.68—10.70 gc., 15.35—15.4 gc., 19.3—19.4 gc., 31.3—31.5 gc., and 88—90 gc. ▲

Micrometeoroid Measurements

(*Continued from page* 43)

problems. What does the sensor actually measure (speed, momentum, etc.), and how can we simulate this measurement in the laboratory? Since micrometeoroids have been observed at velocities of up to about 68,000 miles per hour, no means for accelerating particles of this size and speed presently exists in the laboratory. Glass and metallic beads have been dropped or fired against detectors for calibration purposes, but this method has limitations.

The *amplifier* used in the instrumentation system may be of fairly conventional design, except that noise and power drain should be minimized. Bandwidth requirements are normally not severe, since the sensors typically produce signals that require a bandwidth of less than 500 kc. A possible exception would be the amplifier used with the light-flash sensor, since photomultiplier tubes produce signals which require greater bandwidth, out to several megacycles.

The *data handling* and *storage* function may be handled by a wide variety of circuits and instruments. A magnetic core memory might be used to count the number of pulses coming from a particular sensor. A chain of flip-flop circuits might be used, or a magnetic tape recorder. Upon command from the spacecraft, the data is read out to the telemetry (TM). An article, "Understanding Telemetry" in the April 1964 issue of this magazine, gives a good description of how TM is used to read out signals, so will not be discussed further here.

The "Pegasus" Satellite

In order to collect data concerning micrometeoroids, the National Aeronautics and Space Administration is conducting a series of satellite experiments, Pegasus 1, 2, and 3. Pegasus 1 lifted off from Cape Kennedy, February 16, 1965, Pegasus 2 was launched successfully on May 25, and Pegasus 3 was launched July 30.

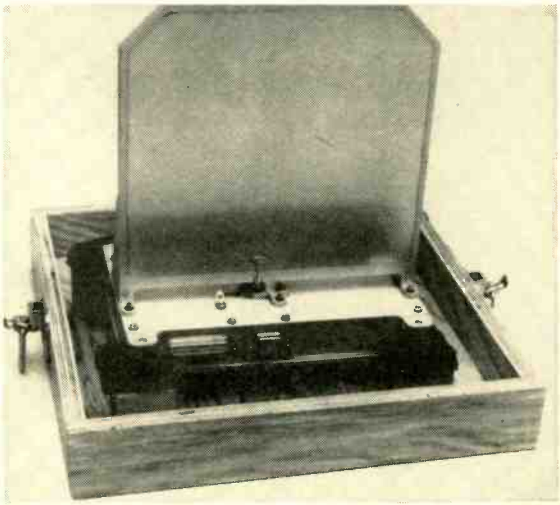
Pegasus uses the capacitor sensor with three different outer aluminum thicknesses: 1½ mils, 8 mils, and 16 mils. The dielectric is Mylar, 50 millionths of an inch thick. The back conductor is copper, 25 millionths of an inch thick. When particles are not discharging the capacitors, the sensors draw very little power, only the small leakage current of the capacitors. The potential across the dielectric is 40 volts. Each capacitor is 20 by 40 inches and 416 such capacitors give a sensor surface of over 2300 square feet. The 96-foot wing span of sensor elements is indicated in the photos. During launch the wings are folded and then deployed when the satellite is injected into orbit (Fig. 2).

Before launch the Pegasus sensors were calibrated by firing ruby particles of 10-mil diameter at velocities of up to about 13,000 miles per hour. Other electrical tests performed prior to launch insure meaningful interpretation of data.

Power for Pegasus is supplied by nickel-cadmium batteries of six ampere-hour capacity. Solar cells mounted on two small outboard panels are used to recharge these cells.

Total weight of the satellite is 3200 pounds, and the satellites are launched into an elliptical orbit of about 300 to 450 statute miles altitude.

The sensor wings are subdivided into 62 logic groups of two to eight capacitors each. The capacitors are interconnected so that the satellite electronics package sees each logic group as one capacitor. A particle hit on any panel will be registered as a hit on the logic group in which that panel is located. The number of hits in each logic group is counted. The direction of the particle path may be estimated by means of attitude information and the region of the hit. The particle energy can be approximated since the thickness of each panel is known. The spacecraft has two telemetry links which monitor 179 different measurements and provide housekeeping data as well. ▲



The Mariner 4 spacecraft, which photographed Mars in mid-July, carried this micrometeoroid sensor assembly and associated electronics gear. Two sensors were used to measure strikes by direct penetration and by microphone. A square aluminum plate yields a microphone signal when struck by particle. Detector weighs 2 lbs. and mounts on the upper side of the spacecraft. The wood case is for shipping.

RECENT PROFESSIONAL INSTALLATIONS OF AR SPEAKERS

AR-2x

($89-$102, depending on finish)

Aeolian-Skinner reverberation system corrects excessively dead acoustics in the chapel of Choate School, Wallingford, Connecticut. Duncan Phyfe, musical director of the school, describes the effect on live pipe organ and chorus as "so natural one is not aware of an electronic reverberation system."

Similar Aeolian-Skinner installations are operating in Christ Church, Cambridge, Massachusetts, and in St. John's Episcopal Church, Washington, D.C. AR speakers were chosen because of their lack of coloration, their undistorted, full-range bass, and their reliability.

AR-2ax

($109-$128)

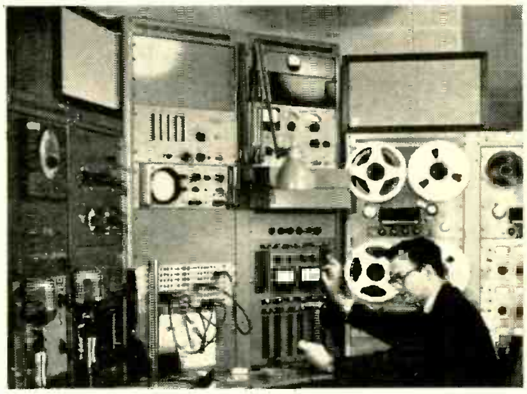
Sound reinforcement system for the summer jazz concerts in the sculpture garden of New York's Museum of Modern Art. Live music had to be amplified without giving the sound an unnatural, "electronic" quality; AR speakers were chosen after testing many brands.

©1965, LINCOLN CENTER FOR THE PERFORMING ARTS

AR-3

($203-$225)

One of the listening rooms in the Library & Museum of the Performing Arts at Lincoln Center in New York City. AR-3's were chosen for these rooms to achieve an absolute minimum of artificial coloration.



Experimental Music Studio of the University of Illinois. Dr. Hiller (seated) writes about the AR-3's, used as monitor speakers: "I wish all our equipment were as trouble free."

AR speakers and turntables are often used professionally, but they are primarily designed for natural reproduction of music in the home. Literature is available for the asking.

ACOUSTIC RESEARCH, INC., 24 Thorndike Street, Cambridge, Massachusetts 02141

Integrated-Circuit Industry

(*Continued from page* 40)

Because the techniques used in making integrated circuits are similar to those used for transistors, the integrated circuit is at least equal to the transistor in reliability. However, the picture is even brighter than this. One sore spot in reliability is the interconnection of components. Because many interconnections are eliminated, the integrated circuit is probably the most reliable device which uses both active and passive components in production today.

As an example of how reliability studies are conducted, the test setup used by *Philco* will be examined. One-hundred and fifty-three modules are connected in a series string and tied back to provide a ring oscillator containing 459 elements. The circuits operate for one million element-hours at 25°C and an additional one million element-hours at 75°C. A failure of any element would stop the ring oscillator from functioning.

Philco found that no failures occurred during two million element-hours of life testing (one million hours each at 25°C and 75°C). Other firms making integrated circuits have had similar experiences. *Fairchild* reports that MIT's Instrumentation Laboratory, working on the Apollo program, has conducted operational life tests on their line of integrated circuits totaling over 50 million hours without any failures.

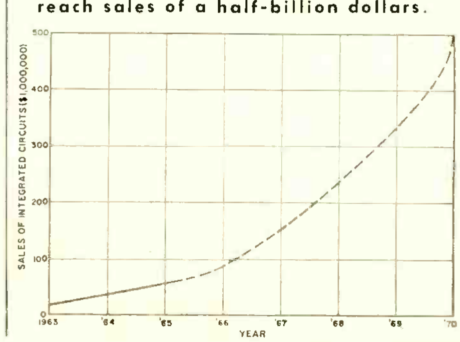
The Future

To summarize, integrated circuits will be used more and more in military, industrial, and consumer products of the future. Many novel devices will be made possible by the use of these ultra-tiny components. Because of their reliability, small size, and decreasing cost, the integrated circuit will become competitive with most discrete circuits that are in use today.

The technician, engineer, discrete component manufacturer, and parts distributor will all be affected.

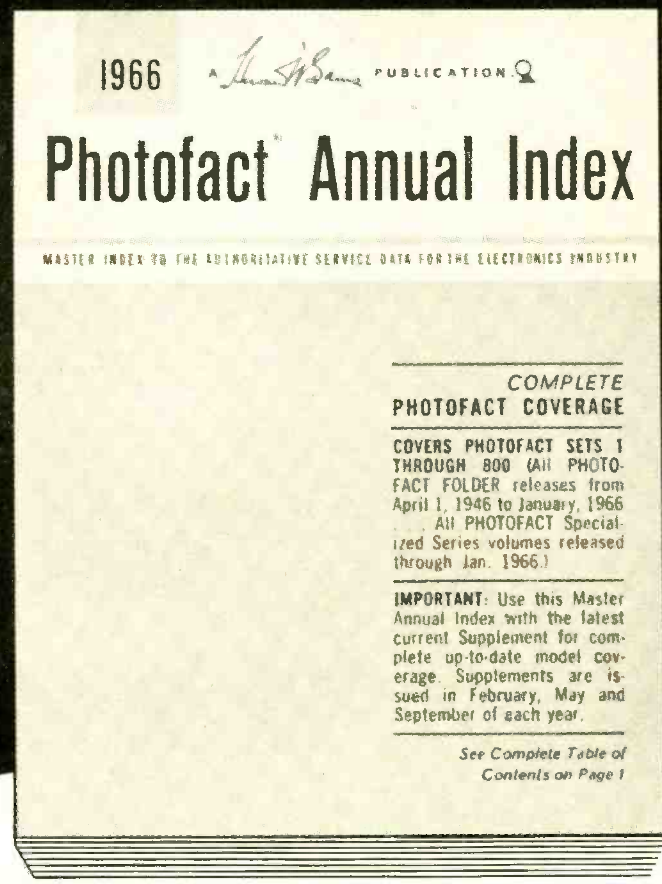
The sales of integrated circuits will probably hit a half-billion dollars in 1970 (Fig. 4). ▲

Fig. 4. Projected growth of the integrated-circuit industry which by 1970 may reach sales of a half-billion dollars.



Free Photofact® Annual Index

for your use throughout 1966



send today for your instant handy guide to the world's finest electronic service data!

covers over 65,000 listings of:

TV Receivers • Home & Auto Radios • Phonos & Hi-Fi
CB Radios • Tape Recorders • Record Changers

NOW INCLUDES—

- Special Index to Color TV Receivers
- Complete Listing of Sams Technical Books
- Complete List of Sams Distributors

Send today for this valuable 128-page guide covering virtually every model of home-entertainment electronic equipment produced since 1946! Helps you locate the proper PHOTOFACT Folder to quickly solve any service problem in any model. PHOTOFACT provides *everything* you need in complete, uniform style for quick, effective repairs: Famous Standard Notation Schematics packed with the service details you need; Full Photo Coverage of all chassis views; Complete Replacement Parts Lists; Tube Placement Diagrams; Alignment Instructions; CircuiTrace® for printed boards; Disassembly Instructions; Dial Cord Diagrams; Changer and Recorder "Exploded Views"—plus dozens of other great features. Send coupon for your FREE copy of the latest PHOTOFACT Index to the service data you need!

FREE! Famous 14-volume NEW STANDARD ENCYCLOPEDIA—the supreme gift for your family—FREE with your purchase of a PHOTOFACT Library! This invaluable Treasury of Knowledge for all the family sells at retail for $149.50—now yours FREE with the purchase of 225 PHOTOFACT Sets or more. See your Sams Distributor for the exciting details, or send coupon today!

NEW "PHOTOFACT ANNUAL INDEX" AND 3 SUPPLEMENTS NOW PROVIDE COMPLETE REFERENCE TO PHOTOFACT COVERAGE:

Send for the Photofact Annual Index—your "master" reference throughout 1966. Once you are on our mailing list, you will automatically receive three additional Index Supplements (in February, May, and September, 1966) to keep you up-to-the-minute on Photofact coverage of the latest equipment released.

SEND FOR FREE ANNUAL INDEX

HOWARD W. SAMS & CO., Dept. EWF-11
4300 W. 62nd St., Indianapolis, Indiana 46206

☐ **Send FREE 1966 Photofact Annual Index** and place my name on your mailing list to receive the Supplements

☐ Send full information on FREE Encyclopedia Offer, Easy-Buy Photofact Library Plan and Standing Order Subscription

My Distributor is ____________

Shop Name ____________

Attn.: ____________

Address ____________

City ____________ Zone ____ State ____

FM SENSITIVITY VERSUS FM QUIETING

IN certain instances, the concept of FM quieting is used to provide a performance rating more suitable than FM sensitivity for comparing different types of FM receiver circuitry. The term "FM quieting" can be more readily understood if compared to the term "FM sensitivity."

FM sensitivity is defined as the amount of signal that must be applied across the receiver antenna terminals to give a specified signal level at the output of the FM detector. For example, in checking sensitivity of a given FM receiver, a 30% modulated FM signal is impressed across the antenna terminals. The amount of signal needed to attain a standard reference level at the output of the detector is then referred to as the FM sensitivity of the receiver. The measurement, in a greater sense, is simply an indication of the receiver's ability to amplify—making it nothing more than a conventional gain check.

While FM sensitivity may be used to evaluate the capability of a receiver to meet a specified operational requirement, it cannot be used meaningfully to compare different types of receiver circuitry such as a vacuum-tube type with a solid-state type device. Moreover, the measurement of sensitivity does not differentiate between signal and noise. For instance, a one milliwatt signal present at the FM detector might contain .5 milliwatt of noise which is undesirable to the listener regardless of the sensitivity of the receiver.

The ratio of the wanted signal to the unwanted noise is called the signal-to-noise ratio.

FM quieting is defined as the ratio of signal plus noise to noise level. For example, in checking the quieting effect of a receiver, a 30% modulated carrier is impressed across the receiver antenna terminals to establish a reference level (signal plus noise) at the output of the FM detector. This reference level must be established below the limiting knee in order to obtain a true ratio.

Removing the FM modulation, but maintaining the carrier, will establish a noise level. The ratio of the signal and noise level to the noise level (expressed in db) is the quieting capability of the receiver for a given carrier level input. While 30 db of quieting will satisfy most listeners, enjoyable noise-free reception requires a quieting effect close to 40 db.

The above information was extracted from *RCA* "Plain Talk." ▲

THE FIELD-EFFECT TRANSISTOR

By GENE L. JACKSON / Aerosystems Engineer, General Dynamics, Fort Worth Div.

Operating principles of a transistor that acts like a vacuum tube in terms of minimum circuit loading and an extremely high input impedance.

THE concept of the unipolar or field-effect transistor (FET) predates that of the conventional junction transistor. The first working model of the FET was developed by *Bell Laboratories* just after the Second World War. However, these early models did not perform well and it was not until recent years that the state of the art allowed transistor manufacturers to develop a practical and marketable FET.

The development of the FET has opened up many possibilities in the field of electronics. Many of the possible applications of the FET have not been thoroughly explored up to this time. The new FET devices can be divided into two main groups: the junction FET and the metal-oxide-semiconductor (MOS) FET. There is considerable difference in the construction and operation of these groups. The junction-type will be discussed in detail here.

One of the main differences between the conventional junction transistor and the junction FET lies in the fact that the conventional transistor is current-controlled and the FET is voltage-controlled. Therefore, the FET draws very little current from the signal source and presents a much higher impedance than conventional transistors. Low input impedance was one of the major problems encountered when technicians began working with transistors several years ago. Although many successful techniques have been developed to overcome this problem, higher input impedance devices will allow the circuit designer to simplify as well as to improve a good many types of electronic circuits.

Construction and Basic Operation

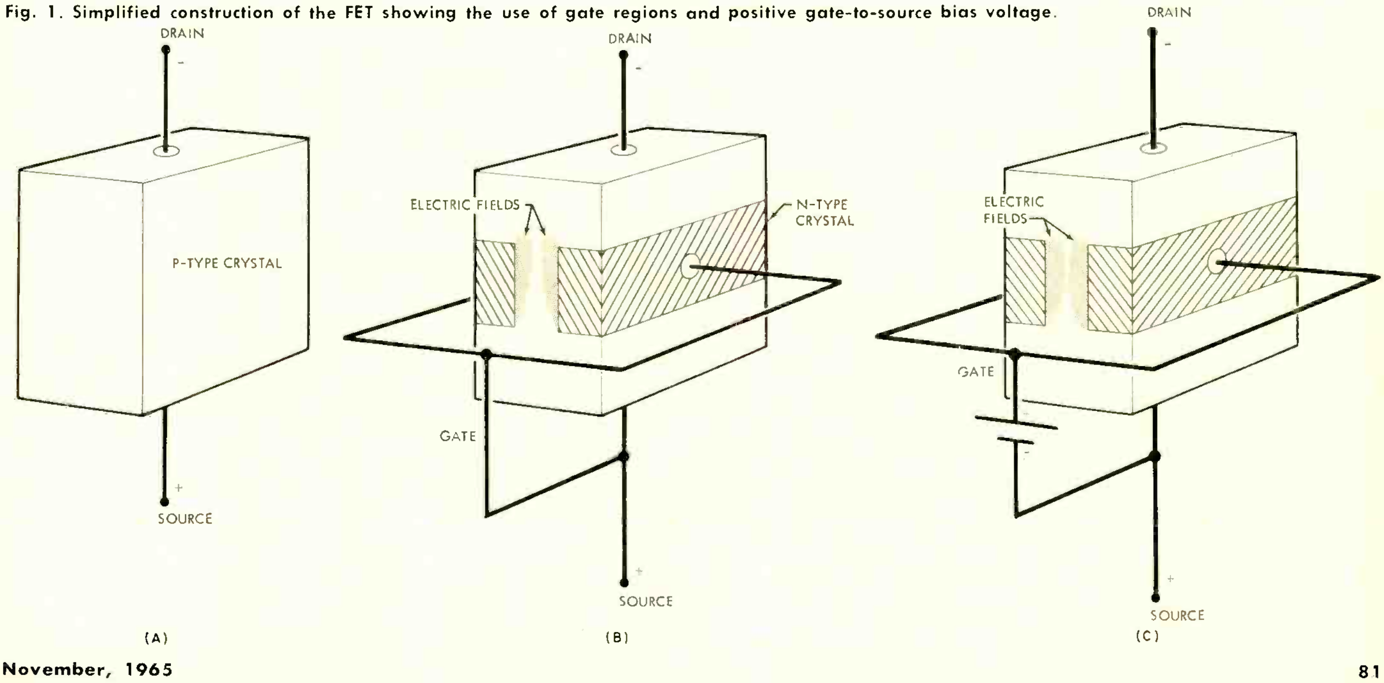
The construction and basic operation of the FET can best be explained by starting with a bar of silicon crystal, as shown in Fig. 1A. The two connections labeled "Source" and "Drain" are simply ohmic-type connections to the crystal. If a voltage is applied across the crystal by making the source positive with respect to the drain, electric current will flow through the crystal in the normal manner for current flow in a *p*-type semiconductor. The amplitude of the current will depend on the potential of the voltage source and on the characteristics of the crystal.

Fig. 1B shows some of the crystal cut or etched away and then the area filled in with *n*-type material. The *p*-type crystal is very narrow at this point and forms a "channel." It is in this channel that control of current through the FET is effected. Normally, the two leads from the *n*-type regions are joined together and the common connection is called the "gate." With the gate connection open and the voltage applied, the current through the crystal will not be materially affected, but the current will now be restricted to the narrow channel.

If the gate is now connected to the source lead, as shown in Fig. 1B, the flow of current through the device will be reduced. The natural resistivity of the *p*-type crystal will cause a voltage drop across the length of the *p*-type crystal bar between the source and the drain connections. This will result in the junctions between the *n*-type crystal in the gate regions and the *p*-type crystal in the main bar being reverse-biased. In other words, the gate areas will be positive with respect to the *p*-type crystal immediately adjoining them.

As in any reverse-biased semiconductor junction, the areas on both sides of the junctions will be depleted of carriers (holes and free electrons) of electric current. This effect is exactly the same as when a junction diode is reverse-biased but the effect is now used in a little different way. With part of the narrow channel between the gate areas depleted of the current carriers, the electrical width of the current-carrying channel has been effectively decreased and therefore the conductivity of the narrow channel has been decreased. This will then decrease the amount of current flowing between the source and the drain.

Fig. 1. Simplified construction of the FET showing the use of gate regions and positive gate-to-source bias voltage.



This effect can also be explained as the building up of an electric field at the above-mentioned junctions. This electric field is shown in Fig. 1B. Notice that it is wedge shaped, being wider toward the drain end of the device. This is because the potential between the gate region and the surrounding *p*-type crystal becomes greater nearer the drain end of the device.

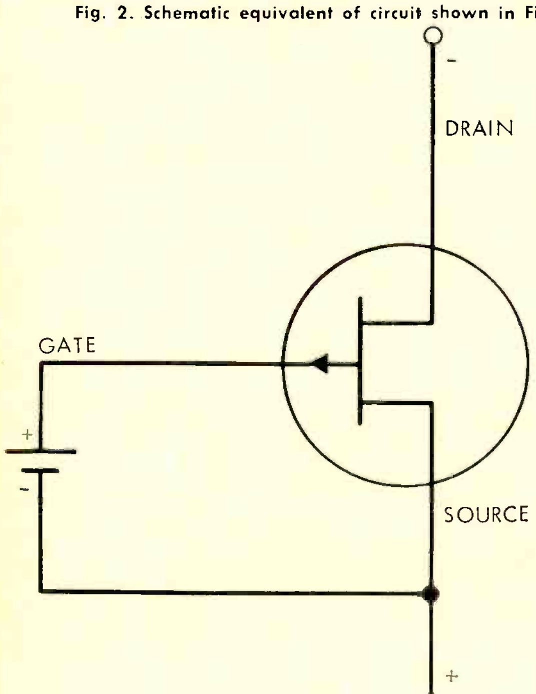
The arrangement shown in Fig. 1B would have very little practical application. However, a configuration somewhat nearer to the operational FET is shown in Fig. 1C. Here a positive bias potential is connected between the gate and the source. With this arrangement, an additional electric field appears at the internal junctions. This new electric field adds to the electric field already mentioned and a further reduction in source-to-drain current results. (*The flow of electrons through the* p-*type FET is from drain to source; "conventional" current flow is in the opposite direction.—Editor*) Technically the two fields are not exactly the same type (the electric field resulting from drain current being tangential to the junction and the electric field resulting from the external applied bias being normal to the same junction), but for all practical purposes they can be treated as being electric fields simply reinforcing each other.

As the positive potential between the source and the gate is increased, the current through the device will decrease. It seems natural to expect that as the potential is further increased, a point would soon be reached where no current could flow in the channel. In practice, the channel current can be decreased to a very low value but it cannot be decreased to zero.

It is now time to introduce the standard symbol for the *p*-type FET. In Fig. 2, the pictorial arrangement of the FET in Fig. 1C is replaced by the standard symbol for the FET but the external connections are the same.

If the FET were constructed from a bar of *n*-type crystal and the gate regions made of *p*-type crystal, the operation would be the same except that the polarity of the voltages applied to the device and the direction of current flow would be reversed. The schematic symbol of the *n*-type FET is the same as the one shown except that the direction of the arrow in the gate connection is reversed. Both types of FET's are being produced commercially at the present time. It must be remembered that the physical configurations of the FET's on the market are much more refined than the example used here, but the basic construction principles are the same.

Fig. 2. Schematic equivalent of circuit shown in Fig. 1C.



Another of the differences between the FET and the conventional transistor can be demonstrated by referring to the circuit of Fig. 3. If the conventional junction transistor were connected in this way (considering the gate, drain, and source analogous to the base, collector, and emitter respectively of a *p-n-p* junction transistor), the transistor current would be at cut-off. In contrast, the FET circuit of Fig. 3 would have a conduction level determined by the resistance value of R_S. The conventional junction transistor must be forward-biased at the input, resulting in very low input impedance, while the input to the FET is reverse-biased, giving it a very high input impedance.

The resistor R_S in the circuit of Fig. 3 allows the device to operate in the region over which the drain current can be controlled (increased and/or decreased). It is readily apparent that this is the same circuit arrangement that has been used to bias electron tubes for many years. The circuit action is the same as for electron tubes. With electron current flow from drain to source, a voltage drop of the polarity shown occurs across the resistor R_S. As stated previously, this voltage acts as reverse bias across the gate-to-source junction and restricts

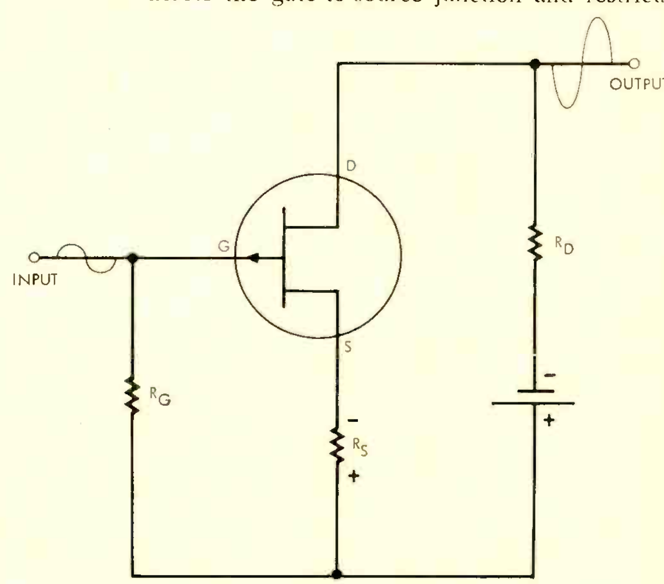


Fig. 3. The basic circuit diagram of an FET amplifier.

the flow of drain current. Because you cannot have this bias without current flowing in the FET, the value of drain current is determined by the value of the circuit components and the applied voltage.

Very little or no voltage will be present across R_G except that resulting from an input signal. When the input signal causes the gate to become positive, the reverse bias across the gate-to-source junction is increased and the current through the FET decreases. The voltage at the drain or output of the circuit will go in a negative direction. Conversely, with a negative input signal, reverse-bias of the gate-to-source junction is decreased and the source-to-drain current increases. With this condition, the voltage at the output becomes less negative or goes in a positive direction. Thus, the signal is amplified and undergoes a 180-degree phase shift as occurs in a vacuum-tube amplifier (common-cathode configuration) or in the conventional transistor amplifier (common-emitter configuration.)

(*In the case of an* n-*type FET, the similarity to a vacuum-tube circuit becomes even more obvious. The gate bias is negative, in this case, and the electron-current flows from the negative source to the positive drain.—Editor*)

Important Characteristics

The characteristics to be described are some of those most commonly found on manufacturers' data sheets. It is important for the user of the FET to be familiar with them.

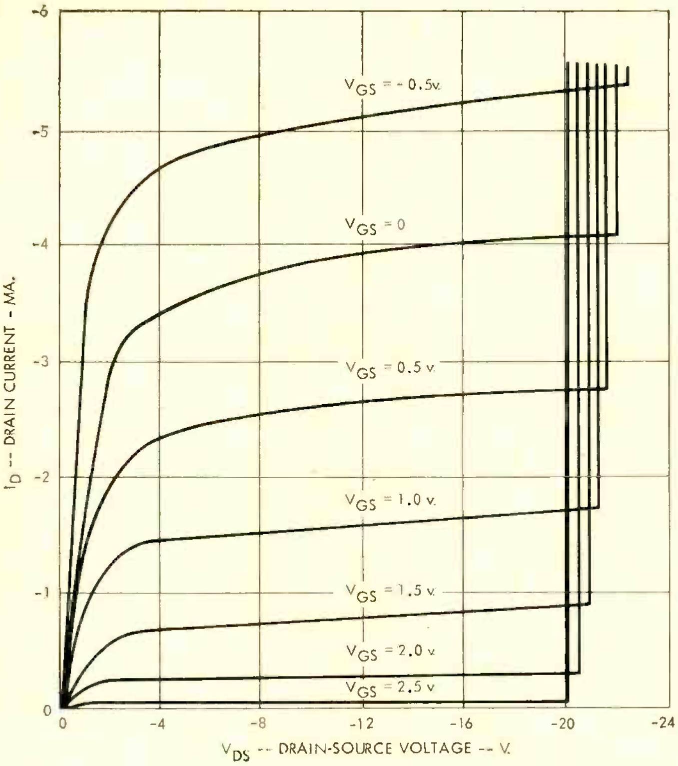


Fig. 4. Typical characteristic curves of "p"-type FET.

Gate Cut-off Current (I_{GSS}). This is nothing more nor less than the reverse-bias current across the junction between the *n*-type material and the *p*-type material of the FET. Because the source and drain leads both are connected to *p*-type crystal, these leads are connected together when measuring this current. With a *p*-type FET, the source and drain leads are connected to a negative potential and the gate to a positive potential. This will reverse-bias the junction. With this arrangement, the only current resulting will be the current due to minority carriers. As with any junction diode, this current will be determined by the characteristics of the crystal and by the temperature of the material. Because temperature can vary and the transistor characteristics are inherent, the amount of gate cut-off current will be determined mostly by temperature. At room temperature, this current will be in the low microampere region.

As with any diode, the junction can be broken down if sufficient reverse-bias voltage is applied across it. Therefore, to prevent possible damage to the transistor, the applied voltage is generally limited to 10 volts or less when measuring I_{GSS}.

Breakdown Voltage (BV_{DGO}). Breakdown-voltage characteristics can best be explained by referring to Fig. 4. The curves are analogous to the I_P *versus* E_P curves of an electron tube and the I_C *versus* V_C curves of a conventional transistor. One of the main differences can be noted in that the V_{GS} curves take a sharp upturn shortly above the 20-volt value of drain-to-source voltage. This point represents the breakdown voltage of the FET under a particular operating condition. Because the gate-to-drain junction is normally reverse-biased, the voltage between the drain and gate will exceed the voltage between the drain and source under normal operating conditions. For this reason, the drain-to-gate breakdown voltage largely determines the breakdown point of the FET.

The drain-to-gate breakdown voltage (BV_{DG}) is a constant value for a particular transistor and can be stated in relation to the other voltage values as follows: $BV_{DG} = BV_{DSX} + V_{GS}$, where the subscript "*X*" denotes the value of drain-to-source breakdown voltage (BV_{DS}) for a particular value of gate-to-source voltage (V_{GS}).

This relationship simply means that the reverse-bias between the gate and source will cause the FET to go into a voltage breakdown condition with a smaller source-to-drain voltage than would otherwise occur. This can be verified by examining the curves of Fig. 4. As the value of V_{GS} goes in a positive direction, the breakdown voltage occurs at a smaller value of V_{DS}. It should be obvious that if the FET is to be used as an amplifier, it must be operated in the region below the breakdown voltage at all times. Also, the value of the applied voltage must always be less than the value of BV_{DG} given on the data sheet for any particular FET.

Saturation Drain Current ($I_{D(ON)}$). This is the symbol for the amount of drain current at zero gate-to-source voltage at a specified value of source-to-drain voltage. With this condition, the current in the channel between the gate region is determined only by the electric field developed in the channel by reason of the voltage drop across the crystal bar between the source and gate regions.

The value of $I_{D(ON)}$ decreases with an increase in temperature because silicon has a positive temperature coefficient causing a larger voltage drop at higher temperatures with the

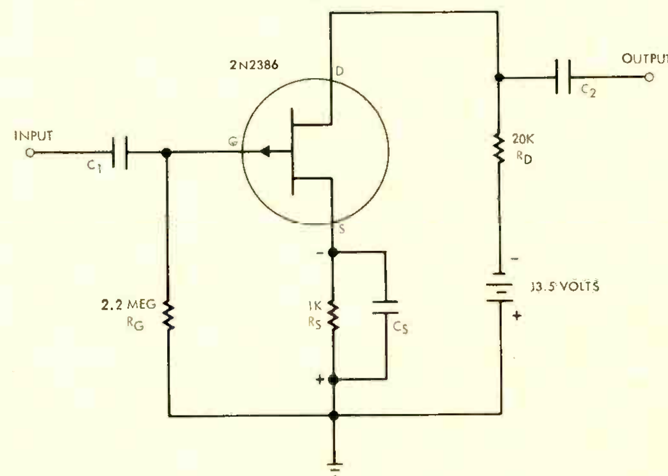
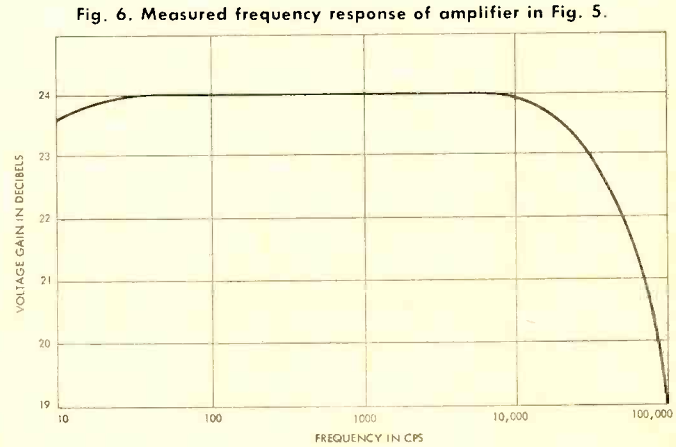


Fig. 5. This simple amplifier circuit was built and tested.

same value of drain current. $I_{D(ON)}$ is measured in the saturation or pinch-off region of the characteristic curve.

Pinch-off Current ($I_{D(OFF)}$) is the current flowing in the FET with a specified value of reverse-bias applied to the gate-to-source terminals. This reverse-bias is usually in the region of 5 volts which is considerably more than enough to bias the FET below the linear operating region and near the drain current cut-off point. As stated previously, the current through the transistor cannot be limited to zero by reverse-biasing the gate-to-source regions. Consequently, $I_{D(OFF)}$ as given on a data sheet is actually the value of drain leakage current that the manufacturer guarantees to be the maximum under specified operating conditions. This value is usually only a few microamperes of current and this value varies little with temperature.

Fig. 6. Measured frequency response of amplifier in Fig. 5.



Those persons who were reared on vacuum-tube theory will feel pleasantly at home working with the FET. The circuit design procedures for the vacuum tube are largely applicable to the FET. The basic amplifier shown in Fig. 5 was designed and constructed in the electronics labs at *General Dynamics*, Fort Worth. This circuit was built to illustrate the simplicity of designing and operating FET amplifiers. We were also interested in checking the performance of a basic amplifier employing a fairly inexpensive field-effect transistor.

Basic Amplifier Circuit

The data sheet for the 2N2386 transistor gives a guaranteed minimum value of BV_{DGO} of 20 volts. The voltage source of 13.5 volts used in this circuit is then safely below this value. R_G was selected so that very little shunting of the input signal would result; therefore giving a high value of circuit input impedance. R_S determines the operating point of the FET while R_D is the load resistance whose value largely determines the amplitude of the output signal voltage. As in any amplifier, the capacitance values are determined primarily by the lowest frequencies that are to be amplified in the circuit.

The input impedance was found to be extremely high at signal input frequencies below 10 kc. Above this value, the input impedance decreased considerably due to the shunting effect of the input capacitance of the FET. However, the input impedance still remained considerably higher than that for conventional transistor amplifiers. The manufacturer lists the input impedance of the 2N2386 above 3 megohms at frequencies up to 1 kc.

The voltage gain was found to be approximately 24 db at frequencies up to 10 kc. and down only 1 db at 30 kc. The curve of Fig. 6 shows the measured frequency response for this amplifier. The small decrease in gain at low frequencies was a result of insufficient bypass and coupling capacitance at the lowest frequencies.

The input impedance and frequency response can be improved considerably with more refined circuit design. In fact, circuits have been designed with input impedance of at least 200 megohms and with good frequency response up to and above 10 mc.

Another major advantage of the FET is low noise characteristics. In general, the FET has proven to have lower inherent noise than either vacuum tubes or conventional transistors. Further, drain current and drain-to-source voltage changes have proven to have little effect on the amount of noise generated in the circuit. These advantages should cause the FET to enjoy a much wider application in the future, especially where high input impedance is required. ▲

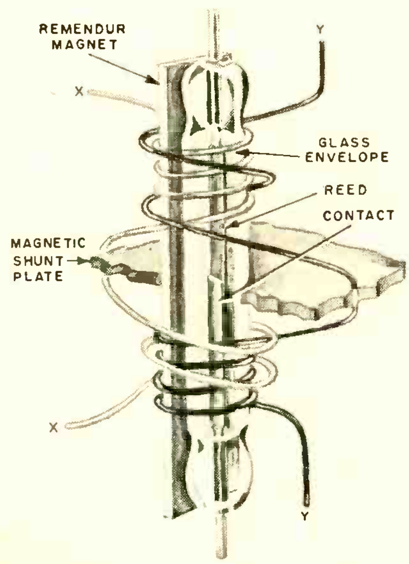
HIGH-SPEED SWITCH

A NEW high-speed switching system for use in automated telephone systems has been developed by *Bell Labs.*

Using reed relays (glass-enclosed contacts operated by external magnets), the reed contacts are made to close by passing a burst of current through an electromagnet winding, closing the reeds, thus forming a closed path for the permanent magnet field.

When arranged in an 8×8 matrix (64 units), passing a control current through a particular set of horizontal and vertical leads, allows only one relay to switch while not disturbing others in the same horizontal row or vertical column. Unique construction of the reed relay element allows closure within half millisecond, and the contacts remain closed without expenditure of additional power, until another pulse opens it.

In a typical switch unit shown in the diagram, windings around the Remendur magnet (cobalt-iron-vanadium alloy with square hysteresis loop and value of coercive force intermediate between those of soft magnetic materials and permanent magnets) and the glass-enclosed reed switch are arranged in such a way that the contact is opened or closed in response to pulses of currents in the x and y leads. For the closed state shown, simultaneous pulses on both the x and y leads effectively cause the Remendur to become one magnet. The two reed sections will be magnetically attracted, closing the contact. To open the contact, a pulse is applied to either the x or y winding. This pulse effectively divides the Remendur into two magnets at the magnetic shunt plate. The ends of the Remendur are then both north (or both south) poles, opening the contact and the circuit. ▲



Integrated Circuit Techniques

(*Continued from page* 28)

silk screened on top of the tin oxide and the remaining area of tin oxide is plated with copper. An electroless plating technique is used and copper is left only on the exposed tin oxide.

Individual resistors may be trimmed to as close a tolerance as required (down to ½%) by making the initial value a little too small and then sandblasting a notch in a loop provided for that purpose. Several of these are visible in the picture.

Semiconductor devices of the "flip-chip" form are added to the tinned copper interconnection. The flip-chip can be just a diode or transistor, or it might be a complicated integrated circuit in monolithic form. Fig. 7 illustrates a "worm's-eye" view of a single transistor as might be seen looking through the substrate.

This type of hybrid fabrication permits monolithic circuits of moderate complexity to be combined with stable resistors. These resistors have a relatively low temperature coefficient and are capable of being trimmed to close tolerances even after final assembly. The fact that capacitors, having the characteristics of a hermetically sealed ceramic unit, may also be included as a valuable asset.

Since the monolithic circuits may be broken down into functional sections, very complicated circuit configurations are feasible with a minimum of interaction and undesirable coupling. In addition, the availability of crossovers can greatly simplify a layout design and decrease the distributed capacitances and inductances in high-speed circuit interconnections.

Although the circuits as currently produced by *Corning* are enclosed in a hermetically sealed package to protect the semiconductor devices, it should be possible to adequately protect them by normal passivation techniques or glass encasements. A mild conformal coating would give added protection.

Converting to Integrateds

Let us consider the various factors involved in taking a circuit from an arrangement using standard or full-size components and developing an integrated circuit which will perform the same basic function. The difficulty and the over-all direction taken would depend very greatly upon the actual circuit requirements.

Digital circuits are typically easier to integrate than analog functions since any capacitors required are usually small in comparison with those which might be required for an audio amplifier. Radio-frequency circuits often require coils and transformers. While it is possible to fabricate a coil with a limited amount of inductance by the thin-film technique, the range is very restricted and the "Q" is very low. The large capacitor or coil problem is solved by means of adding on miniature discrete components.

Let us assume that we must integrate a simple audio amplifier and study the design decisions involved with the conversion from an arrangement using standard components. A normal arrangement might use *RC*-coupled amplifier stages. Since the rather large capacitors would be impossible to make in monolithic or thin-film form, we would do well to consider a redesign to eliminate as many capacitors as possible and preferably all of them. We may do this by careful design and by using a differential amplifier or temperature compensation techniques to stabilize the bias conditions.

If a very minimum of size were required, we would perhaps best consider the monolithic circuit process since it would be possible to contain the entire amplifier within the volume of a TO-5 can or in a flat package roughly a quarter of an inch square and 0.050" thick. To do this, however, we would have to eliminate all capacitors. The circuit could be made of one monolithic block or it could be formed from several monolithic chips within the single can.

Another approach might be preferable if the output power

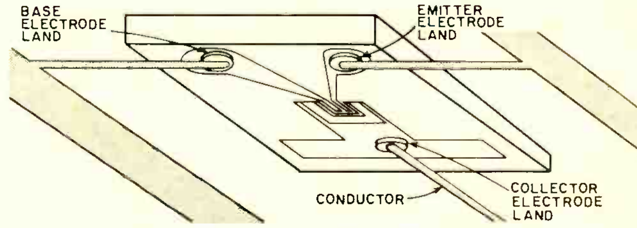


Fig. 7. Construction of a transistor of the flip-chip form.

requirements were too large for the monolithic technique; also, if the quantity were not sufficient to warrant the fabrication of precision masks which might have to be modified several times before the exact performance requirements could be met. In this case we would best turn to the over-all hybrid approach using the flip-chip monolithic active components with plated interconnections and thin-film tin oxide resistors.

The hybrid approach allows us to use standard chips for the matched pair differential stage and other transistors with the custom-designed resistors and interconnections. With this technique we have the advantage of circuit adjustment *after fabrication* and can raise the value of certain critical resistors to insure proper balance or setting of the bias point or gain.

Should an input isolation capacitor be necessary, we might consider the use of a field-effect transistor (FET) for the input stage. The input impedance level would then be high enough to allow the use of rather small coupling capacitors which may be fabricated on the substrate. We could perhaps squeeze in a small miniature tantalum capacitor attached to terminals provided on the substrate.

Some Examples

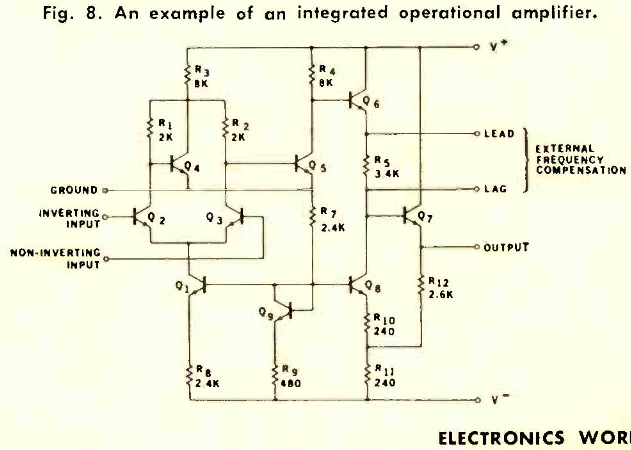
Examples of an integrated four-input gate and a shift register have already been shown. Many digital circuits have been integrated in a monolithic form as might be expected since certain forms of circuits are repeated many times within a given piece of digital equipment. Also, the same type of circuit is more likely to appear in different pieces of equipment of two different manufacturers.

Digital circuits can usually tolerate the rather coarse tolerances and limited ranges for monolithic resistors. They may also be designed to operate over a wide range of speed without any capacitors. A large number of companies offer monolithic integrated flip-flops, gates, shift registers, and other digital circuits as standard items.

Analog circuits are much more likely to be custom designed although common circuits such as operational amplifiers are currently available as standard circuits. Fig. 8 shows the circuit diagram of one such amplifier (μA-702-A) offered by *Fairchild Semiconductor* and yielding an open-loop voltage gain of several thousand and an equivalent input drift due to temperature of about 5 μv./°C.

Radio-frequency amplifiers require tuned circuits and are, consequently, not the easiest circuits to integrate. Nonetheless, some units have been built using monolithic chips com-

Fig. 8. An example of an integrated operational amplifier.



bined with discrete microminiature inductors. *Motorola* has developed a 60-mc. amplifier with a 10-mc. bandwidth and an over-all gain of 61 db minimum. Eight modules of four different types (input matching network, standard amplifier stage, interstage tuning network and filter, and detector) are used and each is contained within a 10-lead TO-5 can.

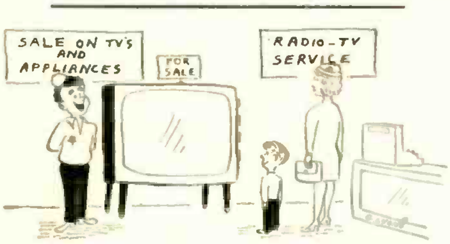
Testing Integrated Circuits

Testing of integrated circuits might at first seem practically impossible from the service technician's viewpoint. He cannot get at any of the individual components within a given module for replacement. Actually, if we consider any given integrated circuit as a component with a given input and output requirement, the task becomes more reasonable. Since we cannot repair the inside parts of an integrated circuit, we need not concern ourselves with pinpointing the specific component which failed, unless a critical failure analysis is necessary in order to provide direction for a design change.

The integrated circuit is tested by applying the required bias levels, providing the various input conditions, and monitoring the output to see if the specs are satisfied. Since temperature effects may be the cause of some troubles, it will generally be necessary to perform some testing at the extreme temperature conditions to eliminate marginal circuits which might work perfectly well at room temperatures.

In the fabrication of integrated circuits, especially those of the monolithic variety, the testing cost represents a sizable portion of the total. Many circuits of the same type are usually made on a single wafer of semiconductor material. It is necessary to test these individual circuits as soon as possible in order to prevent any waste of labor on units which are defective. In some cases, it is only necessary to do a rough check on the individual chip and then perform a more complete test after the chip has been packaged.

Circuits using the hybrid thin-film, thick-film, and monolithic combination may be modified by trimming their individual resistors. It may be wise to perform a complete functional test on the circuit before the conformal coating is added. The resistor adjustment can be made while the circuit is actually operating. ▲



"... and when it wears out, your son can use it as a clubhouse."

Glass for Electronics

(Continued from page 46)

temperature to form rugged, monolithic units. Leads are attached, and the dielectric stack is then fused into a compatible glass case.

Fixed glass capacitors are produced in a range of values from about 0.5 pf. to about 150 μf. and in working voltages to 6000 volts. They are characterized by high "Q," good stability, and excellent efficiency at temperatures to 300°C. Miniature glass trimmer capacitors (Fig. 7) provide a capacitance change of only 0.4 pf. per turn, permitting very precise tuning. The tuning curve is linear, and the units can be hermetically sealed against moisture.

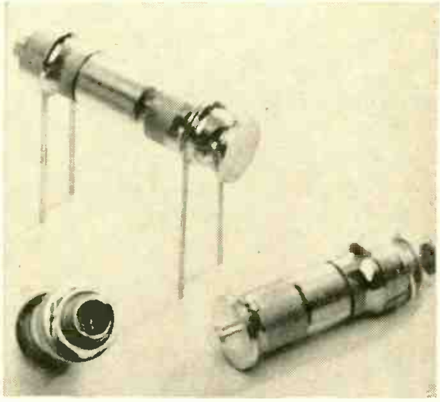


Fig. 7. Precision hermetically sealed glass trimmer capacitors are moisture-proof and possess linear tuning curves.

A very large number of special glasses have been devised to fill particular needs. For instance, rods made of borate- or silicate-base optical glass and doped with oxides of the rare-earth elements neodymium or ytterbium now serve as laser elements. The glass must be of the highest quality, and the rods themselves are tested with a gas laser source to assure optical homogeneity as well as end flatness and parallelism. *Eastman Kodak Company* makes such glass laser rods in sizes up to one inch in diameter and 36 inches in length. Power output as great as three joules per cubic centimeter of glass is reported.

High-silica glass is manufactured in a porous form containing billions of microscopic holes. This product is useful as a moisture-getter, and small slabs of it may be incorporated in semiconductor cases and relay envelopes for that purpose. The glass is mechanically strong, non-dusting, and non-flaking. Porous glass is also fabricated in the form of semi-permeable membranes for isotope separation and is used for chromatography and diffusion studies.

A non-porous glass membrane is used in the sensing electrode in a pH-measuring instrument, which determines the acidity or alkalinity of a solution by means of the hydrogen-ion concentration. A solution of known acidity is placed in the glass electrode and, when the electrode is immersed in the unknown solution, a voltage develops across the glass membrane dependent upon the difference in the hydrogen-ion concentration of the two solutions. Since the membrane is not porous, there is no transfer of electrons at the electrode-solution interface. However, special glass is needed to resist the effects of strong acid or alkaline solutions.

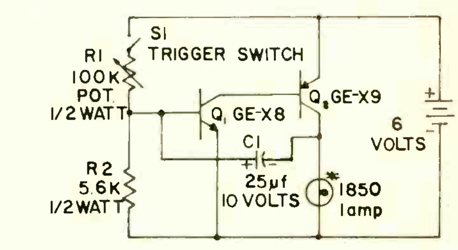
Glass to resist nuclear radiation is usually made with high lead content. It is cast in massive slabs for use in shielding windows in radiation laboratories, aboard nuclear vessels, and in hospitals where radioactive materials are employed. Because of its inorganic nature and its random structure, glass offers high resistance to x-ray and gamma radiation and will not darken with use.

A related product is gamma-ray-sensitive glass, a specially developed glass that will fluoresce upon exposure to ultraviolet light after irradiation by gamma rays. The intensity of the light emission is proportional to the total gamma-ray dose received, so badges made from this material serve as sensitive dosimeters. Dosages from 5 to 1000 roentgens can be measured in this way. ▲

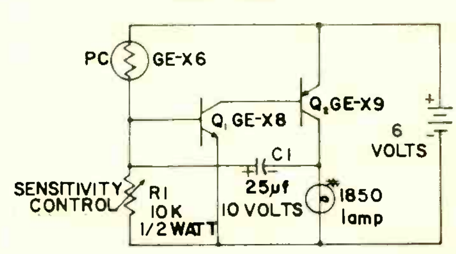
LIGHT TARGET

WHEN the proper level of light falls on the photocell shown in the schematic, the output transistor will conduct giving a pulse of light. When operated in this mode, the circuit may be used as a target in a light shooting gallery. By replacing the photocell and "sensitivity" control with other components as shown in the schematic, the same unit can be used as the light gun. Whenever the trigger is actuated, a short pulse of light results. In the gun version, the lamp can be used with a lens tube to aim the light beam at the light target photocell. ▲

TRIGGERED LIGHT SOURCE



LIGHT TARGET



A treasury of SOUND advice.

It's easy to be an authority on tape when you have a copy of *HiFi/Stereo Review*'s all-new **1966 TAPE RECORDER ANNUAL** handy.

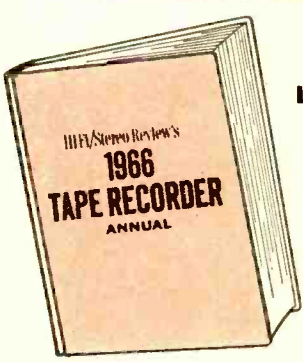
This fact-filled volume contains over 130 pages, more than **20 complete features,** covering every aspect of tape recording. You get expert tips by the dozens, on equipment—making better tapes—editing—copying—sound—on **everything** you want and need to know about tape recording.

PLUS a complete directory of the latest monaural and stereo recorders —the only complete buyer's guide available in the tape recorder field!

Over 100 photos—full data on 220 models from 30 different manufacturers! All the model numbers, specifications, dimensions and prices ... every vital statistic you need to compare the newest recorders and select the finest one in your price range.

The **1966 TAPE RECORDER ANNUAL** is an indispensable guide for everyone who wants better performance, greater versatility and a lot more fun from his tape recorder ...month after month...tape after tape!

If you fit this description...



GET THE EXQUISITE LEATHERFLEX-BOUND EDITION for just $3 POSTPAID!

The 1966 TAPE RECORDER ANNUAL is also available in an attractive, gold-embossed, Leatherflex-bound edition—a superb addition to your library of permanent reference books. This deluxe volume will be mailed to your home, **postpaid,** for just $3.00, when you check the appropriate box on the order form.

SEND JUST $1.25 TODAY FOR YOUR COPY OF THE 1966 TAPE RECORDER ANNUAL

Ziff-Davis Service Division • Dept. TR
589 Broadway • New York, N.Y. 10012

Send me a copy of the 1966 TAPE RECORDER ANNUAL, as checked below:

☐ **$1.25 enclosed,** plus 15¢ for shipping and handling. Send me the regular edition. ($1.50 for orders outside the U.S.A.)

☐ **$3.00 enclosed.** Send me the DeLuxe Leatherflex-bound edition, **postpaid.** $3.75 for orders outside the U.S.A.) Allow three additional weeks for delivery.

name ______________ please print

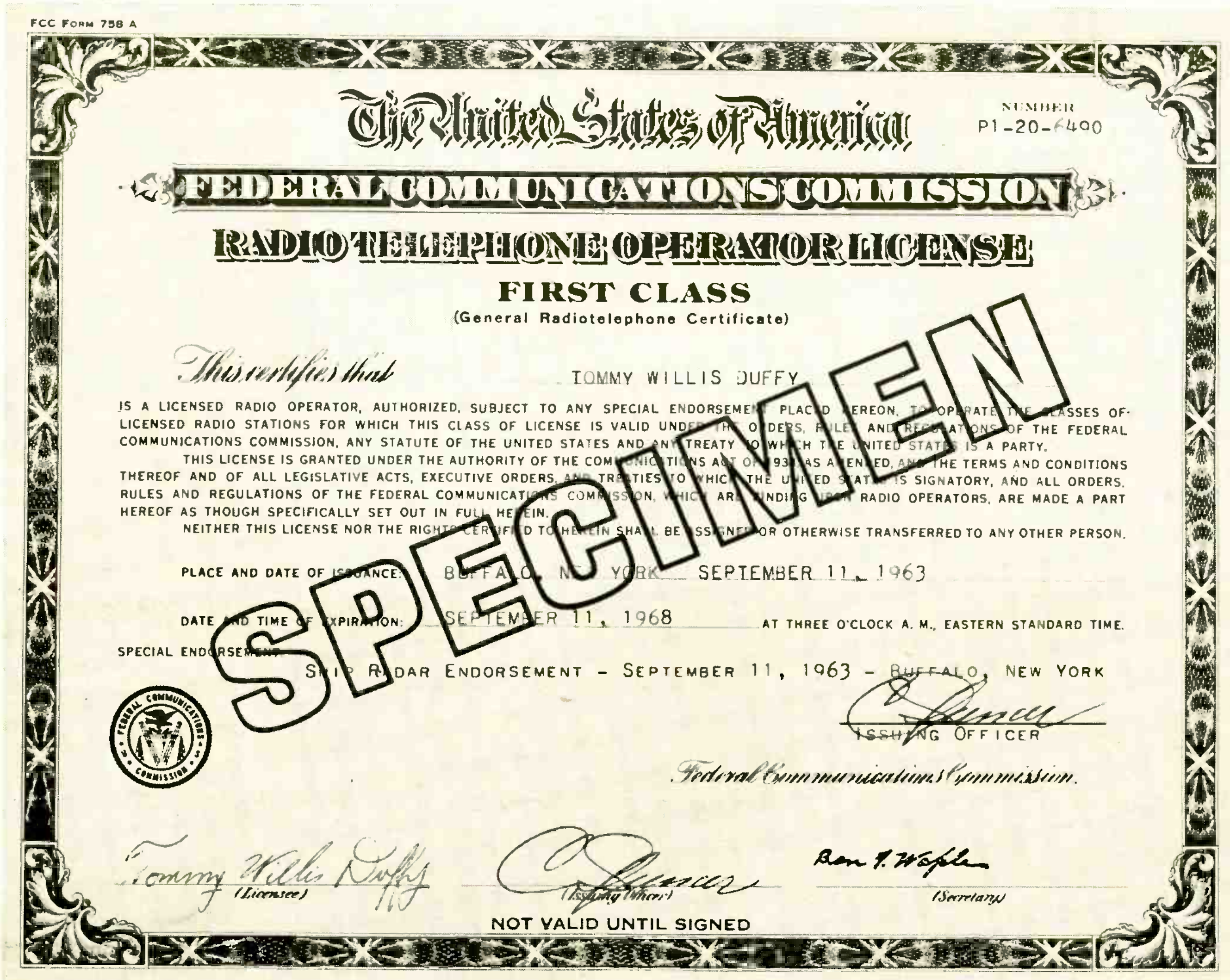
address ______________

EW-11

city ______ state ______ zip code ______

PAYMENT MUST BE ENCLOSED WITH ORDER.

You can earn more money if you have an FCC License


FCC FORM 758 A

The United States of America

NUMBER P1-20-6490

FEDERAL COMMUNICATIONS COMMISSION

RADIO TELEPHONE OPERATOR LICENSE

FIRST CLASS

(General Radiotelephone Certificate)

This certifies that TOMMY WILLIS DUFFY

IS A LICENSED RADIO OPERATOR, AUTHORIZED, SUBJECT TO ANY SPECIAL ENDORSEMENT PLACED HEREON, TO OPERATE THE CLASSES OF LICENSED RADIO STATIONS FOR WHICH THIS CLASS OF LICENSE IS VALID UNDER THE ORDERS, RULES AND REGULATIONS OF THE FEDERAL COMMUNICATIONS COMMISSION, ANY STATUTE OF THE UNITED STATES AND ANY TREATY TO WHICH THE UNITED STATES IS A PARTY.

THIS LICENSE IS GRANTED UNDER THE AUTHORITY OF THE COMMUNICATIONS ACT OF 1934 AS AMENDED, AND THE TERMS AND CONDITIONS THEREOF AND OF ALL LEGISLATIVE ACTS, EXECUTIVE ORDERS, AND TREATIES TO WHICH THE UNITED STATES IS SIGNATORY, AND ALL ORDERS, RULES AND REGULATIONS OF THE FEDERAL COMMUNICATIONS COMMISSION, WHICH ARE BINDING UPON RADIO OPERATORS, ARE MADE A PART HEREOF AS THOUGH SPECIFICALLY SET OUT IN FULL HEREIN.

NEITHER THIS LICENSE NOR THE RIGHTS CERTIFIED TO HEREIN SHALL BE ASSIGNED OR OTHERWISE TRANSFERRED TO ANY OTHER PERSON.

PLACE AND DATE OF ISSUANCE: BUFFALO, NEW YORK SEPTEMBER 11, 1963

DATE AND TIME OF EXPIRATION: SEPTEMBER 11, 1968 AT THREE O'CLOCK A. M., EASTERN STANDARD TIME.

SPECIAL ENDORSEMENT: SHIP RADAR ENDORSEMENT - SEPTEMBER 11, 1963 - BUFFALO, NEW YORK

ISSUING OFFICER

Federal Communications Commission.

(Licensee) (Issuing Officer) Ben F. Waple (Secretary)

NOT VALID UNTIL SIGNED

Employers are paying good money for men holding FCC tickets. Read how to get yours:

When you hold a Commercial License issued by the FCC (Federal Communications Commission) you have written proof that you know and understand basic electronic theory and fundamentals. It's worth plenty . . . particularly to companies on the lookout for qualified electronics technicians. Here's how one of the country's leading office machine manufacturers rates men with FCC Licenses:

> "An FCC License is an asset to any man looking to enhance his career in the field of electronics. At our Company, a licensed man is well-rewarded because an FCC License attests to his knowledge of electronics theory . . ."

Thousands of employers will tell you the same thing. Licensed men get the good jobs. They make more money . . . move ahead faster . . . enjoy exciting, challenging work. What's more, they're needed badly in every field of electronics. Industrial electronics. Radio-TV Broadcasting. Aerospace. Electronics Servicing . . . including mobile and marine radio *plus* CB.

Yes . . . your opportunities are unlimited once you're carrying that FCC Commercial Ticket. AND CLEVELAND INSTITUTE OF ELECTRONICS CAN GET ONE FOR *YOU!* On the facing page, read how four ambitious men just like you have cashed in on CIE's sure-fire FCC Licensing Program. Read about CIE's exclusive money-back offer. And then send in the postage paid reply card. CIE will quickly send you complete FREE information. You will soon be on *your* way to a Commercial FCC License and the many rewards that go with it!

These CIE men have good jobs

(they have Commercial FCC Licenses)

Matt Stuczynski, Senior Transmitter Operator, Radio Station WBOE. "I give Cleveland Institute credit for my First Class Commercial FCC License. Even though I had only 6 weeks of high school algebra, CIE's AUTO-PROGRAMMING teaching method makes electronics theory and fundamentals easy. After completing the CIE course, I took and passed the 1st Class Exam. I now have a good job in studio operation, transmitting, proof of performance, equipment servicing. Believe me, CIE lives up to its promises!"

Ted Barger, Electronic Technician, Smith Electronics Co. "I've been interested in electronics ever since I started operating my own Ham rig (K8ANF). But now I've turned a hobby into a real interesting career. Cleveland Institute of Electronics prepared me for my Commercial FCC License exam . . . and I passed it on the first try. I'm now designing, building and testing all kinds of electronic equipment . . . do a lot of traveling, too. It's a great job . . . and thanks to CIE and my FCC License, I'm on my way up."

Chuck Hawkins, Chief Radio Technician, Division 12, Ohio Dept. of Highways. "Cleveland Institute Training enabled me to pass *both* the 2nd and 1st Class License Exams on my *first* attempt . . . even though I'd had no other electronics training. (Many of the others who took the exam with me were trying to pass for the eighth or ninth time!) I'm now in charge of Division Communications and we service 119 mobile units and six base stations. It's an interesting, challenging and extremely rewarding job. And incidentally, I got it through CIE's Job Placement Service . . . a free lifetime service for CIE graduates."

Glenn Horning, Local Equipment Supervisor, Western Reserve Telephone Company (subsidiary of Mid-Continent Telephone Company). "There's no doubt about it. I owe my 2nd Class FCC License to Cleveland Institute. Their FCC License Program really teaches you theory and fundamentals and is particularly strong on transistors, mobile radio, troubleshooting and math. Do I use this knowledge? You bet. We're installing more sophisticated electronic gear all the time and what I learned from CIE sure helps. Our Company has 10 other men enrolled with CIE and take my word for it, it's going to help every one of them just like it helped me."

FCC LICENSE WARRANTY

A CIE FCC License Course will quickly prepare you for a Commercial FCC License. If you don't pass the FCC exam . . . on the first try . . . after completing your course, CIE will refund all your tuition. You get an FCC License . . . or your money back!

Two out of three men who took the 1st Class Commercial FCC License exam in 1964, failed.

Nine out of ten CIE-TRAINED men who take this exam, pass . . . the very first try!

And that's why CIE can back their courses with the warranty you see at the left. CIE-trained men know their stuff . . . because CIE AUTO-PROGRAMMED Home Study *works!*

Get started now. Send postage-paid reply card for free information about a plan that gets you an FCC License *or costs you nothing!*

CIE Cleveland Institute of Electronics

1776 East 17th Street, Dept. EW-8 Cleveland, Ohio 44114

TUNNEL DIODE SWEEP TRIGGER

By DARWIN P. ADAMS

Inexpensive tunnel diode trigger for triggered-sweep scopes enables stable operation from nearly d.c. up to five mc. even though input trigger level ranges between 100 mv. and 100 v.

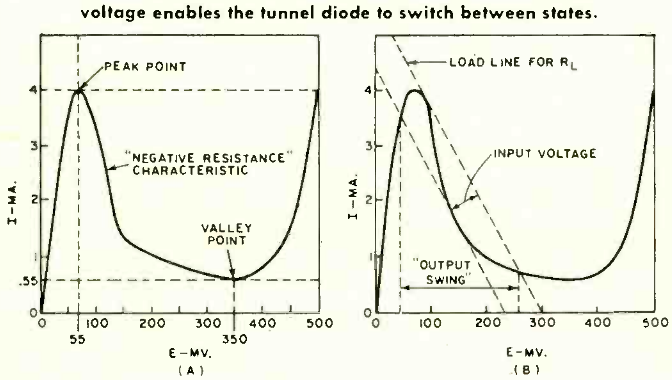
TRIGGERED-sweep oscilloscopes have been used exclusively in professional laboratories for many years. Recently, however, several varieties of triggered scopes have become available at reasonable prices through the surplus market and through new kits. However, most of these scopes lack the sophistication of the laboratory models, and it is still necessary to adjust two or three controls to obtain a trace. Also, on external trigger, the sweep may require as high as two volts for operation at very low or very high frequencies, and it may need this voltage at an impedance of 10,000 ohms or less. (*Editor's Note: One such device is shown on page* 71 *of our Jan.* 1965 *issue.*)

The circuit proposed in this article is designed to precede the input of existing trigger amplifiers and bring the standard of the sweep to that of much higher priced models. Essentially, this circuit will convert a normal trigger sweep to an "automatic" sweep. It produces a square-sided output waveform that will allow an oscilloscope a.c. trigger to operate almost down to d.c. by inserting a high-frequency pulse at each axis crossing of the input signal. This output signal is a constant two volts in amplitude from any input greater than 100 mv. and less than a hundred volts. Input impedance is about 270,000 ohms, and it functions from very low frequencies to above 5 mc.

The constant output voltage allows the trigger-amplitude control of the scope to be left at a single setting. The trigger-level control may then be set anywhere near zero and a trace will appear. Once this setting has been made, the input amplitude may be varied greatly and the trace will remain. This new automatic circuit protects the sweep from overloads due to voltage peaks.

Since the sides of the square-wave output are very steep, the scope's trigger-level control will no longer perform its function. This, however, is the case with most commercial units as well. If, for a special application, the trigger level must be varied, the operator merely switches out the automatic circuit and uses the scope as it was originally designed.

Fig. 1. (A) Typical tunnel diode curve. (B) A small input voltage enables the tunnel diode to switch between states.



The heart of this circuit is the tunnel diode, which is a two-lead semiconductor device. To understand the operation of this element, refer to Fig. 1A, which is a graph of the voltage across the diode *vs* the current through it. It is evident from this diagram that for a current of 2 ma. there are three possible values for the voltage. In fact, this multi-state condition exists over a range of currents. Examining this characteristic more closely, we can understand the manner in which the diode operates. As the voltage applied across the diode is increased (starting from zero), the current increases. When a certain peak point (about 55 mv. in this case) is reached, the current begins to decrease. Since the voltage is applied through a resistor, this sudden decrease in current produces a concomitant increase in voltage. As the voltage increases the current decreases, bottoming at 350 mv. in this case. As the voltage is increased past this point, the current again starts to increase. The peak point (55 mv.) is the first stable state, while the valley point (350 mv.) is the second.

To understand these two states and the voltage change necessary to precipitate a transfer of states, refer to Fig. 1B. The slanting dashed lines represent the slope of the load line of the resistive load (R_L). The intersection of the load line and the curve represents the possible values of I and E for a given supply voltage. This supply voltage is found at the E intercept of the load line, or where I equals zero. Increasing the supply voltage will allow a high current near the peak of the curve; then, as this voltage grows higher, it will allow two possible values, and finally, one value near the valley point.

The extremely sharp jump from one state to the other as the applied voltage varies makes the tunnel diode an excellent trigger device. In the circuit to be shown, it outperforms the conventional two-transistor trigger in both sensitivity and frequency response.

By drawing a load line for R_L, we find that a source resistance which is sufficiently low (about 3.9 ohms) will cause the voltage necessary to trigger the diode to reach zero. At this point the tunnel diode oscillates freely at a few thousand megacycles. In the trigger circuit, the builder must optimize R_L to get the maximum sensitivity without any tendency toward oscillation. This value is approximately 27 ohms.

Circuit Operation

The components preceding the first transistor (Fig. 2, Q1) are designed to provide a d.c.-balanced, high-impedance input protected against high input voltages. Input resistor $R1$, in conjunction with the two back-biased diodes $D1$ and $D2$, form a voltage divider feeding the base of Q1. The ratio of this divider depends upon the amplitude of the input voltage in the manner of a simple clipping limiter. The back-biased diodes will present an impedance of several megohms as long as the input does not vary sufficiently from zero to pull either the positive or negative diode into a forward-conducting condition. Thus, for small input-signal amplitudes, the divider

R1—100,000 ohm, ½ w. resistor
R2—500 ohm potentiometer
R3—820,000 ohm, ½ w. resistor
R4,R6,R12—330 ohm, ½ w. resistor
R5,R7—6800 ohm, ½ w. resistor
R8—10,000 ohm, ½ w. resistor
R9—1800 ohm, ½ w. resistor
R10—2500 ohm potentiometer
R11—3900 ohm, ½ w. resistor
R13, R17—1000 ohm, ½ w. resistor
R14—56,000 ohm, ½ w. resistor
R15—1500 ohm, ½ w. resistor
R16—62 ohm, ½ w. resistor
R_L—27 ohm, ½ w. resistor (see text)
C1—.005 μf. capacitor
C2,C3—.05 μf. capacitor
C4—.2 μf. capacitor
C5—270 pf. capacitor
Q1—2N3391
Q2,Q3—16L64 (see text)
D1,D2—1N625 diode
D3—1N3716 tunnel diode

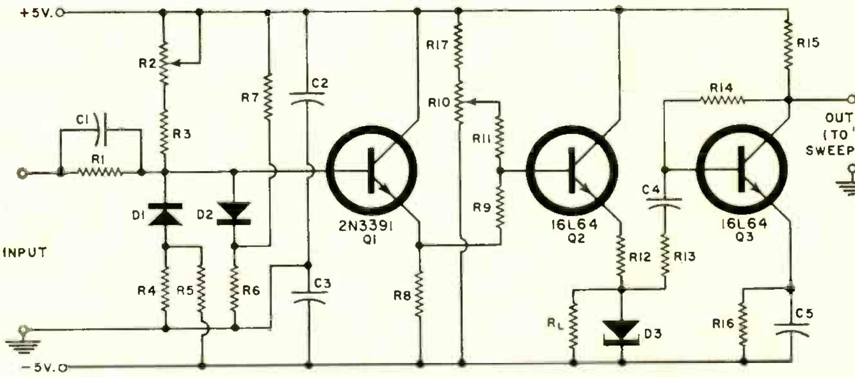


Fig. 2. Schematic and parts list for the tunnel diode triggered sweep converter.

inserts a negligible loss. However, forward-biased diodes present an impedance of only a few hundred ohms; therefore, at the upper and lower portions of a large input signal, the divider will insert a loss approaching 300. This occurs when the input voltage overcomes the reverse voltage applied to the diodes through resistors *R*5 and *R*7.

Since this circuit is sensitive to d.c. voltages as well as a.c., we must be concerned with the d.c. level of the input and input components. With an open circuit on the input, the emitter follower *Q*1 and the input limiter leave a small negative voltage on the base of *Q*1. This is not an acceptable condition for, if a low-impedance input is applied to the circuit, it will tend to change the d.c. level toward zero through *R*1. This change, even though it may be only a few tenths of a volt, will be large enough to move the tunnel-diode (*D*3) bias outside the operating region. The circuit is intended to be sensitive to a 10-millivolt input; therefore, *R*2 and *R*3 are incorporated to provide enough current to bring the base voltage of *Q*1 to zero, or ground potential. When an input load of low impedance is applied, it cannot alter the d.c. level ground potential, and thus the circuit is sensitive only to the input voltages.

Capacitor *C*1 across input resistor *R*1 provides high-frequency compensation for stray shunt capacitances in the elements immediately following. Since the impedance of a capacitor decreases with increasing frequency, the input impedance of this circuit will decrease at the high-frequency end of its operating band. *C*2 and *C*3 are power-supply bypass capacitors and assure that a negligible radio-frequency signal is fed back between different points in the circuit through the power-supply lines.

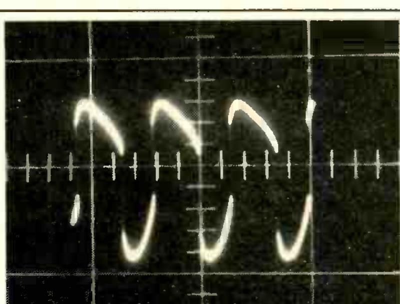
The low leakage and high *beta* of the 2N3391 make it an ideal choice for *Q*1. This first stage is required to present a high input impedance and yet maintain a good d.c. stability. The input impedance of the emitter-follower configuration is approximately *beta* × *load*. Thus, the high *beta* is advantageous for high impedance. The base-to-collector leakage determines the d.c. base-to-collector impedance and is also valuable in maintaining a high input impedance. Low leakage also insures a minimum of temperature-effect d.c. drift in the base current, which allows *R*2 and *R*3 to be quite large and still fix the base voltage reliably at zero. Thus, the circuit attains a respectably high input impedance and at the same time assures negligible d.c. drift. Although the 2N3391 is a transistor of only a medium gain-bandwidth, it is still useful in this circuit. The reason for this is that the emitter-follower configuration has an inherently good frequency response, and so with this transistor its gain is still near unity at several megacycles.

*Q*2 is also an emitter follower and is chosen because of its low output impedance properties. This drives the tunnel diode very well. The 4-ma. tunnel-diode bias current is set by *R*10. *R*12 does not contribute appreciably to the load across the tunnel diode but is inserted as a protection against excessive currents through the diode which could damage it. R_L, as previously discussed, determines the sensitivity and stability of the tunnel diode to the driving current. *R*13 is inserted as a coupling to the last stage. To avoid the possibility of oscillation, it is kept very large with respect to R_L to keep stray shunt capacitances at a tolerable level. Since the output of *D*3 is a square wave, a.c. circuitry can be used following it.

The final stage, *Q*3, yields a gain of 40 db in the conventional bypassed-emitter configuration. The resistor from the collector to base (*R*14) sets the d.c. bias point and allows a small amount of negative feedback to insure the proper operating point without drift due to variations in temperature or power-supply voltage. Since the 16L64 has a gain-bandwidth of nearly 800, a gain of 40 db can be obtained in a single stage with performance up to 6 mc. Using a transistor of lower gain-bandwidth would necessitate having several stages and require that over-all frequency-compensated feedback be incorporated in the circuit.

It is interesting to note that both the 2N3391 and the 16L64 are transistors from a new line of *General Electric* low-cost miniature epoxy silicon epitaxials. These units are about the size of the TO-18 JEDEC case and have an in-line lead configuration that allows greater flexibility in mounting. Most of the units can be obtained for less than one dollar and yet have the performance characteristics of much higher priced transistors.

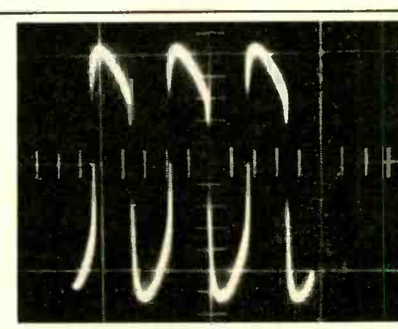
The original unit as designed by the author was built on a fiberglass printed-circuit board produced by the standard



A

Fig. 3. (A) Output waveform at 1 kc. with 20 mv. input. Sharp edges cause good triggering. Curved tops and bottoms do not impair operation. (B) The output waveform at 1 kc. with input of 50 v. Same horizontal and vertical scale as in (A).

B



photographic-etching process from a home-drawn negative. If good high-frequency performance is desired, it is strongly recommended that stray capacitances and inductances be kept at a minimum. Moreover, the tunnel-diode part of the circuit is a potential 2-gc. oscillator, and only a few tenths of an inch in lead length can determine the difference between oscillation and good performance. R_L can be varied to lessen the diode's tendency to oscillate, but the larger it is made, the less sensitive the final circuit becomes. Thus, to a degree, size and sensitivity are inseparably related.

One of the requirements of this circuit is that it operate at d.c. as well as at high frequencies. It is therefore necessary that the power supply be sufficiently regulated to avoid d.c. drift. A simple 10-watt zener without an amplifier will do this job quite well. The exact voltages of +5 and −5 are not required, as the tunnel-diode bias can be varied over a wide range by $R10$ to compensate for small inaccuracies in supply voltage. The voltages should be approximately what are called for, but more important, they should remain the same values that they were when the final alignment was made. Therefore, because zener voltage does change slightly with temperature, allow time for the zeners to warm up.

Before applying power, set $R2$ at maximum resistance and $R10$ at the negative end of its swing. This assures that the tunnel diode current will be very small.

Apply power, and using $R2$, set the base voltage of $Q1$ to zero volts, employing a d.c. oscilloscope or a v.t.v.m. as an indicator. The test instrument must not load the circuit. Connect a scope set to a 100-mv. scale to the connection between $R13$ and $C4$. Introduce a 1-kc. test tone to the input and slowly increase $R10$. Notice the trace rise until it reaches approximately 55 mv. At this point, a square wave should appear. Decrease the 1-kc. input amplitude and readjust $R10$ until maximum sensitivity is attained. (See Fig. 3A.) This is the point at which the tunnel diode is biased midway between its two states. $R10$ actually functions as a sort of trigger-level control; thus, the adjustment made above should be a familiar one. We are merely attempting to find the point at which the trigger level is zero.

Turn the 1-kc. test tone up to a high voltage (50 volts) and observe the trace on the scope. (See Fig. 3B.) No evidence of oscillation should appear. If this evidence does occur, increase R_L to 30 or 33 ohms. If it does not, the over-all sensitivity may be increased by decreasing R_L to 22 or 20 ohms. After making an adjustment in R_L, a check should always be made of the circuit's tendency to oscillate. Oscillation is harmless and will not injure the circuit components. It will, however, impair circuit performance. ▲

NEW PRODUCTS & LITERATURE

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

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

HELIUM-NEON GAS LASER

The LAS-101 is a compact and portable helium-neon gas laser operating at 6328 angstroms with a guaranteed output of 1 mw. multi-mode and, with optional flat mirror, 0.5 mw. single-mode. This new precision instrument is designed for both general laboratory applications and classroom demonstrations.

The unit features a double-walled plasma tube, stable operation from low-voltage power source

(300 volts d.c., 60 ma.), and rugged and completely open construction with molded, clear plexiglass cover for demonstration applications.

Various accessories including the power supply are available. The power supply could also be built at modest cost by the user from instructions included with the laser. Electro Optics

Circle No. 126 on Reader Service Card

SOLDERING INSTRUMENT

The new "Positerm" soldering instrument applies electrical energy to the piece to be soldered, leaving the soldering tip cool. The blade edges of the tips are designed to cut through oxides and films so that good electrical contact can be easily established, while the "V" formed by the two tips provides a self-locating action with the workpiece.

The Model 250 consists of a working head and a companion power supply. The working head is designed to be used either as a gun or as a pencil. It includes a precise adjustable solder-feed mechanism which will take a two-ounce spool of solder (about 2 days' supply for most production line stations). The power supply provides six different heating rates, available at the push of a button. There is a separate circuit with a variety of voltages for accessories such as a thermal stripping attachment. The supply operates from a standard 115-120-volt, 60-cps line. Westinghouse

Circle No. 127 on Reader Service Card

3-INCH SOLID-STATE SCOPE

A 3-inch, completely solid-state d.c.-to-6 mc. scope that weighs only 16 pounds, uses less than 15 watts of power, has calibrated vertical sensitivity, calibrated sweep times, and a triggered sweep.

The Model KN-5005 is designed to meet every present-day testing requirement. It is housed in a sturdy aluminum case which measures 8¾" x 6" x 14". The circuit uses 25 transistors, 18 diodes, a nuvistor, and the CRT. It is designed to operate from any 110-120-volt, 50-60-cycle a.c. line. Allied

Circle No. 1 on Reader Service Card

MOS INTEGRATED CIRCUITS

A new family of standard off-the-shelf MOS integrated circuits, designed especially for low-cost computer, calculator, data processing, communications, and other electronic systems, is now available.

The standard line includes shift registers, binary counters, gates, MOS transistors, MOSFET's (field-effect transistors), and even includes a power MOS. The new units are designed basically for medium-speed systems operated at frequencies up to 1 megacycle. All units will be available on OEM delivery schedules ranging from 2 to 8 weeks and at distributors off-the-shelf. General Instrument

Circle No. 128 on Reader Service Card

SEALED SNAP SWITCHES

A new series of sealed electrical snap switches, for applications where moisture and dust might enter the switching chamber and prevent proper operation, is now available.

All models feature sealed terminal posts, with metal inserts molded into the base. The cover is squarely mated and anchored to the base with a special spring clip. All parting surfaces are cemented together and a silicone rubber boot protects the pin actuator, providing encasement of all working parts.

A variety of switch combinations is available, all detailed in available catalogue sheets. Robertshaw Controls

Circle No. 129 on Reader Service Card

THIN-LINE EDGEWISE PANEL METER

An edgewise panel meter with a true ½" Cormag mechanism has just been developed. This miniature meter measures 1.6" across the front window, 0.5" high, and less than 2.5" in depth behind the front panel. It utilizes only one-fourth the space presently required by 1½" panel meters.

The Model 111, a 2% meter, offers an inherent self-shielding feature which allows it to be mounted on magnetic and non-magnetic panels without need for adjustment. The meter meets

ASA C39.1 specifications. Ranges are from 50 μa. through 2 amps d.c., and from 50 mv. through 300 volts d.c. Rectifier types are also available. Weston

Circle No. 130 on Reader Service Card

TINY ROTARY SELECTOR SWITCH

Designed for use behind control panels, where space is at a premium, the switch is built right into the knob outside the instrument and uses only 3⁄16" behind the panel. This new "Switch-In-Knob" unit has cut 7⁄16" from the dimensions of the firm's standard units.

The Series G has high reliability, superior dielectric strength, and longer life. It is assembled in a clean-room environment to meet applicable MIL-Specs on temperature, humidity, corrosion, vibration, acceleration, shock, and immersion. It is both explosion-proof and waterproof.

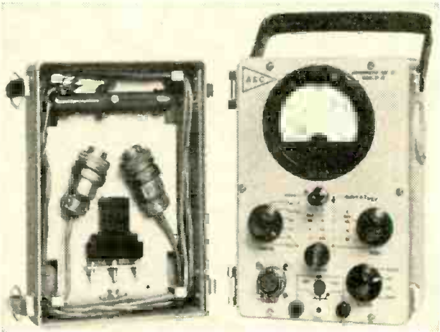
The Series K is developed for instrument and commercial application. Daven

Circle No. 131 on Reader Service Card

IN-CIRCUIT SEMICONDUCTOR TESTER

The semiconductor test set, Model TT-22, is a self-contained instrument built to rigid MIL-Specs and designed for complete reliability in rugged field service. It is designed to quickly detect malfunctioning transistors, rectifiers, diodes, and SCR's, both in-circuit and out-of-circuit.

The instrument is powered by four ordinary 1.5-volt flashlight batteries, removable without



disassembling the tester. Accessories, including two test cables and an adapter socket are stored in the hinged, removable cover. With these and the panel-mounted sockets, tests may be made on any semiconductor including those mounted on PC boards. Abbey Electronics

Circle No. 132 on Reader Service Card

INTEGRATED CIRCUITS

A complete series of commercial HLTTL integrated circuits, which are available in the 8-pin short-cap TO-5 hermetically welded package, is now being offered in a new low-priced line. The units are supplied as standard to a +15° to 55°C temperature range but can also be supplied in various temperature ranges up to −55° to +125°C with corresponding increase in price.

A variety of configurations is available and full details will be supplied on request. Transitron

Circle No. 133 on Reader Service Card

SEMICONDUCTOR PROTECTOR

The new semiconductor protector, SCP, is a high-speed, high-current switching device designed to protect semiconductor equipment and sensitive instrumentation circuitry from overvoltage and overcurrent transients.

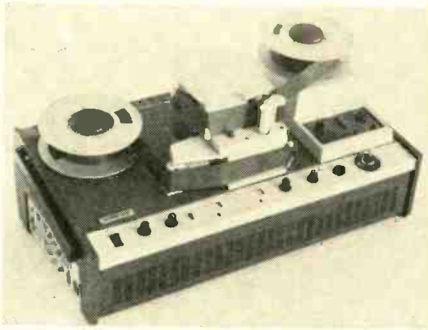
Installed at the input, the SCP senses any overvoltage that varies from the nominal voltage. When the overvoltage transient exceeds the SCP firing point, the SCP shorts the load from the circuit. Line voltage is dropped to a safe voltage point in 500 nsec. or less. After the circuit breaker or fuse is open, the SCP resets itself automatically.

Various models will handle voltage ratings from 3 to 1000 volts at current ranging from 0 to 150 amps with a firing tolerance of ±5%. The unit operates within a temperature range of −50°C to +100°C and has an MTFB greater than one million cycles. ATI Industries

Circle No. 134 on Reader Service Card

PORTABLE VIDEOTAPE RECORDER

An advanced version of the VR-660 broadcast portable videotape recorder is now being offered at a new low price and with improved electronic



circuitry and mechanical design as the VR-660B.

Featuring the helical recording technique, the unit includes a second audio channel and a spare set of recording heads that make possible a 500-hour and/or six-months' warranty. Ampex

Circle No. 135 on Reader Service Card

MICROWAVE TUNNEL DIODES

The industry's first solid-structure microwave germanium tunnel diodes, capable of being incorporated directly into hybrid integrated microwave circuits, are now available.

Based on a thin-film technique which allows passive components to be fabricated on the units while in slice form, these new units do not require external supports. They are designed to withstand repeated temperature cycles from cryogenic to +100°C. They exceed MIL-STD 750 specifications for mechanical shock.

The line is available in three package styles. Diodes with identical performances are offered in the D-5360, D-5560, and D-5570 series. The units are also available in dice form, unpackaged. Sylvania

Circle No. 136 on Reader Service Card

TRANSISTOR POWER INVERTER

A new solid-state power inverter, the "Tempest" Model 50-170, changes the regular storage battery current of a car or boat to 117 volts filtered a.c. Capacity of the inverter is 125 to 150 watts to operate amplifiers, radios, portable TV, lights, can openers, mixers, electric drills, soldering irons, and other electrical equipment rated at 150 watts or less.

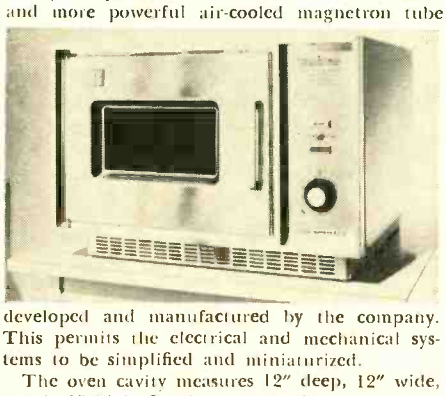
The unit is housed in a heavy-gauge copper-clad case with carrying handle. Terado

Circle No. 2 on Reader Service Card

COMPACT MICROWAVE OVEN

A new, low-cost, compact microwave oven for commercial and institutional food heating is now on the market. Measuring 21⅝" wide by 14⅞" high and 21½" deep, the Model 500 has a power output of 1 kw. Frequency is 2450 mc.

Key component of the new oven is a smaller and more powerful air-cooled magnetron tube



developed and manufactured by the company. This permits the electrical and mechanical systems to be simplified and miniaturized.

The oven cavity measures 12" deep, 12" wide, and is 6" high. It will accommodate all conventional food-service containers. Litton's Atherton Div.

Circle No. 137 on Reader Service Card

PLASTIC FOR TEMPLATES

A photosensitive plastic which can be used to make thin templates of variable design and complexity without the use of expensive metal dies has now been developed.

Identified as "Templex," the material is available either as an unsupported 18" x 24" sheet in thicknesses of 14, 21, and 47 thousandths of an inch, or in sheets of several thicknesses supported by "Cronar" polyester film, steel, or aluminum.

To make templates, a light stencil or negative is used to expose the "Templex" under ultraviolet light from an arc lamp. Where the light passes through the negative, it causes the photosensitive plastic to harden. The sheet of exposed photopolymer material is then washed out in a weak caustic solution which removes the unhardened plastic and provides a template of the original line copy. The process requires about 20 minutes. Du Pont

Circle No. 138 on Reader Service Card

FLATPACK INTEGRATED CIRCUIT

A flatpack integrated circuit that is so sturdy it can withstand a hammer blow has just been introduced. The flatpack construction uses Kovar ribbon leads directly bonded to thin-film aluminum bonding pads on the silicon substrate. The bonding area is ten times that of conventional bonded gold-wire construction and hence far stronger.

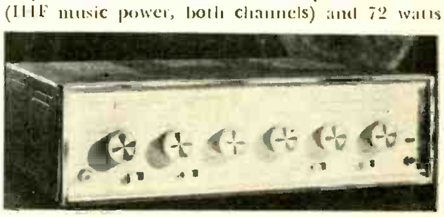
After the leads are bonded, the chips and lead tips are hermetically sealed by coating them with silicon dioxide and molding them in glass. Since gold has been eliminated in the construction, the packages can be stored at 400 C without danger of "purple plague." ITT Semiconductors

Circle No. 139 on Reader Service Card

HI-FI—AUDIO PRODUCTS

90-WATT STEREO AMPLIFIER

A 90-watt solid-state stereo amplifier has been added to the all-silicon transistor line of hi-fi amplifiers as the S-9900. Power output is 90 watts (IHF music power, both channels) and 72 watts



continuous sine-wave both channels. Power bandwidth is 12-35,000 cps at 1% HD. Damping factor is 40. Outputs are stereo to 4 to 16 ohm speaker, stereo record, stereo headphones, and powered mono third channel.

The amplifier measures 14" x 10½" x 4" high. Sherwood.

Circle No. 3 on Reader Service Card

PROFESSIONAL CARTRIDGE

A completely integrated dust-removing device is built right into the stylus of the new "Longhair" cartridge, Model 581. The free-riding long-haired brush extends from the front of the plastic stylus "V-guard." Located inboard of the stylus tip, it engages the grooves in advance of the stylus and prevents any collection of lint or dust on the stylus tip. Due to a pivot assembly in the design, the brush in its metal housing does not affect delicate tracking forces.

Available in two versions (the 581A for use in recording studios for calibration purposes and the models 581EL with elliptical stylus and 581AA with conical stylus for use in record libraries for evaluation and serious listening), each cartridge comes packaged in a black leatherette case with metal stylus container and a miniature metal screwdriver. Stanton Magnetics

Circle No. 4 on Reader Service Card

HEAD-CLEANING RECORDING TAPE

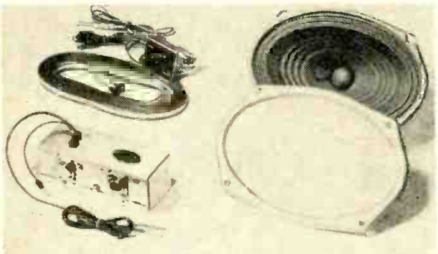
The recently introduced "Ferrotape" features a unique "Head-Kleen" tape leader which is prespliced to the tape at both ends and automatically cleans recording heads of oxide on every tape run-through. There are also reversing/stop tabs spliced in at both ends for operating the new automatic bi-directional or automatic-stop tape recorders.

The new tape is being offered in lengths from 300 to 2400 feet in 1.5 and 1 mil acetate bases and in lengths to 2400 feet in 1.5, 1, and 0.5 mil Mylar bases. Ferrodynamics

Circle No. 5 on Reader Service Card

TRANSISTORIZED REVERB KIT

An all-transistor reverberation kit for use with 12-volt negative-ground cars is now on the market.



The power supply is 12.6 volts d.c. (negative ground) with a 4-watt output and an idle current of 0.25 amp. The kit includes a complete fader control between speakers with switch on "normal" and "reverb."

The unit measures only 6" x 2" x 2½" and comes in two versions: the standard Model RU-304 is for cars not requiring speaker and grille, while the deluxe Model RU-301 comes complete with speaker and grille. Cleveland Electronics

Circle No. 6 on Reader Service Card

PORTABLE LECTERN P.A. SYSTEM

A new, suitcase-size lectern p.a. system, designed for small conference groups or audiences of 500 or more, has been introduced as the "Speech Director." The system, which includes a sound column, a transistor amplifier that operates on batteries or 117-volt a.c., and a deluxe microphone, fits into a case measuring only 21" x 16" x 7⅝".

The unit is easy to set up and use. Lifting the hinged cover creates a 15" x 15" reading table. The speaker system is all plugged in and ready to go. Battery operation for the 20-watt amplifier is rated in excess of 400 hours on one set of batteries. It weighs 20 pounds without batteries and 25 pounds with batteries in place. Argos Products

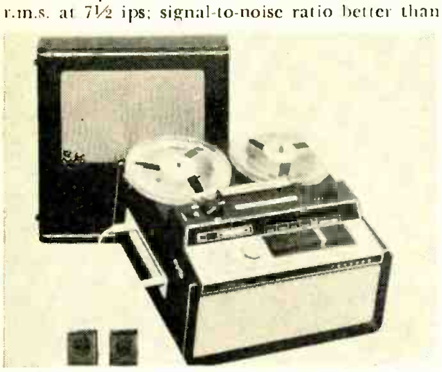
Circle No. 7 on Reader Service Card

PUSH-BUTTON STEREO RECORDER

The Model 444 transistorized, push-button stereo tape recorder offers three speeds and permits special recording and playback effects through use of built-in sound-with-sound.

The recorder features an extension speaker in the lid to permit adequate stereo separation. Ease of operation is insured through jam-proof push-buttons, instant cue, and a digital tape counter.

Specifications include tape speeds of 7½, 3¾ and 1⅞ ips: wow and flutter less than 0.2% r.m.s. at 7½ ips; signal-to-noise ratio better than



40 db per channel; and a frequency response of 50-15,000 cps ±2 db at 7½ ips.

The unit measures 9⅜" high x 13⅜" x 14" deep and weighs 30 pounds. Concord

Circle No. 8 on Reader Service Card

AEROSOL TAPE-HEAD CLEANER

For removing oxide dust from magnetic tape heads, the S-200 magnetic tape-head cleaner in aerosol form has been introduced. It is a formulation of DuPont's Freon TF with other fluorocarbons. The combination of solvent and pressure cleans tape heads in seconds and does not interfere with transmission if applied to running tape.

The cleaner is available in 6-ounce and 16-ounce aerosol cans. Miller-Stephenson

Circle No. 9 on Reader Service Card

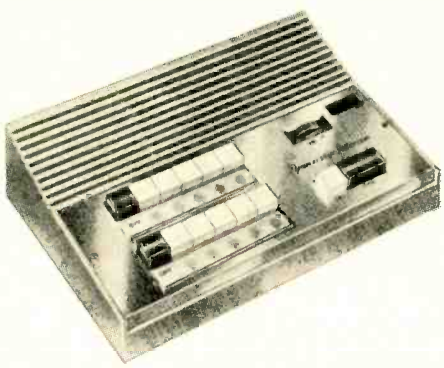
SPEAKER-SELECTOR SWITCH

A new 7-position, stereo speaker selector switch is now available with either a brushed-brass or brushed-stainless steel wall plate. The wall plates are designed for custom mounting to speaker cabinets, control panels, or to standard electrical outlet junction boxes. Wall plate mounting centers 3$\frac{9}{32}$" while the plate size is only 2¾" x 4½" x 1⅝" deep. The switch comes complete with mounting screws and wiring instructions. Switchcraft

Circle No. 10 on Reader Service Card

10-STATION TRANSISTOR INTERCOM

An ultra-selective 10-station transistorized intercom is now available at moderate cost. Up to ten master stations may be connected with up to 5 private conversations taking place at one time. An indicator light circuit provides a silent and



visual signal of a call. Units may also send an oral signal to other units.

Units will communicate up to 1000 feet. Fully transistorized for dependable operation, the intercom operates on economical batteries or can be powered by an optional a.c. power supply. Lafayette

Circle No. 11 on Reader Service Card

LOW-POWER TRANSISTOR AMP

A small low-power transistor amplifier suitable for use in p.a. systems, as a guitar amplifier, surveillance listening system amp, electronic stethoscope, intercom amplifier, or for science projects is now available.

Powered by any 9-volt d.c. source, the amplifier features a sturdy printed-circuit board 5½" long x 1¾" wide. Weight of the unit is 3½ ounces. The circuit uses 5 transistors and 1 thermistor and includes a volume control which is mounted on the circuit board. Schematic wiring diagrams for the various applications are included. Birnbach Radio

Circle No. 12 on Reader Service Card

CB-HAM-COMMUNICATIONS

CB BASE-STATION ANTENNA

A new CB base-station antenna, the "Devant Special," with a 4 db gain over a standard ground plane and 6.5 db gain compared to isotropic source, is now available. The s.w.r. is 1.5/1 or better. The antenna features increased gain plus an all-new appearance resulting from a top hat of 10-inch radials which helps to produce an extremely low angle of radiation.

The vertical element telescopes into a wrapped phenolic base tube which has greater strength than the aluminum element. Radials terminate in a high-strength "Cycolac" base. Mosley

Circle No. 13 on Reader Service Card

100-MW. CB PORTABLES

A three-transistor, portable hand-held CB transmitter/receiver for operation under FCC Regulations Part 15 (license-free), is now being marketed as the GT-3 "Army Commander."

The appearance is similar to military-type walkie-talkies with separate earcup and mouthpiece. The transmitter is crystal-controlled, the receiver is a superregenerator. The unit weighs 10 ounces. Convenient one-hand operation with a press-to-talk button provides coverage of approximately ¼ mile.

The unit comes complete with telescoping antenna, crystal, 9-volt battery, and carrying strap. Lafayette

Circle No. 14 on Reader Service Card

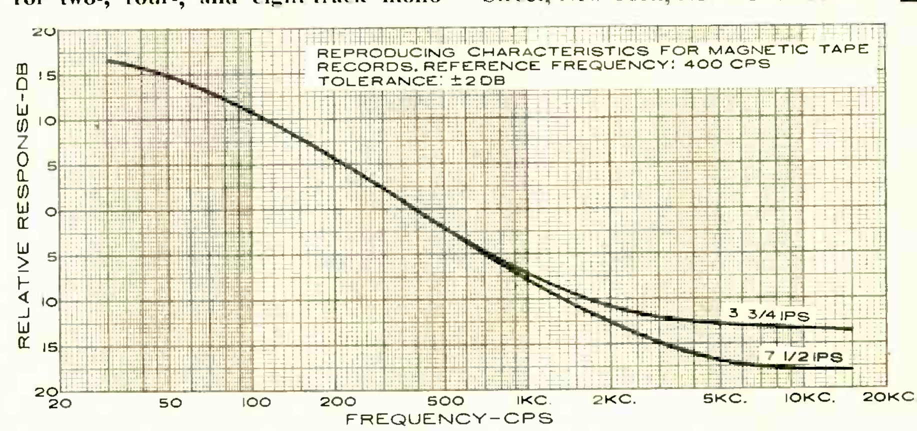
TRI-BAND TRANSCEIVER

A new three-band SSB/AM/c.w. transceiver for use in the 20-, 40-, and 80-meter amateur bands

RIAA ISSUES MAGNETIC TAPE STANDARDS

THE Record Industry Association of America has released technical standards for pre-recorded magnetic tapes. The standards, developed by RIAA's Engineering Committee and approved for distribution by its Board of Directors, covers reel-to-reel and cartridge tapes and includes specifications for two-, four-, and eight-track monophonic and/or stereophonic tapes. The playback equalization curve that is shown directly below was taken from the new standards.

Identified as Bulletin No. E 5, copies of the new standards are available upon written request from the Record Industry Association of America, 1 East 57th Street, New York, New York 10022. ▲



has been made available in either kit or wired versions as the Model 753.

The unit may be used at fixed locations or as a mobile station on a vehicle or boat, for manual push-to-talk or automatic voice-controlled (VOX) radiotelephone operating, or for radiotelegraph communication employing grid-block keying.

When transmitting, power input is 200 watts p.e.p. for SSB or AM, and 180 watts for c.w. Power output is rated at 110 watts p.e.p. for both SSB and AM, and 110 watts carrier power for c.w. Receiver sensitivity is better than 1 μv. for 10 db signal-to-noise ratio. Selectivity, provided by a crystal lattice bandpass filter, is 2.7 kc. at 6 db. Eico

Circle No. 15 on Reader Service Card

ELECTRONIC FOGHORN/HAILER

A compact, solid-state foghorn/hailer, whose entire electronic circuit is contained on a sturdy printed-circuit board, is now being marketed as the "Sea Voice." The new unit has five separate

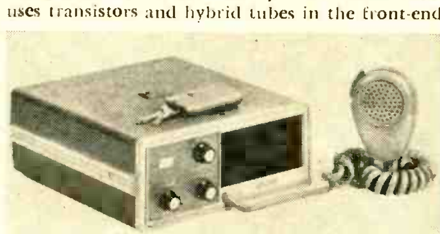
functions: it can be used as a loudspeaker; an automatic or manually operated foghorn; a sensitive directional listening device; and as a warning against theft.

Operating from a 12-volt d.c. source, the instrument's 8-transistor circuit produces 15 watts of power with 20 watts peak. It weighs 6 pounds and measures 9" x 5¾" x 5½". It has three simple controls and a push-to-talk hand-held microphone on a 6-foot, coil-type retractable cord. Signa-Com

Circle No. 16 on Reader Service Card

CB UNIT FOR H.E.L.P

A 6-channel compact model designed especially for mobile use in conjunction with H.E.L.P. is being marketed as the "Sentry CB." The receiver uses transistors and hybrid tubes in the front-end



for low noise while the power supply is all-transistor for low current drain.

Transmitter features include high-level 100% modulation and all-transistor modulator, high-efficiency 5-watt input, and a conservative rating. The "Sentry" has six crystal-controlled channels and comes complete with channel 9 installed. Provisions are made for the addition of any special H.E.L.P. channels which may be authorized in the future. Pearce-Simpson

Circle No. 17 on Reader Service Card

MANUFACTURERS' LITERATURE

COAXIAL CABLE TESTING

Details on coaxial cable evaluation by new time domain reflectometry techniques are presented in a new 15-page application note, No. 67. Entitled "Cable Testing with Time Domain Reflectometry," the booklet includes chapters on the theory of time domain reflectometry, cable characteristics, and testing techniques, as well as methods of minimizing the effects of unwanted signals.

Accompanying the booklet is a special slide rule for determining dielectric constant, propagation velocity, characteristic impedance, and distance between discontinuities. Hewlett-Packard

Circle No. 140 on Reader Service Card

FERRITE CUP CORES

Complete data on temperature-compensated cup core assemblies for filter network applications is contained in a new 6-page bulletin, No. 28A. Intended for the engineer, the bulletin includes four design nomograms for determining inductance, number of turns, copper resistance, and wire gauge.

Ten supplemental engineering sheets provide detailed electrical specifications for various series of adjustable inductor cup core assemblies. Indiana General

Circle No. 141 on Reader Service Card

EQUIPMENT CATALOGUE

The latest in stereo/hi-fi components, electronic test and measuring instruments, ham equipment, and CB transceivers is presented in a new 36-page 1965 equipment catalogue. Both kits and factory-wired models are offered in the illustrated booklet. Eico

Circle No. 18 on Reader Service Card

RECHARGEABLE BATTERIES

Information on new rechargeable silver-cadmium button cells and batteries is presented on two data sheets. One sheet contains a table of rechargeable cell characteristics which compares, parameter for parameter, nickel-cadmium with silver-cadmium cells. The second sheet supplies details on the silver-cadmium type and includes five graphs of performance characteristics. Electrochimica

Circle No. 142 on Reader Service Card

VOLTAGE MEASUREMENT

Detailed information on precision d.c. voltage measurements is offered in a new 8-page application note, No. 70. Covered in the booklet are methods of obtaining standard cell comparisons and establishing precision 0.1- to 1-volt and 1- to 1000-volt sources. Hewlett-Packard

Circle No. 143 on Reader Service Card

ENVIRONMENTAL CHAMBERS

Temperature chambers, air chambers, and fluid and humidity chambers are among the various environmental chambers and related products covered in a new, illustrated 80-page catalogue.

Included in the publication is a special section on engineering data covering temperature gradient, refrigeration, heat transfer, temperature conversion, relative humidity and altitude and pressure conversion. Also supplied is a glossary of terms. Delta Design

Circle No. 144 on Reader Service Card

PHOTOCELLS

Technical data on a new line of photocells utilizing a combined cadmium-sulfide/cadmium-selenide substance is now offered in a 2-page bulletin. Information on response time, temperature characteristics, resistance vs light level, and memory characteristics is presented.

Also available is a 16-page photocell designers' manual. Clairex

Circle No. 145 on Reader Service Card

CIRCUIT BREAKERS

Information on a five-step method for selecting circuit breakers for a wide range of applications is available in a handy chart. Entitled "Select a Circuit Breaker," the chart supplies data on one-, two-, and three-pole circuit breakers. Wood Electric

Circle No. 146 on Reader Service Card

SEARCH UNITS

More than 900 different types of ultrasonic search units for the non-destructive testing industry are listed in a new 17-page catalogue, No. 57-505.

Divided into five sections, the catalogue covers contact-normal beam units, ceramic angle-beam search units, immersion types, custom search units, and accessories. The booklet is fully illustrated and contains a complete price list. Automation Industries

Circle No. 147 on Reader Service Card

CERAMIC MAGNETS

Technical information on barium-ferrite permanent ceramic magnets is supplied in a new 8-page brochure. Four types of barium-ferrite materials are discussed, along with manufacturing methods, tolerances, and applications. D. M. Steward

Circle No. 148 on Reader Service Card

PIEZOELECTRICITY

A new 45-page technical book entitled "Piezoelectric Technology-Data for Designers" is now available. Fully described are characteristics and applications of piezoelectric materials, as well as piezoelectric constants and specific ceramic properties.

Completely illustrated, the book also contains eight pages of conversion charts. Clevite

Circle No. 149 on Reader Service Card

VOLTMETER DATA

Complete information on d.c. voltage measurements and voltmeters is provided in a new 40-page application note, No. 69.

Five illustrated chapters discuss electronic d.c. voltmeters, voltmeter specifications, extraneous noise associated with d.c. voltage measurements, voltmeter cost and selection factors, and calibration of high-accuracy voltmeters. Hewlett-Packard

Circle No. 150 on Reader Service Card

SEMICONDUCTORS

Transistors, diodes, microcircuits, and special products for military, commercial/industrial, and consumer applications are covered in a new 50

catalogue and manual. Bulletin 3138-7 includes specifications and ratings for 43 basic models, as well as performance curves and schematics. Victoreen

Circle No. 155 on Reader Service Card

ELECTROLUMINESCENT PANELS

Technical data on high-resolution, thin-film electroluminescent panels is supplied in a new 4-page booklet. Bulletin No. 6-Y5 discusses two types of panels: prototype test and large-area xy-matrix panels. The large-area panels are designed for scan-type presentation of digital information and are protected by a plexiglass overlay on both sides. Both types have 100 footlamberts at 5 kc. and single yellow-band emission independent of drive frequency. Sigmatron

Circle No. 156 on Reader Service Card

TOGGLE SWITCHES

Toggle switches available in a choice of seven standard colors, eight lever styles, five circuit arrangements, three terminal configurations, and three different ampere ratings for a.c. or d.c. operation are described in a full-color, illustrated, 4-page folder. Cutler-Hammer

Circle No. 157 on Reader Service Card

MOTOR-GENERATOR SETS

Motor-generator sets for computers, missile guidance, ground support, and laboratory testing equipment are described in a new, illustrated 4-page folder. Available models include completely enclosed control consoles, remotely located cabinets, and control cabinets mounted directly on the motor-generator set.

Also offered is a new 8-page illustrated brochure which discusses facilities and testing procedures for motors and generators. Kato Engineering

Circle No. 158 on Reader Service Card

PHOTO CREDITS

Page	Credit
16	Mattes Electronics Inc.
25, 27	General Instrument Corp.
26	Radiation, Inc.
28, 45, 46 (top & center)	Corning Glass Works
31	Clairex Corp.
32	Radio Corporation of America
34	Clevite Corp.
42, 43	Fairchild Hiller Corporation
46 (bottom)	LRC Electronics
60 (top)	Sonar
60 (center)	United Scientific Labs
60 (right)	Scientific Associates Corp.
69	Allied Radio Corp.
70 (top)	Electronic Measurements Corp.
70 (bottom)	Ferris Instrument Co.
76	NASA

ELECTRONICS MARKET PLACE

COMMERCIAL RATE: For firms or individuals offering commercial products or services. 70¢ per word (including name and address). Minimum order $7.00. Payment must accompany copy exceot 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. 40¢ 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**: 1st of the 2nd preceding month (for example, March issue closes January 1st.) **Send order and remittance to**: Hal Cymes ELECTRONICS WORLD, One Park Avenue, New York, New York 10016

FOR SALE

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, Radios, Parts, Picture Catalog 20¢. Meshna, Nahant, Mass.

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. Box 741, [redacted]

TV CAMERAS, transmitters, converters, etc. Lowest factory prices. Catalog 10¢. Vanguard, 190-48 99th Ave., Hollis, N.Y. 11423.

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.

ACHTUNG! Das machine is nicht fur Gerfingerpoken und mittengraben. Is easy schnappen der Springenwerk, blowenfusen und poppencorken mit spitzensparken. Ist nicht fur gewerken by das Dummkopfen. Das rubbernecken sightseeren keepen hands in das pockets. Relaxen und watch das Blinkenlights. This attractive, brass metal plaque only $2.00 ea. ppd. Southwest Agents, Dept. E, 8331 Hwy. 80 West, Fort Worth, Texas 76116.

CANADIANS, transistors, all semiconductors and com- [redacted]

DETECTIVES! Free Brochures; Electronic intelligence devices for your needs and budget. **SILMAR ELECTRONICS**, 3476 N. W. 7th Street, Miami, Fla. 33125.

ELECTRONIC Bargains—Free Catalog, Tubes, Diodes, CRT's Tuner Cleaner, etc. Cornell, 4213-W University, San Diego, Calif. 92105.

TELEVISION Cameras Transistorized also monitors. Spera Electronics, 37-10 33 Street, L.I.C., N.Y.

TRANSISTORIZED Products Importers catalog. $1.00. Intercontinental. CPO 1717, Tokyo, Japan.

INVESTIGATORS—Subminiature Electronic Surveillance Devices. **NEW** 1966 Professional models ready **NOW!** Free details. Trol Electronics-EW, 342 Madison Avenue, New York, N.Y. 10017.

SAFEGUARD Privacy! New instrument detects electronic "bugs", wire tapping and snooping devices. Free in-[redacted]ormation. Dee Equipment, Box 7263-E11, Houston 8, [redacted]exas.

[redacted]V CAMERAS. Model 400 complete with good vidicon [redacted]nd lens. Used as demonstrators. Only $200 F.O.B. [redacted]anguard, 190-48 - 99th Ave., Hollis, N.Y. 11423.

[redacted]ALLICRAFTER SX-88 cost $675 for $265. Robert Ire-[redacted]and, Pleasant Valley, N.Y.

[redacted]UARANTEED Handmade Flight Boots—Elastic Side-

Rectifiers & Transistors

750 MA—Silicon Diodes "Epoxy" or "Top Hat"

PIV		PIV		PIV		PIV	
50	5¢	300	12¢	600	21¢	900	40¢
100	7¢	400	14¢	700	25¢	1,000	55¢
200	10¢	500	18¢	800	32¢	1,100	70¢

Full Leads, all tests, Guaranteed, American made

SILICON POWER DIODE STUDS

AMPS	50 PIV	100 PIV	150 PIV	200 PIV
3	8¢	14¢	16¢	22¢
15	25¢	50¢	65¢	75¢
18*	18¢	40¢	60¢	70¢
35	60¢	80¢	1.15	1.30

AMPS	300 PIV	400 PIV	500 PIV	600 PIV
3	25¢	28¢	35¢	40¢
15	90	1.30	1.40	1.65
18*	85	1.25	1.35	1.60
35	1.90	2.25	2.50	2.90

*Press Fit Package for Alternators

10 Watt Sil. Zener Stud 12-200V........95¢ ea.
1 Watt Zener Diode. axial leads 6v-200v....50¢ ea.
Sil. diode Stud, 1500 piv, 300 ma..........50¢ ea.
Sil. diode, 1500 piv, 50 ma, axial leads....35¢ ea.
Hi-Voltage—Silicon Epoxy diode, 2½"x⅜"x½"
Hoffman—3000 piv 200 ma..............$1.49 ea.
Hoffman—6000 piv 200 ma..............$3.49 ea.
Thermistor bead, 900 or 1200 ohms, 600°F.2/$100

20 WATT GERMANIUM
(internal & external heat sink)

2n1038	28¢	2n1042	35¢
2n1039	35¢	2n1043	45¢
2n1040	45¢	2n1044	60¢
2n1041	60¢	2n1045	80¢

SILICON POWER TRANSISTORS, 85W, 2n1724.$1.50
Philco Sil., NPN, 2n2479, New........3 for $1.00
HF Silicon 2n702, 100 MC 40¢; 2n703-150 MC 60¢

LIGHT SENSITIVE RESISTOR
75 ohms - 10 meg, 100 volts, 150 mw $1.75 ea.

Sil. diodes, 1N200 series, ass't new..15 for $1.00
Ger. diodes. glass, new, exceeds 1N34.15 for $1.00
Nickel Cadmium Battery 9½ oz. 8 amp hr....$1.95

Varicap—Voltage Variable Capacitor
27, 47, 100 pf at 4v., 4:1, new ....$1.25 ea.

2N1300 series, NPN or PNP........ 6 for $1.00
2N1009, untested, miniature case....30 for 1.00
50 Watt Zener, 12 Volts.......... 2.00
2N497—60¢; 2N498—80¢; 2N696—50¢;
2N699—70¢; 2N1252—85¢; 2N650—49¢;
2N243—25¢; 2N1149—20¢; 2N117—20¢;
2N2151—$1.25; 3N35—75¢; 1N429—50¢
70 amp stud, 50PIV—$2.50; 100PIV......$3.50
Top Hat SCR, 400PIV, 750ma 1.75
TO-5 SCR, 400PIV, 1 amp 1.85
Power Resistors 2 lbs ....30/$1.00
Comp. boards, dio, etc. free transistors ..06¢ ea.
Sensitivity Amplifier, 7 tubes 5"x4"x3" 1.75

SILICON CONTROLLED RECTIFIERS

PRV	7 amp	16 amp	PRV	7 amp	16 amp
25	.28	.48	200	1.05	1.70
50	.48	.70	300	1.60	2.20
100	.70	1.20	400	2.10	2.70
150	.80	1.50	500	2.80	3.30
All Tests Stud Type			600	3.00	3.90

Money back guarantee. $2.00 min. order, include postage. Catalog 25c.

Electronic Components Co.
Box 2902, Baton Rouge, La. 70821

CIRCLE NO. 119 ON READER SERVICE CARD

MOVING?

ATTACH LABEL HERE

If you've recently changed your address or plan to in the near future, be sure to notify us at once. Affix address label showing old address here, and print new address below.

My New Address is:

name ______ please print

address ______

city ______ state ______

zip code ______ date at new address ______

Notify us of your address change as far in advance as possible—it takes about 2 months for a change to become effective. (Eg. A notice received in May becomes effective with the July issue.)

Mail to: ELECTRONICS WORLD
1255 Portland Pl., Boulder, Colo. 80311

CHASSIS 26¢, Heat Sinks 17¢, Panels 5¢, Catalog. Hazelton Scientific, Box 163, Hazel Park, Mich.

MESHNA'S TRANSISTORIZED CONVERTER KIT $4.50 Two models——converts car radio to receive 30-50 mc or 100-200 mc (one mc tuning). Meshna, Lynn, Mass. 01901.

SAMS PHOTOFACT Complete in Steel Cabinets. #1 To #775. Half Price. Heinz TV, 725 E. Walnut Street, Pasadena, Calif. 91101.

FM STEREO Tuner, alignment generator. Kit $79.50, Wired $99.50. AmerLabs, 471 Clifton Avenue, Newark 4, N.J.

FREE—FREE—FREE—FREE—FREE—FREE—FREE Send in for your **FREE** one year subscription to Olson Electronics' fantastic value packed catalog—unheard of low, low prices on brand names speakers, changers, tubes, tools, stereo amplifiers, tuners, CB and other values. Credit plan available. If you have a friend interested in electronics send his name and address for a **FREE** subscription also. Olson Electronics, Inc., 422 S. Forge St., Akron, Ohio 44308.

ELECTRONICS ENGINEERING AND INSTRUCTION

FCC LICENSE in six weeks. First class radio telephone. Results guaranteed. Elkins Radio School, 2603C, Inwood, Dallas, Texas.

ELECTRONICS! Associate degree—29 months. Technicians, field engineers, specialists in communications, missiles, computers, radar, automation. Start February, September. Valparaiso Technical Institute, Dept. N, Valparaiso, Indiana.

ELECTRONICS—F.C.C. License Training—correspondence, or resident classes. Free details, Write: Dept. 6, Grantham, 1505 N. Western, Hollywood, Calif. 90027.

REI First Class Radio Telephone License in (5) weeks Guaranteed. Tuition $295.00. Job placement free. Radio Engineering Institute, 1336 Main Street. Sarasota, Fla.

HIGHLY—effective home study review for FCC commercial phone exams. Free literature! **COOK'S SCHOOL OF ELECTRONICS**, Craigmont, Idaho 83523.

LEARN ELECTRONIC ORGAN SERVICING at home. All Makes including transistors. Experimental kit—trouble-shooting. Accredited NHSC. Free Booklet. **NILES BRYANT SCHOOL**, 3631 Stockton, Dept. A, Sacramento 20, Calif.

B.Sc. DEGREE (Engineering) or College Entrance by home study. Send $1 for 1966 prospectus. CIST, Suite 672, 263 Adelaide St. W., Toronto, Canada.

TELEVISION: Electronics: Appliance Repairing: Mailorder: (Low Cost Courses) Guaranteed. Brochure Free. Mike Blizzard Company, Linwood, N.J. 08221.

WANTED

QUICKSILVER. Platinum, Silver, Gold. Ores Analyzed. Free Circular. Mercury Terminal, Norwood, Mass.

CASH Paid! Sell your surplus electronic tubes. Want unused. Clean radio and TV receiving, transmitting special purpose. Magnetrons, Klystrons, broadcast types. Want military and commercial lab/test equipment. Want commercial Ham Receivers and Transmitters. For a Fair Deal write: Barry Electronics. 512 Broadway, New York, New York 10012 (Walker 5-7000).

CASH, SONY TRANSISTOR TV's etc. swapped for G-R, H-P, L&N etc. equipment, special tubes, manuals, military electronics. **ENGINEERING ASSOCIATES,** 430 Patterson Road, Dayton, Ohio 45419.

URGENTLY NEED MILITARY SURPLUS: ARC-27, ARC-34, ARC-38, ARC-44, ARC-52, ARC-55, ARC-73, ARC-84, ARN-14, ARN-18, ARN-21, ARN-59, 51X-2/17L-7, RT-66/GRC THRU 70, RT-77/GRC-9, GRC-19, Test Sets with ARM, UPM, URM, USM, SG Prefixes. Top Dollar Paid. Slep Electronics Company, Drawer 178ZD EW, Ellenton, Fla. 33532, Phone (813) 722-1843.

AUTHORS' SERVICES

AUTHORS! Learn how to have your book published, promoted, distributed. FREE booklet "ZD," Vantage, 120 West 31 St., New York 1.

WANTED WRITERS! Short stories, articles, books, plays, poetry. Will help place, sell your work. Write today, free particulars! Literary Agent Mead, Dept. 37A, 915 Broadway, New York 10, N.Y.

GET IT from GOODHEART!

EVERYTHING UNCONDITIONALLY GUARANTEED!

TWO LV XFRMRS each 115v 60 cy. connect for 115 or 230v. Gives 4 separate 6.3vct 35A secs.. connect for 25.2vct rms 35A or 12.6vct 70A or 6.3vct 140A. 2 weigh 54#. RailEx or Truck collect. remit for two.......... 24.50

ALL-BAND SSB RCVR BARGAIN: Hallicrafters R-45/ARR-7, 550 kc to 43 mc continuous; Voice, CW, MCW, aligned and modified now also modified to include PRODUCT DETECTOR. 2 RF, 2 IF stages. S-Meter. Xtl. w/120/230 v 50/60 cy pwr sply. Hot and SHARP & works like a charm! FOB Los Angeles 199.50

TIME PAY PLAN: Any purchase totalling $160.00 or more. down payment only... 10%

R-23/ARC-5 Command rcvr 190-550 kc.... 14.95
A.R.C. 12 #22 Command rcvr 540-1600 kc. 17.95
ARR-5 rcvr, 60 cy, am/fm, 27-140 mc 179.50
Panadapter 5.25 mc for above. 60 cy...... 69.50
APR-4Y AM/FM Rcvr mod. to 115 v 50/60 cy, with pwr plug, book, tuners 38-1000 mc. 210.00
P.U.R. for tuners 975-2200 and 2175-4000 mc.
RA-62-B is AC pwr sply for SCR-522, only.. 17.95
AN/URR-13(*) Rcvr. 225-400 mc. ....PUR
TDZ 60 cy xmtr 225-400 mc 30 w Po, new ....PUR
LM-14 freq. meter, .01% 125 kc-20 mc... 57.50
TS-323/UR freq. meter 20-480 mc., .001%.199.50
Berkeley #5510 Counter-Timer, 6-digit .. 495.00
SPA-1 Panor. Spect. Analyz. 220-4000 mc. 1450.00
Tektronix 514AD scope dc to 10 mc...... 395.00
Tektronix 513D scope dc to 15 mc 495.00
LP Signal Generator 9½ kc-50 mc....... 195.00
G.R. #1001A sig. gen. 5 kc to 50 mc..... 495.00
H.P. 608B signal generator 10-400 mc.... 475.00
H.P. 608B modified to 10-500 mc........ 525.00
TS-418A/U sig. gen. to 0 dbm 0.4-1.0 gc.. 395.00
Borg-Warner High-Power sig. generators.....PUR
SLRD sig. gen. 275-2750 mc. 20 watts.......PUR

LINE VOLTAGE REGULATION BARGAINS
Largest selection in the WORLD! Ask for list. from Sola 250 VA to Sorensen 10.000 VA!

REGULATED DC POWER SUPPLY BARGAINS
Very large selection! Ask for list of these!

HEWLETT-PACKARD & OTHER METERS, VTVMS
Very large selection! Ask for list of these!

AND MUCH MORE! We have 33 other types of Signal Generators, Precision Bridges, ac & dc Voltage Dividers, Galvos, Calorimetric & Indicating RF Wattmeters, other Spectrum Analyzers, Etc. . . . WRITE. . . . WIRE . . . PHONE . . . YOUR SPECIFIC NEEDS!

WE RENT EQUIPMENT! WE BUY EQUIPMENT!

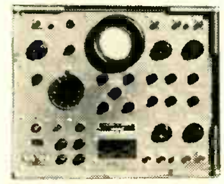
R. E. GOODHEART CO. INC.
Box 1220-A, Beverly Hills, Calif. 90213
Phones: Area 213, office 272-5707, messages 275-5342

CIRCLE NO. 113 ON READER SERVICE CARD

BIG CATALOG

World's "BEST BUYS" in GOV'T. SURPLUS Electronic Equipment

OSCILLOSCOPE



USM-24: 3 inch CR Tube 3JP1; recurrent sweep. 8 cyc. per sec. to 600 KC. Triggered sweep 1.25—125 M Microsec. vert. deflec. sensitivity .035 horz. deflec. 4.0 V.; Horz. response .5 cyc. per sec to 700 KC.; Vert. response 4 cyc. per sec. to 10 MC. Beam mod. response 50 cyc. per sec to 10 MC. Horz. input impedance 300.000 ohms. Vert. input resistance 300,000 ohms. Beam mod. input resist. 56,000 ohms. Operates from 115 Volt 50 to 1000 cycle radio freq. & mod. Circuits use BCN series coaxial connectors. Size: 17x15x15"; Wt.: 60 lbs. USED, serviceable. Prices given below are less blowers, probes, cables, coaxial fittings and as offered:

OS-51/USM-24—Less Front and Back Covers—with Delay Line...... $59.50
OS-26/USM-24—Less Front Cover and Less Delay Line.......... $49.50
OS-26/USM-24—With Front and Back Covers—Less Delay Line.......... $59.50

BC-221 FREQ. METER—per Aug. Ad:
New: $125.00—Used: $79.50

TRANSFORMERS:

SECONDARY:	PRIMARY:	NO.:	PRICE:
4800 VCT 1.7 A	220 V 50-60 cyc	5214	$39.95
2000 VCT 500 MA	115 V 60 cyc	5204	16.95
1000 VCT 400 MA	115 V 60 cyc	8894	8.95
500 VCT 60 MA		8894	
840 VCT 255 MA	115 V 60 cyc	223959	7.95
12.6 VCT 13 A/5 V 4 A		223959	
2.5 V 10A	120 V 60 cyc	9611.144	2.95
5.7 V 21.8 A	115 V 60 cyc	7469149	6.95
6.6 V 10 A	115 V 60 cyc	9T35Y158	2.95
12.8 VCT 20 A	120 V 60 cyc	1043	8.95
24 VCT 6 A	115 V 60 cyc	3992	4.95
36 V 12 A	115 V 60 cyc	CON442	8.95
SOLA CONSTANT VOLTAGE Pri.: 190-250 V 60 cyc; Sec.: 115 V 2000 VA		30M811	75.00

CHOKES:

10 Hy— 75 MA..$ .89   10 Hy—110 MA $1.75
8 Hy—250 MA.. 4.95   8 Hy—300 MA. (oil) 5.95
8 Hy—450 MA.. 6.95   10 Hy—500 MA 6.95

FOR BIG CATALOG—SEND 25¢ (stamps or coin) and receive 50¢ CREDIT on your order!

Address Dept. EW • Prices F.O.B. Lima, O. • 25% Deposit on C.O.D.'s • Minimum Order $5.00

FAIR RADIO SALES
2133 ELIDA RD. • Box 1105 • LIMA, OHIO

AN/APR-4Y FM & AM RADIO RECEIVER
Shipment just received! High precision lab instrument, suitable for monitoring and measuring frequency and relative signal strength of signals from 38 to 4000 Mc., in 5 tuning unit ranges. For 110 V 60 cycle AC operation, built-in power supply. LIKE NEW. SPECIAL . **$88.50**
TN-16, TN-17, TN-18, TN-19 and TN-54 Tuning Units for above in stock. P.U.R.

LORAN APN-4
FINE QUALITY
NAVIGATIONAL EQUIPMENT

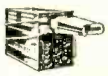
Determine exact geographic position of your boat or plane. Indicator and receiver complete with all tubes and crystal.
INDICATOR ID-6B/APN-4, and RECEIVER R-9B/APN-4, complete with tubes. Exc. Used....$88.50

NEW! APN-4A Receiver-Indicator as above, changed to operate same as APN4-B for improved performance ....NEW $88.50
Shock Mount for above $2.95

INVERTER POWER SUPPLY for above APN-4. INPUT: 24 V DC. OUTPUT: 115 V AC, 800 cycles. Like New $22.50

We carry a complete line of replacement parts and accessories for above.

LORAN R-65/APN-9 RECEIVER & INDICATOR



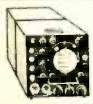
Used in ships and aircraft. Determines position by radio signals from known xmitters. Accurate to within 1% of distance. Complete with tubes and crystal. IN LIKE NEW Condition $88.50
Used, with all parts, less tubes, crystal and visor .... Special **$29.50**

INVERTER POWER SUPPLY for above APN-9. INPUT: 24 V DC. OUTPUT: 115 V AC. 800 cy. Like New **$22.50**

Shock Mount for above $2.95
Circuit diagram and connecting plugs available.

234-258 MC RECEIVER AN/ARR-2
BRAND NEW 11-tube UHF Tunable Receiver with schematic. Only a few at this low price! Complete with tubes. Exc. used $7.95.... **$10.95**

SCR-625 MINE DETECTOR
Complete portable outfit in original packing, with all accessories. Excellent, Used **$29.50**



BC-929 3-Inch Scope, with all tubes, LIKE NEW $16.50

Conversion instructions, with diagram, for 110 V AC operation ....$ .65

LM FREQUENCY METER
Crystal calibrated, modulated. Heterodyne, 125 KC to 20,000 Kc. with Calibration book. Complete, like new **$79.50**
LM Frequency Meter as above. completely checked out, with tubes and crystal, less calibration book. Exc. Used. clean **$34.50**

BC-221 FREQUENCY METER
Equipped with original calibration charts. 125 Kc. to 20.000 Kc with crystal check points in all ranges. Excel. Used with original Calibration Book. Crystal, and all tables. CHECKED OUT.
Unmodulated **$89.50** Modulated **$124.50**
A.C. Power Supply for BC221, checked out..$24.50
BC-221 1000 Kc Crystal Brand New **$8.95**
BC221 FREQ. METER CASE, aluminum with volt. reg. cupply. Shock mounted. BRAND NEW $2.95

SCR-274 COMMAND EQUIPMENT
ALL COMPLETE WITH TUBES

Type Description	Used	Like New	BRAND NEW
BC-453 Receiver 190-550 Kc.	$14.95	$18.95	P.U.R.
BC-454 Receiver 3-6 Mc.	$15.95		P.U.R.
BC-455 Receiver 6-9 Mc.	$13.95	$19.50	P.U.R.

BC946 Receiver, 550-1500 Kc. Complete with all tubes. Brand New, in original packing ......P.U.R.
1.5 to 3 MC. Receiver Brand New $21.50

110 Volt AC Power Supply for all 274 N and ARC-5 Receivers. Complete with metal case, Instructions. Factory wired, tested, ready to operate $12.50
SPLINED TUNING KNOB for 274-N and ARC-5 RECEIVERS. Fits BC-453, BC-454 and others. **Only** .... **49¢**

2.1 to 3 Mc. Transmitter. Brand New $12.95
BC-458 TRANSMITTER—5.3 to 7 Mc. Complete with all tubes and crystal
BRAND NEW **$13.95**
Like New $8.95
BC-459 TRANSMITTER—7 to 9 Mc. Complete with tubes & crystal
Like New **$19.50**
BC-696 TRANSMITTER 3-4 Mc Complete with All Tubes & Crystal. Brand New **$14.95**
Exc. Used $8.95
BC-456 Modulator .... **USED 3.45 NEW $5.95**
ALL ACCESSORIES AVAILABLE FOR ABOVE

SEND FOR BIG NEW G&G CATALOG of Military Electronic Surplus—Sensational Bargains—include 25¢ (Refunded with First Order)

Please include 25% Deposit with order—Balance C.O.D., or Remittance in Full. 50¢ Handling Charges on all orders under $5.00. All shipments F.O.B. Our Warehouse. N.Y.C. All Merchandise subject to Prior Sale and Price Change.

G & G RADIO SUPPLY CO.
Telephone: (212) CO 7-4605
77 Leonard St. New York 13, N. Y.

CIRCLE NO. 114 ON READER SERVICE CARD

REPAIRS AND SERVICES

TV Tuners Rebuilt and Aligned per manufacturers specification. Only $9.50. Any Make UHF or VHF. We ship COD Ninety day written guarantee. Ship complete with tubes or write for free mailing kit and dealer brochure. JW Electronics. Box 51B. Bloomington, Indiana.

METERS REPAIRED, VTUM, VOM. 90 Day Warranty. TV Tuner Service, Box 793 W, Twin Falls, Idaho.

METERS—TEST EQUIPMENT REPAIRED—CALIBRATED. Free catalog. Bigelow Electronics, Bluffton, Ohio 45817.

TUBES

TUBES—TV, Radio Transmitting And Industrial Types At Sensibly Low Prices. New, Guaranteed, 1st Quality. Top Name Brands Only. Write For Free Catalog or Call WAlker 5-7000, Barry Electronics, 512 Broadway. New York, N.Y. 10012.

BEFORE you buy receiving tubes, Transistors, Diodes, Electronic Components and Accessories . . . send for Giant Free Zalytron Current Catalog, featuring Standard Brand Tubes; RCA, GE, etc.—all Brand new premium quality individually boxed. One year guarantee—all at biggest discounts in America! We serve professional servicemen, hobbyists, experimenters, engineers, technicians. Why pay more? Zalytron Tube Corp., 469-W Jericho Turnpike, Mineola, N.Y. 11502.

TUBES—33¢ each. One year guaranteed. Complete stock. Free list. Cornell, 4215—W University, San Diego, Calif. 92105.

FREE Catalog. Electronic parts, tubes, Wholesale. Thousands of items. Unbeatable prices. Arcturus Electronics ZD, 502-22 St., Union City, N. J. 07087.

TRANSMITTING AND SPECIAL PURPOSE TUBES. NEW—NO SECONDS. 6CW4—$1.40. 6146—$2.55, 826—$6.00. 6146B—$4.75, 417A—$3.95. Catalog!! VANBAR Dist, Box 444G, Stirling, N.J. 07980.

PATENTS

INVENTIONS: Ideas developed for Cash Royalty sales. Raymond Lee, 130 "G" W. 42nd, New York, 10036.

PERMANENT PROTECTION!

Electronics World
Deluxe Magazine Files that hold a full year's copies!

Designed to keep your periodicals orderly and easy to refer to. These durable files guard against soiling, tearing, wear or misplacement of issues. They look, feel like leather and are washable! 23kt. gold lettering and exquisite 2-color binding make them highly-decorative additions to your bookshelves.

Shipped POSTPAID! FULLY GUARANTEED!

Only $3.50 each—3 for $10, 6 for $19

Order several today—for ELECTRONICS WORLD and all your other favorite magazines.

Jesse Jones Box Corp., Dept. EW
Box 5120
Philadelphia 41, Pa.
Please send me:

TITLE	QTY.	BLACK BACKING/ MAROON SIDES	MAROON BACKING/ BLACK SIDES
Electronics World	___	☐	☐
___	___	(Other publications shipped in colors available.)	
___	___		

Total amount enclosed $ ___

name ___

address ___

city ___ state ___ zip-code ___

(Payment Must Accompany Order)

CLASSIFIED ADVERTISING ORDER FORM

Please refer to heading on first page of this section for complete data concerning terms, frequency discounts, closing dates, etc.

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31	32	33	34	35

___ Words { @ .40 Reader Rate / @ .70 Commercial Rate } = $ ___

Insert ___ time(s) Total Enclosed $___

NAME ___

ADDRESS ___

CITY ___ ZONE ___ STATE ___

SIGNATURE ___

WORD COUNT: Include name and address. Name of city (Des Moines) or of state (New York) counts as one word each. Zone or Zip Code numbers not counted. (Publisher reserves right to omit Zip Code if space does not permit.) Count each abbreviation, initial, single figure or group of figures or letters as a word. Symbols such as 35-mm, COD, PO, AC, etc., count as one word. Hyphenated words count as two words. EW-1165

TAPE AND RECORDERS

RENT Stereo Tapes—over 2,500 Different—all major labels—free brochure. Stereo-Parti, 1616—E. W. Terrace Way, Santa Rosa, California.

BEFORE renting Stereo Tapes, try us. Postpaid both ways—no deposit—immediate delivery. Quality—Dependability—Service—Satisfaction—prevail here. If you've been dissatisfied in the past, your initial order will prove this is no idle boast. Free Catalog. Gold Coast Tape Library, Box 2262, Palm Village Station. Hialeah, Fla. 33012.

TAPE-MATES makes available to you—**ALL 4** track stereo tapes—**ALL** labels—**TREMENDOUS SAVINGS—POSTAGE-FREE** to your door—for **FREE BROCHURE** write **TAPE-MATES**, 5280-E W. Pico Blvd., Los Angeles, Calif. 90019.

TAPE RECORDER SALE. Brand new, latest models, $10.00 above cost. Arkay Sales, 1028-B Commonwealth Ave., Boston, Mass. 02215.

TAPE-MATES offers the world's first **3 HOUR**—Long play stereo library—**CLASSICAL—POP—JAZZ—DANCE** and **VARIETY**—top recording artists—**ONLY** $9.95—**FREE TAPE-MATES** membership with initial order— for **FREE BROCHURE** write **TAPE-MATES**, 5280-E. W. Pico Blvd., Los Angeles, Calif. 90019.

STEREO TAPES. Save up to 60% (no membership fees, postpaid anywhere USA). Free 60-page catalog. We discount batteries, recorders, tape accessories. Beware of slogans "not undersold," as the discount information you supply our competitor is usually reported to the factory. **SAXITONE**, 1776 Columbia Rd., Washington, D. C. 20009.

TAPE-MATES now offers the first completely **PORTABLE CAR-STEREO PLAYER**—nothing to install—can be used in **CAR—HOME—OFFICE—BOAT** etc., also complete **CAR-STEREO MUSIC LIBRARY** available—for **FREE BROCHURE** write **TAPE-MATES**, 5280-E W. Pico Blvd., Los Angeles, Calif. 90019.

DO-IT-YOURSELF

PROFESSIONAL ELECTRONIC PROJECTS—$1.00 up. Catalog 25¢, refundable. **PARKS**, Box 25565, Seattle, Wash. 98125.

HIGH FIDELITY

LOW, LOW quotes: all components and recorders. Hi-Fi, Roslyn 9, Penna.

HI-FI Components, Tape Recorders, at guaranteed "We Will Not Be Undersold" prices. 15-day money-back guarantee. Two-year warranty. No Catalog. Quotations Free. Hi-Fidelity Center, 1797 (L) 1st Avenue, N.Y., N.Y. 10028.

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

FREE! Send for money saving stereo catalog #E11W and lowest quotations on your individual component, tape recorder or system requirements. Electronic Values Inc,, 200 West 20th Street, N.Y., N.Y. 10011.

FREE—$1.00 Value "Miracle" Record cleaning cloth with every quotation on **HIFI EQUIPMENT.** Our **"ROCK BOTTOM"** prices on **NAME BRAND** amplifiers—tuners—taperecorders—speakers—**FRANCHISED—59 YEARS IN BUSINESS.** Write for this month's specials—**NOW!** Rabsons 57th St., Inc., Dept. 569, 119 W. 57th St., New York, New York 10019.

GOVERNMENT SURPLUS

JEEPS from $53.90 . . . Trucks from $78.40 . . . Boats, Typewriters, Airplanes, Electronic Equipment, 100,000 Bargains "as is" Direct from Government in Your Area. Complete Sales Directory and Surplus Catalog $1.00 (Deductible First $10.00 Order). Surplus Service, Box 820-K, Holland, Michigan.

JEEPS—WALKIE-TALKIES—Receivers—Oscilloscopes—Transmitters—Voltmeters. Uncle Sam's Bargain Prices. Write for latest exciting details. Enterprises, Box 402-B3, Jamaica, New York 11430.

PHOTOGRAPHS

PHOTOGRAPHS and transparencies wanted, to $500.00 each. Valuable information free—Write Intraphoto-EW, Box 74607, Hollywood 90004.

PRICES LOWERED—NO MORE FEDERAL TAX—SAVE $$—AT THE LOWEST PRICES—COMPARE

BRAND NEW
UNITED'S FIRST QUALITY TUBES DISCOUNTS up to 80% OFF

GUARANTEED ONE FULL YEAR! NOT USED! NO PULLS! **WHY PAY MORE?**

Type	Price
00A/UV 200	3.50
01A	2.75
0A2	.90
0A3	.90
0A4G	1.50
0B2	.80
0B3	1.20
0C3	.75
0D3	.75
0G3	2.20
0Y4	1.20
0Z4	.90
1A3	1.49
1A5	2.00
1A6	2.00
1A7	1.05
1AB5	.95
1AX2	.75
1AY2	.98
1B3	.92
1B4P	2.00
1C5	2.00
1C6	1.50
1D5GP	.98
1D7	1.25
1DN5	.75
1E5GP	.98
1E7	.99
1F4	.95
1F5	.95
1F6	1.20
1G3	.92
1G4	1.75
1G6	1.50
1H4	1.25
1H5	2.59
1H6	.98
1J3	.92
1J5	.98
1J6	.98
1K3	.92
1L4	.66
1L6	2.60
1LA4	1.30
1LA6	1.49
1LB4	1.80
1LC5	1.05
1LC6	1.80
1LD5	1.95
1LE3	1.25
1LG5	1.98
1LH4	2.69
1LN5	2.25
1N5	1.85
1P5	2.00
1Q5	1.95
1R4	.80
1R5	.99
1S2A	1.90
1S4	1.49
1S5	.99
1T4	.99
1T5	.80
1U4	.99
1U5	.97
1V	1.85
1V2	.79
1X2B	.95
2A3	3.50
2A5	2.50
2A6	4.50
2A7	1.50
2AF4A	1.31
2AH2	1.10
2AS2	1.10
2AV2	.95
2B3	3.25
2B7	1.95
2BN4	.94
2CY5	1.08
2D21	.75
2DZ4	1.40
2EA5	1.35
2EN5	.81
2ER5	1.21
2FH5	1.30
2FQ5	1.85
2FS5	2.45
2FY5	1.39
2GK5	1.40
2GU5	1.50
2GW5	2.20
2HK5	.98
2X2	.60
2X2A	1.95
3A2	1.20
3A3	1.18
3A4	.74
3A5	1.10
3A8GT	1.25
3AF4	1.40
3AL5	.70
3AT2	1.10
3AU6	.57
3AV6	.66
3AW3	1.18
3B2	2.49
3B7	2.39
3BA6	.86
3BC5	.84
3BE6	.75
3BN4	1.05
3BN6	1.29
3BU8	1.15
3BY6	.99
3BZ6	.79
3CB6	.79
3CE5	.79
3CF6	.90
3CS6	.65
3CY5	1.15
3D6	1.48
3DG4	1.25
3DK6	.82
3DT6	.74
3DZ4	1.40
3EH7	1.30
3EJ7	1.25
3ER5	1.20
3FH5	.95
3FS5	1.08
3GK5	1.40
3GS8	1.15
3GW5	.98
3HA5	1.49
3HK5	1.23
3HM5	1.53
3HS8	1.29
3LF4	2.45
3Q4	1.25
3Q5	2.00
3S4	1.00
3V4	.85

Type	Price
4AU6	.85
4AV6	.70
4BA6	.85
4BC5	.80
4BC8	1.25
4BL8	.87
4BN6	1.30
4BQ7	1.30
4BS8	1.39
4BU8	1.19
4BZ6	.77
4BZ7	1.40
4CB6	.79
4CE5/4CB5	.89
4CS6	.75
4CY5	.98
4DE6	.95
4DK6	.85
4DT6	.77
4EH7	1.29
4EJ7	1.29
4EM6	1.19
4ES8	1.55
4EW6	.91
4GK5	1.42
4GM6	1.25
4GS8	1.15
4GZ5	.86
4GZ6	1.19
4HA5	1.85
4HA7	1.19
4HC7	1.39
4HM6	.91
4HS8	1.18
4HT6	.82
4JC6	1.20
4JD6	1.20
5AM8	1.30
5AN8	1.35
5AQ5	.76
5AR4	1.49
5AS8	1.50
5AT8	1.27
5AU4	1.17
5AV8	1.37
5AW4	1.00
5AZ4	1.85
5B8	1.99
5BC3	.89
5BE8	1.10
5BK7	1.19
5BQ7	1.35
5BR8	1.25
5BT8	1.12
5BW8	1.13
5CG8	1.12
5CL8	1.25
5CM8	1.25
5CQ8	1.35
5CZ5	1.49
5DE8	1.15
5DH8	1.95
5DJ4	1.12
5EA8	1.21
5ES8	2.21
5EU8	1.23
5EW6	.98
5FG7	.92
5FV8	1.05
5GH8	1.33
5GJ7	1.62
5GM6	.90
5GX6	.90
5HC7	1.49
5HG8	1.69
5J6	.96
5KD8	1.35
5KE8	1.70
5T4	3.75
5T8	1.25
5U4	.70
5U8	1.14
5V3	1.30
5V4	1.29
5V6	.75
5W4	1.75
5X4	1.05
5X8	1.20
5Y3	.59
5Y4	1.45
5Z3	1.30
5Z4	2.75
6A3	2.75
6A4	2.20
6A6	1.75
6A7	2.90
6A8GT	2.50
6A8M	2.39
6AB4	.76
6AB7	2.10
6AC5	2.12
6AC7	1.75
6AD7	3.25
6AE5	2.50
6AF3	.99
6AF4	1.35
6AF6G	2.10
6AF11	1.70
6AG5	.89
6AG7	1.95
6AG11	1.34
6AH4	1.19
6AH6	1.49
6AJ5	2.25
6AJ8	1.95
6AK5	1.49
6AK6	.94
6AL3	.99
6AL5	.53
6AL7	1.95
6AL11	1.50
6AM4	1.19
6AM8	1.25
6AN4	2.27
6AN5	1.95
6AN6	2.45
6AN8	1.35
6AQ5	.69
6AQ6	.89
6AQ7	1.37
6AQ8	1.08
6AR5	.91
6AR6	1.50
6AR8	2.00
6AR11	1.48
6AS5	.92
6AS6	1.00
6AS7	2.85
6AS8	1.43
6AS11	1.90
6AT6	.58

Type	Price
6AT8	1.39
6AU4	1.19
6AU5	1.55
6AU6	.62
6AU7	.54
6AU8	1.38
6AV5	1.45
6AV6	.47
6AV11	1.52
6AW8	1.25
6AX3	.94
6AX4	.89
6AX5	1.05
6AX7	1.25
6AX8	1.28
6AY3	.93
6AY11	1.34
6AZ8	1.98
6B4	5.95
6B5	4.00
6B6	1.00
6B7	2.75
6B8	2.46
6B10	1.19
6BA3	1.05
6BA6	.60
6BA7	1.85
6BA8	1.27
6BA11	1.25
6BC4	1.98
6BC5	.72
6BC7	1.27
6BC8	1.35
6BD4	7.00
6BD5	1.20
6BD6	.83
6BD11	1.72
6BE3	.99
6BE6	.74
6BF5	1.19
6BF6	.64
6BF8	1.65
6BF11	1.64
6BG6	2.19
6BH3	1.15
6BH6	.89
6BH8	1.24
6BH11	1.60
6BJ3	.91
6BJ6	.83
6BJ7	1.05
6BJ8	1.19
6BK4	2.69
6BK5	1.25
6BL8	1.34
6BL7	1.26
6BK7	1.14
6BM8	1.03
6BN4	1.05
6BN6	1.03
6BN8	1.03
6BQ5	.79
6BQ6/6CU6	1.45
6BQ7	1.33
6BR8	1.29
6BS8	1.28
6BU8	.94
6BV8	1.05
6BW4	.98
6BW8	1.18
6BX7	1.75
6BY5	1.65
6BY6	.89
6BY8	.89
6BZ6	.70
6BZ7	1.35
6BZ8	1.49
6C4	.54
6C5M	1.63
6C6	2.00
6C8G	2.95
6C9	2.00
6C10	1.53
6CA4	.70
6CA5	1.05
6CA7	1.95
6CB5	3.25
6CB6	.54
6CD6	1.93
6CE5/6BC5	.79
6CF6	.84
6CG7	.75
6CG8	.95
6CH8	1.95
6CK4	1.00
6CL5	3.75
6CL6	1.15
6CL8	1.10
6CM6	1.10
6CM7	.94
6CM8	1.43
6CN7	1.25
6CQ4	1.07
6CQ7	1.80
6CQ8	1.15
6CR6	.81
6CS6	.85
6CS7	.98
6CU5	.84
6CU6	1.45
6CU8	1.49
6CW4	1.59
6CW5	1.20
6CX8	1.42
6CY5	1.03
6CY7	1.05
6CZ5	1.48
6D4	1.75
6D6	2.50
6CZ7	1.95
6D10	1.59
6DA4	.98
6DA5	1.08
6DB5	1.99
6DB6	1.01
6DC6	1.28
6DC8	1.07
6DE4	.98
6DE6	.85
6DE7	1.14
6DG6	.92
6DJ8	1.65
6DK6	.79
6DM4	.96
6DN6	2.54
6DN7	1.21
6DQ4	.91
6DQ5	2.75
6DQ6	1.39

Type	Price
6DR7	1.32
6DS4	1.59
6DS5	1.19
6DT5	1.05
6DT6	.72
6DT8	1.29
6DV4	2.24
6DW4	1.27
6DW5	1.36
6DX8	1.05
6DZ4	1.34
6DZ7	2.98
6E5	1.74
6EA5	1.29
6EA7	1.52
6EA8	1.06
6EB5	1.75
6EB8	1.42
6EH5	1.03
6EH7	1.25
6EH8	1.06
6EJ7	1.28
6EM5	1.15
6EM7	1.73
6EQ5	1.10
6EQ7	1.00
6ER5	1.29
6ES5	1.03
6ES8	1.97
6ET7	1.60
6EU7	.93
6EU8	1.12
6EV5	1.02
6EV7	.99
6EW6	.85
6EW7	1.84
6EX6	2.74
6EY6	1.15
6EZ5	1.21
6EZ8	1.29
6F4	4.75
6F5GT	1.72
6F6G	1.95
6F7	3.95
6F8	3.08
6FA7	.99
6FD6	1.45
6FD7	1.70
6FE5	1.25
6FG5	1.99
6FG6	1.12
6FG7	1.10
6FG8	1.75
6FH5	.95
6FH8	1.24
6FJ5	2.25
6FJ7	1.24
6FM7	1.18
6FM8	1.01
6FO5A	1.35
6FQ7	.79
6FS5	1.35
6FV6	1.33
6FV8	1.06
6FW5	1.39
6FW8	3.49
6FY5	1.11
6FY7	1.14
6G5	2.50
6G6G	2.25
6G11	1.48
6GB5	1.35
6GC5	1.34
6GE5	1.39
6GE7	1.19
6GF5	1.27
6GF7	1.69
6GH8	1.06
6GJ5	1.75
6GJ7	1.22
6GK5	1.39
6GK6	.98
6GL7	1.73
6GM5	1.09
6GM6	.94
6GM8	1.31
6GN8	1.33
6GQ7	1.39
6GR7	1.42
6GT5	1.54
6GU5	1.47
6GU7	1.15
6GV5	1.65
6GV6	1.85
6GV8	1.12
6GW6	1.39
6GW8	1.08
6GX6	.86
6GX7	1.70
6GX8	1.31
6GY5	1.49
6GY6	.88
6GY8	1.29
6GZ5	.98
6HA5	1.39
6HA6	1.88
6HB5	1.52
6HB6	1.59
6HB7	1.08
6HD5	2.19
6HE5	1.34
6HF5	2.69
6HF8	1.42
6HG5	.73
6HG8	1.48
6HJ5	2.10
6HJ8	1.12
6HK5	1.19
6HL8	1.11
6HM5	1.37
6HQ5	1.72
6HR6	.98
6HS6	.98
6HS8	1.08
6HT6	1.19
6HZ6	.98
6HZ8	1.85
6H6	.94
6J4	2.95
6J5G	1.10
6J5M	1.25
6J6A	.67
6J7	1.69
6J7GT	1.49
6J7G	1.50
6J8	2.50
6J10	2.02
6J11	1.82
6JB6	2.25
6JC6	1.36
6JC8	1.04
6JD6	1.19

Type	Price
6JE6	3.05
6JE8	1.35
6JG6	2.08
6JH6	.89
6JH8	1.48
6JK8	1.35
6JM6	1.67
6JN6	1.59
6JN8	1.30
6JS6	2.95
6JT6	1.72
6JT8	1.45
6JU8	1.09
6JV8	1.33
6JZ8	1.28
6K6GT	.90
6K7	1.69
6K7G/GT	1.49
6K8M	2.59
6K11	1.29
6KA8	1.38
6KD8	1.01
6KE8	1.72
6KL8	.93
6KM8	1.16
6KT8	1.25
6KU8	1.63
6KV8	2.12
6KY8	2.65
6KZ8	.94
6L5G	1.50
6L6G	.98
6L6GA	1.48
6L6GB	1.50
6L6GC	1.61
6L6M	3.00
6L7M	2.48
6L7G	1.75
6LB8	1.49
6LC8	1.40
6LF8	1.28
6LM8	1.52
6M11	1.81
6N7M	1.75
6P5	2.50
6Q7	1.95
6Q11	1.29
6R7	2.10
6S4	.76
6S7	1.95
6S8GT	1.50
6SA7GT	1.39
6SA7M	1.49
6SB7Y	2.19
6SC7	1.52
6SD7	1.49
6SF5	1.08
6SF7	2.19
6SG7	1.55
6SH7	1.05
6SJ7GT	1.49
6SJ7M	1.72
6SK7GT	1.30
6SK7M	1.38
6SL7GT	1.19
6SN7GT	.89
6SQ7GT	1.25
6SR7	1.42
6SS7M	1.88
6ST7	1.75
6SU7	2.00
6SV7	1.25
6SZ7	1.25
6T4	1.75
6T8	1.15
6T10	1.54
6U5/6G5	2.35
6U8	1.12
6U10	1.32
6V3	1.67
6V4	.59
6V6GT	.74
6W4	.83
6W6GT	.98
6X4	.56
6X5GT	.72
6X8A	1.05
6Y6GA	1.45
6Z4/84	1.22
7A4	2.25
7A5	1.95
7A6	2.25
7A7	2.35
7A8	2.75
7AD7	1.25
7AF7	2.10
7AG7	2.85
7AH7	1.95
7AU7	.83
7B4	2.35
7B5	2.75
7B6	1.25
7B7	2.50
7B8	2.00
7C4	1.15
7C5	1.19
7C6	2.69
7C7	1.23
7E5	2.00
7E6	1.25
7E7	1.95
7EY6	1.06
7F7	2.59
7F8	3.00
7G7	1.99
7H7	1.65
7HG8	1.29
7J7	2.50
7K7	2.96
7L7	1.99
7N7	2.61
7Q7	1.85
7R7	2.25
7S7	1.79
7V7	1.65
7W7	2.39
7X6	1.35
7X7	2.75
7Y4	2.35
7Y7	1.79
7Z4	2.25
8AU8	1.39
8AW8	1.26
8B10	1.22
8BA8	1.24
8BH8	1.23
8BN8	1.11
8BQ5	.99

Type	Price
8CG7	.86
8CM7	.98
8CN7	.96
8CS7	.98
8CW5	.98
8CX8	1.60
8EB8	1.48
8EM5	1.19
8ET7	1.50
8FQ7	.94
8GJ7	1.31
8GN8	1.29
8JV8	1.32
8KA8	1.40
8LC8	1.40
9A8	1.33
9AU7	.94
9BR7	1.14
9CL8	1.07
9EA8	1.09
9U8	1.05
10AL11	1.53
10BQ5	1.45
10CB	1.41
10DE7	1.14
10DR7	1.49
10DX8	1.05
10EG7	1.54
10EM7	1.62
10EW7	1.45
10GN8	1.29
10HF8	1.70
10HT8	1.21
10JA8	1.29
10JY8	1.49
10KU8	1.73
10Y	.95
11AR11	1.48
11CY7	1.10
11JE8	1.39
11KV8	2.15
12A4	.94
12A5	1.25
12A6	.89
12A7	2.95
12A8	2.95
12A11	1.69
12AB5	1.15
12AC6	.75
12AD6	.80
12AE6	.80
12AE7	1.35
12AF3	1.25
12AF6	.94
12AG6	1.49
12AH7	1.89
12AJ6	.86
12AL5	.65
12AL8	2.23
12AL11	1.51
12AQ5	.86
12AT6	.59
12AT7	1.03
12AU6	.71
12AU7	.83
12AV5	1.48
12AV6	.56
12AV7	1.22
12AW6	1.10
12AX3	.94
12AX4	.85
12AX6	.91
12AX7	.87
12AY3	.96
12AY7	1.55
12AZ7	.94
12B4	.97
12BA6	.56
12BA7	1.90
12BD6	.77
12BE3	.93
12BE6	.59
12BF6	.68
12BH7	.96
12BK5	1.28
12BL6	.89
12BN6	1.48
12BQ6/CU6	1.53
12BR7	1.08
12BS3	1.21
12BT3	1.00
12BV7	1.20
12BW4	.99
12BY7	1.09
12BZ6	.76
12BZ7	1.35
12C5/12CU5	.84
12CA5	1.00
12CN5	1.18
12CR6	.94
12CS6	.95
12CT8	1.45
12CU6/BQ6	1.53
12CX6	.98
12D4	.99
12DB5	.94
12DE5	.92
12DE8	1.12
12DK6	.82
12DK7	1.00
12DL8	2.12
12DQ6	1.44
12DQ7	1.18
12DS7	1.35
12DT5	1.12
12DT7	1.10
12DT8	1.30
12DU7	1.39
12DV8	1.33
12DW7	1.10
12DW8	1.25
12DY8	2.90
12DZ6	.94
12EA6	.91
12EC8	1.22
12ED5	.98
12EG6	1.03
12EK6	.98
12EL6	.69
12EL8	.95
12EM6	1.14
12EZ6	.83
12F5	1.60
12F8	.99
12FA6	.97
12FK6	.79
12FM6	.79
12FQ8	1.08

Type	Price
12FR8	1.48
12FV7	1.25
12FX5	.91
12FX8	1.31
12GA6	.87
12GC6	1.25
12GE5	1.40
12GN7	1.43
12GT5	1.65
12GW6	1.15
12H6	1.40
12J5	1.61
12J8	1.58
12JB6	2.05
12JN6	1.43
12JT6	1.97
12K5	1.19
12K7GT	2.25
12K8G	1.50
12K8M	2.95
12L6	1.18
12L8	.50
12Q7GT	1.39
12Q7M	1.50
12R5	1.07
12SA7	1.49
12SC7M	1.89
12SF5	1.30
12SF7	2.23
12SG7M	1.54
12SH7	1.75
12SJ7	1.40
12SK7GT	1.35
12SK7M	1.47
12SL7GT	1.28
12SN7	.70
12SQ7GT	1.29
12SR7	1.79
12U7	.90
12V6	1.15
12W6	1.15
12X4	.68
13CW4	1.60
13DE7	1.01
13DR7	1.15
13EM7	1.61
13FD7	1.66
13FM7	1.08
13GB5	1.36
13GF7	1.70
13J10	1.83
14A4	1.45
14A5	1.35
14A7	1.85
14AF7	1.85
14B6	1.85
14B8	1.95
14C5	1.75
14C7	2.19
14E6	1.39
14E7	1.39
14F7	2.95
14F8	2.23
14GT8	.95
14H7	1.95
14J7	1.95
14N7	1.95
14Q7	1.95
14R7	2.35
14S7	1.95
14W7	1.85
14X7	1.75
14Y4	1.75
15AF11	1.64
15BD11	1.73
15CW5	.92
15FY7	1.18
15HB6	1.25
15KY8	1.65
16AQ3	.92
16GK5	.93
16GK6	1.15
16GY5	1.90
17AX3	.91
17AX4	.92
17AY3	.92
17BE3	.98
17BF11	1.57
17BH3	.98
17BQ6	1.65
17BS3	1.12
17C5	2.30
17C9	2.40
17D4	.96
17DA4	1.10
17DE4	1.12
17DM4	1.05
17DQ6	1.33
17DQ7	1.75
17EW8	.99
17GE5	1.34
17GJ5	1.82
17GV5	1.48
17GW6	1.38
17H3	.79
17HC8	1.24
17JB6	1.89
17JG6	2.02
17JM6	1.65
17JN6	1.70
17JZ8	1.19
17L6	1.45
17LD8	1.35
17W6	1.15
18A5	1.34
18FW6	.68
18FX6A	.74
18FY6A	.63
18GD6	.64
19	1.00
19AU4	1.26
19BG6	1.95
19BQ6	2.35
19C8	1.25
19CL8	1.17
19EA8	1.09
19GQ7	1.99
19HS6	.85
19HV8	1.23
19JN8	1.04
19Q9	1.15
19T8	1.14
2050	1.25

Type	Price
21EX6	1.95
21GY5	1.32
21HE5	1.65
21HJ5	1.62
21KA6	1.75
22	1.15
22BH3	1.07
22BW3	1.21
22DE4	.98
22JG6	1.95
23Z9	2.69
24A	1.35
25A7	3.25
25AC5	2.50
25AK4	1.19
25AV5	1.54
25AX4	.94
25BK5	1.14
25BQ6	1.45
25B8	1.93
25C5	.65
25CA5	.98
25CD6	1.94
25CU6	1.48
25DN6	1.95
25EH5	.92
25F5	1.25
25L6	.77
25W4	.87
25W6	.95
25Z5	1.50
25Z6	.94
26	1.40
27	1.60
27GB5	1.49
28D5	1.50
30	1.25
31	1.50
32	1.15
32ET5	.80
32L7	.85
33	1.15
33GY7	1.95
34	1.15
34DG5A	.95
34GD5	.71
35-51	1.50
35A5	1.94
35B5	1.07
35C5	.66
35EH5	.74
35L6	.86
35W4	.35
35Y4	1.62
35Z3	1.54
35Z5	.58
36	1.50
36AM3	.51
37	1.10
38	1.10
39/44	.95
41	1.40
42	1.98
43	2.85
45 2A3	3.25
45Z3	.55
46	.95
47	3.00
48	4.00
49	3.50
50	1.75
50A1	2.60
50A5	2.10
50B5	.86
50C5	.65
50DC4	.63
50EH5	.72
50FE5	1.44
50FK5	.79
50FY8	2.50
50HC6	.86
50HC8	.89
50HK6	.77
50L6	.81
50X6	1.96
50Y6	1.49
50Y7	1.42
53	3.50
55	2.75
56	1.25
57	1.50
58	1.50
59	3.00
60FX5	.87
70L7	.89
71A	1.25
75	2.62
76	1.50
77	1.50
78	1.65
80	1.25
81	1.35
82	1.49
83	1.75
83V	3.00
84/6Z4	1.35
85	.98
89	1.50
89Y	2.00
417A	5.25
117L7	3.29
117M7	3.25
117N7	4.25
117P7	4.25
117Z3	1.56
117Z6	2.23
5881	2.05
6146	2.50
6146W	5.95
6336	4.75
6336A	9.50
6550	3.25
6550MP	7.00
7258	2.50
807	.75
809	3.75
ECC83/12AX7	.90
EL34/6CA7	1.85
EL84/6BQ5	.85
EZ80/6V4	.55
GZ34/5AR4	1.50
KT-88	4.95
KT-88MP	11.00

• • • SEND FOR COMPLETE PARTS CATALOG WITHOUT COST • • •

TERMS: Minimum order $5.00 exclusive of postage. Remit full price plus postage. NO C.O.D. The above list does not reflect our entire stock as we have one of the largest selections of SPECIAL PURPOSE, BROADCAST & TV TUBES in the U.S. Write for quotation.

ABOVE PRICES SUBJECT TO CHANGE WITHOUT NOTICE

UNITED RADIO CO.

ESTABLISHED 1920
BOX 1000R, DEPT. EW 11
NEWARK, N.J.

SEND FOR COMPLETE PARTS CATALOG

THIS AD CANCELS ALL PREVIOUS QUOTATIONS BY MAIL OR ANY OTHER ADVERTISING MEDIUM

CIRCLE NO. 86 ON READER SERVICE CARD

RECORDS

DISCOUNT Records, All Labels—Free Lists. Write Cliff House, Box 42-E, Utica, N.Y.

PROTECT Your Records! Two Cleaning Cloths $1.00. Towers, Lafayette Hill, Pa. 19444.

EQUIPMENT

McGEE RADIO COMPANY. Big 1966 Catalog Sent Free. America's Best Values. Hi-Fi-Amplifiers—Speakers—Electronic Parts. Send name, address and zip code number to McGee Radio Company, 1901 McGee Street, Dept. EG, Kansas City, Missouri 64108.

HYPNOTISM

FREE Hypnotism, Self-Hypnosis, Sleep Learning Catalog! Drawer H400, Ruidoso, New Mexico 88345.

PHOTOGRAPHY—FILM, EQUIPMENT, SERVICES

MEDICAL FILM—Adults only—"Childbirth" one reel, 8mm $7.50; 16mm $14.95. International W, Greenvale, Long Island, New York.

SCIENCE Bargains—Request Free Giant Catalog "CJ"—148 pages—Astronomical Telescopes, Microscopes, Lenses, Binoculars, Kits, Parts, War surplus bargains. Edmund Scientific Co., Barrington, New Jersey.

EDUCATIONAL OPPORTUNITIES

LEARN While Asleep, hypnotize with your recorder, phonograph. Astonishing details, sensational catalog free! Sleep-Learning Association, Box 24-ZD, Olympia, Washington.

LEARN while asleep. Remarkable, scientific. 92% effective. Details free. ASR Foundation, Box 721, Dept. e.g., Lexington, Kentucky.

USED Correspondence Courses and Books sold and rented. Money back guarantee. Catalog free. (Courses Bought). Lee Mountain, Pisgah, Alabama.

EARN Valid Undergraduate or Graduate Degree Through Correspondence. Catalog Gratis. Dean, Bretton Woods University, 3936 East 10th Street, Indianapolis, Ind. 46201.

MAGNETS

PERMANENT-Alnico-Ceramic-Flexible-Assemblies. What you need, we have. Maryland Magnet, 5412-E Gist, Baltimore, Maryland 21215.

INVENTIONS WANTED

INVENTORS. We will develop, help sell your idea or invention, patented or unpatented. Our national manufacturer clients are urgently seeking new items for outright cash sale or royalties. Financial assistance available. 10 years proven performance. For free information, write Dept. 42, Wall Street Invention Brokerage, 79 Wall Street, New York 5, N.Y.

INVENTORS. Outright cash sale or royalties for your inventions. Patented. Unpatented. Active demand from our client manufacturers. Financial assistance available. Write Dept. 48, United States Invention Brokerage, 78 Wall Street, New York 5, N. Y.

WISCONSIN State Inventors Association Welcomes You. Investments earn 5%. Development Loans Available. Box 162, Sheboygan, Wis. 53082.

IMMEDIATE cash, for Patent Applications, free Patent Searches. Write for details, Universal Patents, 184-Y, Marion, Ohio.

STAMPS

500 FINE Mixed U.S. 15¢, Wright, Box 753-X, Hagerstown, Maryland 21740.

100 DIFFERENT Turkey—15¢! Approvals, Bargain Pricelists. Yntema-Schneider, Box 728B, Holland, Mich. 49424.

PLANS AND KITS

TACHOMETER! Fully Transistorized for All make Cars. 0-10,000 RPM. Build for under $7.00. Send $2.00 for details. Group Laboratory, Box 87, Prospect Hts., Ill. 60070.

BUSINESS OPPORTUNITIES

INVESTIGATE Accidents—Earn $750 to $1,400 monthly. Men urgently needed. Car furnished. Business expenses paid. No selling. No college education necessary. Pick own job location. Investigate full time. Or earn $6.44 hour spare time. Write for Free Literature. No obligation. Universal, CZ-11, 6801 Hillcrest, Dallas 5, Texas.

SELL CB Equipment—Dealerships available to aggressive people who can sell Citizens Band Radio full or part time. Knox Electronic, Dept. 194, Galesburg, Ill. 61401.

FREE BOOK "990 Successful, Little-Known Businesses." Work Home! Plymouth-845K, Brooklyn, New York 11218.

I MADE $40,000.00 YEAR by mailorder! Helped others make money! Start with $10.00—Free proof. Torrey, Box 3566-N, Oklahoma City, Oklahoma 73106.

HELP WANTED

EARN extra money selling advertising book matches. Sample kit furnished. Matchcorp, Dept. MO-115, Chicago, Ill. 60632.

REAL ESTATE

FLORIDA WATER WONDERLAND—Home, cottage, Mobilsites. Established area. $590 full price, $9.00 a month. Swimming, fishing, boating. Write: Lake Weir, Box KE38, Silver Springs, Fla. AD 6-1070 (F-1)

FREE!—FALL-WINTER CATALOG Big, 180 pages! Selected Best thruout the U.S. Thousands of properties described, pictured—Land, farms, homes, businesses, —Recreation, Retirement. 490 offices, 35 states coast to coast. World's Largest. Mailed **FREE! STROUT REALTY**, 50-ZD East 42nd St., N.Y., N.Y. 10017.

DETECTIVES

DETECTIVE Opportunities. Experience unnecessary. Write, Wazgner, 125 W. 86th, New York 10024.

EMPLOYMENT INFORMATION

FOREIGN Employment. Construction, other work projects. Good paying overseas jobs with extras, travel expenses. Write only: Foreign Service Bureau, Dept. D, Bradenton Beach, Florida.

NEW ORLEANS and Vicinity Job Ads $2.00. C.I.E., Box 50794, New Orleans, La.

MISCELLANEOUS

WORLDWIDE Export and Buyers Guide $1.50. Burke Associates, Manchester, Mass.

100 WINE, Cider, and Beer Recipes. All State and Federal Laws 10 Day Guarantee. $2.50. Country Winemaker, Box 243EG, Lexington, Mass. 02173.

WINEMAKERS: Free illustrated catalog of yeasts, equipment. Semplex, Box 7108, Minneapolis, Minn. 55412.

POEMS Wanted for new Songs. Tin Pan Alley, Inc., 1650 Broadway, New York, N.Y. 10019.

ENVELOPES. Paper. Ribbons. Stencils. Carbons. Ink. Catalog: Tower, Lafayette Hill, Pa. 19444.

CLASSIFIED ADVERTISERS — the **1966 COMMUNICATIONS HANDBOOK** closes October 25th. For 75¢ a word, your advertising message will be seen and responded to for an entire year by 150,000 readers. And, if you act now, you can also include your classified ad in the **1966 SPRING ELECTRONIC EXPERIMENTER'S HANDBOOK** in combination with the **COMMUNICATIONS HANDBOOK** for just $1.10 a word. For even greater savings, reserve now for the **1966 FALL ELECTRONIC EXPERIMENTER'S HANDBOOK** and appear in all 3 Handbooks for $1.55 a word. Send copy and remittance today to Hal Cymes, 1 Park Ave., N.Y., N.Y. 10016.

CIRCLE NO. 101 ON READER SERVICE CARD

ELECTRONICS WORLD NOVEMBER 1965

ADVERTISERS INDEX

Printed in U.S.A.

WORLD'S LARGEST SELLING AND WORLD'S NEWEST Hand Size V-O-M's

TRIPLETT

MODEL 310-C
World's Newest
Volt-Ohm-Milliammeter

MODEL 310
World's Largest Selling
Volt-Ohm-Milliammeter

BOTH TESTERS SHOWN ACTUAL SIZE

1. **HAND SIZE AND LIGHTWEIGHT,** but with the features of full-size V-O-M's.
2. **20,000 OHMS PER VOLT DC; 5,000 AC (310)—15,000 AC (310-C).**
3. **EXCLUSIVE SINGLE SELECTOR SWITCH** speeds circuit and range settings. The first miniature V-O-M's with this exclusive feature for quick, fool-proof selection of all ranges.

SELF-SHIELDED Bar-Ring instrument; permits checking in strong magnetic fields. FITTING INTERCHANGEABLE test prod tip into top of tester makes it the common probe, thereby freeing one hand. UNBREAKABLE plastic meter window. BANANA-TYPE JACKS—positive connection and long life.

Model 310—$37.50 Model 310-C—$44.50 Model 369 Leather Case—$3.20

ALL PRICES ARE SUGGESTED U.S.A. USER NET, SUBJECT TO CHANGE

CIRCLE NO. 97 ON READER SERVICE CARD

THE TRIPLETT ELECTRICAL INSTRUMENT COMPANY, BLUFFTON, OHIO

310-C PLUS FEATURES

1. Fully enclosed lever range switch
2. 15,000 Ohms per volt AC (20,000 O/V DC same as 310)
3. Reversing switch for DC measurements

MODELS 100 AND 100-C

Comprehensive test sets. Model 100 includes: Model 310 V-O-M, Model 10 Clamp-on Ammeter Adapter; Model 101 Line Separator; Model 379 Leather Case; Model 311 leads. ($67.10 Value Separate Unit Purchase Price.) MODEL 100—U.S.A. User Net. .$64.50

MODEL 100-C—Same as above, but with Model 310-C. Net. $71.50

USES UNLIMITED: FIELD ENGINEERS • ELECTRICAL, RADIO, TV, AND APPLIANCE SERVICEMEN • ELECTRICAL CONTRACTORS • FACTORY MAINTENANCE MEN • ELECTRONIC TECHNICIANS • HOME OWNERS, HOBBYISTS

THE WORLD'S MOST COMPLETE LINE OF V-O-M's • AVAILABLE FROM YOUR TRIPLETT DISTRIBUTOR'S STOCK

New from RCA!

ALL SOLID-STATE CB 2-WAY RADIO WITH ALL SILICON TRANSISTORS

New RCA Mark 10 Transistorized CB Radio

only $189.95*

Here's the latest, and the finest in a long line of exceptional 2-way radios from RCA. The new all transistor RCA MARK 10 with the operating features you have been asking for...engineered to provide the most dependable communications possible. Check this partial list of RCA MARK 10 advantages:

- All silicon transistors assure dependable communications at temperatures ranging from −23° to +130°F.
- 12 crystal-controlled transmit and receive channels with illuminated channel selector
- Combination "S" meter and relative RF output meter
- Operates from 12-volts DC power source (positive or negative ground)
- 3-watt public address system with volume level fully controllable by receiver volume control
- Provision for tunable receive, AC operation, and external speaker (optional)
- Crystal-controlled double conversion, superheterodyne receiver provides frequency accuracies greater than 0.004%
- Separate AGC amplifier eliminates blasting and overloading, minimizes fading
- Six-stage IF bandpass filter for maximum selectivity without ringing
- Low distortion, series type noise limiter with automatic threshold adjustment
- Receiver power regulated for maximum stability
- Acoustically designed cabinet with audio characteristics shaped for maximum intelligibility
- External speaker jack (de-activates internal speaker)
- Compact, lightweight. Only 3⅜" high, 5¾" deep, 8½" wide, weighs less than 4½ pounds

See it at your Authorized RCA Citizens' Band Radio Distributor. To find him, look for stores displaying this symbol. It's your assurance of top-quality RCA CB equipment.

*Optional distributor resale price

RCA ELECTRONIC COMPONENTS AND DEVICES, HARRISON, N.J.

The Most Trusted Name in Electronics