Electronics World

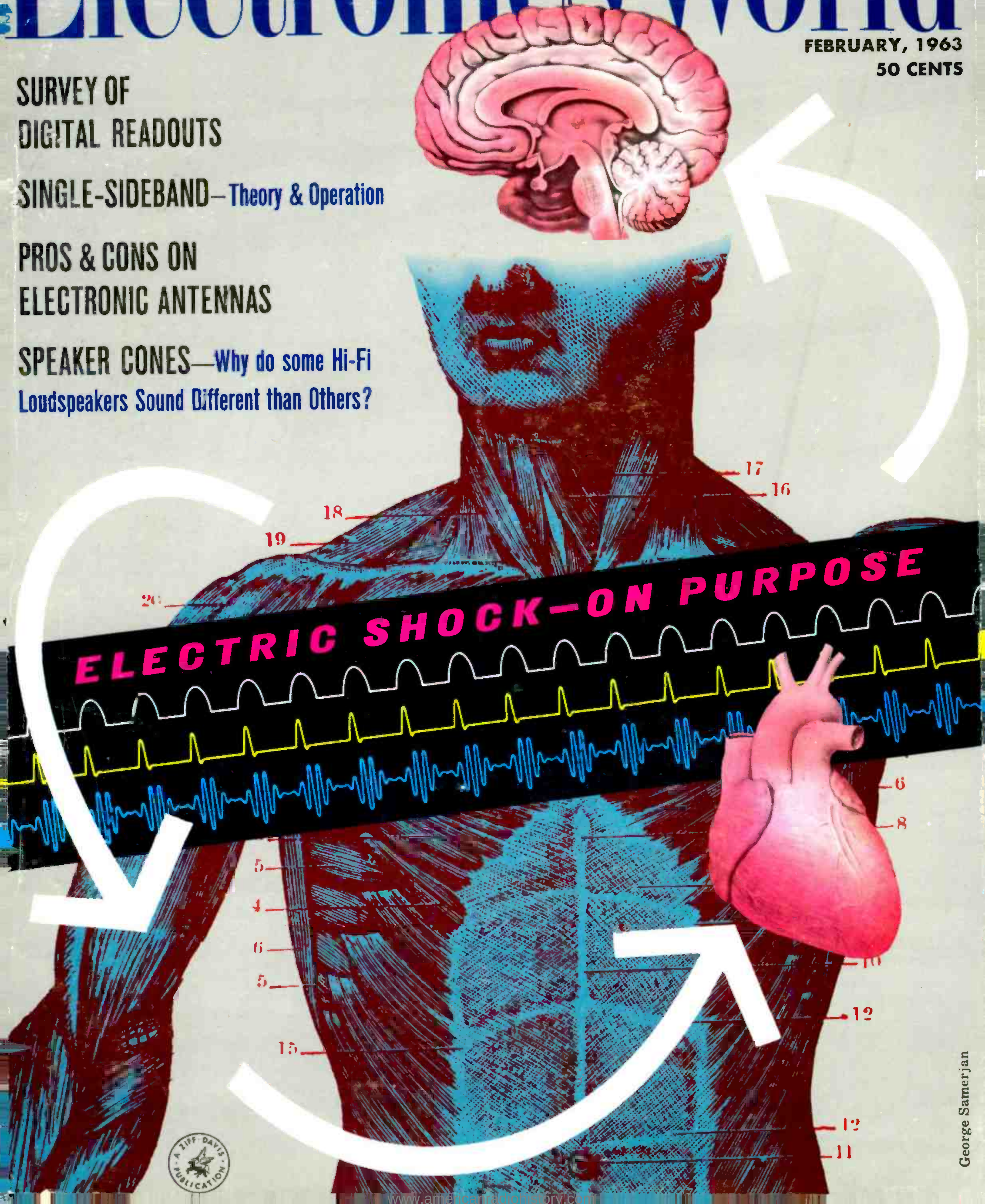
FEBRUARY, 1963
50 CENTS

SURVEY OF DIGITAL READOUTS

SINGLE-SIDEBAND—Theory & Operation

PROS & CONS ON ELECTRONIC ANTENNAS

SPEAKER CONES—Why do some Hi-Fi Loudspeakers Sound Different than Others?



George Samerjan

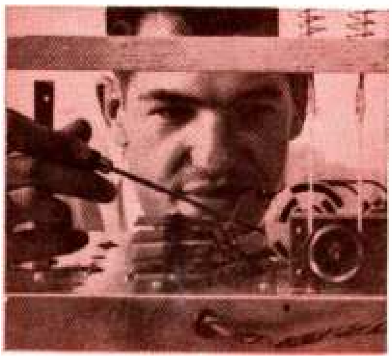
A ZIFF-DAVIS PUBLICATION

Where You Train Is As Important As Your Decision To Train

Electronics is a growing and expanding industry. That's why so many ambitious men are deciding to train for careers in this exciting field. They recognize the opportunities to advance and prosper. But, where a man trains and how the school of his choice teaches Electronics . how it encourages him to reach his goals and realize his ıbitions . . . is most important to his success.

ıis is a fast changing world. A school offering Electronics ·urses must keep pace. That's why NRI—with nearly 50 years specialized experience—now offers eight choices of training ithin the one field of Electronics. Select the course of most ·terest to you and receive the kind of home-study training that ·epares you for a specialized career. NRI's large staff of ·ecialists is always on the job keeping course material up-to-ıte . . . helping you earn your way while training . . . assisting ıu with job placement when ready. In short, whatever branch Electronics you select, NRI is qualified through ıowledge and experience to help you grow.

·ECIAL TRAINING EQUIPMENT INCLUDED



RI "learn by practice" ethod is the time-proved ay to learn easier, faster, ·tter. Most NRI courses in·ude—at no extra cost—spe·al training equipment to give ıop and laboratory experi·ıce in your own home. All ıuipment is yours to keep.

Projects you build, experi·ents you perform, make RI lessons come to life. Complex subjects become interest·g, easy to grasp. Your first projects are measuring voltage ıd current in circuits you build yourself. You use a Vacuum ıbe Voltmeter which you construct. Later on, you progress to more involved experiments. If you like working with your ıands, you'll enjoy learning Electronics with NRI.

·HE PROVEN WAY TO BETTER PAY

·est of all, NRI provides training right in your own home and . your spare time. No time wasted getting to school. You fit ·udy hours to your own schedule. You go as fast or as slow ; you like. Check the training of most interest to you; cut out ıd mail the postage-free card now. Read about Electronics ·pportunities, NRI courses, the NRI trial plan, convenient ·rms.

nri America's Oldest and Largest Radio-TV Electronics Home-Study School

Pick the ELECTRONICS CAREER You Want

1 INDUSTRIAL ELECTRONICS
Learn Principles, Practices, Maintenance of Electronic equipment used today in business, industry, defense. Covers Electronic controls and measurement, computers, servos, telemetry, multiplexing, many other subjects.

2 RADIO-TELEVISION SERVICING
Learn to service and maintain AM-FM Radios, TV sets, Stereo Hi-fi, PA systems, etc. A profitable, interesting field for part-time or full-time business of your own.

3 COMPLETE COMMUNICATIONS
A comprehensive training course for men seeking careers operating and maintaining transmitting equipment in Radio-TV Broadcasting or mobile, marine, aviation communications. Prepares you for FCC License.

4 FCC LICENSE
Prepares you quickly for First Class License exams. Every communications station must have one or more FCC-licensed operators. Also valuable for Service Technicians. You train at home.

5 MOBILE COMMUNICATIONS
Training in installation and maintenance of mobile equipment and associated base stations like those used by fire and police, taxi companies, etc. Prepares you for First Class FCC License exams.

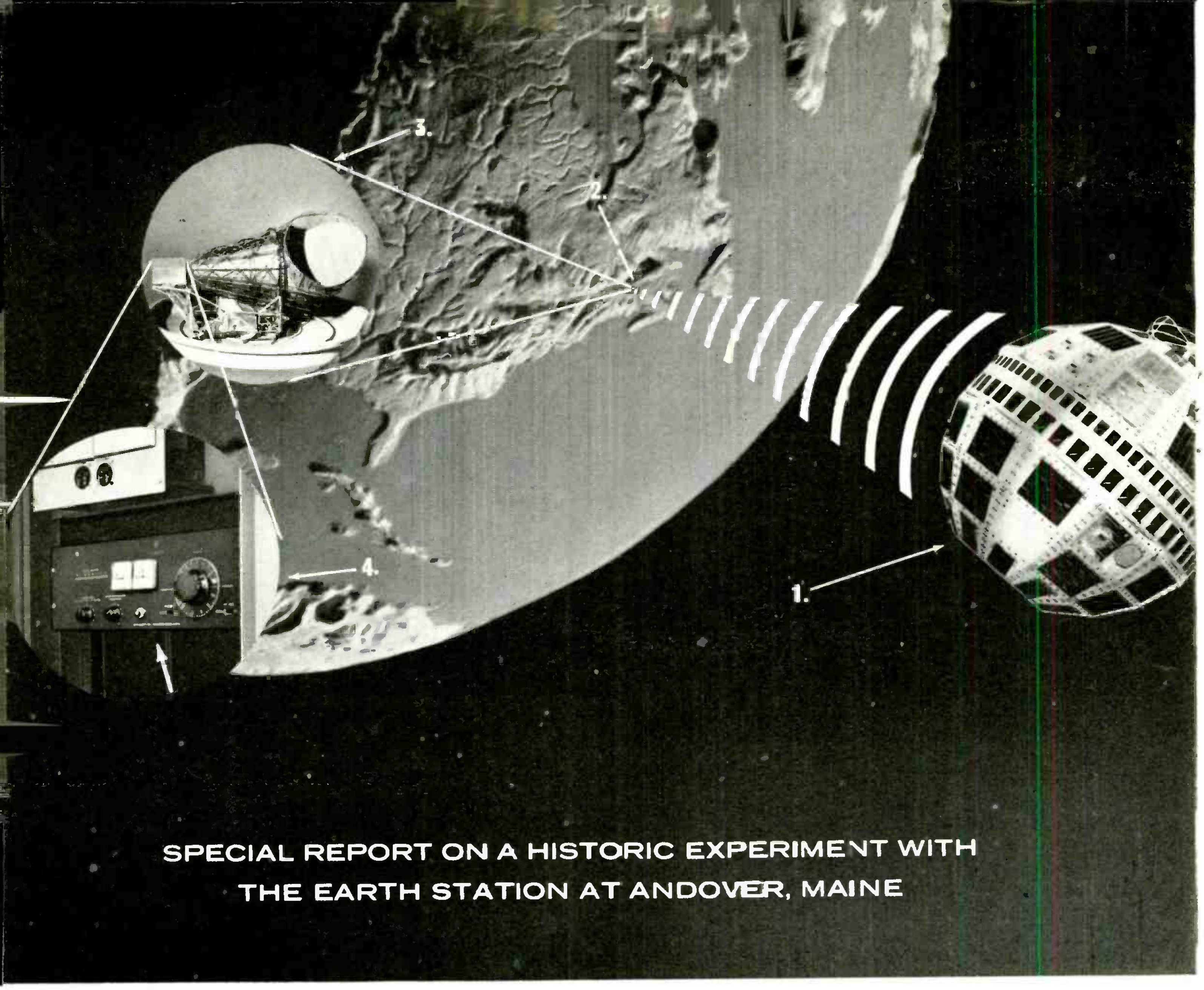
6 MARINE COMMUNICATIONS
Shipboard transmitting equipment, direction finders, depth indicators, radar are all covered in this course. You prepare for your First Class Radiotelephone License with Radar Endorsement.

7 AVIATION COMMUNICATIONS
For men who want careers working with and around planes. Covers direction finders, ranges, markers, loran, shoran, radar, landing systems, transmitters. Prepares you for FCC License exams.

8 MATH FOR ELECTRONICS
From basic arithmetic review to graphs and electronic formulas in one complete "short course" package of five carefully prepared texts. Quick, complete and low in cost.

MAIL POSTAGE-FREE CARD NOW

ELECTRONICS WORLD is published monthly by Ziff-Davis Publishing Company at 434 South Wabash Avenue, Chicago 5, Illinois. Subscription rates: one year United States and possessions $5.00; Canada and Pan American Union countries $5.50; all other foreign countries $6.00. 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. February 1963: Vol. 69, No. 2.



Scott® tuner used for Telstar tests...

Bell System engineers wanted to test FM reception from the Telstar Satellite orbiting in outer space. They used the sensitive Scott 310-D broadcast monitor tuner (rack mounted) for this unique experiment. FM signals were sent to Telstar where they were rebroadcast to the earth station for Communicating by Satellite at Andover, Maine. The Scott FM tuner was successfully used on this project.

Scott congratulates the Bell System on their spectacular achievement and is proud to be part of this historic project.

The Scott 310-D was a logical choice. Like all Scott tuners it offers exceptional sensitivity and selectivity. Scott pioneered Wide-Band FM circuitry. Scott engineers perfected "Time Switching" multiplex circuitry for high fidelity reception. Only Scott silver-plates FM front-ends for highest sensitivity. Scott invented the first foolproof FM Stereo signaling device — the Sonic Monitor*.

350B FM Stereo Tuner

If you want the very best FM Stereo reception choose the tuners selected by professionals . . . choose the tuner most FM stations use for monitoring their own broadcasts off the air . . . choose Scott, America's most reliable name in FM Stereo.

*Patent Pending

These superb Scott FM Stereo Tuners are proud products of the same engineering laboratories that developed the 310-D used in Telstar.

If you seek perfection choose one of these superb Scott tuners: 4310 Broadcast Monitor FM Stereo Tuner, $475*; 350B FM Stereo Tuner, $219.95*; 333 AM/FM Stereo Tuner, $259.95*; 370 FM Stereo Tuner, $169.95*; LT-110 FM Stereo Tuner Kit, $159.95*; 340 FM Stereo Tuner/70 Watt Stereo Amplifier, $379.95*; 355/208 AM/FM Stereo/80 Watt Stereo Tuner Amplifier, $469.90*.

Here's how the "Telstar" experiment worked

1. FM signals were relayed from Bell Telephone System Telstar satellite orbiting the earth at 16,000 M.P.H. at heights varying from 500 to 3,000 nautical miles. **2.** Signals were beamed to the "Earth Station for Communicating by Satellite" at Andover, Maine, where **3.** a giant horn antenna 180-feet long and 95-feet high received the signals. **4.** Installation of Scott 310-D Broadcast Monitor Tuner (Rack Mounted) at Andover, Maine.

Write today for new 1963 Hi-Fi Guide including complete details on Scott FM Stereo tuners and kits and complete "Telstar" report.

SCOTT®

H. H. SCOTT Inc., 111 Powdermill Rd., Maynard, Mass. Dept. 160-2
Export: Morhan Exporting Corp., 458 Broadway, N.Y.C.
Canada: Atlas Radio Corp., 50 Wingold Ave., Toronto

*Slightly higher west of Rockies, subject to change with this notice.

FEBRUARY 1963 / VOL. 69 NO. 2

Electronics World

CONTENTS

INDUSTRIAL

TEST EQUIPMENT

HI-FI AND AUDIO

GENERAL

COMMUNICATIONS

MONTHLY FEATURES

ZIFF-DAVIS PUBLISHING COMPANY
Editorial and Executive Offices
One Park Avenue
New York 16, New York
ORegon 9-7200

MIDWESTERN and CIRCULATION OFFICE
434 South Wabash Avenue
Chicago 5, Illinois
WAbash 2-4911
Midwestern Advertising Manager
Gilbert J. Jorgenson

WESTERN OFFICE
9025 Wilshire Boulevard
Beverly Hills, California
CRestview 4 0265
Western Advertising Manager
Bud Dean

FOREIGN ADVERTISING REPRESENTATIVE
D. A. Goodall Ltd., London, England

NEW TV CO

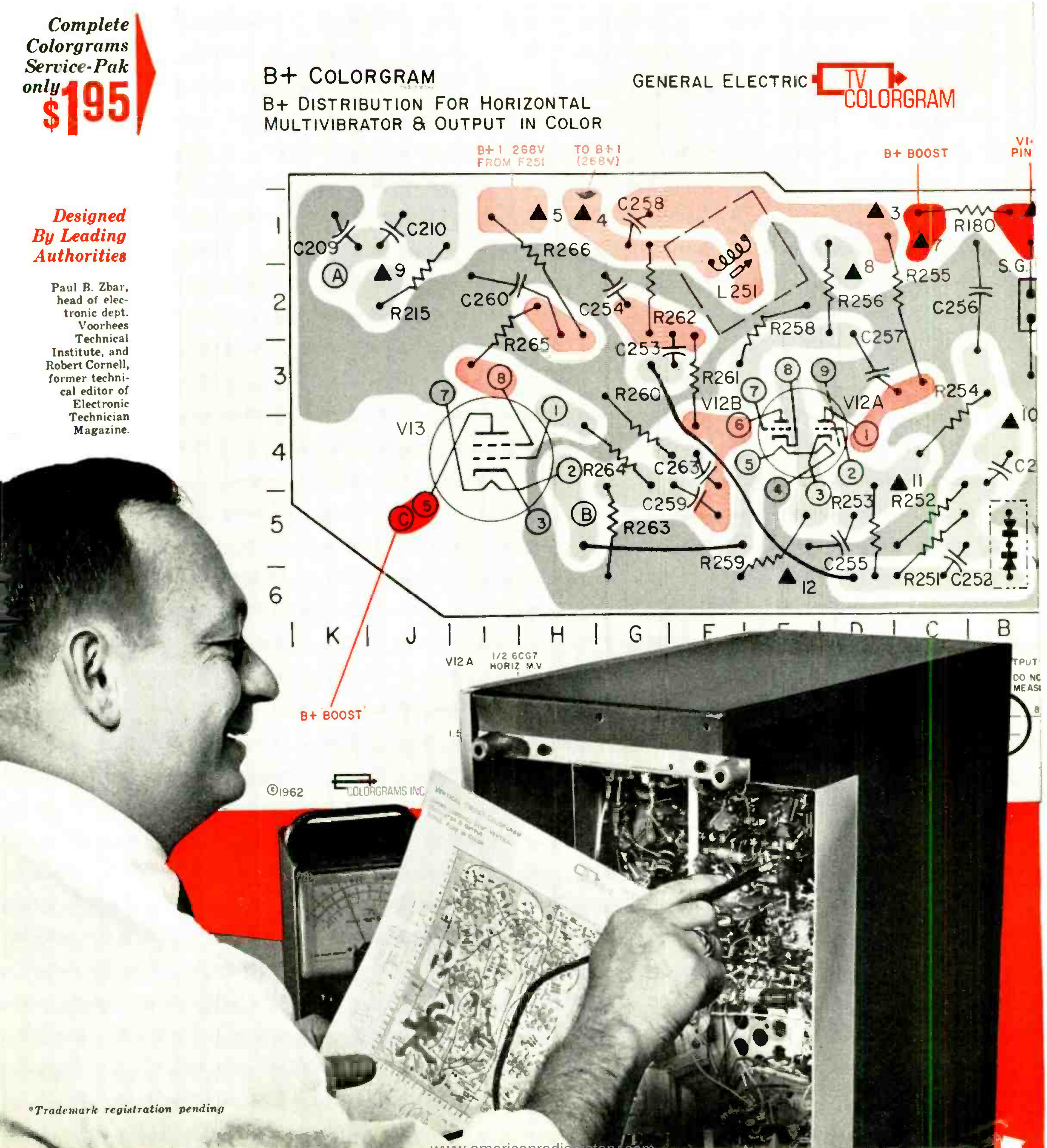
amazing color-coded system pinpoints

• individual COLORGRAM CHARTS highlight specific TV receiver functions • RAPID REPAIR MANUAL

***Complete Colorgrams Service-Pak only* $1.95**

Designed By Leading Authorities

Paul B. Zbar, head of electronic dept. Voorhees Technical Institute, and Robert Cornell, former technical editor of Electronic Technician Magazine.



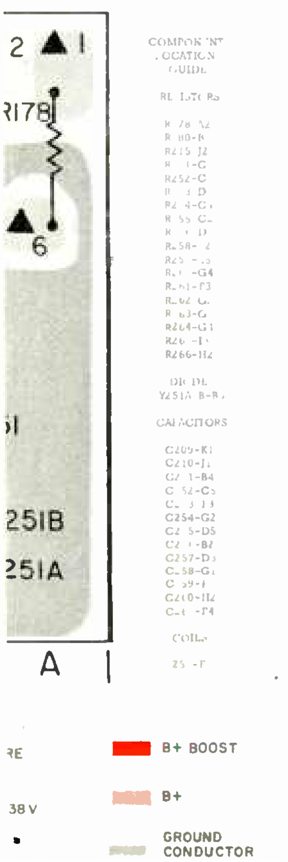
*Trademark registration pending

LORGRAMS*

hard-to-find components, conductors

- COLOR-KEYED MASTER SCHEMATIC
- all based on original TV manufacturers' data

CHASSIS: LW



PRINTED U.S.A.

COLORGRAM Charts (see sample on left hand page) are the key to a remarkable new method designed to help you isolate TV receiver difficulties in less time and with less effort than has ever before been possible. The COLORGRAM system simplifies the use of any repair procedure you normally use.

EACH COLORGRAM CHART SHOWS SEPARATE CIRCUIT SECTIONS

Each COLORGRAM Chart is clearly color-coded to show signal-flow and continuity as distinctly as the color-marked route on a road map. Each COLORGRAM Chart shows test points and voltages. The entire ground conductor is shown in its own distinctive color throughout all the COLORGRAM Charts. Every component in the circuit is clearly identified, and its relationship to other components made readily recognizable.

There is a COLORGRAM Chart (like the sample shown) for each of these TV receiver functions: *IF*, *Video*, *Audio*, *Vertical* and *Horizontal*, (showing sync and sweep circuits), *B+ distribution* and *AGC circuitry*.

COLORGRAMS ISOLATE TROUBLE AREAS

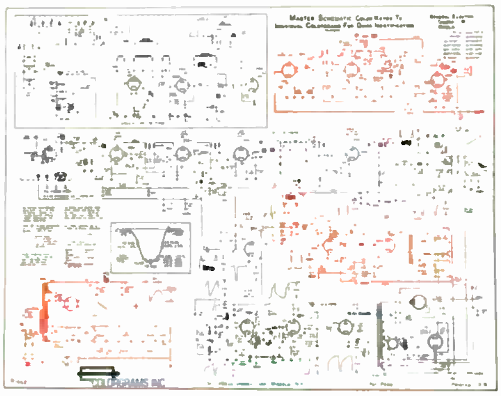
Each COLORGRAM Chart enables you to color-shoot with little or no reference to schematic or manual. If you have a video problem, refer to the Video COLORGRAM Chart—audio problem, the Audio COLORGRAM. The circuit is conveniently color-coded, localized and isolated. Even when a signal leaves the board and then returns, components and signal path are clearly indicated. You can concentrate on that small portion of the set most likely to be the cause of trouble. There's no time wasted working back and forth between schematic and set looking for test points — wading thru superfluous information—identifying components incorrectly.

SPEED PRINTED CIRCUIT SERVICING

Where receivers use printed circuits, each COLORGRAM Chart represents the actual signal conductor pattern of the specific PC board, exactly as you see it in the set. Color-coding helps you easily concentrate on the signal flow of interest. And each component is clearly located and identified.

COLOR-KEYED MASTER SCHEMATIC IDENTIFIES COLORGRAM CHART AREAS

Easy-to-read schematic, provides an overall view of the receiver circuit. Shows the *Tuner*, *IF*, *Video*, *Audio*, *Vertical* and *Horizontal* sections, color-keyed to the colors used in individual COLORGRAM Charts. Also includes test points, waveforms, voltage, resistance, capacitance, practical alignment data, etc.



RAPID-REPAIR MANUAL CONTAINS PRACTICAL SERVICE DATA

This effective guide to the use of the COLORGRAM System contains original manufacturer's service notes, special instructions, circuit modifications, parts list and parts numbers. Includes Pictorial Tube and Component Location Charts, Tube Failure Guide.

COLORGRAMS can help you with your TV repair problems—ACT TODAY!

NOW AVAILABLE
TV Colorgram Service Paks For:
☆ RCA ☆ General Electric ☆ Motorola ☆ Admiral ☆ Emerson ☆ Philco ☆ Westinghouse ☆ Magnavox. *Other popular makes and circuits to be announced soon.*

get the colorgram story use this coupon

COLORGRAMS* INC.
Division of TVDevelopment Corp.
469 JERICHO TURNPIKE
MINEOLA, NEW YORK

Please send me:
( ) Free cross-referenced COLORGRAM catalog.
( ) Name of nearest Colorgram distributors

NAME ______________________ (please print)

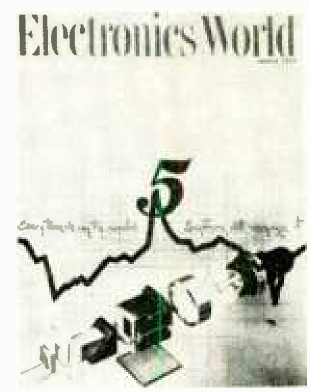
COMPANY ______________________

CITY ______________ ZONE ______ STATE ______________

Please fill in this information. My occupation is:
( ) TV technician ( ) Engineer ( ) Hobbyist ( ) Other ________ (please specify)

CIRCLE NO. 108 ON READER SERVICE PAGE

COMING NEXT MONTH



Special Features

Bionic Computers—Machines that Imitate the Brain—Will future computers be able to learn, reason, and think for themselves? By studying the human brain and nervous system and by imitating their operation, we are building electronic devices that come close to approximating "human" performance.

Sound-Operated Fiber-Optic "Brain Cell"—Details on a practical application of "bionics" as represented by Sperry Gyroscope Company's "SCEPTRON," a spectral comparative pattern recognizer which identifies signals by their spectrum or frequency content. The unit can be exposed to any signal in the audio frequency range and will memorize it—it will then recognize that signal when it is repeated.

ANTENNAS FOR BUSINESS RADIO

Most users, and even some engineers, do not fully appreciate how much the antenna contributes to the over-all performance of a two-way radio system. Howard H. Rice of Motorola Inc. has prepared a basic "handbook" of antenna types, outlining the advantages and disadvantages of each and discussing installation and maintenance procedures for maximum radiation.

TURNTABLE TESTING AT HOME

Edgar Villchur, president of Acoustic Research, Inc., details the most important characteristics which can be checked by the audiophile at home to determine the performance of his own turntable. The tests are relatively simple and the techniques involved produce results that are just as valid as many lab measurements. Among the characteristics that can be checked in this way are speed drift, warp wow, arm inertia and pivot friction, tracking error, and the use of test records for determining flutter and rumble.

SOLID-STATE 3-CHANNEL COLOR ORGAN

A compact, well-designed display device that produces changes in color intensity and hue in step with musical signals. This transistorized unit can be connected to the output of any hi-fi amplifier and is capable of handling up to 1 kw. of light power.

COLOR-PATTERN GENERATORS

Curious about how an NTSC-bar or rainbow pattern are produced? Walter J. Cerveny, chief engineer for The Hickok Electrical Instrument Co., provides the answers on operation, applications, and points to consider before making the purchase of such an instrument.

All these and many more interesting and informative articles will be yours in the March issue of ELECTRONICS WORLD . . . on sale February 19th.

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

M. T. Birmingham, Jr.
Vice President and Treasurer

Robert P. Breeding
Circulation Director

Charles Housman
Financial Vice President

Stanley R. Greenfield
Vice President

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 Department, 434 South Wabash Avenue Chicago 5 Illinois. 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

← CIRCLE NO. 137 ON READER SERVICE PAGE

CIRCLE NO. 131 ON READER SERVICE PAGE

...for the Record

By **W. A. STOCKLIN**
Editor

New CB Regulations

In our editorial "CB and the FCC" (July, 1962 issue) we discussed a new law involving the FCC which would apply to class D Citizens Band licensees. Basically, it concerned the forfeiture of licenses and the imposition of rather severe fines for violating operating rules and regulations. We did feel, before further penalties were imposed, that the FCC should re-evaluate the problem and clarify, once and for all, proper CB operation and regulations.

As a result of similar suggestions from many other sources, the FCC has finally prepared extensive amendments to Part 19 of its Rules and Regulations as pertains to the Citizens Band. We have just received a copy of the proposed amendments and regulations and find that not only have they clarified many of the previously misinterpreted regulations, but they have spelled out in considerable detail just what is and what is not permitted in the Citizens Band. The proposed amendments are much too long to be reprinted here, but we would like to review some of the more important changes.

1. Communications among units of different stations will be restricted to only five channels in the Citizens Band. These are channels 12 (27.105 mc.), 13 (27.115 mc.), 14 (27.125 mc.), 15 (27.135 mc.), and 23 (27.255 mc.). Communications among units of the same station will be permitted on all 23 channels.
2. Except for communications between units of the same station, there will be a 3-minute time limit on contacts between stations. After this 3-minute period, the stations must remain silent for at least 5 minutes and monitor their frequencies before any further communications are made.
3. Transmissions relating to the technical performance or capabilities of the radio equipment will be forbidden, except for brief tests not exceeding 1 minute during any 5-minute period. This testing must not interfere with any communications already in progress.
4. Unincorporated associations will no longer be eligible for a station license, except if proof can be shown that a station license could not feasibly be issued to an individual member.
5. The maximum power input permitted will remain at 5 watts, but maximum power output will now be restricted to 3.5 watts.

Other prohibitions include the transmission of material intended for entertainment purposes, for advertising, or promoting the sale of goods or services. Messages transmitted in codes, ciphers, or by speech scramblers will not be allowed. A licensee of a CB station who sells such equipment may not allow prospective customers to operate under his license. Communications over a distance of more than 150 miles is not allowed.

There are, of course, a great number of other changes. Those listed above are, in essence, the major points of interest. Bear one thought in mind, that the FCC has again emphatically stated with respect to CB operation, "There has been no intention to permit the operation of radio solely for the amusement of the operator or as a hobby in or of itself."

These new restrictions will, at least on the surface, seem to be quite rough on a good many users of Citizens Band equipment, particularly those who are trying to use the band for no useful purpose other than hobby activity. On the other hand, we feel that the FCC has been patient long enough, has been quite fair, and should be congratulated on a job well done.

The most drastic change is the one confining communications between units of different stations to only five channels. It is in these cases that most of the "hamming" has occurred, and those individuals who have found great enjoyment in this form of communications will, obviously, complain vehemently. This reaction is certainly unjust since we do have available many types of amateur radio licenses and amateur radio bands where this form of operation is not only permitted, but frankly encouraged.

There is a real need for the Citizens Band for private use as well as for business. Considering that we now have 350,000 licensed users, all since 1958, and that there is limited radio spectrum space available, we should make every effort to use these channels wisely and in the spirit for which they were originally intended. ▲

LETTERS FROM OUR READERS

TUBES FOR HI-FI

To the Editors:

I have just read your editorial on transistorized hi-fi equipment in the December ELECTRONICS WORLD.

I think that you do a disservice to your readers by implying that transistors are inherently better than tubes. There is no reason why transistorized equipment, *per se*, should have wider frequency response, better transient response, less phase shift, higher damping factor, or any other advantage which you discuss. Transistors can result in more compact and more efficient equipment—but these advantages have nothing to do with quality of sound reproduction.

The transistor amplifier does give the opportunity to dispense with the output transformer (although tubes also permit this with some added complications). This will ultimately result in a reduction of cost but some of the other attributed advantages are rather dubious. I think you will find that every engineer will agree that a transformer is a far more linear device than a transistor. Getting rid of the transformer does not automatically bring an improvement in quality. On the contrary, the elimination of the transformer creates severe problems of impedance matching, d.c. off-set of the loudspeaker, and other disadvantages.

In a few years, it should be practical to make transistorized equipment which can compete with tube equipment on the basis of quality and price. Which type will sound better cannot be predicted at this point since nobody has sufficient knowledge of the relative contribution made by each of the many subtle factors which influence sound quality. Anybody who expects a major breakthrough in sound quality has been more exposed to copywriting than to laboratory efforts.

DAVID HAFLER
President, Dynaco, Inc.
Philadelphia, Pa.

° ° °

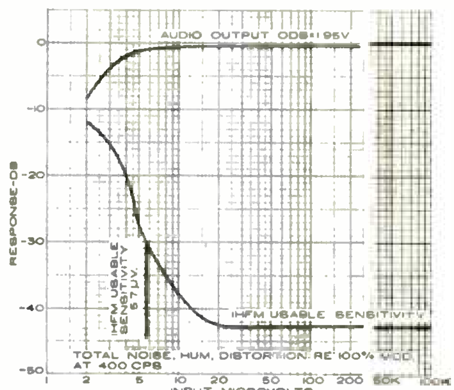
DYNA FM TUNER

To the Editors:

I found your lab report on the *Dyna* FM tuner (FM-1) and multiplex adapter (FMX-3) quite interesting and informative. However, the figure given in the text for IHFM usable sensitivity does not agree with the value shown on your graph (page 24). Which is correct?

ROBERT SWEENEY
Akron, Ohio

Reader Sweeney's eyes are much sharper than those of our printer. Although the page had the correct cut on it when we proofread the lab report, an incorrect cut was inserted on the page just before it was printed. The correct



graph for the Dyna tuner and adapter is shown here. Note that the IHFM usable sensitivity measured by Hirsch-Houck Laboratories *is 5.7 microvolts and that the 0-db audio output is 1.95 volts r.m.s.*
—Editors.

° ° °

NON-DIRECTIONAL STEREO

To the Editors:

I was extremely disappointed in the article "Non-Directional Stereo Effects" by Charles J. Hirsch in your October issue. It seems to have been based on the argument that: "Stereo is better, therefore stereo is better."

In a very scholarly way, Mr. Hirsch has made several extremely poor comparisons. For instance, he states that the major drawback of monophonic reproduction is the cancellation of tones from two out-of-phase sources at the same frequency. At the same time he states that two musicians cannot synchronize their instruments to the accuracy needed to sustain this cancellation. Normally there are several instruments in an orchestra producing tones of nearly the same frequency with random phase orientation. Any two of these tones may cancel momentarily, but for all to cancel simultaneously is highly improbable.

On the basis of random phase relationships, and varying individual amplitudes, the resultant is normally a non-zero variable. Such a summation takes place at each ear continuously, whether the sounds come from a single speaker or multiple speakers.

Mr. Hirsch also draws an invalid comparison between binaural listening (with

earphones) and stereo listening. He claims that "stereo suffers *appreciably fewer* annulments of tones and creates appreciably fewer beats." The first part of this statement may be true, since doubling the number of speakers doubles the number of random phase vectors, but this is equally true of two speakers for monaural sound. The latter part is manifestly *not true*. The beat notes are due to non-linearity of the human ear, and any two signals at sufficient amplitude and different frequency will produce a beat note. Both of these signals may be on the same channel (L or R), is which case there is *no advantage* over monaural listening. However, one may be on one channel and one on the other. In this case there is a slight advantage (2 to 3 db) in the beat amplitude due to the attenuation of the R channel in reaching the left ear and the L channel in reaching the right ear. Under normal stereo listening conditions, the opposite channel attenuation will not exceed this amount.

A further indication of the prejudice displayed is in the conduct of the "field tests," in which the listener was allowed to select the form of reproduction himself, as well as evaluate the quality. Such a test, in an area such as this where the differences included are at the limit of detection, is completely worthless. Only a slight pre-bias towards stereo (and *everyone* knows that stereo sounds better!) would end in overwhelming results toward the stereo reproduction. The only way to evaluate these small differences is to have the listener select the type of reproduction he likes best without *knowing* which type it is.

I found the article stimulating and full of new ways of stating well-known facts, but I consider that the conclusions reached were established *a priori*, and the argument filled in to that end. A large portion of the discussion is valid with respect to differences between binaural channels, but is invalid with respect to occurrences within a given channel (L to R), and is not valid for stereo to the extent that stereo is *not* binaural.

LT. CMDR. ROBERT IRVING, U. S. Navy
Engineering Duty (Electronics)

° ° °

SILICON RECTIFIER CHECKER

To the Editors:

The article "Silicon Rectifier Checker" appearing on page 98 of the November, 1962 issue of ELECTRONICS WORLD was taken from a "Tech-Tip" I wrote. Unfortunately, the parts list contained an error in two resistor values. $R4$ and $R5$ should each be 14 ohms instead of the 10-ohm value indicated.

K. H. SUEKER
Technical Products Manager
Westinghouse Electric Corp.
Youngswood, Penna. ▲

READER SERVICE PAGE

Please use the coupon at the bottom of this page to obtain more information about products advertised in this issue.
Simply circle the number on the coupon that corresponds to the number at the bottom of the advertisement in which you are interested.

Additional information on items mentioned in **"New Products & Literature"** can also be obtained by following this same procedure.

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

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

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

TOTAL NUMBER OF REQUESTS

N **Void After Feb. 28, 1963** **2**

Please send me additional information concerning the products of the advertisers whose code numbers I have circled.

100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119
120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139
140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159
160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179

NEW PRODUCTS & LITERATURE

						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	36	37	38
39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60

(Key numbers for advertised products also appear in Advertisers Index)

NAME ____________________

ADDRESS ____________________

CITY ____________________ ZONE ________ STATE ____________________

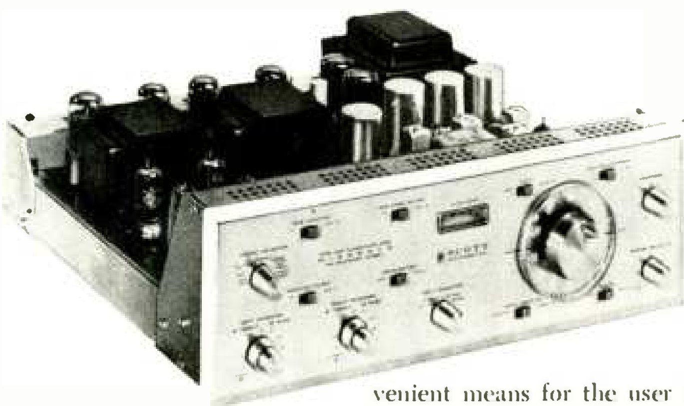
EW Lab Tested

AUDIO PRODUCTS TESTED BY HIRSCH-HOUCK LABS

H. H. Scott Model 340 Integrated Tuner-Amplifier
Don Bosco PHD-100 Universal Signal-Tracer Lab Set (page 20)
Citroen Model 660 Tape Recorder (page 96)

H. H. Scott Model 340 Integrated Tuner-Amplifier

For copy of manufacturer's brochure, circle No. 58 on coupon (page 15).



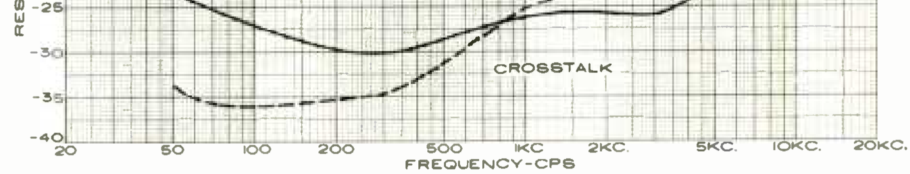
THE *Scott* 340 is a complete stereo tuner-amplifier on one chassis. It has an FM stereo tuner, essentially similar to the company's Model 350, plus a 60-watt stereo amplifier and preamplifier.

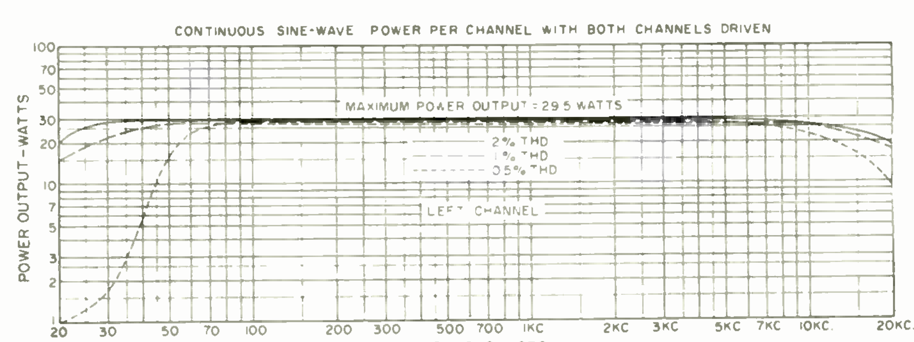
The tuner has a cascode r.f. amplifier, pentode mixer and triode oscillator, two i.f. amplifiers, a limiter, and a wide-band ratio detector. The multiplex decoder uses switching circuitry. A unique feature is the "Sonic Monitor" for identifying stereo broadcasts. When the "Sonic Monitor" switch is placed in the "Monitor" position, the 38-kc. oscillator in the multiplex decoder is detuned a few hundred cycles. Its output is combined with the 19-kc. received pilot carrier in the diode detector. The second harmonic of the 19-kc. carrier, generated in the diode, beats with the internal oscillator to produce an audible tone in the speakers. If no pilot carrier is present, only a slight rushing sound is heard.

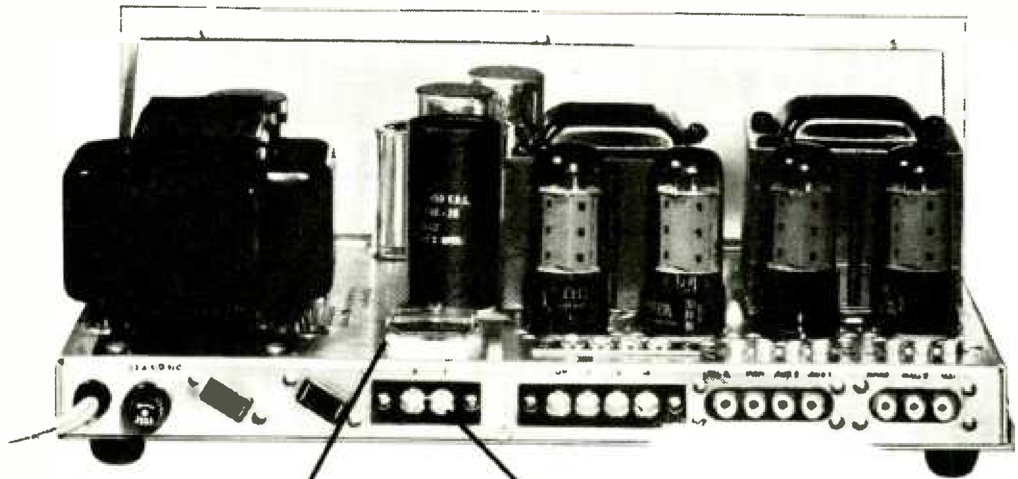
The "Sonic Monitor" is not automatic—there is no indication on a stereo broadcast when it is in its "Listen" position. However, it does offer one real advantage over ordinary visual signal indicators. When the tuning dial is adjusted for loudest and clearest audio tone, the best stereo separation is obtained. In general, stereo tuners do not give their optimum separation when tuned for maximum signal level, but until now there has not been any convenient means for the user to optimize his tuning. With the "Sonic Monitor", we found that the tuner-amplifier could be tuned by ear to obtain the best separation of which the unit was capable.

The amplifier is rated at 30 watts per channel (music power), using a pair of 7591 output tubes in each channel. There are inputs for high- and low-level magnetic cartridges, plus a tape head. A front-panel switch selects the appropriate equalization for record or tape listening. The input selector has positions for phono (or tape), FM mono, FM stereo, plus an extra high-level input. There is a switchable sub-channel filter which reduces noise in stereo reception, at some loss of separation. There are the usual bass and treble tone controls, separate for each channel. The volume control can be loudness compensated by a slide switch, boosting the bass response at the lower volume settings. There is also a tape monitor switch, for listening to tape recordings off the tape as they are being made. A scratch filter is effective on all inputs.

The stereo selector switch is exceptionally flexible. In addition to normal stereo and reversed-channel stereo, it has "Bal. Left" and "Bal. Right" positions, in which both channels are combined and fed to only one speaker at a time. These positions are used with the bal-







1. Others don't have this.

2. Others don't have this.

3. Others <u>can't</u> have this.

Three points of superiority of the Fisher KX-200 StrataKit over all other single-chassis stereo control-amplifier kits:

1. Built-In d'Arsonval Meter. For easy, positive adjustment of bias and balance — with laboratory accuracy. Assures peak performance from the start; permits 'touching up' for continued peak performance throughout the years, regardless of tube aging. No other single-chassis control-amplifier kit has this vital feature.

2. Third-Speaker Output with Volume Control. Blends the two stereo channel outputs to feed a third loudspeaker system—at any desired volume level. Ideal for center-channel stereo fill-in or for a mono extension speaker in another room. Another Fisher exclusive among control-amplifier kits.

3. The Fisher Name. The inimitable Fisher exclusive. Your guarantee of a head start in kit building — before you even pick up your screwdriver.

And there is something **under** the chassis, too, that others don't have: StrataKit construction — assembly by totally error-proof stages (strata). Each stage corresponds to a **separate** fold-out page in the instruction manual. Each stage is built from a **separate** transparent packet of parts (StrataPack). Major components come already mounted on the extra-heavy-gauge steel chassis. Wires are **pre-cut** for every stage — which means every page. Result: Absolutely equal success by the experienced kit builder or the completely unskilled novice!

The KX-200 has a power output of 80 watts (IHFM Standard) — 40 watts per channel. Harmonic distortion at rated output is 0.4%. The architectural brass-finish control panel is styled to match all other Fisher-built components. Price **$169.50***.

The KX-100 StrataKit, an advanced 50-watt stereo control-amplifier kit with center-channel speaker output, $129.50*.

The KM-60 StrataKit, world's most sensitive FM Stereo Multiplex wide-band tuner available in kit form, $169.50*.

The KS-1 3-way speaker kit, only Slim-Line loudspeaker system available in kit form, $59.50.**

FREE! $1.00 VALUE! The Kit Builder's Manual: a new, illustrated guide to high-fidelity kit construction.

The Kit Builder's Manual

FISHER RADIO CORPORATION
21-38 44th Drive
Long Island City 1, N. Y.

Please send me without charge The Kit Builder's Manual, complete with detailed information on all Fisher StrataKits.

Name____________________

Address____________________

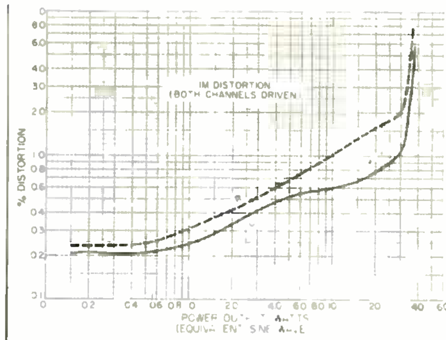
City________Zone____State________

07211

THE FISHER

*WALNUT OR MAHOGANY CABINET $24.95. METAL CABINET, $15.95. **IN UNFINISHED BIRCH ($64.50 IN UNFINISHED WALNUT.) PRICES SLIGHTLY HIGHER IN THE FAR WEST.
EXPORT: FISHER RADIO INTERNATIONAL, INC., LONG ISLAND CITY 1, N. Y. CANADA: TRI-TEL ASSOCIATES, LTD., WILLOWDALE, ONT.

CIRCLE NO. 117 ON READER SERVICE PAGE



ance control to adjust the relative channel volumes. There are also positions in which either right or left channel is fed to both amplifier channels and speakers, and one in which the outputs of a stereo cartridge are paralleled for playing mono records.

In our lab measurements, the IHFM usable sensitivity of the FM tuner was 3.6 μv. At 100% modulation, the distortion of the tuner was 1.4%, increasing somewhat at very high signal-input levels. The stereo performance of the tuner was excellent, with channel separation of 30 to 35 db at lower frequencies and better than 20 db all the way up to 8 kc. As mentioned before, these figures are typical of those obtainable by the user, because of the "Sonic Monitor."

The tuner had very low drift (there is no a.f.c.), a capture ratio of 5 db, and extremely low hum (−65 db referred to 100% modulation).

The amplifier had excellent frequency response and equalization characteristics, being within ± 1.5 db of the ideal response from 20 to 20,000 cps. The scratch filter was mild in its action, but nevertheless quite effective. The power amplifiers exceeded the manufacturer's specifications handily, developing over 30 watts per channel in continuous operation (with both channels driven) at 2% IM distortion. At outputs under 10 watts, the IM distortion was a fraction of a per-cent. The power response was quite uniform over the entire range, with full output obtainable at 1% or 2% harmonic distortion. At 0.5% distortion, the output below 50 cps was limited. Hum levels were low, about −70 db to −80 db on the "Extra" input and −64 db on "Phono," referred to 10 watts. The amplifier was stable under any capacitive or resistive load we could apply.

The 340 operated as nicely as it measured, delivering top quality sound from both tuner and phono inputs. We did feel that the switching system for the FM stereo and "Sonic Monitor" sections was undesirably complex. For example, the "Sonic Monitor" switch must be set to "Monitor" to tune in a stereo broadcast, and returned to "Listen" to hear the program. The input selector must be set to "FM MPX" to make this circuit operative. Finally, there is an a.g.c. switch which must be in "Mono" for the tuning meter to operate, and should be

in "MPX" when listening to stereo broadcasts. We could not detect any improvement in stereo broadcast noise levels when using it, however. It would be much more convenient if the "Sonic Monitor" function could have been included as an extra position on the input selector switch, which would make its use a simple one-handed operation.

Apart from these minor criticisms, the *Scott* 340 must certainly be classed as one of the finest integrated stereo tuner-amplifiers we have tested. It sells for $379.95, less case. ▲

Don Bosco PHD-100 Universal Signal-Tracer Lab Set

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

THE PHD-100, manufactured by *Don Bosco Electronics, Inc.*, is a novel signal-tracing instrument. Incorporating the company's "Stethotracer" and additional accessories, the set should prove very useful as a laboratory and field tool, as well as for radio and TV servicing. The "Stethotracer" resembles a fountain pen in size and shape, and contains a tiny 3-transistor amplifier and a 1.5-volt battery. The clip serves as a power switch, turning the unit on when it is pushed toward the tip of the "pen."

The amplifier output appears at a miniature connector on the side of the case, into which plugs a three-foot cord. The other end can be plugged into a small earphone, or a twin banana-plug adapter for connecting to a v.t.v.m. or oscilloscope. The input of the amplifier accepts any of several interchangeable heads, which extend the usefulness of the "Stethotracer" into many areas. The basic attachments include three prod tips, having 0-db, 20-db, and 40-db attenuation. A fourth prod has a built-in diode, and is used as an r.f. detector.

There are five additional screw-on heads for special applications. One has a standard phone jack, into which the output of a phono cartridge or tape head may be plugged. Another contains a 93-mil track width magnetic tape head, which can be held against a moving magnetic tape or sheet, allowing the program to be heard without additional amplification. This can be used to study magnetic recording behavior. There is a dynamic microphone head, covering speech frequencies, and a vibration pick-up operating from 200 cps to beyond audibility. Finally, there is a gold-plated microwave demodulator head, covering from 300 mc. to 10,000 mc. The entire set comes in a handsome, fitted case, measuring 10⅜" x 7¼" x 1½".

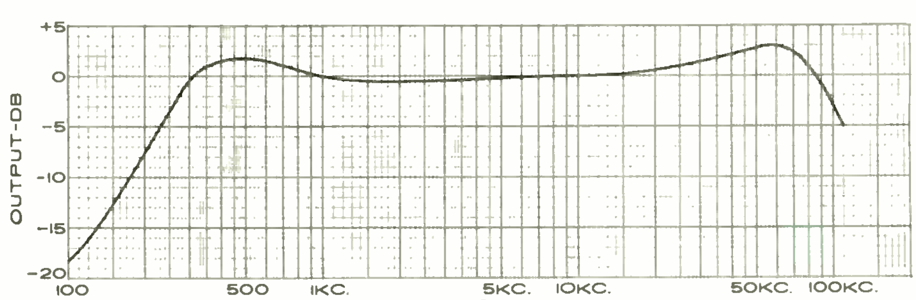
We measured the electrical performance of the "Stethotracer" by driving it from an audio generator and measuring its frequency response and distortion. This was done with the output adapter connected to an oscilloscope and v.t.v.m.

Frequency response was within ±3 db from 250 cps to 100,000 cps, falling steeply outside these limits. Mid-frequency voltage gain was 800. Since the input impedance is much higher than the output impedance, the actual power gain is much higher. The nominal output impedance is 600 ohms. The input impedance at 1000 cps was 4000 ohms direct, 50,000 ohms through the 20-db head, and 330,000 ohms through the 40-db head. Through the r.f. head it was 50,000 ohms.

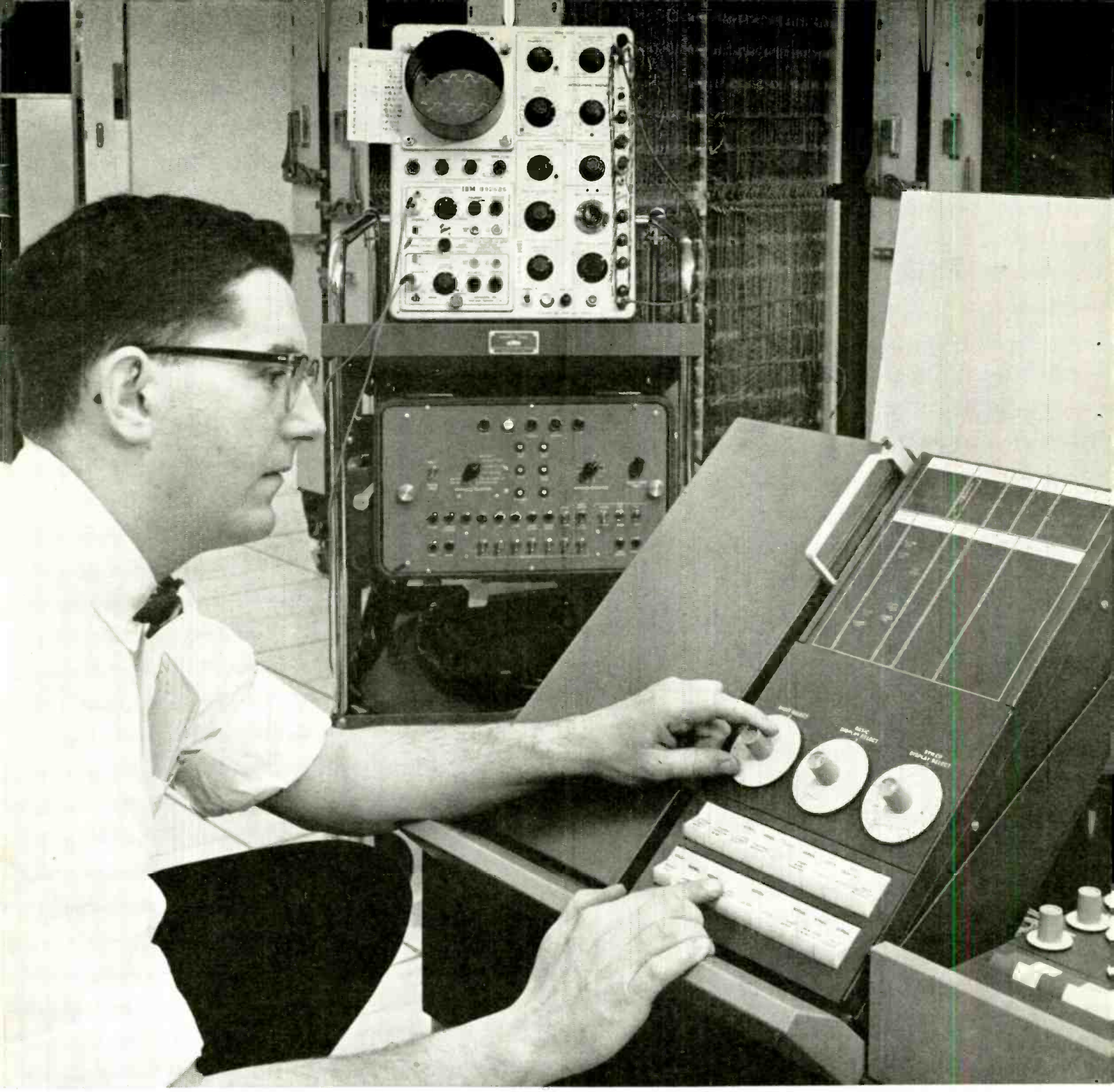
The "Stethotracer" is rated to deliver 0.176 v. (r.m.s.) output. At 0.1 volt the harmonic distortion was 4.5%, rising to 6% at 0.2 volt. The residual noise level in the output was 3.5 millivolts measured with the input open-circuited. The measured attenuations of the 20-db and 40-db heads (which are not intended as precision attenuators) were 16.8 db and 44.3 db respectively.

We used the lab set under a variety of conditions, and were impressed by

(*Continued on page* 96)



CIRCLE NO. 146 ON READER SERVICE PAGE



Why Fred got a better job . . .

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

After congratulating Fred on his promotion, I asked him what gives. "I'm going to turn $10 into $10,000," he said. "My tuition at Cleveland Institute was only $10 a month. But, my new job pays me $10 *a week* more . . . that's $520 more a year! In twenty years . . . even if I don't get another penny increase . . . I will have earned $10,400 more! It's that simple. I have a plan . . . and it works!"

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

NEW, MODERN, PORTABLE . . . FOR THE MAN ON THE GO . . .

as easy to use as a voltmeter

3.58 COLOR BURST

- A new 3 inch Extended View Portable Scope with New Features and Performance Unmatched by even the most Costly 5 inch Oscilloscopes

NEW

SENCORE PS120 PROFESSIONAL WIDE BAND OSCILLOSCOPE

Lowest priced Wide Band 3 inch Scope anywhere. All hand wired.

Only 124⁵⁰ net

Kit $74.50

Here it is, the scope that technicians, engineers and servicemen from coast to coast have been demanding. A portable wide band scope that can be used on the job anywhere, yet has the highest laboratory specifications for shop or lab. Cumbersome color TV sets, remote audio and organ installations and computers are just a few of the jobs that make owning a scope of this type so essential. Why consider a narrow band scope, when for only a few dollars more, this professional wide band sensitive scope equips you for any job.

• The PS120 provides features never before offered. Only two major controls make the PS120 as easy to use as a voltmeter. Even its smart good looks were designed for functional efficiency. New forward thrust design, creating its own shadow mask, and full width calibrated graph increase sharpness of wave form patterns. A permanent chromed steel carrying handle instead of untidy leather strap and a concealed compartment under panel for leads, jacks and AC line cord make the PS120 the first truly portable scope combining neatness with top efficiency.

• Electrical specifications and operational ease will surpass your fondest expectations. Imagine a wide band scope that accurately reproduces any waveform from 20 cycles to 12 megacycles. And the PS120 is as sensitive as narrow band scopes . . all the way. Vertical amplifier sensitivity is .035 volts RMS. The PS120 has no narrow band positions which cause other scopes to register erroneous waveforms unexpectedly. Another Sencore first is the Automatic Range Indication on Vertical Input Control which enables the direct reading of peak-to-peak voltages. Simply adjust to one inch height and read P-to-P volts present. Standby position on power switch, another first, adds hours of life to CRT and other tubes. A sensitive wide band oscilloscope like the PS120 has become an absolute necessity for trouble shooting Color TV and other modern circuits and no other scope is as fast or easy to use.

S P E C I F I C A T I O N S

WIDE FREQUENCY RESPONSE:
Vertical Amplifier—flat within ½ DB from 20 cycles to 5.5 MC, down — 3 DB at 7.5 MC, usable up to 12 MC.
Horizontal Amplifier—flat within — 3 DB from 45 to 330 KC, flat within — 6 DB from 20 to 500 KC.

HIGH DEFLECTION SENSITIVITY:

		RMS	P/P
Vertical Amplifier—	Vert. input cable	.035V IN.	0.1V/IN.
	Aux. vert. jack	.035V/IN.	0.1V/IN.
	Through hi-imped. probe	.35V/IN.	1.0V/IN.
Horizontal Amplifier—		.51V/IN.	1.44V/IN.

HIGH INPUT RESISTANCE AND LOW CAPACITY:

Vert. input cable	2.7 Meg. shunted by approx. 85 MMF
Aux. vert. input jack	2.7 Meg. shunted by approx. 20 MMF
Through hi-imped. probe	27 Meg. shunted by 8.6 MMF
Horiz. input jack	330 K to 4 Meg.

HORIZONTAL SWEEP OSCILLATOR:

Frequency range—	4 ranges. 15 cycles—150 KC
Sync Range—	15 cycles to 8 MC usable to 12 MC

MAXIMUM AC INPUT VOLTAGE:

Vertical input cable— Aux. vert. jack— Hi-imped. probe—	1000 VPP (in presence of 600 VDC)
Horiz. input jack—	approx. 15 VPP (in presence of 400 VDC)

POWER REQUIREMENTS:

Voltage—	105-125 volts. 50-60 cycle
Power consumption—	On pos. 82 watts Stby. pos. 10 watts

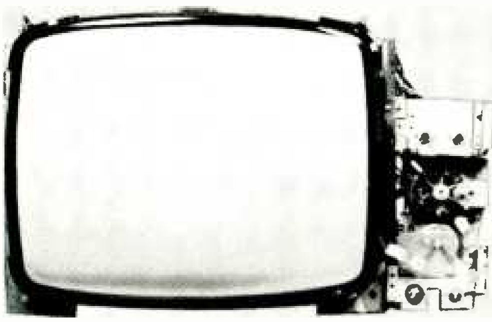
SIZE: 7″ wide x 9″ high x 11¼″ deep—weight 12 lbs.

The PS120 is a must for color TV servicing. For example, with its extended vertical amplifier frequency response, 3.58 MC signals can be seen individually.

SENCORE
ADDISON 2, ILLINOIS

looks innocent...but this chassis has a "tough dog"* repair problem

***no picture—raster okay—sound distorted**



you may be able to solve the trouble in an hour or more ...... or you can do it in minutes

With a PHOTOFACT® Folder by your side, the job takes just minutes. You use the Tube Placement and Tube Failure Check Charts (found in every PHOTOFACT TV Folder) and test the Video, AGC and IF tubes—they check okay. Adjusting the AGC control produces a weak picture, but the contrast control has no effect.

Referring to the Standard Notation Schematic, there is a normal waveform at the Video grid. There is a weak signal at the plate. Voltages are high. In just minutes, you've pinpointed the trouble. When comparing resistance with the handy chart, rotating the contrast control varies the reading, but you find it's high. The answer: A cold solder joint at the center of the control. Trouble solved—in just minutes—with PHOTOFACT!

YOU EARN MORE DAILY when you have PHOTOFACT at your fingertips. It's your time-saving troubleshooting partner for everything that comes into your shop. Just reach for the easy-to-find PHOTOFACT Folder you need for any model. It provides *everything* you want—complete, uniform, authoritative.

You get: Famous Standard Notation Schematics packed with all the service details you need; full Photo Coverage of all chassis views; Complete Replacement Parts Lists; Tube Placement Diagrams; full Alignment Instructions; actual Waveform Photos; CircuiTrace® for printed boards; Alternate Tuner data; Terminal Identification and Connections; Disassembly Instructions (including auto radio removal); Field-Servicing Notes; Dial Cord Stringing Diagrams; Changer and Recorder "Exploded Views"—plus dozens of other great features.

Own the complete PHOTOFACT Library—so you can instantly put your hands on all the quick help you need for any job on your bench! If you're not now a PHOTOFACT Library owner, you're more than paying for it in the time you lose every day. So take the *right* step to time-saving, profit-building servicing—see your Sams Distributor for details on an Easy-Buy PHOTOFACT Library and Standing Order Subscription—or send coupon today!

SEND COUPON

FREE FILE CABINETS

OWN YOUR PHOTOFACT LIBRARY THIS EASY-BUY WAY

More than pays for itself from the first day you put it into your shop! Now available to you on a Special Easy-Buy Deal: **• NO INTEREST • NO CARRYING CHARGES • ONLY $10 DOWN • UP TO 30 MONTHS TO PAY.** And you get FREE file cabinets with your PHOTOFACT Library—so you have all you need for time-saving, money-making service work right at your fingertips. Get the PHOTOFACT Library details today.

START A STANDING ORDER SUBSCRIPTION TODAY—Keep up with the rapidly-increasing current model output! See your Sams Distributor or send coupon now for full details.

HOWARD W. SAMS & CO., INC.

Howard W. Sams & Co., Inc., Dept. 5-B3
4300 W. 62nd St., Indianapolis 6, Indiana

- ☐ Send full information on Easy-Buy Plan
- ☐ Enter my Photofact Standing Order Subscription

My Distributor is:__________

Shop Name__________

Attn.__________

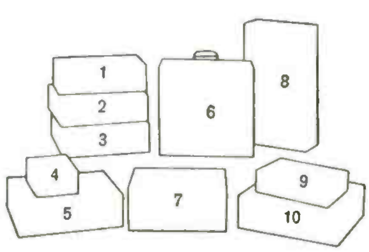
Address__________

City__________Zone____State______

108 KITS
and FACTORY-WIRED too!

EICO offers you the BEST BUYS of both.

All EICO models are available as Kits or assembled and Factory-Wired. So, whether you build it yourself or we do it for you—either way—they look, sound and perform identically . . . all best buys and top performers.



Over 2 million **EICO** instruments in use. Uni-card holders can buy at any **EICO** dealer with no down payment. Budget terms at most dealers.

Listen to the EICO Hour, WABC-FM, N. Y., 95.5 MC. Mon.-Fri. 7:15-8 P. M. Export Dept., Roburn Agencies Inc., 431 Greenwich St., New York 13

1. **FM Multiplex Stereo Tuner ST97**
   Semi-Kit **$99.95** Wired **$149.95** Incl. Metal Cover & FET
2. **40-Watt Integrated Stereo Amplifier ST40**
   Kit **$79.95** Wired **$129.95** Incl. Metal Cover
3. **70-Watt Integrated Stereo Amplifier ST70**
   Kit **$99.95** Wired **$149.95** Incl. Metal Cover
4. **FM Multiplex Autodaptor MX99** (Patent Pending)
   Kit **$39.95** Wired **$64.95** Incl. FET Cover Optional $2.95
5. **FM-AM Stereo Tuner ST96**
   Kit **$89.95** Wired **$129.95** Incl. Metal Cover & FET
6. **Transistorized Stereo/Mono 4-Track Tape Deck RP100**
   Semi-Kit **$299.95** (Patents Pending)
   (Tape transport assembled & tested; electronics in kit form)
   Wired **$399.95**
   (Handwired throughout by skilled American craftsmen)
   Carrying Case **$29.95** Rack Mount **$9.95**
7. **100-Watt Stereo Dual Power Amplifier HF89A**
   Kit **$99.50** Wired **$139.50** Enclosure E8 $4.50
8. **Slim 3-Way Speaker System HFS6**
   Kit **$52.50** Wired **$62.50**
9. **12-Watt Integrated Amplifier HF12**
   Kit **$34.95** Wired **$57.95** Incl. Metal Cover
10. **Stereo Dual Preamplifier ST84**
    Kit **$59.95** Wired **$89.95** Incl. Metal Cover

EICO®

3300 N. Blvd., L.I.C. 1, N.Y.

EICO 3300 N. Blvd., L.I.C. 1, N.Y. EW-2

☐ Send FREE 32-page catalog & dealer's name

☐ Send FREE booklet "Why Stereo"

☐ Send new 36-page Guidebook to HI-FI. Enclosed is 25c for postage & handling

Name__________

Address__________

City______ **Zone**___ **State**______

Add 5% in West

Carefully controlled shock can facilitate medical diagnosis, treat diseases, and save lives. The techniques and electronic circuits are described.

By ED BUKSTEIN / Author "Medical Electronics"

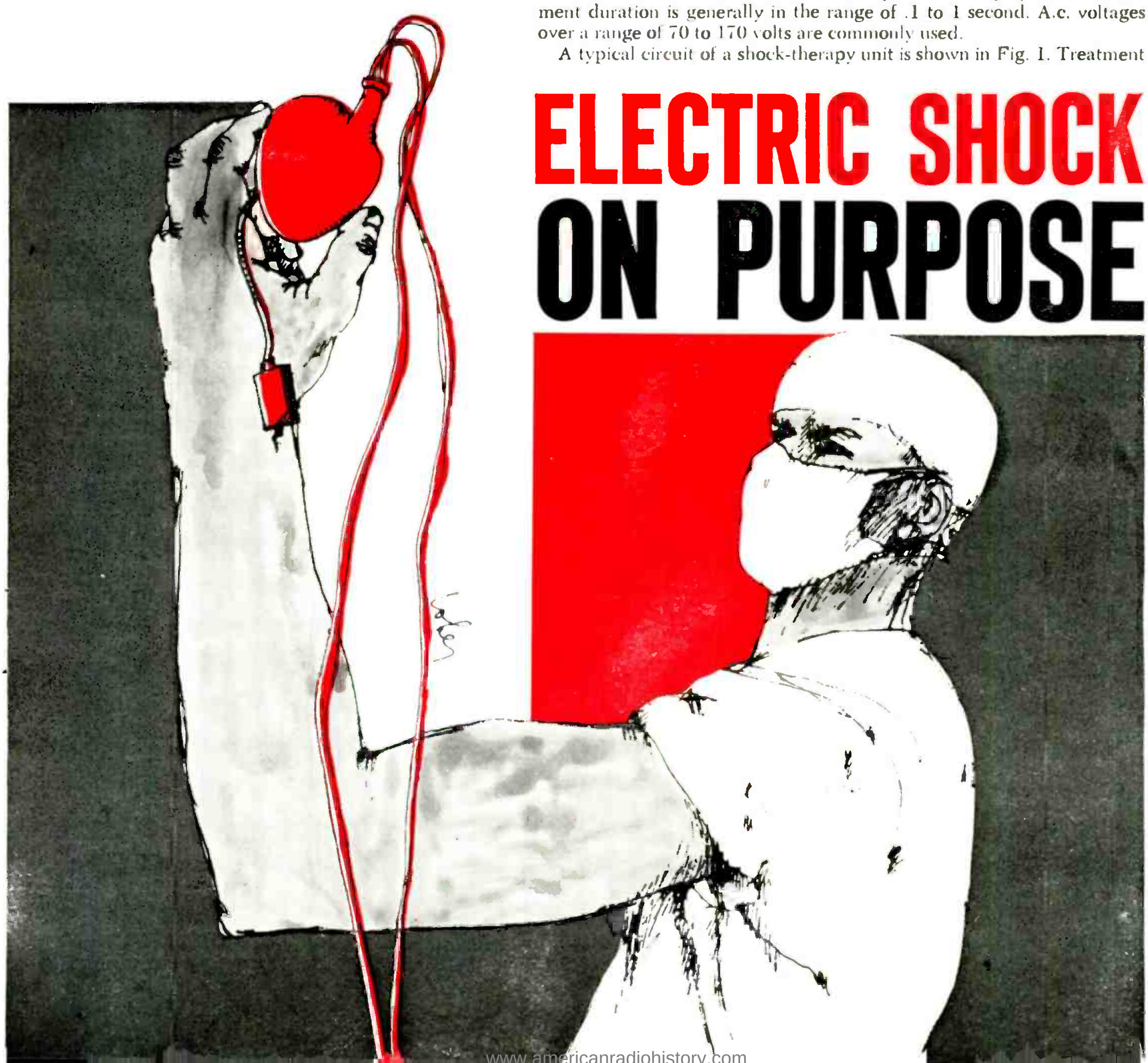
ACCIDENTAL electric shock is an experience which at best is annoying and at worst is fatal. It is regarded with feelings ranging from mild apprehension to pure abhorrence. This is fortunate because it encourages a cautious attitude and a deep respect for things electrical. Nonetheless, electric shock can be both intentional and beneficial. Under the supervision of a skilled physician, amperes can be as useful as antibiotics. Carefully controlled electric shock can facilitate medical diagnosis, treat diseases, and save lives.

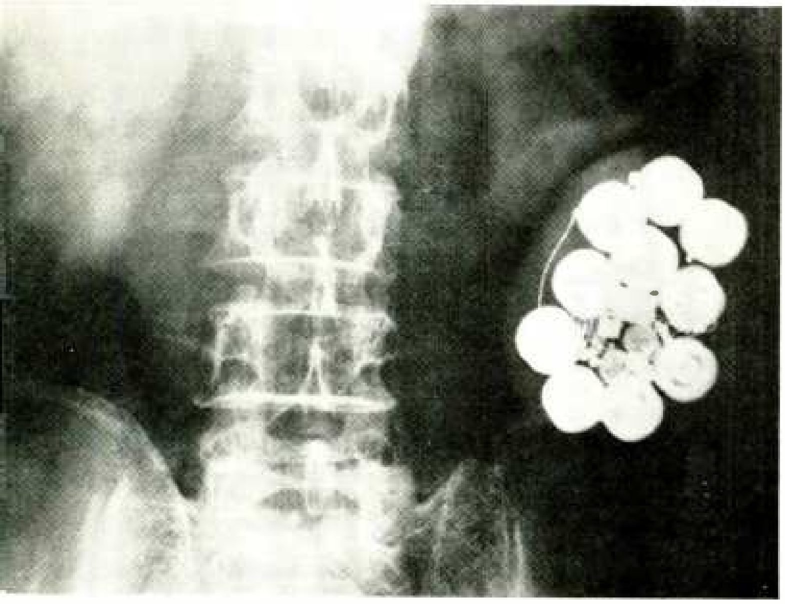
Electric Shock Therapy

Perhaps the best-known use of electric shock in medicine is its employment for the treatment of mental disorders. As an alternative to insulin shock and other forms of chemo-therapy, electroshock offers the advantages of being easily and accurately controllable. The treatment, sometimes referred to as *electrical convulsant therapy* (ECT), is accomplished by means of electrodes, one on each side of the patient's head. The electrodes are moistened with a conductive paste to improve the electrical contact, and a sine wave of current is passed through the brain. Currents up to several hundred milliamperes are employed, and treatment duration is generally in the range of .1 to 1 second. A.c. voltages over a range of 70 to 170 volts are commonly used.

A typical circuit of a shock-therapy unit is shown in Fig. 1. Treatment

ELECTRIC SHOCK ON PURPOSE





X-ray view of implanted pacemaker, which stimulates the heartbeat. The large circular areas are the mercury cells that operate the two-transistor (smaller circular areas) circuitry.

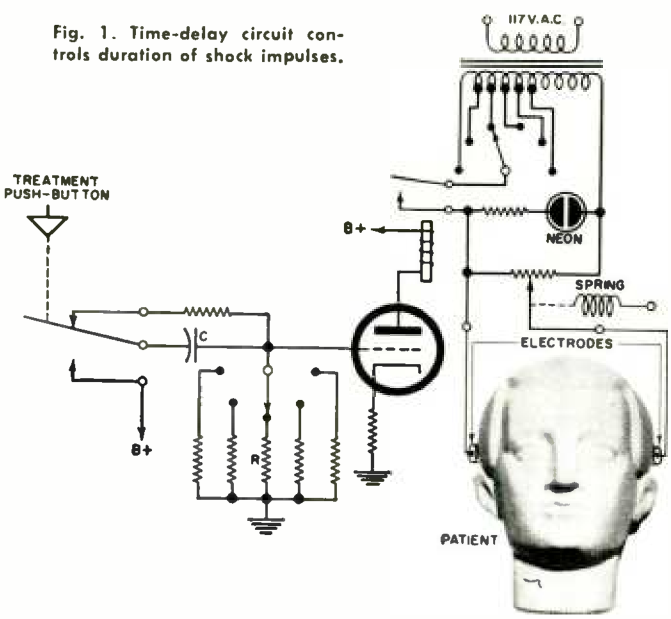


Fig. 1. Time-delay circuit controls duration of shock impulses.

current is adjusted by means of a switch that selects one of several available taps on the transformer. A time-delay circuit controls the duration of the treatment, which commences when the treatment push-button is depressed. At this time capacitor *C* begins to charge from the B-supply, and the resulting voltage drop across resistor *R* drives the tube grid positive. The relay therefore energizes and completes the circuit from the transformer to the patient. As the capacitor continues to charge, the voltage drop across *R* gradually decreases and ultimately allows the relay to de-energize. The relay contacts now open to terminate the treatment.

Several values of resistance are available so that the time constant of the charging circuit can be changed. In this manner the treatment duration can be preset. When the treatment is finished, as indicated by extinction of the glow in the neon indicator, the operator releases the push-button. The back contact of the push-button now discharges the capacitor through a small resistance, preparing the instrument for the next patient.

Sudden application of voltage to the patient causes muscular contraction which may be so severe as to cause sprains, dislocations, or even broken bones. The sudden contraction can be prevented by allowing the treatment current to build up gradually as indicated in Fig. 2. Known as *glissando,* this mode of treatment is achieved by means of the spring-wound potentiometer in Fig. 1. Before the treatment is started, the shaft of the potentiometer must be advanced to its extreme (minimum output) position. This action winds the spring. Through a mechanical linkage, the spring is released when the treatment button is depressed. The spring now drives the potentiometer shaft to its opposite extreme, gradually increasing the magnitude of the treatment current. A safety interlock switch is mounted on the potentiometer to prevent treatment until the potentiometer spring has been wound.

Electrodiagnosis

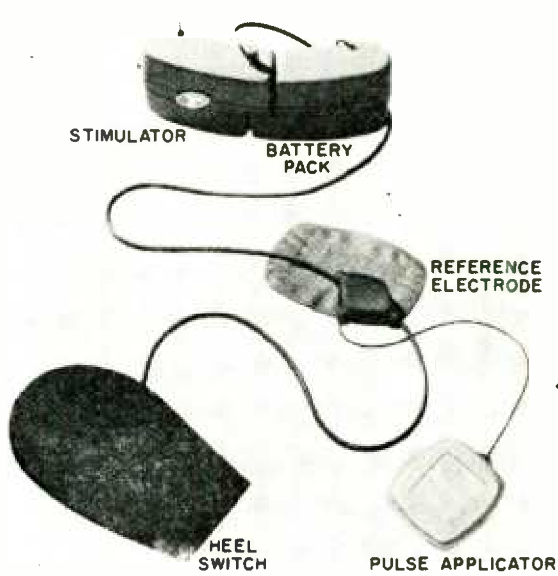
Late in the eighteenth century, Luigi Galvani discovered that a frog leg could be made to twitch by bringing it into contact with two dissimilar metals. Although the reason for this was not known at the time, we now know that the twitch resulted from electrical stimulation of the nerve and muscle tissue (the dissimilar metals functioning as a battery). This discovery established the basis for modern electrodiagnostic techniques. Today, electrical stimulation is employed to produce muscular contraction for the purpose of testing the muscle and its nerve supply. Both direct and alternating currents are used for muscle stimulation, the former are known as *galvanic* and the latter as *faradic* currents. Various waveshapes, referred to as *modalities*, are illustrated in Fig. 3.

Galvanic current is obtained from a conventional rectifier circuit of the type commonly used for B-supply. A mechanical interrupter such as a vibrator may be connected in series with the output to produce pulsed galvanic current. The surging galvanic modality is the unfiltered output of the power supply and is produced by opening a switch that disconnects the filter capacitors. Faradic current is generated by periodically interrupting the current flow through the primary of a transformer. As shown in Fig. 5, a vibrator is used to alternately make and break the primary circuit.

Still another modality consists of a 60-cps sine wave that is amplitude modulated to make it less painful to the patient. The modulation is produced by a motor-driven potentiometer.

Diagnostic currents are applied to the patient through metal electrodes moistened with an electrically conductive paste. The *active* electrode is positioned over the muscle to

Components of transistorized muscle activator. Device produces pulses that activate leg muscles, enabling wearer with serious motor nerve damage to walk almost in a normal manner.



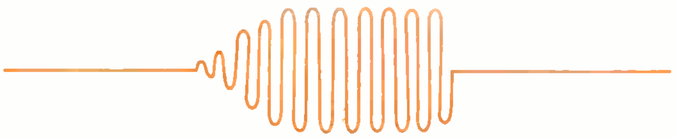


Fig. 2. Glissando eliminates severe muscular contractions.

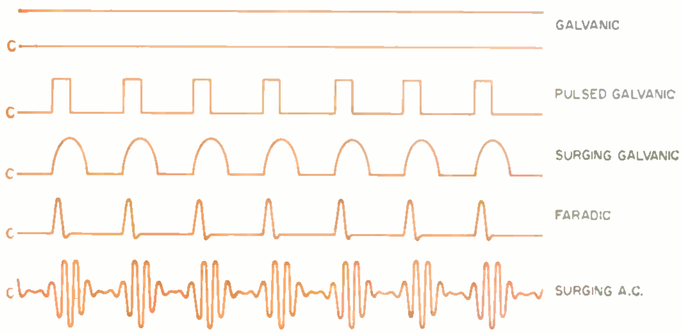


Fig. 3. Waveforms employed for nerve and muscle stimulation.

be tested, and the larger *dispersing* electrode is placed elsewhere on the body. The active electrode is smaller in area than the dispersing electrode so that current flow will be concentrated in the region of the muscle being tested.

Direct current (galvanic) will cause a muscle to contract if the current is sufficient in both amount and duration. The minimum current required to produce contraction is known as the *rheobase* value. The minimum duration required with a current twice rheobase is known as the *chronaxie* value. Chronaxie measurement is useful diagnostically because an increase in this value indicates degeneration of the nerve supply to the muscle.

Steady galvanic current produces contraction only briefly when the current is first applied. Interrupted (pulsed) galvanic current, however, produces a condition of sustained contraction. The muscle remains contracted because there is insufficient time for it to relax between successive pulses of stimulating current. If a muscle fails to respond in this manner, an increased chronaxie value is indicated (the muscle cannot contract within the duration of each pulse of stimulation). The same test can be performed using faradic rather than pulsed galvanic current.

Sawtooth stimulation is also useful diagnostically. Healthy tissue will not respond to the slowly rising current—a characteristic known as *accommodation*. Denervated muscle however, cannot accommodate and therefore contracts in response to the sawtooth stimulation. On this basis, the diagnostician can determine whether the nerve supply to a muscle is intact and functioning normally. An advantage of the sawtooth waveform is that it elicits response from injured but not from normal tissue. Contraction of the denervated muscle is therefore not obscured by contraction of adjacent healthy tissue. A further advantage of sawtooth stimulation is that it is less painful because the sensory nerves also possess the property of accommodation.

Sawtooth stimulation is usually obtained from a thyratron relaxation oscillator similar to those which were once popular as sweep generators in oscilloscopes. A typical circuit is shown in Fig. 6. Capacitor *C* in this circuit charges from the B-supply until the voltage across it is sufficient to ionize the thyratron. The ionized gas now provides a low-impedance discharge path for the capacitor. When *C* has discharged to the de-ionization potential of the thyratron, the gas de-ionizes and *C* begins to recharge. The slow charge and rapid discharge of the capacitor produce the sawtooth output. Sawtooth frequency can be controlled by varying either *R* or *C*. The capacitor-selecting switch is a *coarse* step control, and variable resistor *R* is used as the *fine* continuous control.

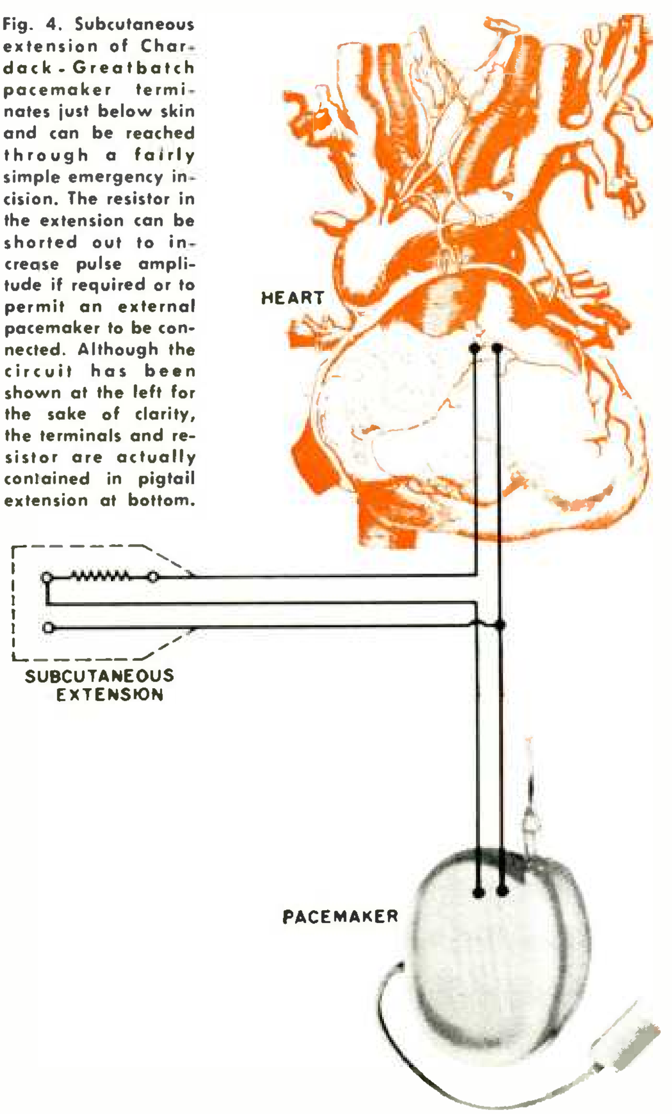
Electrical stimulation is useful for *treatment* as well as diagnosis. Electrotherapeutic current, for example, is used to exercise paralyzed (denervated) muscle. The nerve supply may eventually regenerate and regain control of the muscle, but until this happens the muscle must be artificially stimulated. Without such exercise, the muscle will atrophy from prolonged inactivity.

Cardiac Resuscitation

Cardiac arrest is a medical emergency that demands immediate attention. If normal or near-normal heartbeat is not restored within a matter of minutes, the condition is fatal. The cardiac arrest may take either of two forms: *fibrillation* or *standstill*. Fibrillation is a condition in which the heart muscle goes "out of sync," that is, the muscle fibers contract at random rather than in a coordinated sequence. The heart therefore loses its effectiveness as a pump for forcing the blood through the circulatory system. Cardiac *standstill* is a condition in which the heart muscle does not contract at all.

Cardiac fibrillation is treated by shocking the heart electrically. As a result of this shock, all of the muscle fibers of the heart contract simultaneously. This leaves the heart in a condition of standstill from which it may recover spontaneously or may be triggered by a pulse generator. The instrument employed to shock the heart out of fibrillation is known as a "defibrillator." By means of a pair of electrodes as shown in Fig. 7, 60-cps current is passed through the heart. Currents as high as 15 amperes may be employed if the electrodes are applied to the surface of the chest. Less current is required if fibrillation occurs during cardiac surgery because the electrodes can then be applied directly to the

Fig. 4. Subcutaneous extension of Chardack-Greatbatch pacemaker terminates just below skin and can be reached through a fairly simple emergency incision. The resistor in the extension can be shorted out to increase pulse amplitude if required or to permit an external pacemaker to be connected. Although the circuit has been shown at the left for the sake of clarity, the terminals and resistor are actually contained in pigtail extension at bottom.



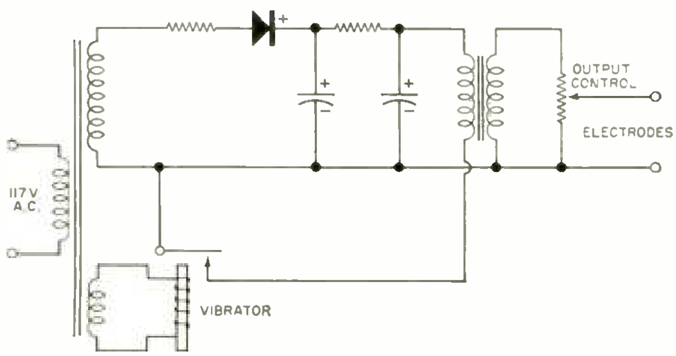


Fig. 5. Circuit of generator used for faradic stimulation.

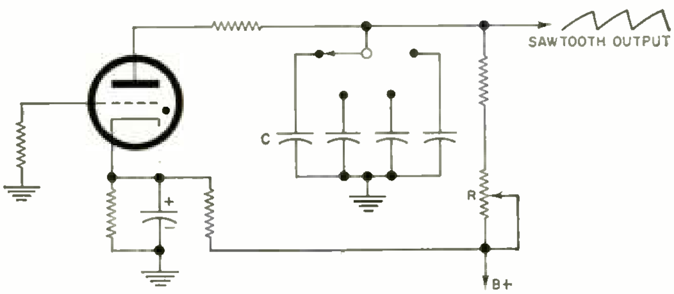


Fig. 6. A relaxation oscillator for sawtooth stimulation.

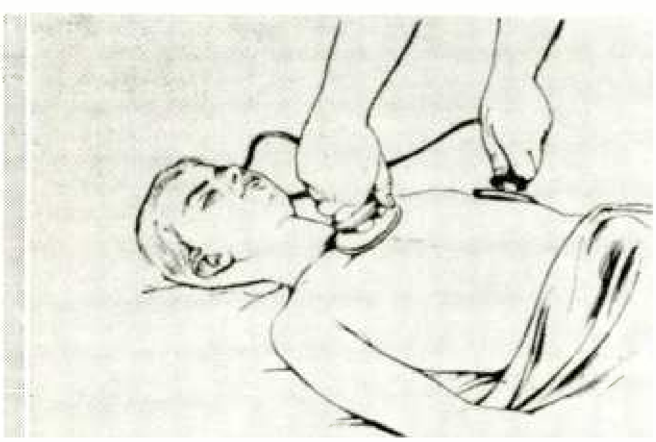
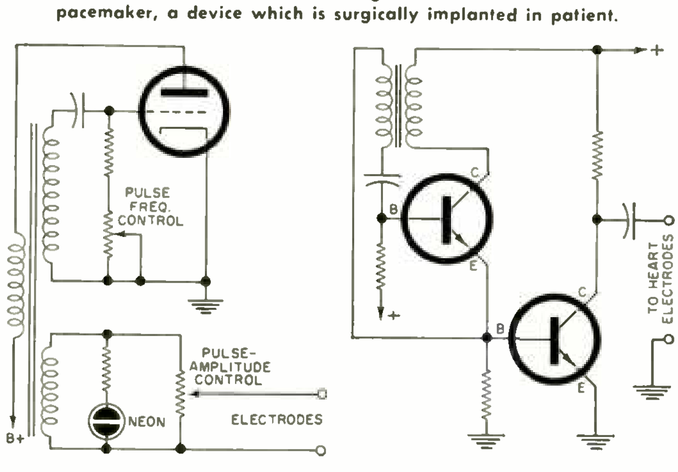


Fig. 7. Application of external defibrillator electrodes.

Fig. 8. (A) Blocking oscillator generates pulses used to trigger the heartbeat. (B) Circuit diagram of the two-transistor pacemaker, a device which is surgically implanted in patient.



heart. Shock duration is in the range of .1 to .5 second and is controlled by a time-delay circuit.

The defibrillator shown in the photo is designed for both closed-chest and open-chest cardiac resuscitation. Output voltage can be set by means of a front-panel control to 120, 240, 360, 500, 750, or 1000 volts. Another front-panel control permits adjustment of shock duration to .15 or .30 second, or to manual control which permits the operator to control the shock duration by means of a push-button. An auxiliary foot-switch can be connected to the unit and used instead of the front-panel push-button.

Cardiac standstill is treated by stimulating the heart with a pulse generator known as a "pacemaker." Each pulse causes the heart muscle to contract, allowing the heart to regain a normal rhythm. Pulse duration is generally in the range of 2 to 4 milliseconds, and pulse rate is adjustable from 20 to 200 pulses per minute. A representative circuit employing a blocking oscillator is shown in Fig. 8A. Output is coupled from an additional winding on the blocking-oscillator transformer. A potentiometer between this winding and the electrodes permits control of pulse amplitude.

Implanted Pacemaker

In addition to its use for emergency treatment, the pacemaker is employed on a *continuous* basis for long-term correction of heart block. Such block may occur following cardiac surgery, coronary thrombosis, or in patients with Stokes-Adams disease.

Earliest efforts to apply electronic "pacemaking" to such patients involved an external pacemaker and external electrodes strapped to the chest. This technique, however, requires considerable output power from the pacemaker and therefore necessitates a physically large instrument. By contrast, only a few milliamperes of stimulating current are required if the electrodes are placed directly on the heart. This consideration led to the use of an external pacemaker in conjunction with internal (implanted) electrodes. By means of leads passing through the chest wall, the external pacemaker is connected directly to the patient's heart.

A serious disadvantage of this technique is that infections occur frequently at the site where the leads pass through the chest wall. To overcome this problem, a system employing a radio link has been developed. A small, external transmitter is pulsed on and off at the desired heartbeat rate, and this signal is picked up by a small receiver previously implanted in the patient. Output leads from the receiver carry the stimulating pulses to electrodes in contact with the heart. Although the technique eliminates the need of through-the-chest connecting leads, it still requires the use of external equipment.

The obvious next step was the development of a *completely* internal pacemaker meeting the requirements of small size and long life expectancy. Such a unit could be surgically implanted in the patient and connected to electrodes in contact with the heart. A two-transistor circuit employing miniature components is shown for such a device in Fig. 8B. The first stage is a blocking oscillator that develops pulses of proper duration and repetition frequency. These pulses are directly coupled from the emitter resistor of the first stage to the base of the second stage. The second stage is a grounded-emitter amplifier whose output is applied to the heart electrodes.

The Chardack-Greatbatch pacemaker shown in Fig. 4 is a self-contained, implantable unit that weighs only 8 ounces. Including its battery of ten mercury cells, the pacemaker is 6 centimeters (2¼") in diameter and 1.5 centimeters (⅝") thick. Life expectancy of the battery supply is estimated at five years. This instrument produces output pulses of 2-milliseconds duration in the frequency range of 50 to 60 pulses per minute. Output rating is 10 milliamperes into a 1000-ohm impedance, which is well above the stimulation threshold (typically 3 to 5 milliamperes). The entire pacemaker assem-

(*Continued on page 97*)

DIGITAL READOUTS

Though you can "see" a voltage on an oscilloscope, there is always the chance of an interpretation error. These devices will convert signals directly to numbers or letters eliminating all ambiguity.

By WALTER H. BUCHSBAUM, Industrial Consultant, ELECTRONICS WORLD

ONE OF the unfortunate aspects of electronics is that all signals are invisible. We can see the results of an electric current when it is converted into mechanical motion, or into light, but special devices are needed to change signals into directly readable form. Though this consideration is important when testing and troubleshooting, it becomes a much greater problem with electronic data-handling machines and computers. There are many important applications ranging from digital voltmeters to stock-market quotation and airline flight-reservation boards in which numbers and letters must be displayed.

One advantage of a number or letter indication over a meter indication is that a reading error is less likely. Another is that everyone seeing the number knows exactly what is meant without having to interpret a meter scale, or worry about parallax and scale-factor errors. This is particularly important when the electronic system is used to display information to the general public in applications such as pari-mutuel betting or bowling score announcements. Readouts are also widely used in industrial electronics.

Just as the applications vary so do the types of readouts. There are some that display all letters of the alphabet as well as numbers, called alpha-numeric types, but the vast majority simply show the numbers 0 through 9 and possibly symbols such as + or —. From a technical viewpoint, all readouts can be divided into three major categories according to their operating principle. In the electro-mechanical group, the electrical signal is converted into mechanical motion which turns a drum or tape to display the desired character. Another category is called optical because the signal actuates lights. The third group consists of devices that combine mechanical and optical action. Within each category there are variations, too, depending on construction, driving signals, operating speed, and input codes.

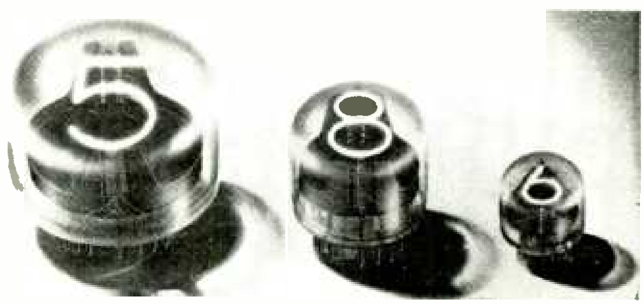
Optical Readouts

The basic optical readout is the pilot light with a number painted on the lens. When large numbers are displayed, the pilot lights take up a lot of room and reading the full number is cumbersome and inconvenient. It would be simpler if the pilot lights for each decade could be behind each other; this is the principle of the edge-illuminated, engraved numbers shown in Fig. 2. Ten small lamps are located above each of the ten pieces of Lucite. When a lamp is on, only its associated Lucite plate is edge-illuminated and its engraved numeral displayed. The numerals on the other Lucite pieces can barely be seen; since they are not illuminated they appear only as a slight blur. As numerals are switched, they appear to travel back and forth due to the positioning of the Lucite plates behind one another. This type of numerical readout is found primarily in digital voltmeters and other test equipment as well as in some older computer accessories. Servicing consists of simply replacing bulbs which are located either at the top or bottom of the readout assembly. If a Lucite plate has become warped or cracked, a replacement can simply be inserted in the correct slot.

Similar to the edge-illuminated readout shown in Fig. 2 is one which *General Radio Co.* imports from England and installs in its equipment. In this "Numerick" unit the individual lamps are at the rear and the Lucite plates are arranged in a series of nesting U's. Instead of engraving the numerals as smooth lines, the English supplier, *KMG Electronics*, forms the numerals with a series of small dots, presumably for better visibility. To avoid interference between parallel Lucite plates, thin sheets of opaque reflecting material are placed between the plates except at the viewing window.

A refinement of the Lucite "in-line" readout is the *Burroughs Corp.* "Nixie" neon indicator shown in Fig. 1. Here, the principle of cathode glow, familiar in neon lamps, causes one of ten cathodes shaped like a numeral to glow. As in the case of the Lucite readout, the numerals not illuminated can be seen, but in the "Nixie" the glowing number is so bright that the others are practically invisible. Another advantage is that the numerals are so close behind each other that the illusion of the motion of numbers is greatly minimized. Recent

Fig. 1. Numeral in "Nixie" tube is glowing cathode as in neon lamp.



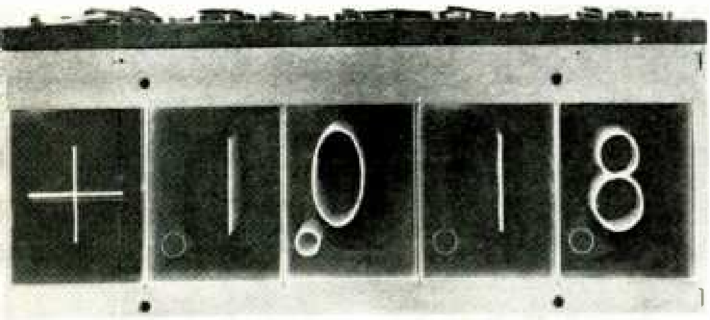


Fig. 2. Numerals are engraved on Lucite that is edge-illuminated.

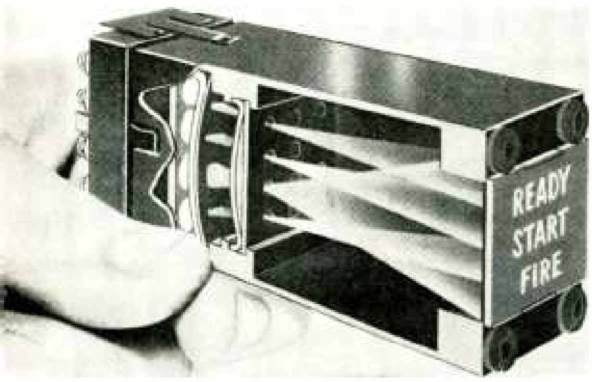


Fig. 3. Projection readout is combination of small slide projectors.

versions of the "Nixie" have been designed for greater viewing angle and there are even some available in semi-rectangular envelopes to permit closer spacing. "Nixies" are available in a wide range of sizes and, accordingly, in a range of different voltages. Numeral sizes range from 0.3" high to 2" high. Operating voltages range from 120 to 300 v. between cathode and anode.

Actual firing and extinguishing voltages vary. Of particular interest are the low-voltage "Nixies," which are available in combination with transistors under the trade name "Trixie," that enable a transistor circuit to drive the "Trixie" directly. Although transistors cannot switch the entire firing voltage, a series resistor (*R*, Fig. 5) forms a voltage divider with the transistor which operates as a switch to light a particular numeral. "Nixies" usually are reliable but have a limited life. Numerals get dim, don't light up at once, flicker, or only part of a number glows. The only remedy is replacement, which is simple since they plug into a socket.

A readout that presents a single-place indication is the projection type available from *Industrial Electronic Engineers, Inc.* and shown in cutaway view in Fig. 3. It is simply a compact arrangement of individual transparency projectors, all focused on the front screen. In addition to numerals, any combination of words, colors, and symbols can be obtained by this method since separate lamps, transparencies, and lenses are used for each letter, word, or numeral. Projection type readouts are available in character sizes from ⅝" to 3⅜" and units can be stacked alongside or above each other practically without limit. Access to the lamps is from the rear by means of a quick-disconnect, spring-loaded plug assembly. Servicing is not a problem since the only defect can be in the lamp and the circuit driving it. The optical portion is effectively sealed and trouble-free. Because the lamps require a fair amount of power, projection-type readouts are usually driven by relays rather than directly by transistors.

Another type of one-plane readout produces the characters by combining individual segments, each of which is illuminated separately. In Fig. 6 the numeral six is formed by six separate neon bulbs, each shining through a slot, whose combined illuminated areas form the desired letter. Behind the optical portion are a number of resistors which make up the matrix necessary to light the right segments for each numeral. Variations of the *I.D.E.A., Inc.* model shown here range in size from ⅜" to 10" high and vary in complexity from the seven-stroke version for numerals to a sixteen-segment arrangement which shows both letters and numerals. This type of readout has the advantage of reliability since only the neon lamps can get dim and they are easily spotted and replaced. The matrix resistors generally do not fail because little power is dissipated by them. Power requirements range from 1 watt at 150 volts for the smallest to 1.2 watts at 200 volts for the largest unit. Driving signals usually go through relays rather than transistors or tubes.

Based on the same method of making up symbols from basic lines is another type of optical readout which employs electroluminescence to generate the light (Fig. 7). The front of the glass-and-phosphor sandwich contains a transparent conducting coating while the back has conducting strips in the shape of individual segments. Each of the rear segments has a separate terminal. The a.c. is applied between the conducting front coating ("transparent conductor") and the desired segments ("conductor segments") to produce a numeral or letter. These electroluminescent readouts are already in use in some counters and digital voltmeters and many other applications are planned. *Sylvania*, *Westinghouse*, and *RCA* make them. Because a relatively large a.c. potential (200 volts is a typical value) is required, this type of readout is usually driven either by tubes or relays. Troubleshooting consists of replacing the entire unit since it is a complete, sealed-in-glass assembly.

Electro-Mechanical Readouts

The next method of displaying numbers is by rotating a drum or belt on which numbers and letters have been printed until the desired character appears at a window. That is how

Fig. 4. Solenoid-driven readout is used in stock quotation and reservation boards.

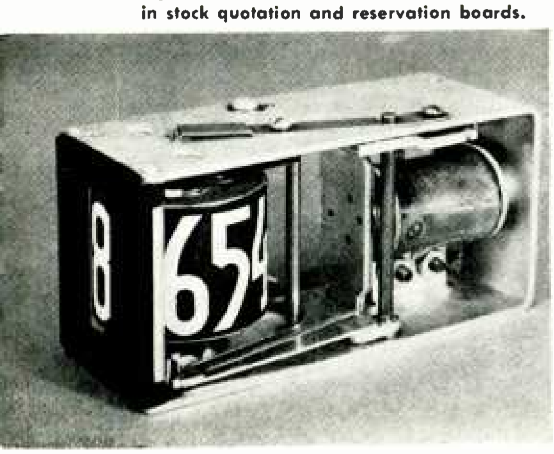


Fig. 5. With this drive circuit, "Nixies" can be used with transistorized equipment.

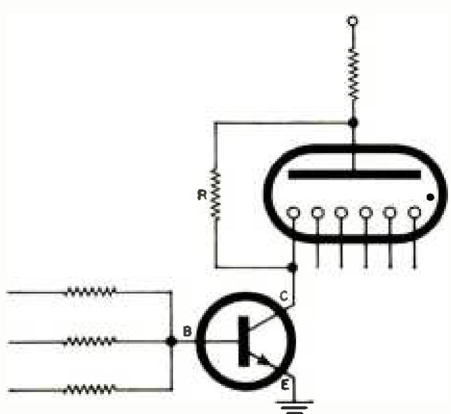
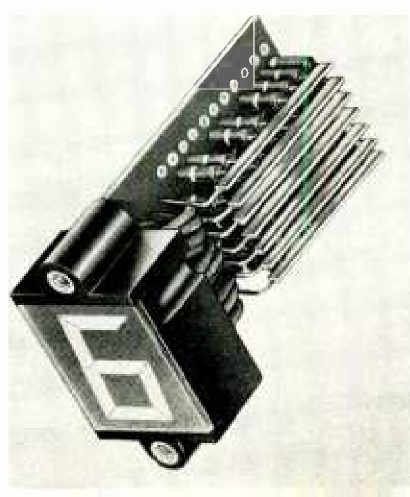


Fig. 6. Numeral is formed by neon lamps whose light penetrates individual slots.



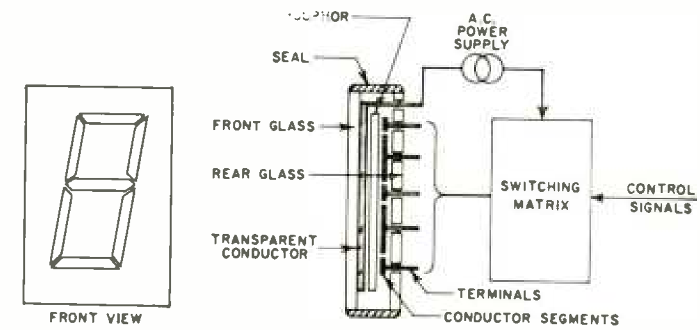


Fig. 7. Electroluminescent readout needs high a.c. driving voltage.

all electro-mechanical readouts work, but details on how to stop the right character in front of the window, merit some discussion. One of the most widely used readouts is shown in Fig. 4. This *Teleregister* unit, available in various sizes, is used on stock market quotation boards, airline reservation-status boards, and in many other data systems. The numeral drum is driven by a ratchet drive from the solenoid at the rear of the unit. A printed-wiring commutator is mounted on the drum and contacted by stationary brushes that transfer the solenoid circuit to an external control circuit. When the circuit is opened, a number of pulses cause the solenoid to rotate the drum until it reaches a blank position at which time the commutator shuts power off. Troubleshooting this unit requires mechanical ingenuity and a familiarity with relays and stepping switches. The most likely defect is either contact trouble or else a broken connection, spring, or defective contact.

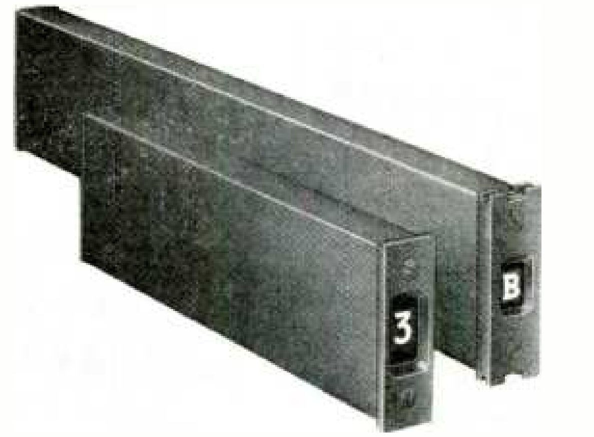
A more complex readout is the *Union Switch and Signal Co.* series, two of which are shown in Fig. 8. The shorter unit displays numerals by means of a drum and the longer model uses a flexible metal tape to display up to 64 characters. Both units are driven by a very precise mechanism and are capable of accepting binary information to produce a display of numbers or letters. The lower illustration shows the internal view of the drum-type numeral indicator. One-half of the assembly contains a special, flat d.c. motor which drives the numeral drum through a worm-gear arrangement. A binary coded printed wiring commutator is part of the drum. The other half of the assembly contains the brushes for the commutator and printed wiring to bring the brush connections to the plug-in socket at the rear of the indicator. A four-bit binary-code input connects power to the motor until the drum and its commutator are in the correct binary code position, which also corresponds to the decimal number to be displayed. At that position power to the motor is shut off. In the case of the 64-character version the tape passes over two drums, one in front and one in the rear, and each of these drums has a commutator and a set of brushes, providing the required 6 bits of binary code for 64 positions. Illuminated versions of this readout are also in use and contain a very small bulb behind the rim of the numeral drum. The drum rim is made of transparent plastic permitting light to pass through.

Troubleshooting this readout can be quite complex since poor brush contact, excessive friction, and other defective contacts and wiring may be hard to locate in the compact assembly. The motors are quite small and delicate so that failure of the motor itself should not be ruled out. Like the *Teleregister* unit shown in Fig. 4 this readout uses considerable d.c. power and is generally driven through relay contacts.

An entirely different type of electro-mechanical readout is *Patwin's* "Magneline" indicator shown in Fig. 9. In this unit the numeral drum is part of the armature of a ten-pole d.c. motor. A small permanent magnet, shown in Fig. 10, is attached to the large numeral drum. Stationed around the magnet are ten electro-magnets, like the stationary poles of a d.c. motor. When two opposite coils are energized, the permanent-magnet armature and the numeral drum attached to it will turn to line up the magnet. If d.c. power is removed, the residual magnetism in the soft iron pole and the permanent magnet itself will be sufficient to maintain the drum's position until another set of poles is energized. The typical value of power required to energize the coils is 200 ma. at 6 v. d.c. Relays are usually used to translate from the machine data code to the decimal switching selection required here. Troubleshooting is simple because there are no moving contacts. It is only necessary to measure the resistance of each of the ten field coils to find electrical defects. Short of excess friction or a broken drum, very little can go wrong mechanically.

Another version of the multi-pole d.c. motor drum readout is the new *A.C.E. Co.* Model SV-1 shown in Fig. 12. It is basically the same as the "Magneline" unit except that the

(*Continued on page* 66)



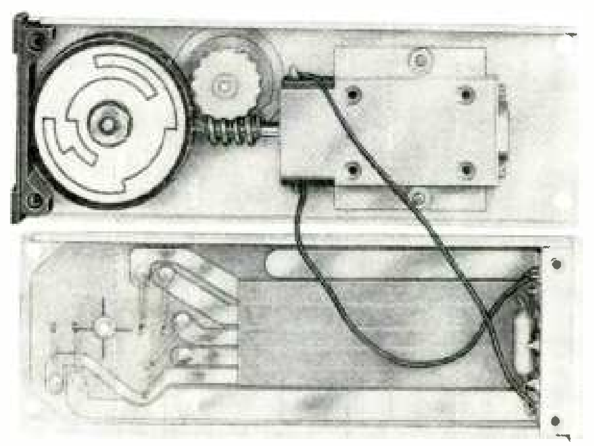


Fig. 8. Top: 12 (left)- and 64 (right)-character readouts. Exposed view below shows drum of smaller unit. Larger uses flexible tape.

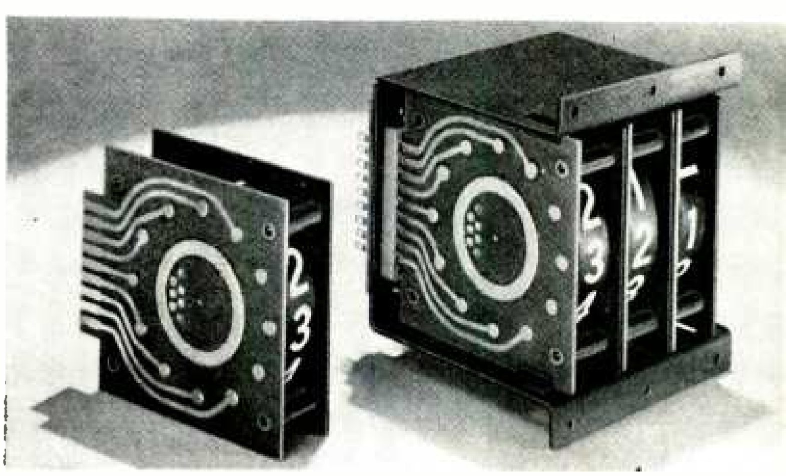
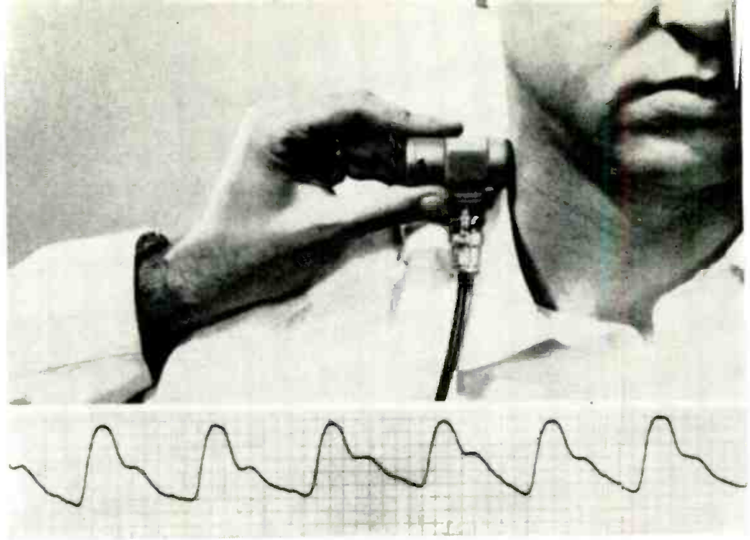


Fig. 9. Numeral drum is armature of ten-pole motor in "Magneline" unit.

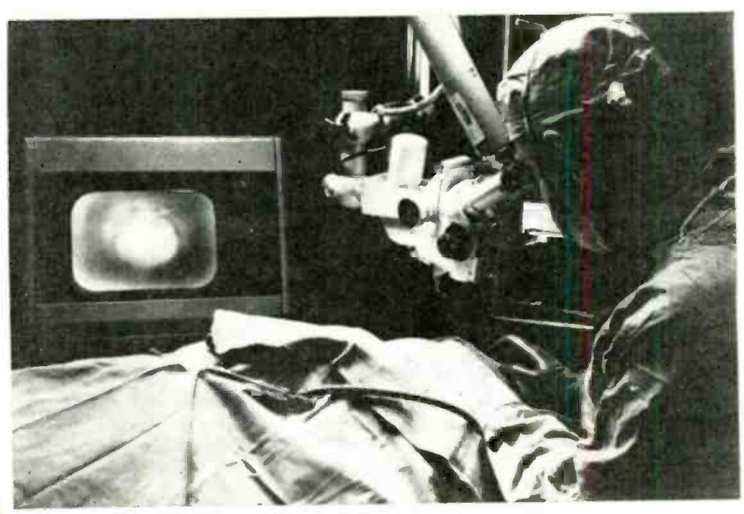
RECENT DEVELOPMENTS IN ELECTRONICS



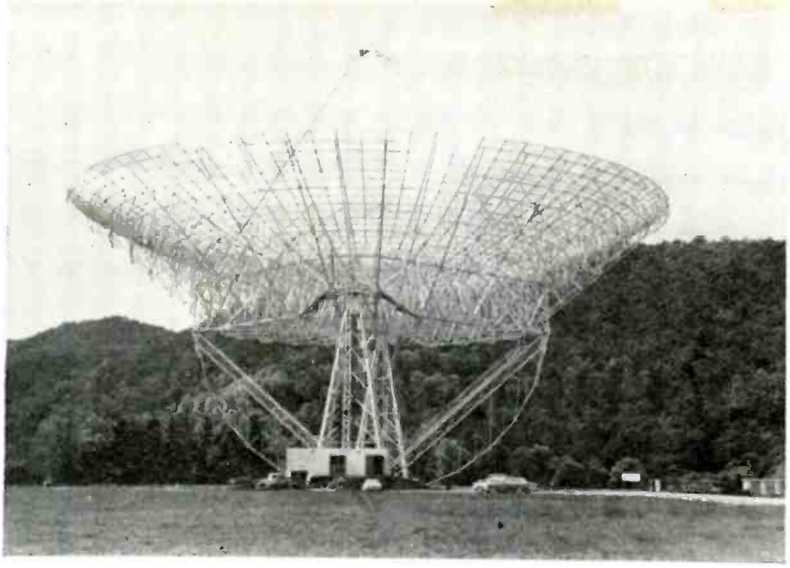
↑ **Ultrasonic Transducer**
Ultrasonic energy is being used to measure pulsations and movements of blood vessels and organs deep within the human body. In operation, a series of ultrasonic pulses from the transducer shown are directed in a narrow beam in the direction to be viewed. Measurements are made of the amount of time for an echo to return as well as its amplitude and phase. The different acoustic impedances of biologic structures produce the echoes. The bottom illustration is a recording of pressure in a neck artery as seen on a unit developed by Sonomedic Corp.

← **New Color Tube Plant**
Rows of color TV picture tubes travel along a special conveyor at RCA's new Marion, Ind. production plant. During this operation, a glare-proof window is bonded to the face of the tube. The window eliminates the need for an external safety glass in the TV set.

TV-Viewed Microsurgery →
A new closed-circuit TV system, demonstrated at the New York Polyclinic Hospital, enables as many as 30 doctors to study microsurgical procedures at the same time. A 1½-lb. TV camera, developed by DuMont, is mounted directly on the barrel of an operation microscope. Procedures as seen by the surgeon through the microscope are reproduced, greatly enlarged, on the TV screen.

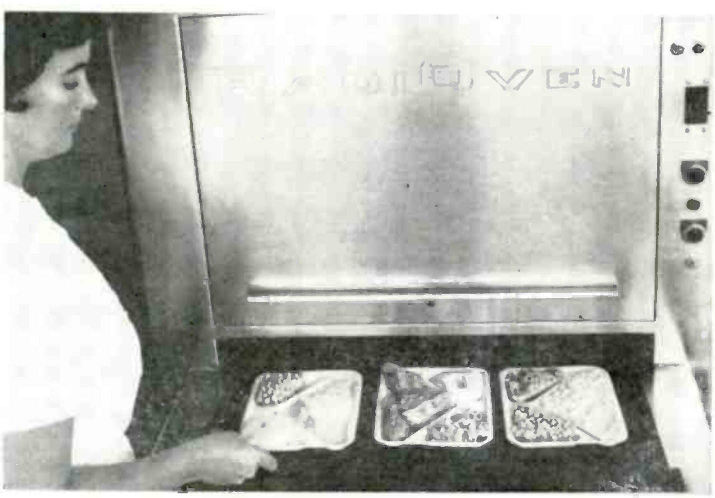


← **Semiconductor Crystal Laser**
A tiny semiconductor crystal suspended inside a glass container filled with liquid nitrogen is being used here to generate a beam of coherent infrared light. The laser beam is produced when large amounts of electric current are passed through the semiconductor junction. The nitrogen is used for cooling the device. The new laser, developed at General Electric Laboratories, does not require pumping by means of a light or r.f. source. Instead, large pulses of current directly inject electrons and holes into the junction region of a tiny diode made of gallium arsenide. The directional beam is emitted from the junction-plane edges at two carefully polished and precisely parallel sides of the device. The crystal heart of the new laser is approximately cube-shaped, each edge measuring about one-third of a millimeter.



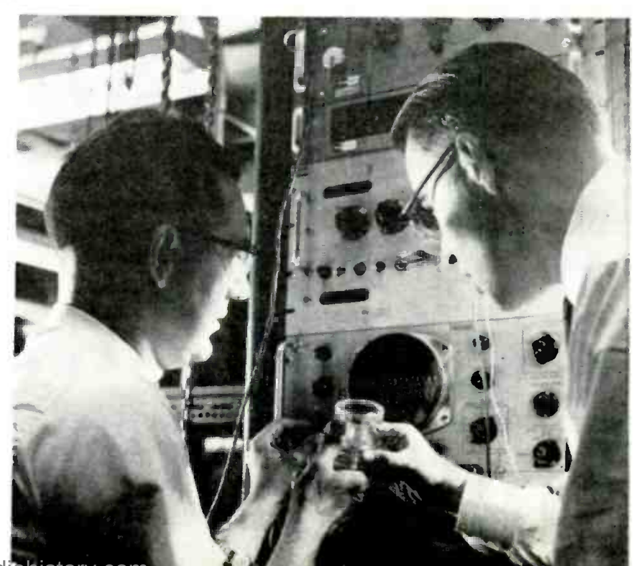
←300-foot Radio Telescope
The world's largest movable radio telescope has been put into operation at the National Radio Astronomy Observatory, Green Bank, West Va. The huge telescope has an antenna with a 300-foot diameter; its feed point is 225 feet from the ground; and its total weight is 600 tons. Known as a "transit" telescope, the parabolic reflector can be moved in a north-south direction only. Reception is possible on 750 and 1400 mc. simultaneously. Received data is automatically recorded on paper charts or punched at high speed onto tapes for subsequent analysis in a computer. Among the first objects to be studied is the planet Jupiter, a strong radio-wave emitter.

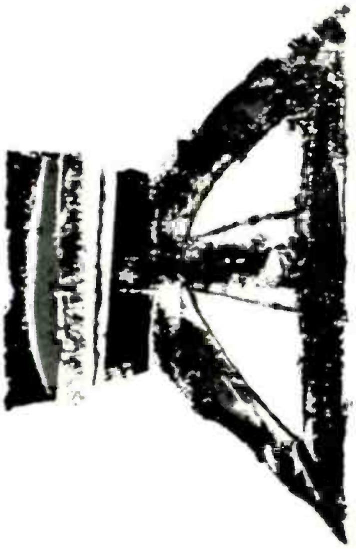
Super-Power Klystron →
A new method of focusing the electron beam in high-power klystrons was described by Sperry engineers. The klystron microwave amplifier shown produces 22 megawatts of energy using a permanent magnet (keg-like object at left in photo) for beam focus rather than an electromagnet that has been standard in the industry for 15 years. This was the first time such high power had been attained using this technique. Permanent magnet focusing previously had been limited to amplifier tubes producing only thousands of watts of power. Normally, the magnet girdles the middle of the tube, being located between the top of the cathode and the base of the output waveguide.



←Conveyorized Electronic Oven
A conveyorized electronic oven, capable of heating hundreds of meals an hour from a frozen state to hot, has been demonstrated recently. The unit is equipped with five 2-kw. magnetrons, four above the conveyor belt and one below it. The oven will reheat as many as five individual meals abreast in their packages, all in a matter of minutes. Originally designed by Phillips, the unit is being manufactured and marketed in this country by S. Blickman, Inc.

Experimental Transistor Microphone →
A new type of microphone that acts as its own amplifier has been developed by Bell Telephone Labs scientists. The mike is at least four times more sensitive than the carbon telephone transmitter, the most sensitive microphone now in use. The unit can be made very small and light—about the size of a tiny button—and has many potential applications. Its main parts are a diaphragm, a sapphire stylus, and a junction transistor. Sound waves vibrate the diaphragm, move the stylus back and forth. The stylus bears against the transistor and causes the junctions resistance to change in step with the signal. This results in a varying current in the base-emitter circuit; an amplified signal is obtained in the collector-emitter circuit. The transistor mike uses 20-100 times less current and has up to 100 times the efficiency of a typical carbon microphone.





HI-FI LOUDSPEAKER CONES

By CHARLES L. McSHANE / Chief Engineer, Cinaudagraph Acoustical Labs

We know one speaker sounds different from another and we are beginning to understand why. Here are some design and construction variations that produce such differences.

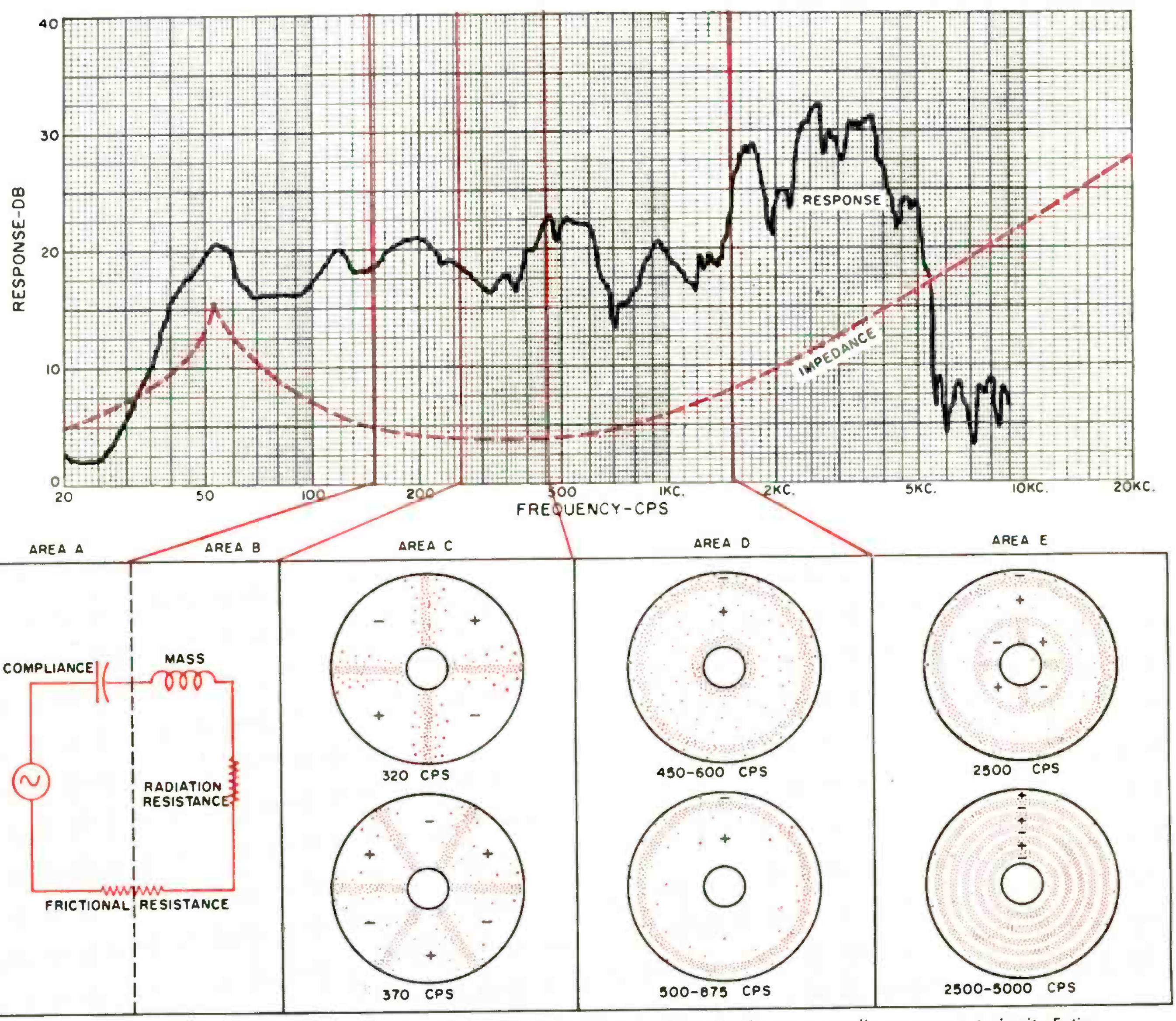


Fig. 1. Performance of a 10-inch loudspeaker. (Area A) Output determined by simple mass-compliance resonant circuit. Entire cone moves in phase. (Area B) Mass-controlled range. Output dependent on moving-system mass, air coupling, and motor efficiency. Entire cone moves in phase. Output may be modified by broadened resonance "Q." (Area C) Radial nodal action superimposed on piston movements of cone. May become severe enough to cause subharmonic "cone cry." (Area D) Edge resonance effects may be controlled by design of edge suspension; more severe when suspension is wide with many folds. (Area E) Increased output after edge hole modified by heavier voice coil, shallow curvilinear cone profile, apex decoupling rings, and other cone stock. The various sections of the loudspeaker cone are seen to move independently of each other as indicated by nodal patterns.

TO a large degree the performance of any hi-fi system is influenced by the behavior of the cones used in the speakers. The measured response characteristics as well as the subjective listening quality of a speaker or speaker system may be largely determined by such things as the cone shape, the paper pulp formulation, and the placement of stiffening body ribs and rolls. The speaker designer must select from a large number of varying cone paper pulp formulations as well as die configurations.

A mathematical analysis of a vibrating disc may be obtained from classical physics texts, but the vibrating conical shell or "cone" has thus far eluded theoretical treatment. An electromechanical analogy that purports to represent the mechanical stiffness, mass, and frictional losses of a loudspeaker mechanism can only be considered valid for low and middle frequencies. At higher frequencies smaller segments of the cone move independently and form innumerable mechanical resonant circuits. In general, the mode of vibration and mechanical "Q" of these circuits produce the characteristic timbre or "tone quality" of any loudspeaker. The speed of sound in the paper pulp and its characteristic internal dissipation may be varied over a wide range in order to control mechanical "Q's" and influence nodal modes.

It is the purpose of this article to discuss from a practical, intuitive viewpoint some of these fundamental problems. Among them are the following: (1) some of the more familiar vibrational phenomena associated with cone behavior; (2) methods the speaker designer uses to control and "shape" the over-all response characteristics of a speaker; and (3) the theoretical and practical requirements of modern high-compliance woofers.

While a great deal of material discussed here has been covered in depth in acoustical texts by Rayleigh, Morse, McLachlan, Olson, and others, it is felt that a non-mathematical, simplified treatment would be of particular interest to the audiophile who may only want to know why one loudspeaker sounds different from another and some of the constructional details that make these differences.

A "felted" paper cone is manufactured by a flotation process in which paper pulp and water are drawn through an aluminum or brass screen. This is accomplished by a variable vacuum, which may be adjusted for both pressure and time. The screen is made from perforated aluminum or brass stock, which is spun to the precise shape of the cone. The deposit of pulp left on the screen is the embryonic cone. Variations of vacuum pressure, the time cycle, and the thickness of the pulp and water mixture in the tank produce varying characteristics. Further elements in controlling paper pulp characteristics involve the method of removing the wet cone from the screen, waterproofing treatments, and drying methods. For example, the use of a hot pressing die to force-dry the cone compresses the fibers and gives a characteristically lower internal dissipation, more pronounced nodal activity, and "peakier" response.

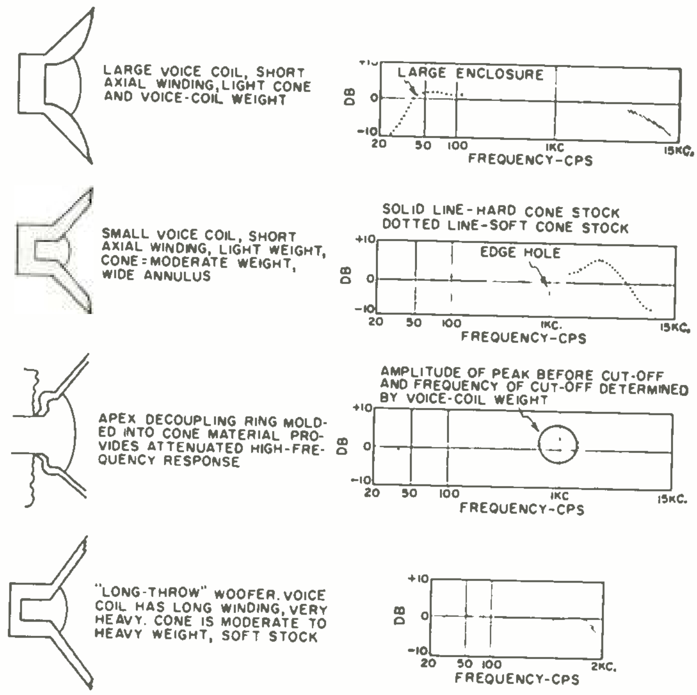
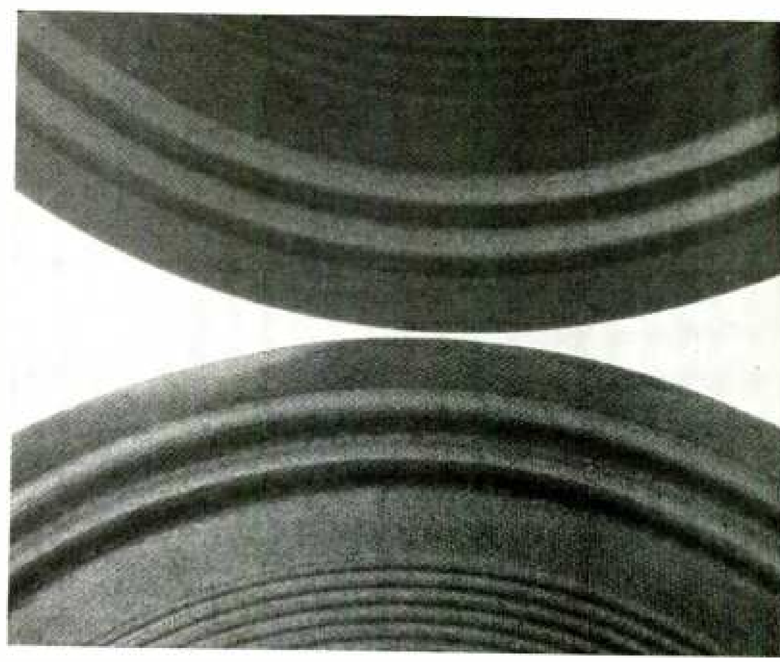


Fig. 2. Construction features and their effect on response.



Identical speaker cone dies may produce a variety of characteristics through variations in pulp stocks. Cone on top is soft, wooly stock with die marks less apparent. Cone at bottom is considerably harder in finish with more compressed fibers.

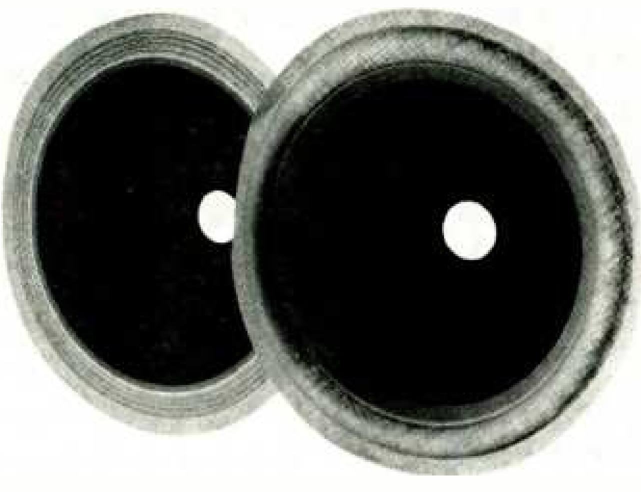
Typical Cone Behavior

Figure 1 shows a sound pressure versus frequency-response graph of a commercial ten-inch loudspeaker. While this speaker in no way represents what we would call "high fidelity," the behavior of the cone is typical in some ways of all cones. The measurements were taken in an anechoic chamber, substantially free of reflections down to about 70 cps. The microphone was placed 18 inches away from the speaker on its axis. The speaker was mounted in an infinite baffle large enough to avoid raising the bass resonance.

The major response variations are indexed by letters which are keyed to the nodal pattern illustrations. Notice that the first discernible nodal patterns begin at a frequency almost three octaves above the major moving system bass resonance. Below this frequency output may be calculated on the basis of a simple electro-mechanical analogy. The rise in output at resonance (area A) will be determined by the mechanical "Q" of the moving system. Mathematically, speaker "Q" is defined as "Q" = $2\pi f_o M/R$, where f_o is the main bass resonance frequency. The components M and R are simplified representations of the combined moving-system mass (including the cone and voice coil) and the lumped resistive losses including air loading, radiation resistance, magnetic damping, and various mechanical viscous losses in the speaker and enclosure.

If the cone mass is increased, and assuming everything else remains the same, the "Q" will increase. This means greater cone excursion at the primary bass resonance.

The available magnetic gap energy affects three acoustical elements: (1) mechanical "Q" at the bass resonance and the shape of the voice-coil velocity curve; (2) output in the



Molded fabric edge suspensions employed in high-compliance, long-throw woofer designs. After assembly, fabric is treated with rubber or viscous compound to seal interstices of fabric.

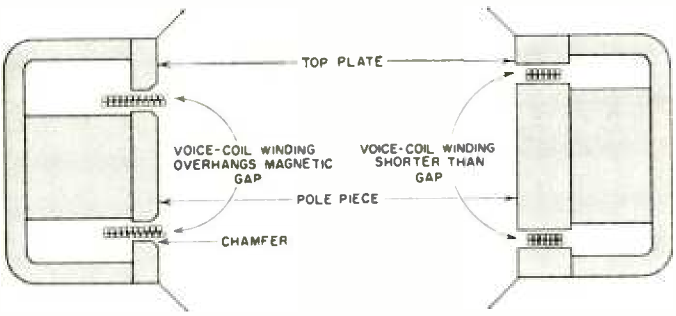


Fig. 3. Construction at left shows moderate voice-coil diameter, long axial winding. There is a constant ratio between flux lines and voice-coil wire during long excursion. Construction at right shows a larger voice-coil diameter along with a shorter axial voice-coil winding and deep magnetic gap.

Modern high-compliance woofer speaker using loop-type annulus and overhanging voice-coil design. Unit is typical of the loudspeakers used in present-day compact speaker enclosures.

piston band; and (3) output in the bass range and the balance between bass and mid-range.

Above resonance in area B it is assumed that the cone executes simple piston-like movements with all parts of the cone moving in phase. The response curve shape is determined by the degree of control exerted over the bass resonance (as discussed above), and by the mass of the moving system versus the electrical drive and motor efficiency.

In area C, output is reduced because the cone is vibrating out of phase in several areas. There are four or six nodal lines on the cone. These lines extend radially and separate several sections of the cone, each vibrating out of phase with the adjacent area. Radial nodes are associated with bending of the cone material in its weakest area near the edge. Deep straight-sided cones seem particularly prone to radial node activity. The design of the edge suspension also influences radial break-up. Edge dissipation of circumferential or radial nodes plus the suspension stiffening effect are significant factors in this response area.

Complete elimination of this type of node is most difficult. The more obvious and violent manifestations of this include subharmonic "cone cry," which can be eliminated by judicious selection of cone shape, pulp, and reinforcing body ribs. However, low-grade variations of these nodes may exert a subtle influence even in the middle bass range. These variations may involve only the outer area of the cone, and may be described as "edge flapping." They are prevalent in high-compliance woofer designs. A sound pressure response graph may or may not indicate their presence, but during violent cone excursions they may be observed under a strobscopic light through the use of lycopodium powder.

The next major response variation (area D) is associated with the design of the edge suspension. If the edge suspension is wide with many folds in order to provide maximum cone movement for the bass frequencies, its own acoustical influence will be felt. In our commercial ten-inch speaker there are two edge rolls, and the suspension is about ¾" wide and weighs 2.3 grams. The total cone mass is 6.30 grams. It can be readily seen that the edge suspension (accounting for about a third of the total cone mass) is likely to exert a significant influence on response.

Middle and Higher Frequencies

At frequencies above 370 cps the cone moves in phase out to the point where the paper bends in order to form the first edge roll. At this point a rolling action, involving only the small section separating the cone piston area from the edge suspension causes a rise in acoustical output between 450 and 600 cps. The voice coil suddenly "sees" a reduced mechanical driving point impedance and the apex area is driven independently. The response hole after the peak occurs because the edge suspension moves out of phase with the piston area of the cone. The depth, width, and frequency of the edge hole is determined by the weight and compliance of the individual rolls comprising the edge suspension. In general, a compliant cone with many folds or rolls produces a more severe edge hole. Often a viscous fluid is applied to the edge suspension to eliminate or minimize the effect. However, such fluids may introduce viscous resistivity and mass that reduce efficiency. A broad, but not too severe edge hole may sometimes be desirable. A "sway-back" curve with the 1000- to 2000-cps area depressed by perhaps 4 db provides a "mellow" effect that may compensate for limitations in amplifier and enclosure construction.

Response in area E is the key to maintaining a desired listening effect for any loudspeaker. The energy balance in this range makes the speaker sound either "harsh," "bright," "soft," or "mellow." To a large extent the designer can select the type of response he wants. Mechanically the controlling elements include: (1) voice-coil size; (2) the ratio between voice coil and cone mass; (3) cone shape and pulp stock; (4) cone body decoupling or stiffening rings; and (5) the dissipation characteristics of the annulus-suspension (the amount of acoustical energy traveling out to the cone edge that is reflected back into the cone versus the amount the annulus-suspension absorbs).

Figure 2 shows the response-curve effects that are usually obtained by variations in these mechanical features.

(*Continued on page* 82)

the ELECTRONIC ANTENNA PROS and CONS / An EW Symposium *Conducted by CHARLES S. TEPFER*

Do integrated combinations have any special merit? Six leaders in antenna and booster design evaluate advantages and disadvantages for Electronics World.

DESPITE the periodic introduction of new designs, the TV antenna field has not been marked by any revolutionary developments in quite a while. In the past year or so, a significant innovation has given everyone something to talk about: the "electronic" antenna.

To be sure, the term is not accepted everywhere in the industry. Some talk of the integrated amplifier-antenna, others of a booster simply mounted on the antenna, and still others of such coinages as a "Transis-Tenna." Whatever its name, the product is being promoted and sold as something new in many quarters. Everyone who uses or deals with antennas wants to know exactly what the development means.

To get the most authoritative information, ELECTRONICS WORLD has directly queried six leading sources. Since both a signal amplifier and an antenna are involved, whether or not design is integrated, manufacturers of both types of equipment were approached. Strictly as discussion "starters," the following four questions were put to them:

1. Why has it taken so long for antenna-mounted boosters to come into being?

2. Is there any appreciable difference between an antenna-booster combination and a separate antenna with the booster mounted on the mast?

3. Are there such things as boosters that are specifically designed for the antennas on which they are mounted?

4. What are the differences between vacuum-tube and transistorized boosters?

The answers were not only varied but, in turn, raised a number of other questions—and for these, too, there were many answers. For example, the "best" spot for the booster depends not only on noise level and matching, but on how amplifier power is supplied and environmental considerations. (Should it be protected from the elements? Or is heat build-up indoors, as in an attic, less desirable?) In turn, these factors depend on whether tubes or transistors are used. Which system affords the best dependability and/or the easiest maintenance?

These examples merely suggest the multiplicity of relevant factors and the need to strike a balance when they clash. The disagreement in the answers is no indication that the industry doesn't know what it's talking about. It rather illustrates differences in design philosophy.

Instead of confusion, then, discerning readers will find the bases for choosing solutions that most closely serve particular reception needs. Is the level of signal or of noise the greater problem? How many sets will be fed? What are the physical characteristics of the building involved? And so on. The clues are scattered. But they are here.

John R. Winegard
President
Winegard Antenna Systems

MAST-MOUNTED antenna amplifiers have been available for almost as long as TV itself. Although their advantages for weak signal reception have always been well known, until recently their use had been very limited because of the lack of an ultra-low-noise amplifier at an economical price. The introduction of the *Winegard* "Powertron" electronic antenna, with its built-in amplifier, overcame former objections and set a new TV reception standard.

In the early engineering of the "Powertron," it was found, from our many laboratory and field tests, that the only way to get maximum over-all performance and best system signal-to-noise ratio was to design the amplifier and the antenna together. Our findings agreed perfectly with theory because, although most TV antennas and amplifiers are called 300-ohm devices by their respective manufacturers, they are not that perfect. There is no such thing as an all-channel antenna that has an exact 300-ohm impedance on all 12 v.h.f. TV channels. Nor is there such a thing as a TV booster that has exact 300-ohm impedance on all channels.

It is common practice in the industry to call an antenna or an amplifier "300 ohms" if its voltage-standing-wave-ratio does not exceed 2:1 at any frequency involved when the device is connected to a 300-ohm source or load. This degree of mismatch is normally of no consequence. However, when two such units are used together, the *total* mismatch can be as high as 4 to 1, and the results can be quite undesirable. The only way to eliminate this possibility is to design amplifier and antenna together, so that variation in impedance characteristics from the design center is always under control.

Simply mounting a good, universal, antenna amplifier on any conventional antenna will improve the signal-to-noise ratio of that system. But such a method *can never be as perfect* as that of a true electronic antenna, where an ultra-low-noise amplifier and a high-gain, all-channel antenna are engineered as one. (There is no price advantage either way.)

We manufacture both tube and transistor amplifiers for the following reasons: While present transistors are as good as tubes as far as low noise and gain are concerned, their use is limited strictly to remote fringe areas because they will not work in areas that have a mixture of strong and weak signals. Transistors tend to overload and cause picture interference when the sum of all the TV and FM signals in an area is about 20,000 microvolts or more. Now it is possible, with current transistors and circuits, to raise this input level somewhat by changing the bias voltage on the transistor to a less than optimum value. This, however, results in less gain and, even more serious, a loss in noise figure. Existing tube amplifiers are immune to this overload problem up to approximately 250,000 microvolts.

We are introducing an electronic antenna that has a new ultra-low-noise amplifier with the amazing signal input of 400,000 microvolts. When these are available, an electronic antenna can be used anywhere—even within a stone's throw of a TV station—without cross modulation and overload problems. Removing this last limitation will, of course, further increase the popularity of electronic antennas by allowing their use in areas where a local transmitter is present. Many people in such areas would like to be able to pull in distant stations and need an electronic antenna. We will follow up with a similar antenna for FM.

Electronic antennas answer another need in modern households. There is a trend to two and three TV and FM sets in a home, plus the desire by many viewers to have the convenience of antenna plug-in outlets in several rooms. The extra gain made possible by antenna amplification offsets the loss that occurs when splitting up an antenna lead-in to feed several sets or outlets.

Edward Finkel
Vice President, Sales
JFD Electronics Corp.

ACTUALLY, antenna-mounted boosters have been available for several years. These units, however, were bulky and expensive. Engineers had to use several tubes (such as 6J6 and 6AK5) and many more components to get satisfactory gain and bandwidth for all TV frequencies. The first breakthrough came with the introduction of the 6BQ7 and 6BK7 tubes, used in cascode circuitry. Subsequently, frame-locked tubes, such as the 6DJ8, enabled the designer to use a single tube for a high-gain, low-noise circuit. It has only been during the past year or so that efficient, very-high-frequency transistors were manufactured at a price that makes possible an economical transistorized amplifier.

There are some problems relative to boosters specifically designed for the antennas they are mounted on. As is well known, the impedance of an antenna varies more or less across its design frequencies. We found it economically impractical to design an antenna amplifier to perfectly match this characteristic. Furthermore, the antenna characteristics also vary with height above ground, weather, and surrounding objects in an unpredictable manner.

The one advantage of the "matched" amplifiers is that they have presented to the public the concept of an "electronic antenna." We make available a broad line of antenna-amplifier combinations, as well as the amplifier by itself. All amplifiers are designed for 300-ohm input and output impedances. In this way, each user can match the appropriate combination to his precise area requirements.

As for location, there are two basic advantages to an antenna-mounted amplifier as against a mast-mounted type. As mentioned, it is almost impossible to match the amplifier input to the antenna precisely. If, at some frequency or frequencies, there is an appreciable mismatch, a length of line between amplifier and antenna allows a standing wave to be set up, and this can seriously affect the picture. At the same time, an incorrectly terminated short length of line can very easily act as a stub or trap to certain channels.

Noise is the other important consideration. There is no way of preventing an antenna from picking up atmospheric and man-made noise. Consequently, the antenna's output consists of both desired signal as well as noise. But noise is also picked up by the transmission line; the longer the line, the greater the noise pickup. The booster, in turn, will amplify whatever appears at its input; it cannot differentiate. So, for best signal-to-noise ratio and, consequently, least snow in the picture, the signal should be amplified *before* additional noise is added to it. The best way to accomplish this is to amplify the signal at the antenna terminals.

In terms of gain and bandwidth, there is little if any difference between a well-designed transistor booster and a vacuum-tube type. The major disadvantage of a tube unit is lack of reliability. Tubes necessitate more frequent replacement. Since they also require higher operating voltages than transistors, it becomes impractical to send both the high voltage (100 to 150 volts d.c.) and the low-voltage filament current through the transmission line to the amplifier. Thus, the power supply must be in the amplifier itself, increasing its weight and bulk, and making it more liable to expensive repair. Sensitivity to weather is another disadvantage of the tube-type booster. Water may enter the unit, when it rains or snows. The high d.c. voltages present may cause electrolysis and accelerated corrosion of metallic parts.

Transistor boosters suffer from limited signal swing and increased tendency to cross modulation. A transistor, by its nature, cannot handle as wide a range of signal amplitudes as a vacuum tube. This can be overcome, however, by the proper choice of transistor. *JFD* uses the *Amperex* PADT-28, a post-alloy diffused type. This unit can handle signal levels up to about 25,000 microvolts in a properly designed circuit. Cross modulation can be controlled by the use of appropriate traps at the antenna.

An important feature of a transistor is its extremely low power drain and, so far as the consumer is concerned, low operational costs. As a corollary to this, the transistor generates much less heat and correspondingly less component breakdown. Finally, a transistor is much more resistant to vibrational breakdown than a tube.

Don Rogers
Manager
Distributor Products Engineering
Jerrold Electronics Corp.

JERROLD has been making mast-mounted preamplifiers for almost a full decade. The first ones, developed for community antenna systems, were called "De-Snower" preamplifiers. The reason such units did not catch on with consumers, until the transistor models came along, is that they worked with coaxial cable and sold for well over $100.

To offset these limitations, we brought out models that use either coax or twinlead and list for well under $100. This really started us in the consumer end of the market. However, it was only a relatively few months after that that we were able to come out with the "Powermate" transistor amplifier. This dropped the price for an antenna amplifier from $89 list to $39 and enabled a simple and inexpensive installation.

The difference in performance between transistor and tube boosters is slight. Both can be designed for approximately equal gain and noise figure. Transistor models tend to be simpler and more compact because they do not require as elaborate power-supply circuits and do not generate as much heat. On the other hand, the good r.f. transistors so far available do not have the overload capabilities of tubes, which restricts their use in strong signal areas.

In addition to the magic of the idea of transistors, there is the very real advantage that their probable life is well above that for ordinary receiving tubes. This reduced need for maintenance in a mast- or antenna-mounted device encourages its wider use.

There are small advantages in designing an amplifier as an integral part of an antenna, but these relate principally to optimizing the impedance match between the antenna and amplifier. Accordingly, we would expect the improvement over a well-installed, separate-amplifier arrangement to be less than 1 db. There are of course advantages in mechanical simplicity.

The improvement in TV picture quality from using a booster is either an increase in contrast due to the additional amplification or an improvement in signal-to-noise ratio due to improved noise figure, or both. No booster can improve the *S/N* ratio of the incoming signal at the antenna. It can only rescue the signal and amplify it so as to conserve that original *S/N* ratio, before the signal is attenuated by the lead-in transmission line.

The noise figure of a device is the ratio of its output S/N ratio to that which would obtain with a perfect noiseless device. It is on the order of 5, 10, or 15 db for any practical TV set or booster. The problem is that the noise figure of the booster should be as low as possible to avoid worsening, and perhaps to improve the figure of the entire system.

Advertising claims in the consumer market tend to be less specific than in the industrial market, where the appeal is made to technically trained people. In general, claims of the "up to" type are less trustworthy than statements of average gain, and these are less useful than statements of low noise, where the most reliable claim is one which states a maximum noise figure you can verify experimentally.

The transistorized "Powermate" uses low-voltage a.c. rather than d.c. to power the preamplifier. There are three very good reasons for this:

1. It eliminates any and all nuisance associated with polarity. This we have found to be a tremendous problem with consumers even when a switch is provided, because wires become disconnected, switches get thrown, etc., and service calls are made unnecessarily.

2. By putting the filter and rectifier up in the preamplifier we protect the transistor against static discharges and similar voltage surges.

3. We greatly reduce the possibility of corroding the exposed twinlead terminals due to electrolytic action that can take place when a constant d.c. voltage is present.

There can also be small but very real advantages and disadvantages in one type of neutralizing circuit, transistor, transformer core, etc., over another, but these depend to a great extent on the engineering considerations and how they are incorporated into the circuit. Thus it is almost impossible to judge the relative merits of products employing them on the basis of such isolated criteria. Judgment must be based on the extra values really achieved, such as flatness of response, immunity to both low and high temperatures, long-time freedom from hum modulation, shielding between amplifier and antenna, and ease of satisfactory installation. The important question is, "How does the unit perform in the field under operating conditions and over a relatively long period of time?"

As to the balance between performance and cost, there is an optimum installation for any receiving problem. To start with, there is no substitute for an antenna large enough and effective enough to capture a signal which is adequate *at the top of the mast*. But when we consider that the antenna array doubles in size for every 3 db increase in signal desired, it becomes obvious that, once the antenna is large enough to secure a good *S/N* ratio, we can add more gain for less money and less storm hazard by electronic methods. Thus we can overcome downlead and splitting losses and deliver a good signal to the receivers with a simpler and more satisfactory installation.

I believe that this accounts for the increasing popularity of electronic antennas and outdoor amplifiers.

Ben Tongue
Vice President & Chief Engineer
Blonder-Tongue Laboratories, Inc.

I BELIEVE we were the first to introduce the mast-mounted transistor booster. Why hadn't anyone ever done it before? Probably because reasonably priced, high-gain, low-noise transistors were not available until recently. It was also felt that it would be difficult, if not impossible, to neutralize a grounded-emitter transistor for the entire two-octave frequency range from 54 to 216 mc. Inadequately neutralized transistors are prone to oscillate when improperly terminated. Our model IT-3, an indoor transistor booster, was something of an engineering breakthrough.

Once the IT-3 had proved its effectiveness, we decided to design a mast-mounted unit. Our tube-powered, mast-mounted boosters are quite successful, and we thought that a transistor unit might be well accepted.

One problem with transistor boosters is that they more easily overload than tube units. We reduce cross modulation by placing an electrolytic capacitor between the base and emitter returns, but the problem persists. Since this method is not universally used, there are a few areas where some transistor boosters will not work. These are areas where there are strong local signals in addition to desired weak ones.

As for the claim that a built-in booster is more efficient than a separate unit, this is invalid when the separate antenna is truly designed for best average performance over all channels into a 300-ohm load. All good boosters, of course, are matched to 300 ohms.

Another factor to consider is oscillation. If the output can couple to the input – more likely in built-in boosters – the amplifier will oscillate. Besides, a separate booster can be reached more easily for servicing and, if weather conditions destroy the antenna, the booster can still be used. Also, a separate booster can always be mounted indoors.

On this last point, I feel it is a good idea to mount even a transistor booster indoors. In the first place, boosters are mast-mounted for only one reason: to improve the signal-to-noise ratio. Of course, every booster adds some noise, but if it is mast-mounted, it amplifies the signal before it is deteriorated by the downlead. A hundred feet of downlead, when wet, can attenuate the signal by up to 10 db on channel 13. Since the noise level remains about the same, the signal-to-noise ratio is affected adversely by this loss. So normally we say that the booster should be mounted as close to the antenna as possible. However, let's suppose that 20 feet of wire would take us into the attic. Twenty feet of twinlead would only attenuate the signal by 2 db under the worst weather conditions. And 2 db is not enough attenuation to cause an easily discernible difference in picture quality. Therefore, you would be better off to mount the booster in the attic. One word of caution though: attics sometimes get very hot and transistors are sensitive to heat. A transistor booster should not be installed in areas where the temperatures may exceed 120 degrees F.

Harold Harris
Vice President, Engineering
Channel Master Corp.

THE development of new, low-noise v.h.f. transistors within the last year and a half has been the principal reason for the revived interest in TV boosters. Some earlier TV tuners used cascode circuits, which had a high-band noise figure of between 7 and 8 db. These were replaced about two years ago with circuits using the frame-grid tube, which has a noise figure of about 6 db. The transistors used in the new boosters have a still lower noise figure—about 4½ db.

It must be remembered that the ability of a booster to improve picture quality depends not so much upon its gain as upon its noise figure. The noise figure must be below the noise figure of the TV set. The greater the difference, the greater the improvement in picture quality. Since most sets in current use employ cascode tuners (7 to 8 db noise), it is easy to see the tremendous improvement that a low-noise, transistorized booster (4½ db noise) can make.

Of course, mounting the booster on the antenna goes a long way to improve the picture quality by eliminating the effects of line loss, which may be 2 db or more on the typical installation. Tube-type boosters overcome the line loss but do not necessarily improve the noise figure of the TV set. Transistorized boosters, on the other hand, not only overcome the noted line loss but also provide an approximate 3 db improvement in noise figure (with TV sets using cascode tuners). *Channel Master* boosters are designed to provide the highest signal-to-noise ratios currently possible.

The development of the low-noise transistor was also a great improvement because of its much greater reliability over electron tubes. This refers both to the transistor itself and the associated circuit components.

For those who prefer it, we offer a packaged combination of antenna and booster. From the engineering standpoint, however, there is no unusual merit in such an arrangement. The chief advantage it might have is the fact that the output impedance of the antenna can be accurately matched to the input impedance of the amplifier. Yet the fact is that better-designed antennas are made to match—not a booster—but the 300-ohm impedance of standard transmission line.

Designing a booster to have an input impedance of that value is not difficult. Furthermore, the booster leads can be treated as an integral part of the input circuit, so that their effect can be predicted and included in the impedance measurement to insure a 300-ohm system figure. This has actually been done in the case of some boosters, including our "Telstar." I doubt that the advantages claimed for the matched booster-antenna combination would add up to 1 db.

There are important differences among the power units used for antenna boosters and I would like to explain why we use our system. Our a.c.-to-d.c. converter is in the case behind the TV set, so we send d.c. up to the booster. We feel that the rectifier and associated components are the most likely parts to need replacement after a long period of time. Mounting them at the antenna would be a hardship for the service technician and expense for the set owner. Also, there really is little problem of polarity reversal because, if a service technician installs the system, he will set it up so that the polarity is correct for the best picture (this is readily apparent). After that, there is really no reason for the set owner to make any change. If there is, he need only reverse the antenna leads at the power supply. D.c. at the booster terminals does not invite corrosion because the terminals are well shielded and in a water-tight case. Incidentally, because the case is water-tight, there is no reason to put the booster any place but on the mast or antenna. Water on the down-lead will not attenuate signal as much as some think, and attic heat may harm the transistor amplifier.

All the foregoing tends to obscure the most important issue, which is simply this: good TV reception starts with a good antenna. There is no substitute for a good antenna. A booster should not be used as a "crutch" for an inadequate one. The reasons for this are simple. An antenna provides what might be called "pure" signal. There is no circuitry to generate noise. The purpose of any receiving antenna system is to pick up as much signal as possible. Then, and only then, are we ready to talk about amplifying this signal.

Since good TV reception demands, first of all, the proper selection of a suitable antenna, this choice should be made solely on the basis of the best antenna available for a particular reception problem.

Once the proper antenna has been selected, it is then a simple matter to add a well designed booster, like the "Telstar," which has a very high signal-to-noise ratio. Furthermore, the consumer who selects his antenna and booster separately affords himself the advantage of full freedom of choice among the many different boosters on the market. And this is also important because boosters, too, differ in quality and features. From a mechanical viewpoint, this presents no problems. The booster can be attached quickly.

L. H. Finneburgh
President
The Finney Company

WHY HAS IT taken so long for mast- or antenna-mounted amplifiers to become popular? Probably the best answer is the wait for a satisfactory and reasonably low-priced transistor. It was difficult enough to replace tubes in a mast-mounted booster and, of course, the replacement of a tube in an antenna-mounted booster is even more difficult and inconvenient. Even with a transistorized amplifier, antenna-mounted, I believe it is intelligent to have the amplifier attached in such a manner that it can be easily removed if and when servicing is required. Likewise, I believe it is desirable to have the design such that, on those few occasions when the amplifier might require removal for service, the complete antenna is left intact and still usable for reception.

Undoubtedly there is a slight theoretical difference between an amplifier mounted at the antenna terminals and one mounted on the mast, since even a 3- or 4-foot length of 300-ohm line connecting the antenna terminals to the input of an amplifier mounted on the mast would have some slight calculable losses. However, the losses of such a short length are extremely small and negligible. Therefore, if both the antenna and the amplifier are properly designed for 300-ohm

(*Continued on page* 92)

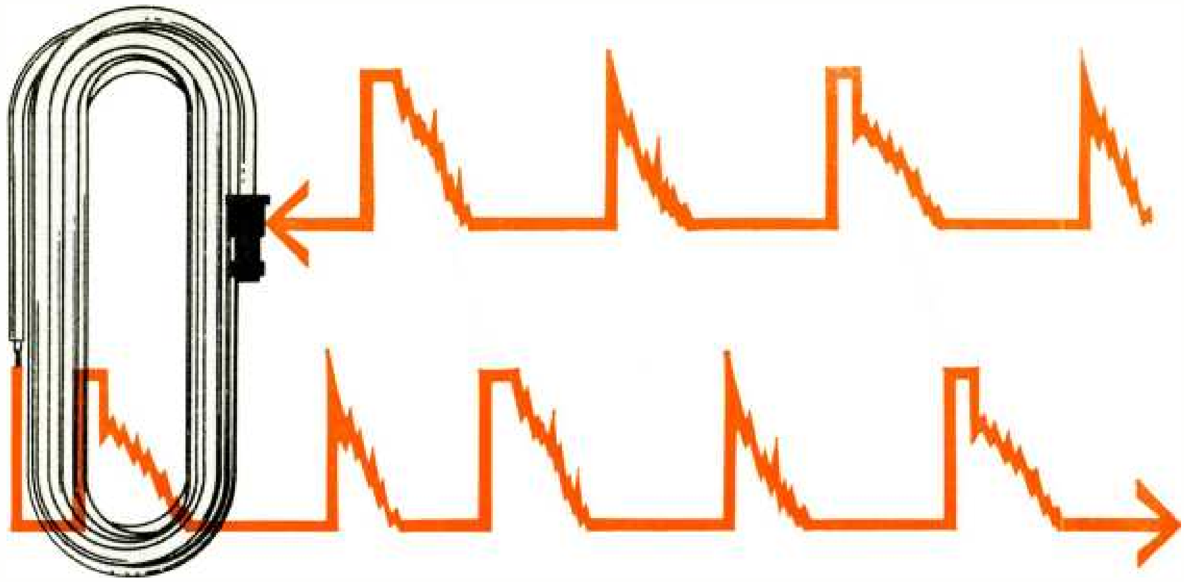
SONY TRANSISTOR SUBSTITUTION DIRECTORY

SONY NO.	CES NO.*	TYPE AND SERVICE	AMERICAN NUMBER	AMERICAN MFGR.
2T11, 2T12 2T15-2T17		P—a.f. amp.	2N322	MOT, G-E
2T13		P—a.f. amp.	2N323	MOT, G-E
2T14		P—a.f. amp.	2N324	G-E
2T21		P—a.f., l.s.	2N319	MOT, G-E
2T22, 2T25		P—a.f., l.s.	2N320	MOT, G-E
2T23, 2T24		P—a.f., l.s.	2N321	MOT, G-E
2T26		P—a.f., l.s.	2N319	MOT, G-E
2T51		N—bc. con.	2N169A	G-E, SYL
2T52		N—i.f. amp.	2N169A	G-E, SYL
2T53		N—i.f. amp.	2N168A	SYL
2T61-2T63 2T64, 2T64R, 2T65, 2T65R, 2T66, 2T66R, 2T67		N—a.f. amp.d.	2N647	RCA
2T69		N—a.f. amp., l.s.	2N647	RCA
2T73, 2T73R		N—bc. r.f. amp., con., mix., osc.	2N168A	SYL
2T74		N—bc. con.	2N168A	SYL
2T71, 2T72, 2T75, 2T75R, 2T76, 2T76R, 2T77, 2T77R		N—i.f. amp.	2N169	G-E
2T78R		N—ci., r.f., g.	2N167	G-E
2T82-2T86		N—a.f. amp., l.s.	2N576	SYL
2T201	2SA121, 2SA123	P—r.f. amp., con., mix., osc.	2N384	RCA, SYL
2T203	2SA124	P—FM amp., con. mix., osc.	2N384	RCA, SYL
2T204, 2T205		P—ci., r.f., g.	2N384	RCA, SYL
2T204A, 2T205A		P—ci., r.f. amp. mix., osc.	2N384	RCA, SYL
2T311, 2T312	2SB48	P—a.f., l.s., d.	2N322	MOT, G-E
2T313, 2T314	2SB49	P—a.f., l.s., d.	2N323, 2N324	MOT, G-E G-E
2T315	2SB50	P—a.f., l.s., d.	2N508	MOT, G-E
2T321, 2T322	2SB51	P—a.f., l.s.	2N319 2N320	MOT, G-E MOT, G-E
2T383	2SB53	P—l.n., a.f., l.s.	2N526	MOT, G-E, SYL
2T501		N—a.f., p	2N326	SYL
2T511-2T513		N—bc. con., mix.	2N169A	G-E, SYL
2T520-2T523		N—i.f. amp.	2N169A	G-E, SYL
2T551		N—r.f.	2N168A	SYL
2T552		N—r.f. amp.	2N169A	G-E, SYL
2T681		N—l.n., a.f. amp.	2N647	RCA
2T682		N—ci., sw.	2N585	RCA, GI, SYL
2T701		N—con.	2N168A	SYL
2T2001		P—con.	2N384	RCA, SYL
2T3011	2SB140	P—ci., a.f., p.	2N301	RCA, SYL
2T3021	2SB141	P—ci., a.f., p.	2N301A	RCA, SYL
2T3030	2SB142	P—a.f., p.	2N301	RCA, SYL
2T3031, 2T3032	2SB143	P—a.f., p.	2N301	RCA, SYL
2T3032, 2T3033	2SB144	P—a.f., p.	2N301	RCA, SYL
	2SB27	P—a.f. p-amp.	2N176	MOT, RCA
	2SB28	P—a.f. p-amp.	2N351	RCA
	2SB29	P—a.f. p-amp.	2N376	RCA
	2SC15	N—ci., vhf.osc.	2N1564, 2N1565	TI
	2SC191-2SC197	N—ci., r.f.amp.	2N332-2N336	RAY, TI, SYL, G-E

HITACHI TRANSISTOR SUBSTITUTION DIRECTORY

NUMBER	TYPE AND SERVICE	AMERICAN NUMBER	AMERICAN MFGR.
2SA12	P—455 kc. amp.	2N218	RCA
2SA13	"	2N410	RCA
2SA15	P—540-1640 kc. con.	2N219	RCA
2SA16	"	2N412	RCA, SYL
2SA80	P—s-w con.	2N370	RCA. SYL
2SA81	P—s-w local osc.	2N371	RCA
2SA82	P—s-w mixer	2N372	RCA
2SA83	P—455 kc. amp.	2N373	RCA. SYL
2SA84	P—540-1640 kc. con.	2N374	RCA. SYL
2SA208	P—med. speed sw.	2N578	GI, RCA
2SA209	"	2N579	GI, RCA
2SA210	"	2N580	GI, RCA
2SA211	"	2N581	GI. RCA
2SA212	"	2N404	TI, RCA. MOT, SYL, G-E, RAY, GI
2SA217	"	2N582	GI. RCA
2SB68	P—h.v. sw.	2N398	SYL. MOT, RCA, GI
2SB73	P—l.n., a.f. amp	2N220	RCA
2SB75	P—cl. A a.f amp.	2N215	RCA
2SB76	P—cl. A a.f. amp.	2N406	RCA, SYL
2SB77	P—l.s. a.f. amp.	2N217	RCA. SYL
2SB78	"	2N408	RCA, SYL
2SB83	P—p. a.f. amp. and sw.	2N301	RCA, SYL
2SB84	"	2N301A	RCA, SYL
2SB89	P—l.s. a.f. amp.	2N270-5	RCA
2SB183	P—cl.A, a.f. amp.	2N105	RCA
2SB184	P—l.s. a.f. amp.	2N105	RCA
2SC89	N—m.s. sw.	2N585	RCA, GI, SYL
2SC90	"	2N1090	GI. RCA, MOT
2SC91	"	2N1091	RCA. GI
2SD75	N—cl. A a.f. amp.	2N1010	RCA
2SD77	N—l.s. a.f. amp.	2N647	RCA
2SD120	N—h.p. sw.	2N1480	RCA
2SD121	"	2N1482	RCA
2SD122	"	2N1484	RCA
2SD123	"	2N1486	RCA
2SD124	"	2N1488	RCA
2SD125	"	2N1490	RCA

*CES—Communication Engineering Standard
P—"p-n-p"; N—"n-p-n"; con.—converter; mix.—mixer; osc.—oscillator; a.f., l.s.—audio frequency, large signal; a.f., d.—audio frequency, driver; a.f., p.—audio frequency, power; ci.—computer-industrial; l.n.—low noise; sw.—switching; bc.—broadcast; r.f.—radio frequency; r.f., g.—radio frequency, general use; amp.—amplifier; s-w—shortwave; h.v.—high voltage; m.s.—medium speed; h.p.—high power; MOT—Motorola, G-E—General Electric, SYL—Sylvania, RCA—Radio Corp. of America, GI—General Instrument Corp., RAY—Raytheon, TI—Texas Instruments.



Electromagnetic Delay Lines

By SIDNEY L. SILVER / B. Eichwald & Co.

When pulse signals must have a precise, short time lag, artificial transmission lines or delay cables are used. Here is how these devices operate and their applications.

IN THE complicated circuitry of modern communications systems, it is commonly required to delay a signal or information for precise time intervals. Devices such as radar systems, computers, guided missiles, television synchronizing generators, pulse-forming networks, and telemetering systems all require delay lines to control the time position of information.

Delay circuits are also used to synchronize sweep circuits and time-base calibration in oscilloscope and sweep generators. To obtain the desired timing and sequence of operation, a master signal or pulse is delayed by means of some electronic or mechanical device which has a definite period of transmission between its input and output. An electronic circuit which performs this function is called a delay line or storage network.

Basically, a delay line is a passive network that retards or delays an electric signal for a specific length of time, usually in the microsecond range. The type of delay circuit employed depends on the characteristics of the data to be delayed and the time delay required. Purely electrical devices are practical for short delays in the .1- to 20-microsecond range because of the long paths required at the high velocity of electrical propagation. This article restricts itself to the electromagnetic type of delay line, which falls into three basic categories; the lumped-constant delay line, the distributed-constant delay line, and the delay cable. The electrical characteristics of each type may overlap, inasmuch as the basic principles for all types of electromagnetic delay lines have much in common.

Lumped-Constant Delay Lines

In its simplest form the lumped-constant delay line is composed of a series of low-pass filter sections with mutual inductance between the successive sections. The time required to charge the capacitance through the inductance in the network results in a time delay or phase shift. As shown in Fig. 1, the series inductors and the shunt capacitors are lumped together to simulate the distributed characteristics of a real transmission line. In effect, the lumped-constant delay line is an artificial transmission line which has been compressed in a small volume. A true transmission line has almost no deterioration of frequency response up to hundreds of megacycles. However, an artificial transmission line has characteristics similar to a low-pass filter, insofar as such a filter tends to reject all frequencies higher than the cut-off value. For this reason, a large number of filter sections are used in the line so that the cut-off frequency is more sharply defined. If an insufficient number of sections are used, the

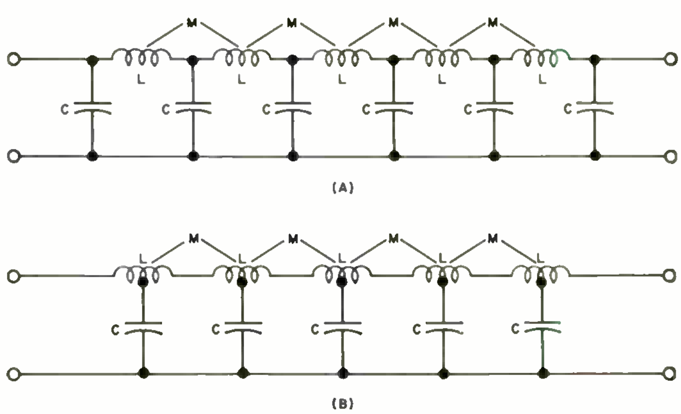
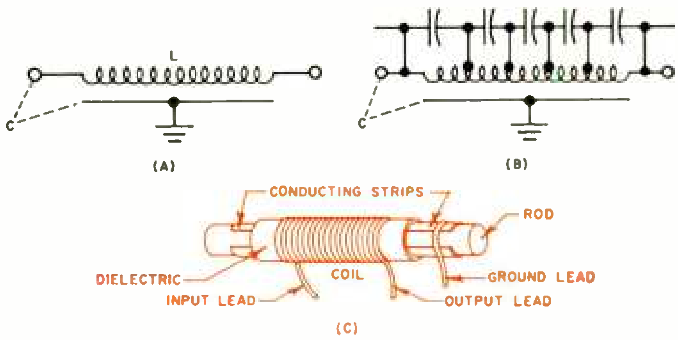


Fig. 1. (A) A lumped-constant delay line with mutual coupling (B) Delay line with optimum mutual coupling between section parts.

Fig. 2. (A) Distributed-constant delay line. (B) Line with compensating capacitors. (C) Distributed-line construction technique.



cut-off frequency of the line is low so that the bandwidth is restricted.

One problem in a delay line, which is not apt to arise in a true transmission line, is that the time delay in an artificial line may vary with frequency. This condition is best controlled by adjustment of the mutual coupling between the two halves of each section, as well as the mutual coupling between adjacent sections. Fig. 1B shows such an arrangement where the mutual coupling is calculated to be at its optimum value to give linear phase response.

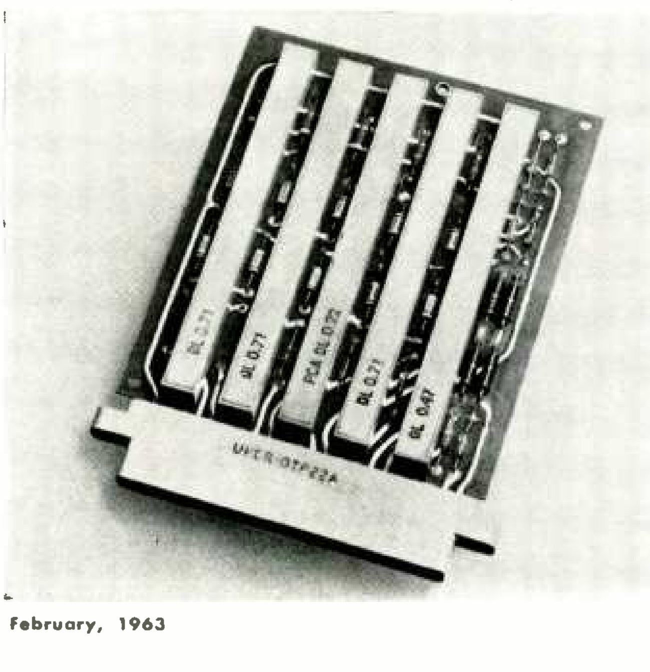
Distributed-Constant Delay Lines

The same principles that govern lumped-constant units apply to distributed-constant delay lines. As shown in Fig. 2A, the capacitance and inductance are distributed along the line to more closely approximate the transmission line. The coil provides a continuous inductance along the line, and the capacitance is obtained between the coil and the ground plane. Time delay of a signal is accomplished by storage in the magnetic field of the coil and in the electrostatic field between the coil and ground in close proximity. These two parameters also comprise the mutual coupling between any two parts of the line and the capacitance between them.

If a low frequency is fed into the delay line, the amplitude and direction of the current will be the same, with the common magnetic field producing a large value of inductance. If the frequency is sufficiently high, there is a reversal of the direction of the current because of the delay in the line. Since the time delay is dependent on inductance, this apparent loss of inductance will result in a shorter delay time. One method of minimizing this variation in time delay is indicated in Fig. 2B. Compensating capacitors are added to the winding in such a manner as to increase the high-frequency delay time. The coupling between turns having a different phase relationship is thereby reduced, so that the bucking effect is negligible. This type of compensation reduces the bandwidth of the line, due to the attenuation of high frequencies caused by the high impedance of the parallel-tuned circuit. However, careful adjustment of these capacitors will yield a constant delay time over the usable frequency range.

Fig. 2C illustrates the construction of a distributed-constant delay line. The line normally consists of a multi-layer coil of insulated wire around a ceramic rod that has been coated with a conductive material, such as silver, to provide a ground conductor pattern. The rod is covered with a thin layer of dielectric, such as Mylar or Teflon. The entire unit is then encapsulated to resist moisture and vibration. Fig. 3 shows a group of distributed-constant delay lines employed in pulse work, mounted on a printed-circuit assembly. These lines are designed for short delay intervals and provide a high ratio of delay-to-pulse-rise time, in minimum space.

Fig. 3. Distributed-constant lines mounted on printed circuit.



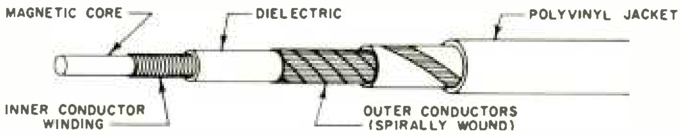


Fig. 4. Cutaway diagram showing construction of delay cable.

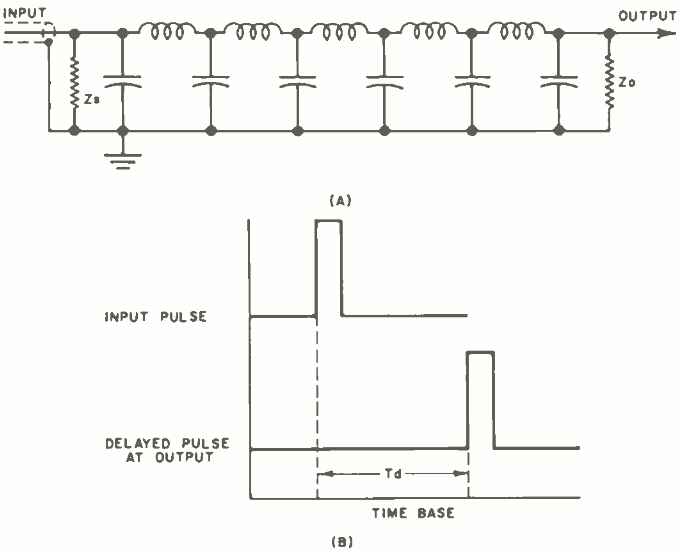


Fig. 5. (A) Properly terminated line. (B) Time-delay relation.

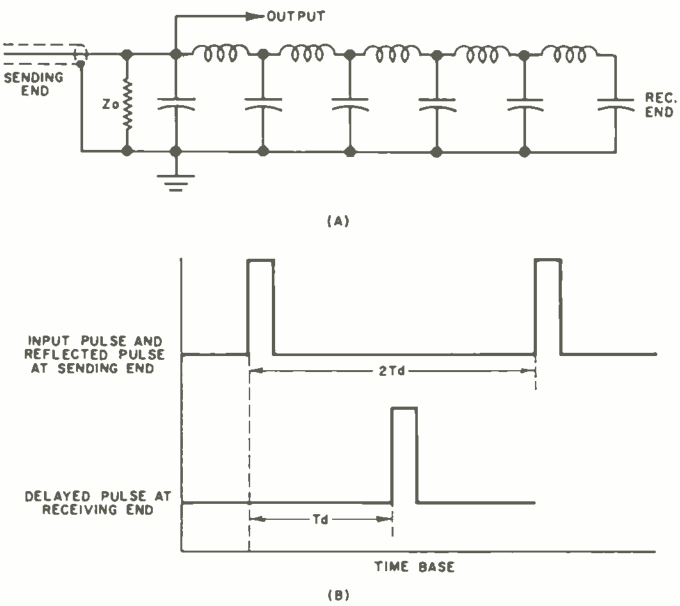
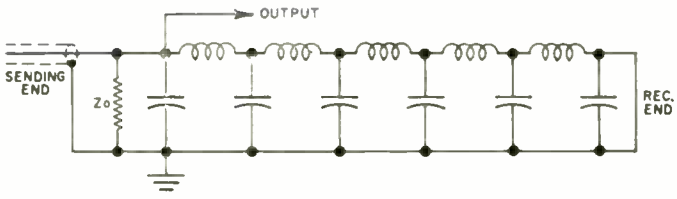


Fig. 6. (A) Open-circuited line. (B) Output pulse produced.

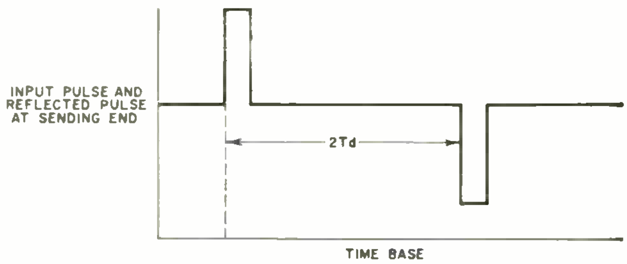
Delay Cables

Essentially, the delay cable is a distributed-constant delay line with a much longer winding for a given delay. Consequently delay per inch is very small and the cut-off frequency characteristic is such that the attenuation increases gradually with increasing frequencies. Practical delays may vary from a fraction of a microsecond to 20 microseconds. Within these limits, any delay period can be obtained by cutting and calibrating the line.

Fig. 4 shows a cut-away view of the delay cable. The flexible magnetic core carries the closely wound inner conductor. A low-loss dielectric, such as polyethylene, is applied over the inner conductor in the form of overlapping tape. The outer conductor consists of parallel wires which are spirally wound.



(A)



(B)

Fig. 7. (A) Short-circuited line. (B) Output pulse produced.

Finally, a polyvinyl jacket is extruded over the cable core. The cable is cut to any desired length and endcaps are molded to each end to provide a humidity seal.

Theoretical Considerations

Normally, delay lines are used for step functions (pulses) and square waves rather than sine waves. Since step functions are composed of a fundamental and odd harmonics, these frequency components must be delayed equally to assure minimum pulse shape distortion. In a properly designed delay line, the sum of the frequencies and phase angles which comprise the output pulse will assume the form of the input pulse as closely as possible.

A delay line may be defined by three properties: its cut-off frequency, its equivalent length, and its characteristic impedance.

The frequency response (3-db points) may be related to the pulse rise time by the equation: $BW = .36/T_r$, where BW = bandwidth in megacycles, T_r = rise time in microseconds. Equivalent length is usually expressed as a delay time equal to the time taken to traverse the network. This is given by: $T_d = N\sqrt{LC}$, where T_d = time delay in seconds, N = number of sections, L = inductance per section in henrys, and C = capacitance per section in farads.

The characteristic impedance of a delay line is found by the formula: $Z_o = \sqrt{L/C}$ where Z = characteristic impedance in ohms, L = inductance per section in henrys, and C = capacitance per section in farads.

A delay line, if terminated in its characteristic impedance (Z_o) at the receiving end and properly matched to its source impedance (Z_o) at the sending end, will reproduce at its output a waveform applied to its input terminals. Fig. 5A shows a properly matched delay line where the input voltage is dissipated in the terminating resistance without reflection. The input waveform shown in Fig. 5B is reproduced at the output terminals with negligible distortion and with a time delay determined by the electrical length of the line.

If a delay network terminates in a short-circuit or open-circuit, multiple reflections of the waveform occur back and forth along the line. Reflections generally are undesirable, but for special applications such as pulse-forming circuits, they can be used to advantage. Fig. 6A indicates a delay line properly terminated in its characteristic impedance at the sending end but unterminated at the receiving end. A delayed pulse appears at the receiving end and an additional pulse of the same polarity is reflected to the input terminals. The reflected pulse is delayed by two times the total delay of the network, as given in Fig. 6B, which is the time required for a pulse to travel to the end and back.

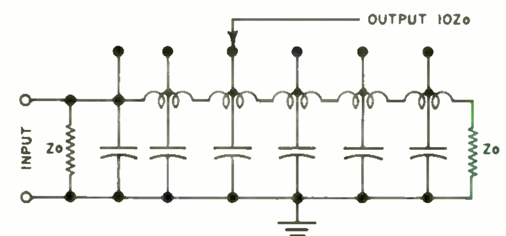
If the receiving end of a delay network terminates in a short-circuit, no pulse appears at the receiving end, but an inverted voltage pulse is reflected back to the input. Fig. 7A shows a delay line properly terminated in its characteristic impedance at the sending end but short-circuited at the receiving end. When the reflected wave reaches the sending end it is absorbed in the matching termination. The resultant time interval, as given in Fig. 7B, between the original pulse and its delayed counterpart, is equal to twice the total delay of the network.

Variable Delay Lines

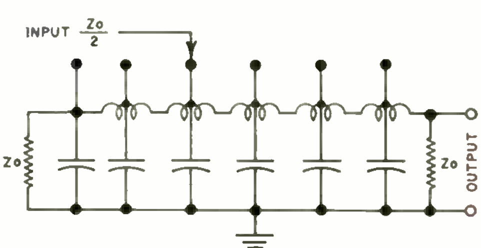
According to application, it may be necessary to provide for a variable time delay while maintaining a low attenuation at high frequencies. Where high delay-to-rise-time ratios are required, lumped-constant delay lines can be tapped at different points to give a series of delays. A common method of connecting a variable tapped delay line to a high-impedance output is shown in Fig. 8A. The output impedance should be 10 times or more the impedance of the line, to minimize reflections from the line back to the source.

In Fig. 8B, the line is connected for a low output impedance. The source is fed into the line tap and sees one-half the characteristic impedance of the line. Maximum power transfer without reflections is obtained when the source impedance is equal to one-half the load impedance (Z_o).

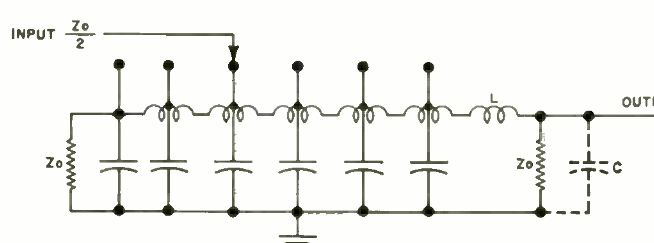
If the load impedance is capacitive, as in the input of a tube, a compensating network should be added to provide a constant impedance over the desired frequency range. Fig. 8C shows a half-section of low-pass filter, consisting of the



(A)



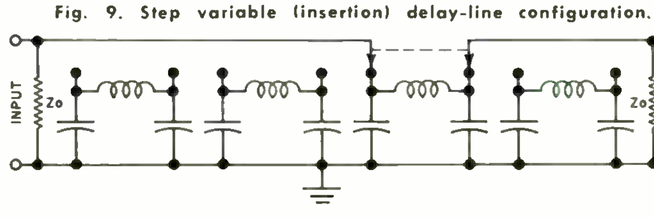
(B)



(C)

Fig. 8. (A) Variable tapped delay line for high-impedance output. (B) Connection for low-impedance output. (C) If the load is capacitive, a series inductor is added to line as shown.

Fig. 9. Step variable (insertion) delay-line configuration.



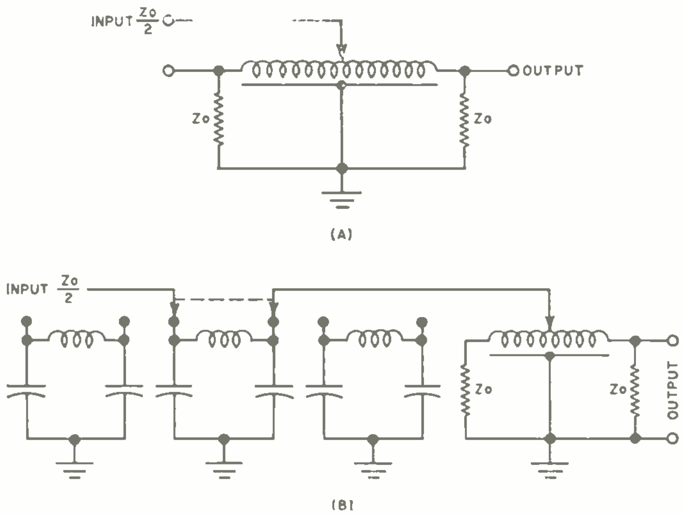


Fig. 10. (A) Continuously variable delay line. (B) Series connection for step variable and continuously variable delay network.

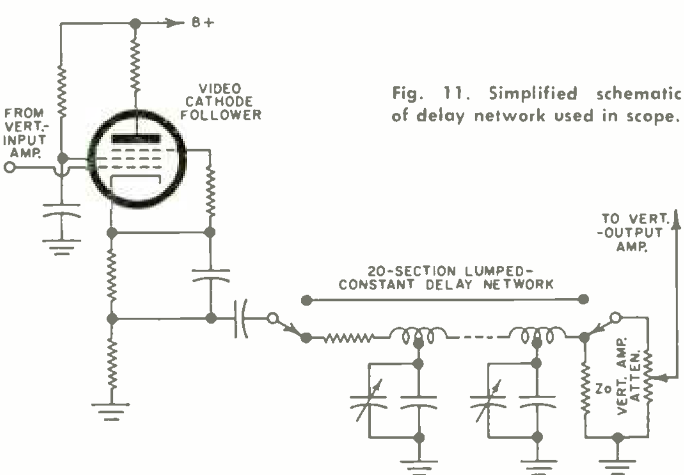


Fig. 11. Simplified schematic of delay network used in scope.

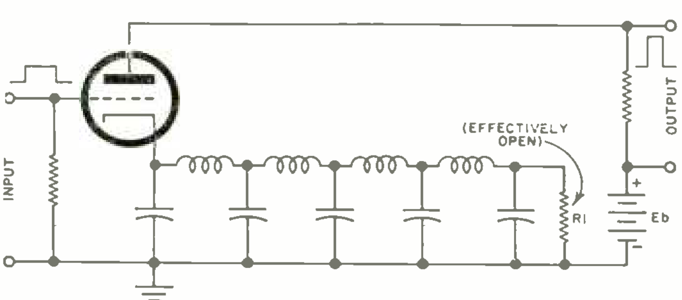


Fig. 12. Delay line employed to form a narrow output pulse.

tube input capacitance and an added inductor in the termination of the line. Where high-impedance delay lines are used, more elaborate compensating networks are required to provide a constant over-all delay response.

In applications where a tapped line cannot be used, because of the high impedance required at the tap, an insertion or step-type of variable delay line is employed. As shown in Fig. 9, the switch selects the number of *LC* networks connected in tandem, so that a desired amount of time delay can be secured. Since each delay setting is a complete delay line, the external load can be matched to the impedance of the line.

Where variable time delay with a small resolution time is required, a continuously variable delay line is employed. Fig. 10A shows a distributed-constant delay line using a continuous solenoid with a slider arm wiping along the coil. The movable contact can travel from one end of the line to the other, picking up the signal at any point along the line. The resolution time may be defined as the smallest incremental time delay that can be achieved.

For longer delay, two or more delay lines can be connected in series whenever their characteristic impedances are equal. In this case, the total time delay will be the sum of each individual unit and the rise time will be equal to the square root of the sum of the squares of the rise time of each unit. Fig. 10B shows a delay network consisting of a stepped variable delay line and a continuously variable delay line. The former serves as the coarse control for time variation, while the latter serves as the fine control. To minimize reflections, the input terminal should be coupled to a source impedance equal to one-half the characteristic impedance of the variable line.

Delay-Line Applications

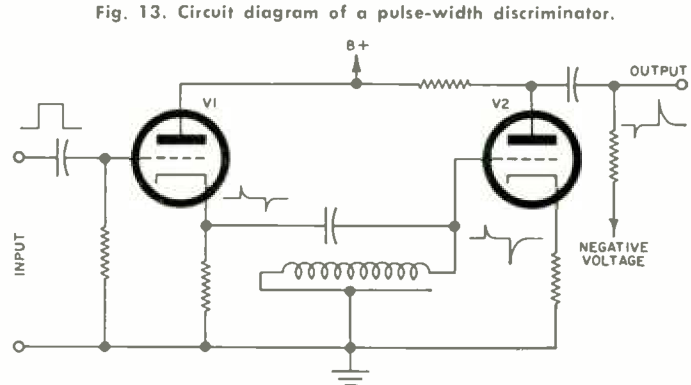
An important function of delay lines is their use in the vertical deflection system of wide-band oscilloscopes and synchroscopes, to permit complete viewing of the leading edge of steep-fronted pulses. The time delay, usually in the ¼- to ½-microsecond range, is sufficient to delay the input signal before it reaches the vertical deflection plates. This permits the time-base voltage to be fed to the horizontal deflection plates, so as to start the sweep before the input signal is superimposed upon it. Such action is important in the observation of random pulses and transients where it is necessary to follow the complete variation of the input signal. Fig. 11 shows a lumped-constant delay network consisting of 20 *m*-derived sections used in the vertical amplifier of an oscilloscope. By using an optimum value of mutual coupling, uniform time delay is obtained for frequencies well above the cut-off of the vertical output amplifier. To obtain smooth impedance matching between sections of the network, trimming capacitors are employed. In this application, the network must be properly terminated in its characteristic impedance to avoid reflections.

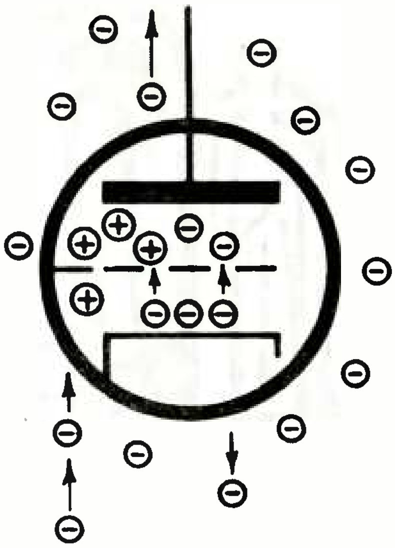
A common method of pulse generation in microwave radar systems is illustrated in Fig. 12. In order to transmit short bursts of r.f. energy, the radar transmitting tube is modulated by rectangular pulses of short duration. These pulses are formed in a delay network terminating in a resistance much greater than the characteristic impedance of the line. Normally the amplifier tube is in a non-conducting state until triggered by the positive input pulse. At this instant plate current increases sharply and establishes a voltage wave between cathode and ground. The voltage travels down the line and upon reaching the effectively open end, is reflected back to the cathode without change in polarity. This sudden increase in cathode voltage is sufficient to cut off the tube. Thus, the leading edge of the output pulse is formed as the tube starts to conduct and coincides with the leading edge of the grid pulse. The trailing edge of the output pulse is formed as the delay line cuts off the tube and bears no relationship to the grid voltage. After the tube is cut off, the delay line slowly discharges through the terminating resistor until the cathode voltage becomes sufficiently low to allow the tube to conduct, or until a trigger pulse again drives the tube into conduction.

Delay lines are commonly used in decoding units of missile guidance systems. To extract the intelligence transmitted by

(*Continued on page* 99)

Fig. 13. Circuit diagram of a pulse-width discriminator.





RECEIVING TUBE GRID CURRENT

By A. SZILASI / Mgr. of Engineering, Westinghouse Electric Corp.

Four different kinds, each with its own causes and effects, can be separately identified and measured.

IN DEVICES built to check receiving tubes, there is an increasing tendency to include one test that may appear to be unnecessary or, at least, of little importance: the measurement of grid current. The allowable limit may be as little as one or two microamperes, which may strike some people as being severe. Since plate current is often 10 ma. or more, a change in the grid current of less than one one-ten thousandth of this amount seems of no importance.

To understand the effect of grid current, we have to remember that the electron tube, as normally used, serves as a device with a very high input resistance. This value is measured as the damping effect of the input on preceding circuitry that feeds into it. For example, it would not make much sense to design a circuit with a very high "Q" and then follow it with a parallel resistance—like the input of the next stage—that is small. We would lose the advantages of the high-"Q" design. This need to maintain a high input resistance is the reason that the grid is usually connected to ground or to the tube's cathode through a high-value, external resistor, which may be as much as 2 or 3 megohms. The presence of grid current effectively lowers the input resistance.

Where no tuned circuit precedes the tube's input, grid current may still change loading on the foregoing circuit and can also affect operation of its own stage. When the current exists, it will produce an additional voltage drop across the grid resistor. This is not an effect produced by signal current, which may be normal and desirable; it is purely a d.c. effect independent of signal.

If the grid current is very small, we can either disregard the d.c. effect or compensate for it by adjusting bias accordingly. In the case of higher grid current, however, there is danger that it will change during the life of the tube and, as a result, a shift in characteristics will occur. In addition, there is something of a problem when the tube has to be replaced.

Tube engineers distinguish four kinds of grid current, each with its own causes and effects. They can be present simultaneously, but one will usually overshadow the others. One of these is identified as a positive grid current; the three others are all negative, albeit produced in different ways.

Positive Grid Current

When a grid is positive with respect to the cathode or only slightly negative (by less than 1 volt), its relationship to the cathode is somewhat like that of the tube's plate. Some of the cathode-emitted electrons will go to the grid, as they normally flow to the plate. To complete the circuit (Fig. 1A), they will go from the grid through the grid resistor to ground, and thence back to the cathode.

Since the effect of this phenomenon, as we shall see, is to make the grid more negative, it may seem confusing to identify it as positive grid current. Nevertheless, the conventional concept of current flow holds that it moves in a direction opposite to that of electron movement. Thus this current, conceived as moving from grid to cathode, is considered positive.

To account for the effect on grid voltage, consider the flow of electrons from the grid itself through the grid resistor to ground. With this direction of movement, the drop across the resistor is such that the ground end, away from the grid, is less negative or more positive. The grid end is more negative. (Compare this to voltage at the plate of a tube, which is more negative than the voltage on the side of the plate dropping resistor that is away from the tube. Here, too, electron movement is away from the tube's electrode, back to the supply.)

With most conventional tubes, this positive grid current will disappear altogether if we apply 1.5 volts or more of negative bias to the grid. The latter electrode then repels rather than attracts electrons. In some circuits, however, this positive grid current is desirable. It may be used, for example, to produce automatic bias across a grid resistor. This technique is often found in oscillator circuits.

Gas Current

Most often, when grid current is mentioned, we think in terms of a current in a negative direction, opposite to that

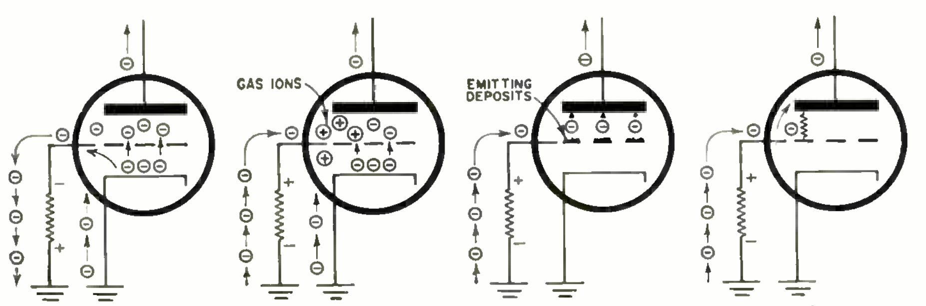


Fig. 1. Inadequate bias causes (A) "positive" grid current. Some cathode-emitted electrons are attracted to the grid, return to ground through external resistor. "Negative" grid current may be caused by (B) positively ionized gas particles that draw electrons from grid, (C) matter deposited on grid, or (D) leakage from grid to another electrode.

just described. One such type is gas current. This is always due to an imperfect vacuum in the tube.

Even with the best exhaust techniques in manufacture, there will be some gas molecules left in a sealed-off tube. When these are struck by fast-moving electrons during operation, they tend to ionize positively by surrendering electrons that go to the plate. The ions are attracted to the negative grid, from which they take on electrons that have moved up through the external resistor (Fig. 1B). Since the direction of movement at the grid is opposite to that in the case first described, negative current is involved.

In conventional terms, the positive charge moves away from the grid, through the grid resistor and ground, back to the cathode. This makes the grid end of the resistor more positive than the ground end. The bias thus produced will consequently counteract the normally applied negative bias.

Certain conditions of circuit operation will influence the value of gas current. The velocity of emitted electrons is a key factor, since this will affect the degree of ionization. Velocity, in turn, is influenced by the levels of plate and screen voltage. Total emission current also affects gas-current value. If the cathode connection is disrupted, for example, gas current must disappear.

Normally tubes display very little or even unmeasurably small gas current. The value may be .5 microampere or less. High values, of course, indicate loss of vacuum. Furthermore, the undesired effect can build itself up. The resultant reduction in bias can permit a substantial increase in plate current. Plate temperature then rises, and additional gas is thus released from the plate metal, increasing gas current still further. This avalanche effect can lead to arcing and destruction of the tube.

Grid Emission Current

To obtain emission, cathodes are coated with such materials as barium which, when heated, release electrons. Sometimes a quantity of barium will be evaporated from the cathode and deposit on the grid. If the grid itself rises to a certain temperature, it can then act like a cathode, albeit a rather poor one. It will emit electrons that tend to move toward the positively charged tube electrodes (Fig. 1C), such as the plate of a triode or the plate and screen grid of a pentode.

From the plate and screen-grid circuits, these electrons will return to ground, then move up from ground and through the grid resistor back to the grid itself. Since grid current is in the same direction as when gas exists, it is another form of negative current and the voltage drop across the resistor tends to make the grid more positive.

Heating of the grid is necessary to produce such emission. Thus cathode temperature and plate dissipation are the two principal contributing factors. A small reduction in either of these produces a considerable reduction in emission-caused grid current. The value of grid bias, however, has little effect where emission is a factor. Considering the magnitude of positive voltages normally applied to plates and screen grids (100 volts or more), a bias change has little effect on the potential difference between control grid and plate or screen grid.

Grid Leakage Current

A conducting bridge can be formed between the grid and some other electrode in the tube. Sometimes this is a metallic deposit on the mica spacer, connecting the grid holes and some other electrode inserted into the mica. Sometimes the bridge is formed by sublimation on the glass of the stem. Since the grid is normally the most negative point in the tube, electrons will move from it. The direction of conventional current will once more be away from the grid—negative—making the grid more positive.

Such leakage can be represented by an ohmic resistor between the elements involved. Grid-to-plate leakage is illustrated in Fig. 1D. When the tube is out of its circuit, therefore, leakage is often independent of the direction of current and can be measured even in a cold tube without heating the cathode. Its value varies little with temperature.

Measurement Techniques

The simplest, most straightforward way of measuring grid current is by inserting a microammeter between the grid and the bias source, or between the grid and ground if cathode bias is used. A grid resistor in series with the microammeter is not necessary for this test, but is advisable for protecting the instrument in the event of a short.

The meter polarity will distinguish between positive and negative grid current. In the case of positive grid current, as in Fig. 1A, the negative pole of the meter must be connected to the grid to obtain a reading; in the case of negative grid current, the positive pole of the meter connects directly to the grid.

Positive grid current should disappear after the bias is increased beyond −1.5 volts. If it persists after application of a higher negative bias, it must be assumed that an a.c. signal is superimposed over the d.c. bias, driving the grid into the positive region. This signal can originate from an outside disturbance or from oscillation in the tube under test itself. Unwanted a.c. must be suppressed, or the test readings become meaningless.

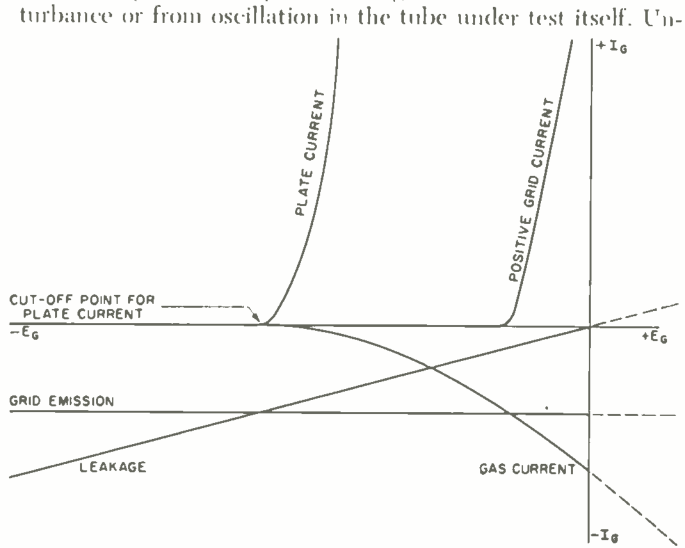


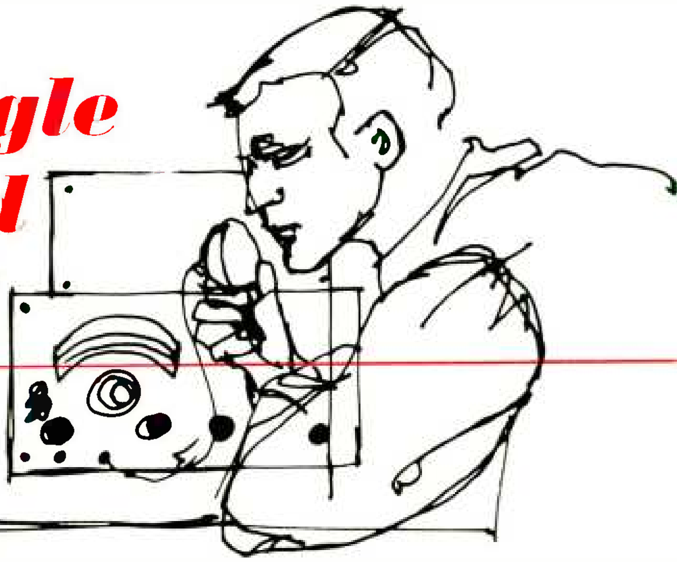
Fig. 2. The four types of grid current as functions of bias.

Negative grid current can usually be measured once the positive current is eliminated; that is, if sufficient bias is applied to the grid. Since the values are normally quite small, the sensitivity of the meter should allow for measurements down to .1 microampere.

A d.c. v.t.v.m. with very high input resistance can be used as an alternate measuring instrument. The voltage drop produced by grid current across the grid resistor is measured and Ohm's Law is used to determine the current. The high-impedance microammeter is essentially the same as the v.t.v.m., with the difference that no additional resistor has to be inserted between grid and ground and that calibration is directly in microamperes.

An indirect method of determining grid current, the bias shift measurement, makes use of the tube under test as a kind of vacuum-tube voltmeter in association with a meter movement. With no resistor in the grid circuit, a current meter is inserted in the plate circuit and plate current is noted. A resistor is then placed in the grid circuit. If grid current is now present, the bias will shift and plate current will also change, in a direction depending on the direction of bias change. A negative grid current (grid more positive, Fig. 1B, C, or D) will produce a plate current increase; a positive grid current (grid more negative, Fig. 1A) will decrease plate current. The plate current change is determined by the following formula:

(Continued on page 84)



Single Sideband Simplified

By R. E. BAIRD, W7CSD
Head, Electronics Dept., Oregon Technical Institute

A basic look for the ham or communications technician and a non-mathematical description of SSB with vectors.

THE woods are full of hams with SSB transmitters. Some of these are people with five thumbs on each hand for pushing buttons. They can also read directions as to what to do after turning dial "A," adjusting meter "B," and pushing switch "C." Let's hand it to the commercial boys for putting out a product that the non-technical ham can operate without spreading chaos over the whole band.

However, there are many hams who would really like to know just what is taking place in their rigs—whether "store-bought" or constructed from plans published in a magazine or handbook. While it is comforting to know that the equipment is working all right, there are some hams who would also like to know what they are doing and why.

This article is presented in the hopes of removing a little of the fog surrounding the subject of SSB. We are not going to try to develop any exotic circuitry. We will discuss circuits that are both commonly used and easy to understand. The more complex circuits are simply elaborated versions of the basic theory—so it makes sense to learn the simple circuits first.

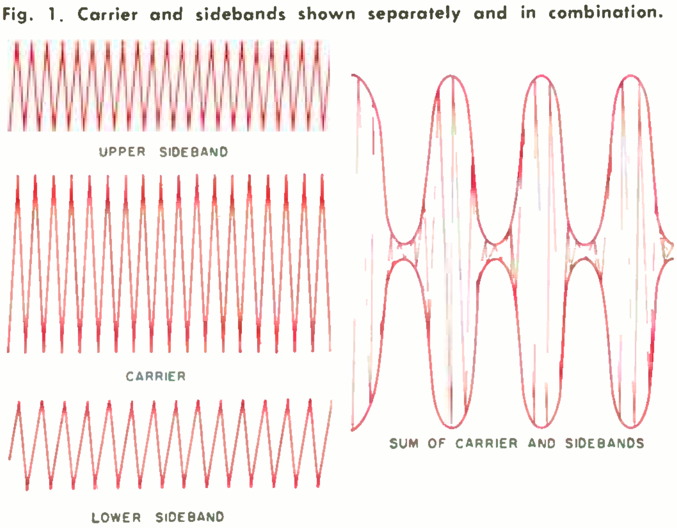
Little Known Facts About AM

Before diving off the deep end to start an exploration of SSB, perhaps it would be well to review what we know (or don't know) about AM. At the risk of becoming very unpopular, we are going to disillusion a few people about some things they have believed all of their lives. It is to be hoped that the shock doesn't drive anybody to permanent c.w.! But, the fact remains, on AM the amplitude of the carrier is *constant*. It does not change. I can hear you saying it now—"I have been watching the amplitude change on my oscilloscope for the last umpteen years and those electrons don't lie." Very true, but you haven't been looking at the carrier alone. You have been looking at a composite of the carrier plus the two sidebands. The composite signal does double on the positive peaks and reduce to zero on the negative peaks with 100% amplitude modulation. But the carrier alone does not change in amplitude.

If you have a very selective receiver and a good oscilloscope you can actually apply modulation to the transmitter with, say, a 5000- or a 10,000-cps pure tone and pick out the lower sideband, the carrier, and the upper sideband in the i.f. section of the receiver. If you tune to the carrier frequency you will note no change as modulation is applied. Of course, the sidebands will change.

An attempt to reproduce the three pictures is illustrated in Fig. 1. In Fig. 1A, we have the components that make up 100% modulated AM. Actually all three should be sine waves in shape. At any rate, assuming we could draw a sine wave of the carrier at, say, 3900 kc. and the sidebands at 3910 kc. and 3890 kc. respectively, we could actually add all three waves together instant by instant and come out with the well-known modulation pattern shown in Fig. 1B, the sum of the three signals. This is what your oscilloscope sees.

Fig. 1. Carrier and sidebands shown separately and in combination.



Vector Representation

Now we have to dig back into the theory of a.c. circuits a little in order to draw any pictures that will have meaning when we talk about single sideband. We have to show that an a.c. voltage or current can be represented by a rotating vector. Going back to the beginning, the reader will recognize that if we rotate a conductor in a uniform field, as in Fig. 2, the greatest number of lines of force will be cut per unit of time when the conductor is passing point "A" because at that point the direction of motion is perpendicular to the lines of force. At point "B," the direction of motion is parallel to the lines of force and hence none are being cut. Between these two points the conductor will be cutting lines of force on a slant. The generated voltage in the conductor, when plotted against time (and in this case position), will give the well-known sine curve, Fig. 2B.

Now suppose for some reason or other there was a second conductor spaced some distance behind the first conductor (let's take a spacing of 90 degrees). In this case the second conductor would also generate a sine wave of voltage but it would occur later than the first. Since one cycle is equal to 360 degrees, we can also calibrate the horizontal axis in degrees and the second sine wave would appear 90 degrees later than the first sine wave. See Fig. 3A. Now again suppose we wanted to connect these two conductors in series and get the sum of the two voltages. In this case we would merely have to add the instantaneous values at each point and we could get the third somewhat larger curve. It would be a little inconvenient to have to get involved in all this curve drawing every time we wanted to get the sum of two a.c. voltages. There must be a simpler way and here is where the use of vectors comes into the picture.

A vector is any quantity that has both magnitude and direction, usually represented by an arrow drawn to scale at a certain angle. If we are considering a single voltage we could use any position as a reference. For example, we could use zero degrees as a reference. So, in the case of the first conductor mentioned above, we could draw a vector of maximum length at zero degrees to represent the voltage at zero degrees or point "A" in Fig. 2. The instantaneous voltage 45 degrees later would turn out to be .707 times the maximum value. At 90 degrees the instantaneous value would be zero, and so on for as many positions as you care to take. However, instantaneous values are not very convenient to work with and usually more than one voltage (or current) is under consideration at once. For this reason, the effective or r.m.s. values are usually used.

Although all of the vectors are rotating, we usually take one as a reference and refer the others to it. If all of the voltages are at the same frequency there is no change in angle between the vectors and so we can draw a stationary picture. Perhaps a concrete example will clarify the matter.

Let voltage "A" in Fig. 3A be taken as the reference. Let's assume that the r.m.s. value is 10 volts, as read on a meter. We can now lay this off 10 units on the zero reference axis. Voltage "B" in Fig. 3B is 90 degrees behind "A" (traditionally in mathematics, positive rotation is taken in the counterclockwise direction), so we lay off 10 units 90 degrees behind "A" or straight down. If we apply the parallelogram rule we find the result to be approximately 14 volts. This is actually what a voltmeter would read if the two conductors in the above example were connected in series.

Now Back to AM

Going back to Fig. 1A, we find that we have three a.c. signals to be added together. If we do this by vectors rather than by combining sine waves, it will be much easier to understand some of the aspects of SSB later. We have a slightly different situation than in the above example in that the frequencies are not all the same. So let's use the carrier voltage as the reference.

In this case, the upper sideband which is higher in frequency is rotating faster than the reference or is rotating in a counterclockwise direction with respect to the carrier. The lower sideband is lower in frequency and is rotating slower than the reference or is rotating in a clockwise direction with respect to the carrier. Fig. 4 shows the vector sum of the sidebands and the carrier for several instants of time. Fig. 4A shows an intermediate value in the neighborhood of 60% positive modulation. In Fig. 4B, the sidebands cancel and the total amplitude is equal to the carrier alone. Fig. 4C shows 60% or 70% negative modulation while in Fig. 4D the sidebands add directly and oppose the carrier, resulting in zero amplitude or 100% negative peak. Fig. 4E shows a low per-

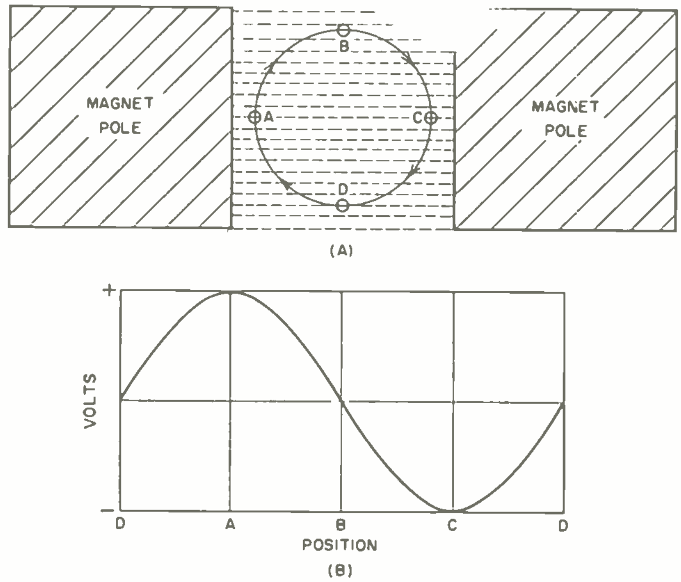


Fig. 2. Method employed to generate a sine-wave voltage.

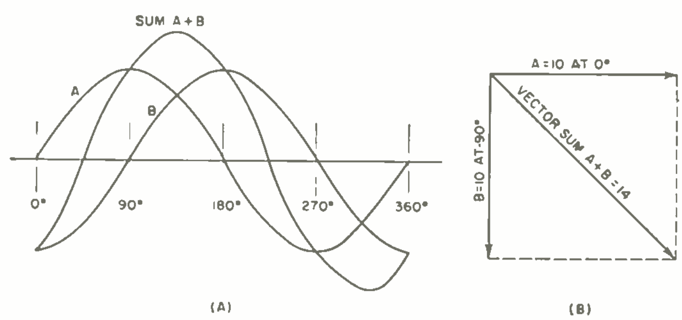
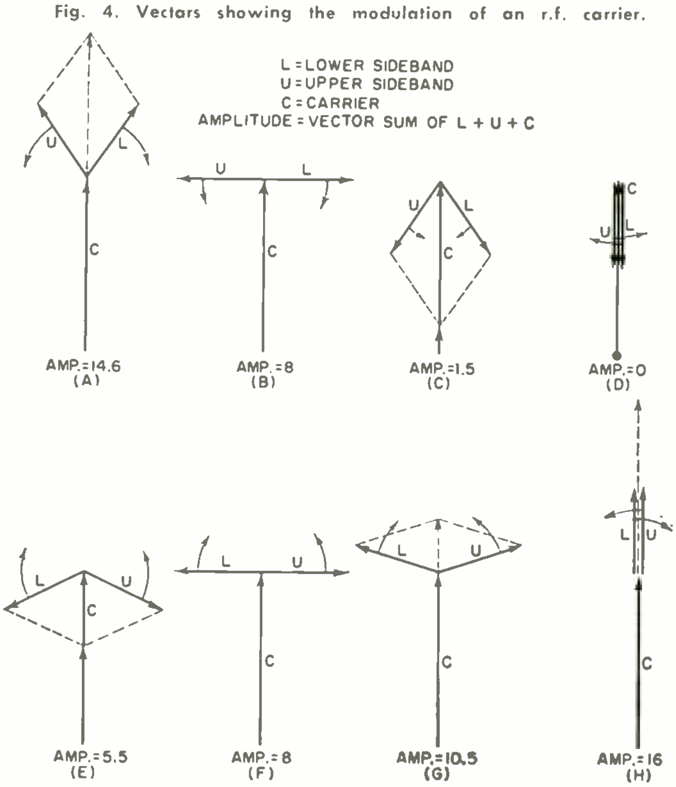


Fig. 3. Vector sum of two 90-degree sine-wave signal voltages.

Fig. 4. Vectors showing the modulation of an r.f. carrier.



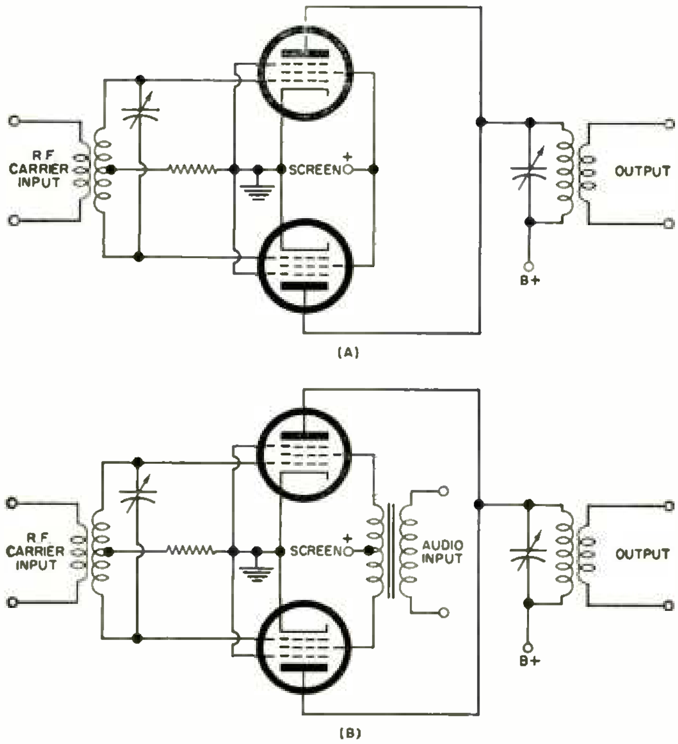


Fig. 5. Balanced modulators with and without audio signals.

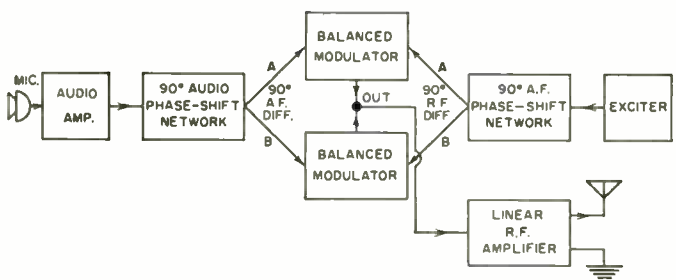


Fig. 6. Block diagram of SSB rig employing phasing method.

centage of negative modulation. In Fig. 4F we are back to carrier level again and Fig. 4G shows a low value of positive modulation. In Fig. 4H the sidebands add directly and in the same direction as the carrier, making a 100% positive peak.

The Balanced Modulator

In general there are two SSB systems in common use, the filter system and the phasing system. Both methods require a balanced modulator which removes the carrier. So let's see what goes on in a balanced modulator.

There are several types of balanced modulators, but perhaps the easiest to understand uses two pentodes with modulation applied to the screen grids. This avoids getting more than one kind of signal on any one grid. Fig. 5A represents the balanced modulator before modulation is applied and this circuit merely removes the carrier. At first glance this may look like a standard push-push output doubler. The only difference is that both the grid and plate circuits are tuned to the same frequency. As one grid goes in the positive direction, driving its plate to greater current, the other grid is going negative, driving its plate lower in current. The two plate current changes cancel each other and hence nothing comes out at the output.

This is the method of removing the carrier from the SSB transmitter. The amount of carrier suppression is determined by the match of the two tubes and possibly by some external balancing controls. We will assume that the ideal situation of perfect cancellation exists.

Now let's apply some modulation. Fig. 5B shows the same circuit as Fig. 5A but with a modulation transformer connected in push-pull to the two screen grids. Let us assume that the positive half of an audio cycle is reaching the screen grid of the upper tube. At the same time the negative half of the audio cycle reaches the lower tube. This will increase the plate current of the top tube and decrease the plate current of the lower tube at the audio frequency, thus unbalancing the circuit. There will now be a resultant r.f. energy output across the output.

Now just what kind of r.f. energy will this be? Actually we are amplitude modulating both tubes; there are two carriers and two sets of sidebands. Remembering what has been said about AM previously, we know that the carriers stay at constant amplitude during the process of modulation and therefore remain canceled in the output. So the only energy that can appear in the output is sideband energy. If we had modulated the screens in parallel, everything would have canceled out, but by applying the modulation in push-pull the phasing is such that we come out with both sidebands and no carrier.

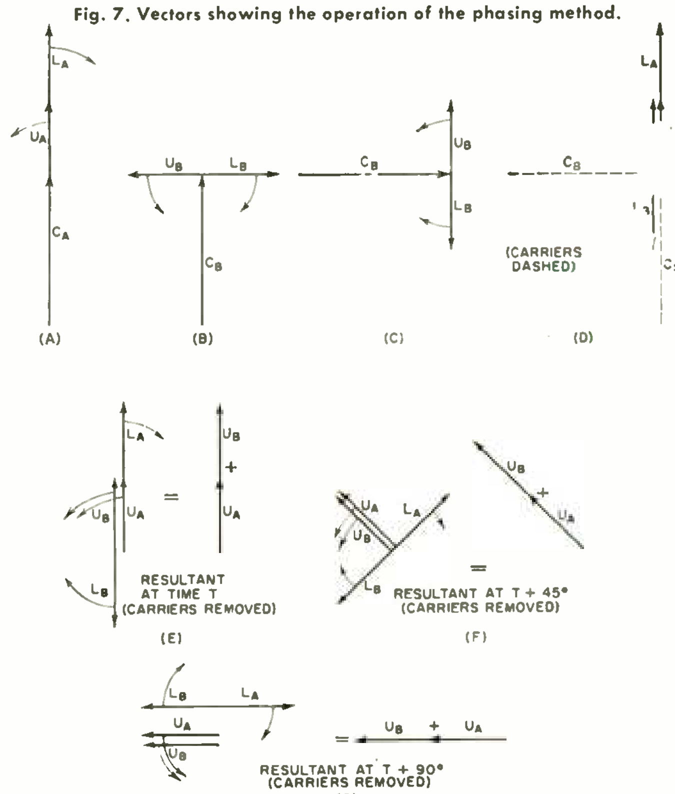
Getting Rid of One Sideband

From the balanced modulator we have two sidebands. In order to have single sideband we must remove one or the other of these two sidebands and have only one remaining. The simplest method of doing this is by means of a *filter*. If a bandpass filter can be designed so that it will pass one sideband and reject the other, we have one possible answer. Such filters have been designed, and several commercially built ham transmitters use this system. The filters are available separately for those who wish to home-brew their own. It is a formidable job to design and build such a filter although the use of surplus crystals brings this chore within the realm of possibility for the enterprising ham. The main drawback to the filter system is that, to get effective filtering, they have to be built for just one frequency and this is usually a rather low frequency. In order to get output on the desired ham band it is necessary to use heterodyne action and special mixing.

The alternate method of removing the unwanted sideband is the *phasing method*. This system is widely used but not too

(*Continued on page* 64)

Fig. 7. Vectors showing the operation of the phasing method.



FM MULTIPLEX SIGNAL GENERATOR

By THOMAS E. REAMER

Construction of a service instrument that develops a composite stereo signal for the alignment of multiplex adapters or the multiplex circuitry in tuners or receivers.

SINCE FM stereo broadcasting began over a year ago, there has been a constant growth in the number of multiplex adapters and multiplex tuners reaching the consumer market. Some of this equipment may now be in need of adjustment and the service technician must be prepared for it. This means a special generator to duplicate the signal at the multiplex output jack of an FM tuner.

Evaluating and adjusting multiplex circuitry by using broadcasts from FM stations is unsatisfactory because of the sporadic and inconvenient timing of test tones. A commercial multiplex signal generator would be the answer, but unfortunately they are quite expensive. A practical approach to the solution of the problem is to build your own generator. A generator built by the author to service multiplex adapters and multiplex circuitry in FM tuners and receivers is shown in Figs. 4 and 6.

Signal Generator Requirements

FM multiplex broadcast standards require that one channel contain the sum of the left and right audio ($L+R$) and that the second channel carry the audio difference ($L-R$) signal. The $L+R$ signal modulates the FM carrier directly but the $L-R$ signal amplitude modulates a 38-kc. carrier; the 38-kc. carrier is suppressed and its sidebands modulate the FM carrier. An accurate and correctly phased 19-kc. pilot carrier is also transmitted for subsequent reinsertion of the 38-kc. carrier at the receiver.

The signal produced by a generator should duplicate the output at the detector (before the de-emphasis network) of an FM tuner. This signal includes the sidebands of the audio modulated 38-kc. carrier ($L-R$) and the 19-kc. pilot carrier. There should be an input to the generator so an externally generated audio signal can be used to modulate the left or right channels or both simultaneously.

Performance data for this generator are shown in Table 1. The audio-frequency range for best performance is about 20-5000 cps but a 10-kc. signal may be used if corrections for generator distortion are made. The channel separation measurements were made with the oscilloscope pattern of the composite output without the 19-kc. pilot. An audio signal was fed to either the left or the right channel. The total signal peak-to-peak voltage was compared to the amplitude of the crosstalk signal above and below the zero-voltage line. By adjusting the balance controls on the front panel of the generator for each audio frequency, the separation can be considerably improved. The distortion measurements were made with a 15-kc. low-pass filter at the output of the generator and the 19-kc. pilot turned off. Some 38 kc., however, came through the filter and raised the distortion figures slightly. The output level was also measured with the 15-kc. low-pass filter inserted and the 19-kc. pilot turned off.

Total residual output without any audio modulation and without 19 kc. was 0.02 v. r.m.s., all 38 kc. (Before the installation of the 53-kc. low-pass filter, $L2$, appreciable 76 kc. was coming through.) When fed a 19-kc. pilot from a broadcast station, the generator oscillator frequency is about 19 kc. ±2 cps. The composite output voltage is 2-3 v. r.m.s., sufficient to drive most multiplex adapter circuits.

Signal Development

Significant points in the block diagram of Fig. 5 are keyed with circled letters to the oscilloscope waveforms in Figs. 1 and 3 to show how the output signal is developed.

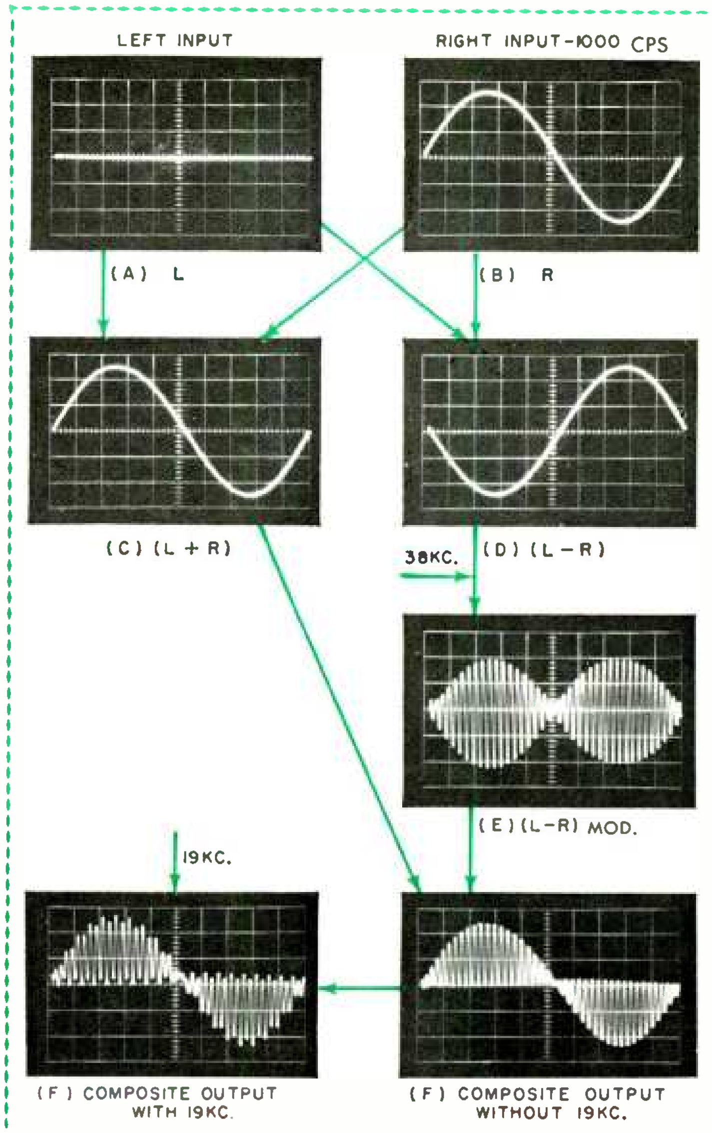


Fig. 1. Waveforms show development of composite signal when 1000-cps signal is fed to right channel and no signal is fed to left channel. Letters refer to points in block diagram shown in Fig. 5.

Assume that an audio-frequency sine-wave voltage from an external oscillator or the 1-kc. internal oscillator is applied to the right-channel input, B, in Figs. 1 and 5. The signal enters

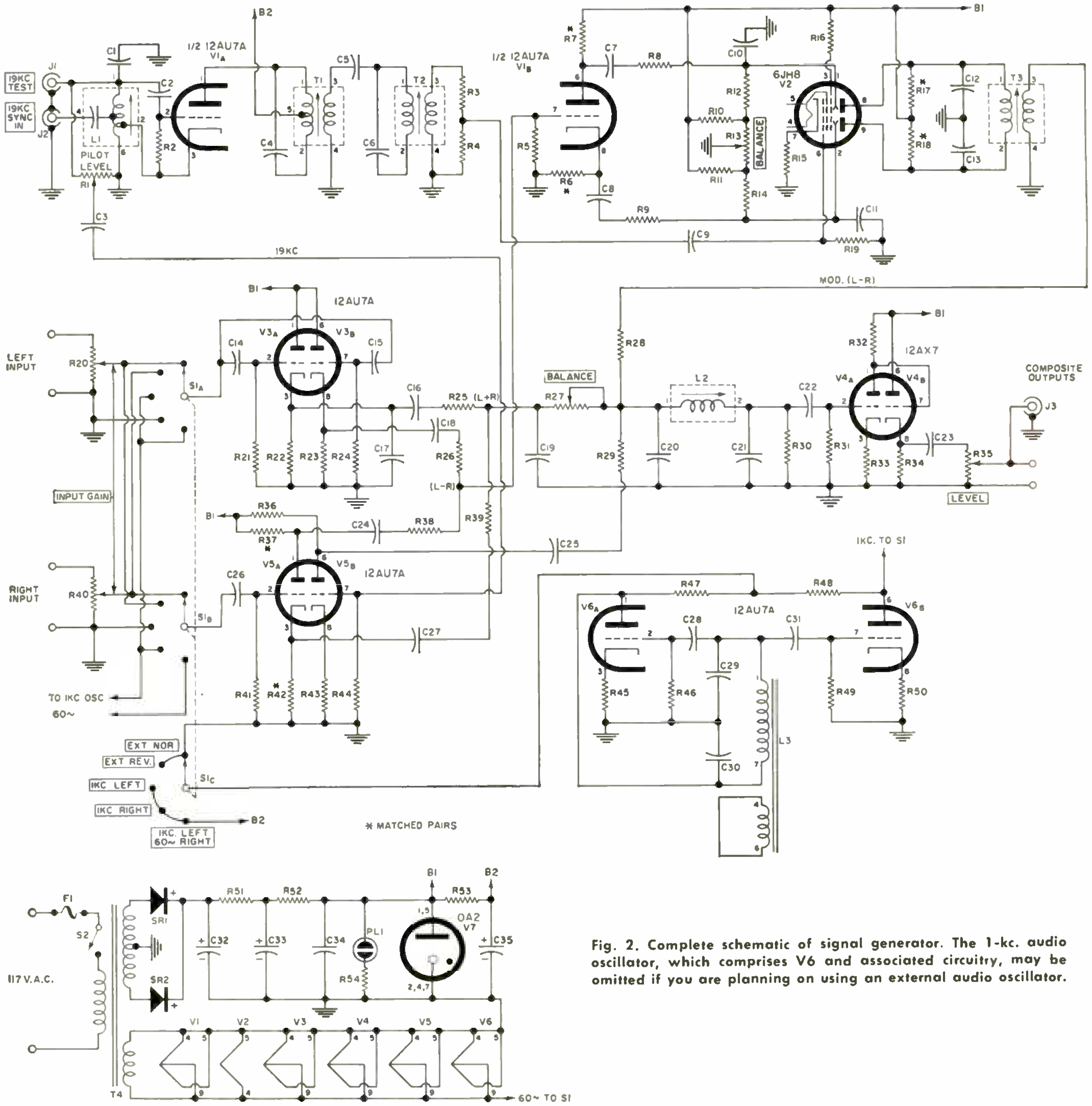


Fig. 2. Complete schematic of signal generator. The 1-kc. audio oscillator, which comprises V6 and associated circuitry, may be omitted if you are planning on using an external audio oscillator.

R1—100,000 ohm linear-taper pot
R2,R10,R11—220,000 ohm, ½ w. res.
R3—12,000 ohm, ½ w. res. ± 5%
R4—2200 ohm, ½ w. res. ± 5%
R5,R21,R24,R31,R41,R44—1 megohm, ½ w. res.
R6,R7—22,000 ohm, ½ w. matched res.
R8,R9,R19,R50—10,000 ohm, ½ w. res.
R12,R14—150,000 ohm, ½ w. res.
R13—10,000 ohm, linear-taper pot
R15—220 ohm, 1 w. res.
R16,R28,R48—47,000 ohm, ½ w. res.
R17,R18—6800 ohm, ½ w. matched res.
R20,R40—1 megohm, linear-taper pots: concentric shafts. Centralab F1-51 and R2-51 or equiv.
R22,R23,R30,R32,R34,R36,R43—22,000 ohm, ½ w. res.
R25,R26,R38,R39—68,000 ohm, ½ w. res. ± 5%
R27—250,000 ohm linear-taper pot
R29—68,000 ohm, ½ w. res.
R33—1500 ohm, ½ w. res.
R35—50,000 ohm linear-taper wirewound pot
R37,R42—22,000 ohm, ½ w. matched res.
R45—330 ohm, ½ w. res.
R46,R49—100,000 ohm, ½ w. res.
R47—6800 ohm, ½ w. res.
R51—4000 ohm, 10 w. res.
R52,R53—2000 ohm, 10 w. res.
R54—200,000 ohm, ½ w. res.
C1—.01 µf., 400 v. mica capacitor
C2,C4,C31—.001 µf. 400 v. mica capacitor
C3,C9,C14,C15,C26,C28—.01 µf., 400 v. Mylar capacitor
C5—.001 µf. 400 v. disc capacitor
C6,C12,C13—.0015 µf. 400 v. mica capacitor
C7,C8,C16,C18,C24,C25,C27,C29—.1 µf., 400 v. Mylar capacitor
C10,C11—100 µµf., 400 v. disc capacitor
C17—.002 µf., 400 v. disc capacitor
C19—470 µµf., 400 v. mica capacitor
C20,C21—300 µµf., 400 v. mica capacitor
C22—.15 µf., 100 v. Mylar capacitor
C23—.5 µf., 200 v. Mylar capacitor
C30—.04 µf., 600 v. Mylar capacitor
C32,C33,C35—40-40-40 µf., 450 v. elec. capacitor (Sprague TVL-3787 or equiv.)
C34—.05 µf., 400 v. disc capacitor
T1,T2,T3—38-kc. output transformer (Miller 1355 or equiv.)
T4—Power trans. pri: 117 v.; sec: 600 v. c.t. @ 65 ma., 6.3 v. @ 2.7a. (Triad R-5A or equiv.)
S1—3-p.5 pos. ceramic rotary switch
S2—S.p.s.t. switch on rear of R40
L1—19-kc. locked-oscillator coil (Miller 1354 or equiv.)
L2—Low-pass filter (Miller 1351 or equiv.)
L3—.2—1.5-hy., 100-ma., 95-ohm tapped choke. (Triad C26X or equiv.)
F1—½ amp fuse
J1,J2,J3—Phono jack
SR1,SR2—Silicon diode, 750 ma., 600 p.i.v. (1N2071 or equiv.)
PL1—NE-51 neon lamp or Dialco 249-7841-937 assembly (eliminate R54)
V1,V3,V5,V6—12AU7A tube
V2—6JH8 tube (G-E)
V4—12AX7 tube, V7—0A2 tube

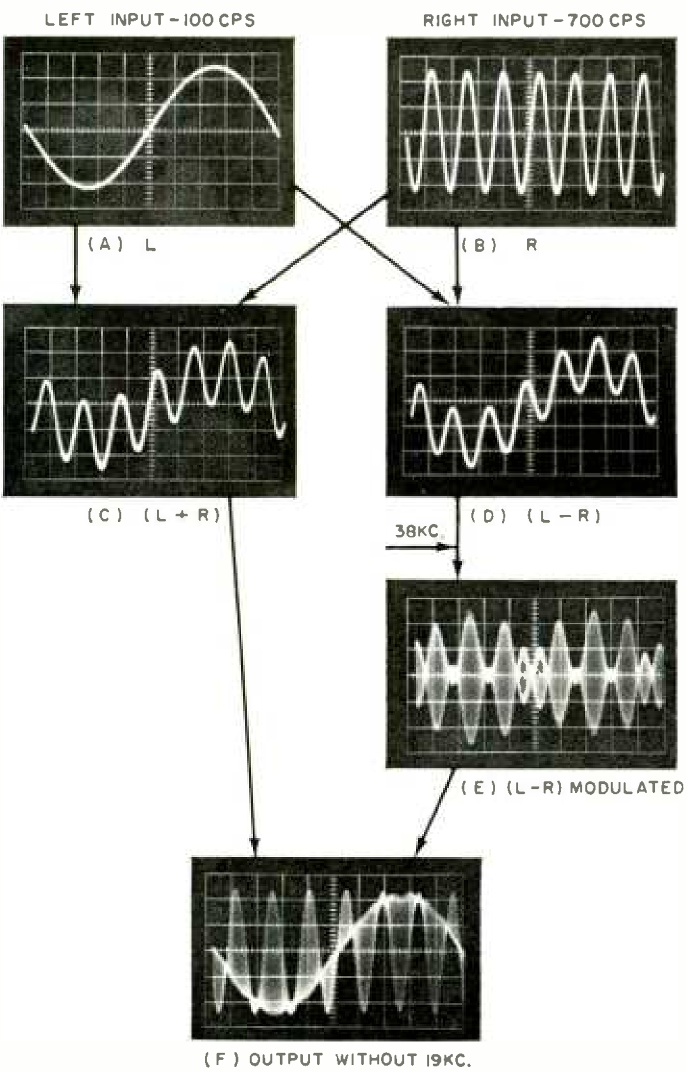
phase-splitter *V5A* from which the non-inverted (cathode-follower) output goes to matrix junction *C* and then to junction *F*. The inverted signal from *V5A* goes to matrix junction *D* and then to the suppressed-carrier modulator. The 38-kc. suppressed carrier output, a series of elliptical modulation envelopes (*E*, Fig. 1) goes to junction *F* where it is combined with the 1-kc. audio signal from *C* to form a series of alternately inverted semicircular modulation envelopes (*F*, Fig. 1).

An additional signal, the 19-kc. pilot carrier, of low amplitude, is also sent to junction *F*. The signal at *F* is shown at the bottom of Fig. 1 with (left) and without (right) the 19-kc. signal. The final output at *G* (Fig. 5) is the same as at *F* except that it is inverted.

If, on the other hand, the audio input is fed to the left channel input (*A*), the signal is divided but not inverted. One signal goes through cathode-follower *V3A* to *C* then to *F*. The other identical signal goes through another cathode follower (*V3B*) to *D*, to the suppressed-carrier modulator, and then to *F*. The appearance of this signal at *F* on the oscilloscope is superficially identical to the signal obtained from the right-channel input described above. The significant difference in the two signals is that the 38-kc. modulation differs in phase by 180° in the left and right input waveforms.

If audio signals of different frequencies are fed to both the left and right channels, an interesting series of interactions occurs. Refer to Figs. 3 and 5. The resistor matrix at *C* linearly mixes the *L* and *R* signals and produces waveform *C* in Fig. 3; this is the (*L*+*R*) signal. A similar linear mixing occurs at *D* except that the right-channel input has been inverted. This is the [*L*+(−*R*)] or (*L*−*R*) signal. This signal is fed to the suppressed-carrier modulator, the output of which is a series of elliptical envelopes of differing amplitude (*E*, Fig. 3). The signal is then combined with the (*L*+*R*) signal in matrix *F*. The resulting complex waveform (*F*) bears a superficial resemblance to the two original audio frequency inputs (Fig. 3, *A* and *B*). Added to this composite signal is the 19-kc. pilot carrier.

Fig. 3. Development of composite signal when a 100-cps signal is fed to left channel and a 700-cps signal is fed to right channel.



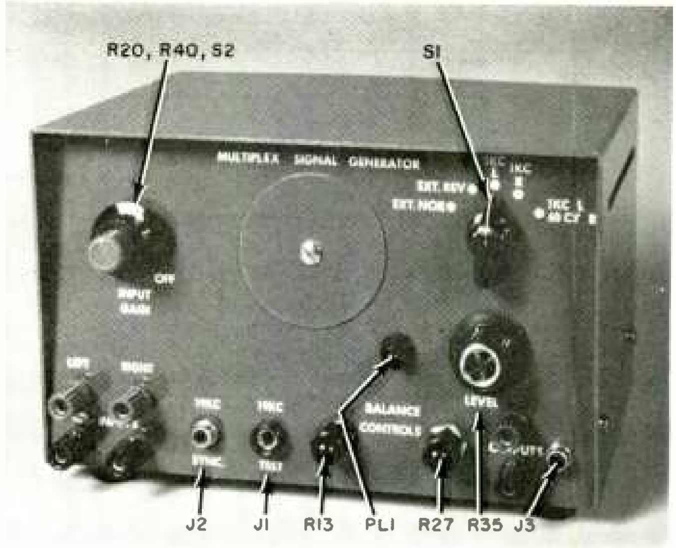


Fig. 4. Author's generator has provision for output-level meter.

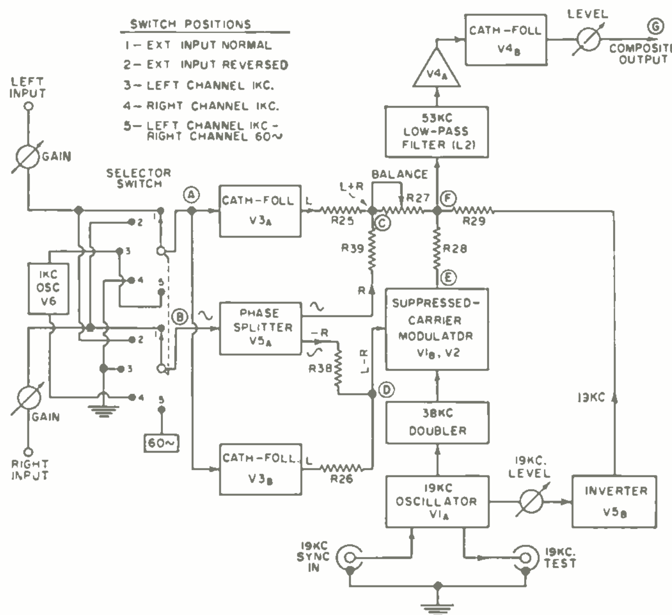


Fig. 5. Block diagram. Circled letters refer to Figs. 1 and 3.

Pilot and Subcarrier Phase Relations

The phase relationship of the 19-kc. pilot and the 38-kc. subcarrier is specified by the FCC; that is, the 38-kc. subcarrier must cross the time axis with a positive slope each time the 19-kc. pilot carrier crosses the time axis in either direction. This generator produces a signal that conforms to this requirement. When the *L*−*R* signal is *positive* (Fig. 1, *D*, third and fourth quadrants of audio sine wave) and the 19-kc. and 38-kc. signals are considered *before mixing* at *F*, the 38-kc. signal crosses the time axis with a positive slope each time the 19-kc. signal crosses the time axis in either direction. The appearance of the 19-kc. and the 38-kc. signals *after* linear mixing at *F* is an amplitude modulated 38-kc.

signal as shown in Fig. 1, *F* (right half of left waveform) and expanded in Fig. 7, right.

When the $L-R$ signal is negative (Fig. 1, *D* first and second quadrants), the 38-kc. signal will cross the time axis in a negative-going direction when the 19-kc. signal crosses the time axis to produce a modulated 38-kc. signal of the form shown in Fig. 1, *F* (left half of left waveform) and expanded in Fig. 7, left. The suppressed-carrier modulator circuit consisting of *V1B*, *V2*, and *T3* shifts the phase of the 38-kc. signal 180°. Switching tube *V2*, and the tuned circuit consisting of *T3*, *C12*, and *C13*, in effect, shift the phase of the incoming 38-kc. signal from *T2* by ±90° depending on the polarity of $L-R$ as described above. The phase of the 19-kc. signal is *not* changed as it is mixed with the 38-kc. signal after the switching circuit at *F* in Fig. 5.

However, for a left-channel input to the generator, the $L-R$ audio signal at D, Fig. 1, is inverted, *i.e.*, the positive $L-R$ falls in the first and second quadrants, and the negative $L-R$ in the third and fourth quadrants. In the final composite output, the two amplitude modulated 38-kc. signal waveforms shown in Fig. 7, are also reversed right for left.

In summary, the structure of the modulated 38-kc. signal has two well-defined forms, one for a positive $L-R$ and a second for a negative $L-R$, as shown above. The external shape of the composite envelope, however, depends upon the form of the audio-input signals and may be quite complex for dual-channel voice or music.

An interesting experiment is to reinsert a 38-kc. carrier signal in the proper phase with the generator output with a 1-kc. right-channel only input. As the 38-kc. is slowly applied, the semicircular envelopes are changed into a modulation envelope that is flat on the top, but at the bottom (Fig. 8) clearly shows the shape of the original audio frequency. Reinsertion of the 38-kc. signal as above but with only a left-channel input produces a modulation pattern that is flat at the bottom but modulated at the top. Some multiplex adapters reinsert the carrier in this manner and detect the output to recover the audio information.

Table 1

Frequency cps	Channel Separation db		Output Harmonic Distortion % (**)		Output Level db (1 kc. = 0 db)*	
	left	right	left	right	left	right
20	25	21	—	—	−2.5	−2.5
40	20	22	2.0	1.65	−1.0	−1.0
400	20	28	1.9	1.8	0	0
1000	21	26	1.8	1.5	0	0
1000*	24	27	1.75	1.4	0	0
3000	16	18	1.4	1.25	0	0
5000	14	16	1.7	1.5	−1.0	−1.0
10 kc.	14	14	8.0	6.0	−4.0	−2.0

No-input residual output: 0.02 v. r.m.s., 38 kc. (19-kc. off). *Internal 1-kc. osc. amplifier flat from 20 cps to 40 kc., down 1 db at 50 kc. **Measured with 15-kc. low-pass filter at generator output; 19 kc. off.

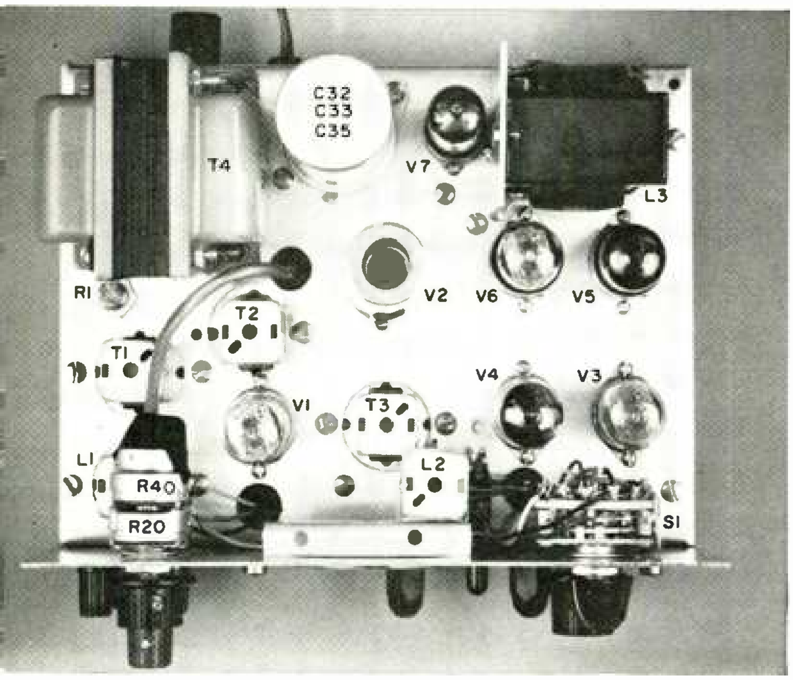


Fig. 6. Top view of chassis. Do not position choke L3 too near T4.

Circuit Description

The complete schematic of the signal generator is shown in Fig. 2; a few sub-circuits deserve detailed discussion. The suppressed-carrier or double-sideband modulator has been experimented with by radio amateurs. Don Stoner in his book "New Sideband Handbook" shows several circuits for producing this form of modulation, including push-pull balanced modulators, ring modulators using solid-state diodes, and beam-switching tubes. Stoner's enthusiasm for the beam-switching tube and his method of d.c. balancing the deflection plates convinced the author that this is a worthwhile circuit. As you can see in Fig. 4, d.c. centering control *R13*, "Balance," is mounted on the front panel to permit rapid touching up of symmetry of the composite-output waveform. *T3*, Fig. 2, serves as the output transformer (its primary is tuned to 38 kc. by *C12*, *C13*) for the 6JH8 switching tube. A single triode, *V1B*, acts as a phase splitter for the 38-kc. carrier. An interesting result of suppressing the 38-kc. carrier is that a complete modulation envelope occurs every time the modulating signal crosses the time axis (Fig. 9). Reinsertion of the 38-kc. carrier in a multiplex adapter restores the suppressed-carrier modulation envelope to the familiar form found in conventional AM modulation.

The 1-kc. internal audio oscillator, *V6A*, is a Colpitts circuit. By applying the signal at the top of inductor *L3* (rather than at the plate of *V6A*) to *V6B*, the harmonic distortion is reduced. The *B+* supply to this oscillator is disconnected by switch *S1C* when it is in the "Ext. Nor." and "Ext. Rev." positions to avoid leakage to the input circuits.

(*Continued on page* 68)

Fig. 7. Enlargements of left (left) and right (right) halves of waveform of Fig. 1F shows mixed 19-kc. and 38-kc. frequencies when L — R is negative (left) and when L—R is positive (right). Audio signal is applied to the right channel only.

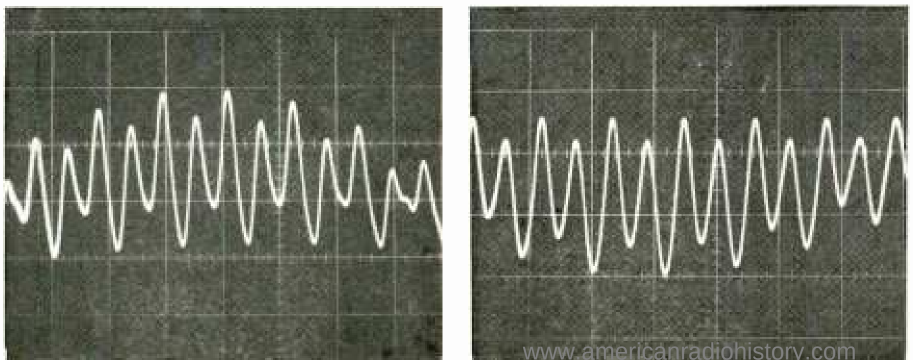
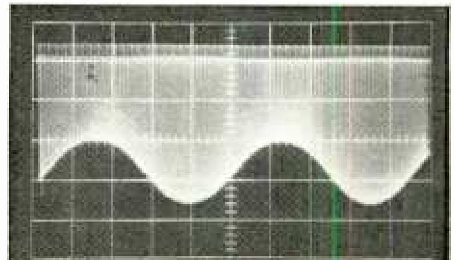
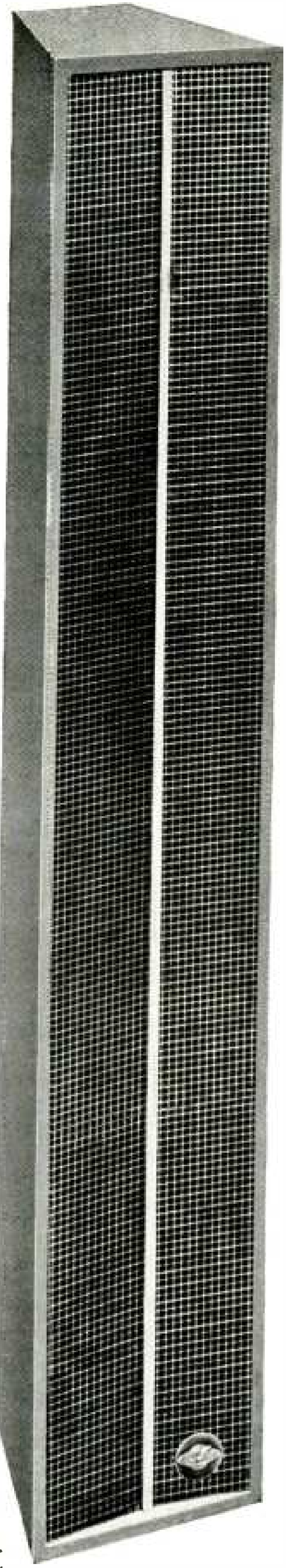


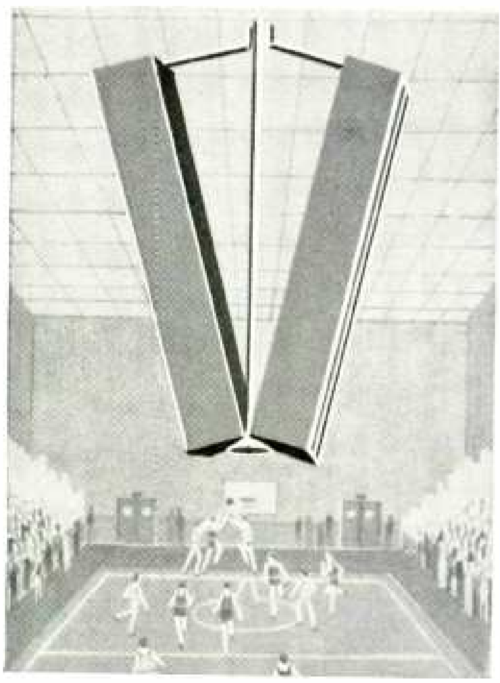
Fig. 8. 38-kc. subcarrier added to right-channel generator signal puts audio at bottom. Left-channel input puts it at top.



UNIVERSITY PROUDLY ANNOUNCES **ANOTHER** SOUND SOLUTION: THE UNILINE CS-3 SOUND COLUMN!

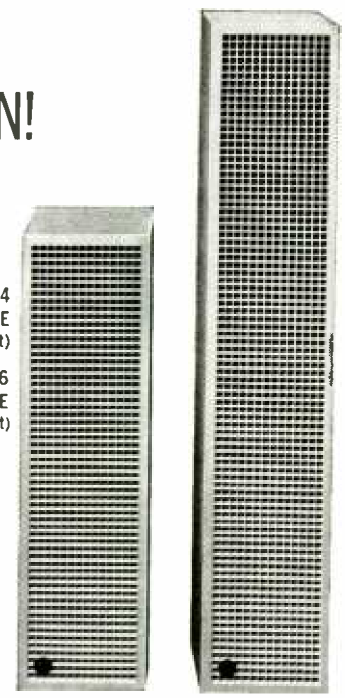


THE CS-3 SOUND COLUMN SOLVES EXTREME REVERBERATION PROBLEMS WITH EXTREME EASE AND ECONOMY.



MODEL CS-4 UNILINE (Right)

MODEL UCS-6 UNILINE (Far Right)



Here's the newest way to rid yourself of P.A. installation headaches in problem areas. Use the new University CS-3 Sound Column! It's specially designed to meet moderate power requirements—ALL AT A PRICE FAR LOWER THAN YOU'D EVER EXPECT FOR SUCH PERFORMANCE.

How? Easy—and with the same superb engineering and quality control that goes into all the Uniline products. With the CS-3 you get: ☐ superb speech reproduction in moderate-size areas; ☐ excellent music in high reverberation areas; ☐ extremely wide sound coverage; ☐ the complete answer to feedback difficulties. And, as with all Uniline Sound Columns, the CS-3 is ACOUSTICALLY TAPERED to prevent high frequency beaming... a University exclusive!

And don't forget another important characteristic of the CS-3: High 'A' (High Audibility), which is evidenced by a considerable decrease in distortion, improving intelligibility and increasing listener comfort. This is particularly noticeable when standing or sitting close to the sound source, for, as you know, conventional loudspeakers tend to 'blast' under similar circumstances.

So, for optimum dispersion (at all frequencies), for uniform sound levels (within the beam), for speech and music in high reverberation areas auditoriums, terminal waiting rooms, industrial areas, gyms, pools and churches)... FOR UNILINE SOUND QUALITY AT INCREASED SAVINGS... choose the CS-3, University's newest (and lowest-priced) addition to the Uniline Sound Column family. $89.95 dealer net.

SPECIFICATIONS:

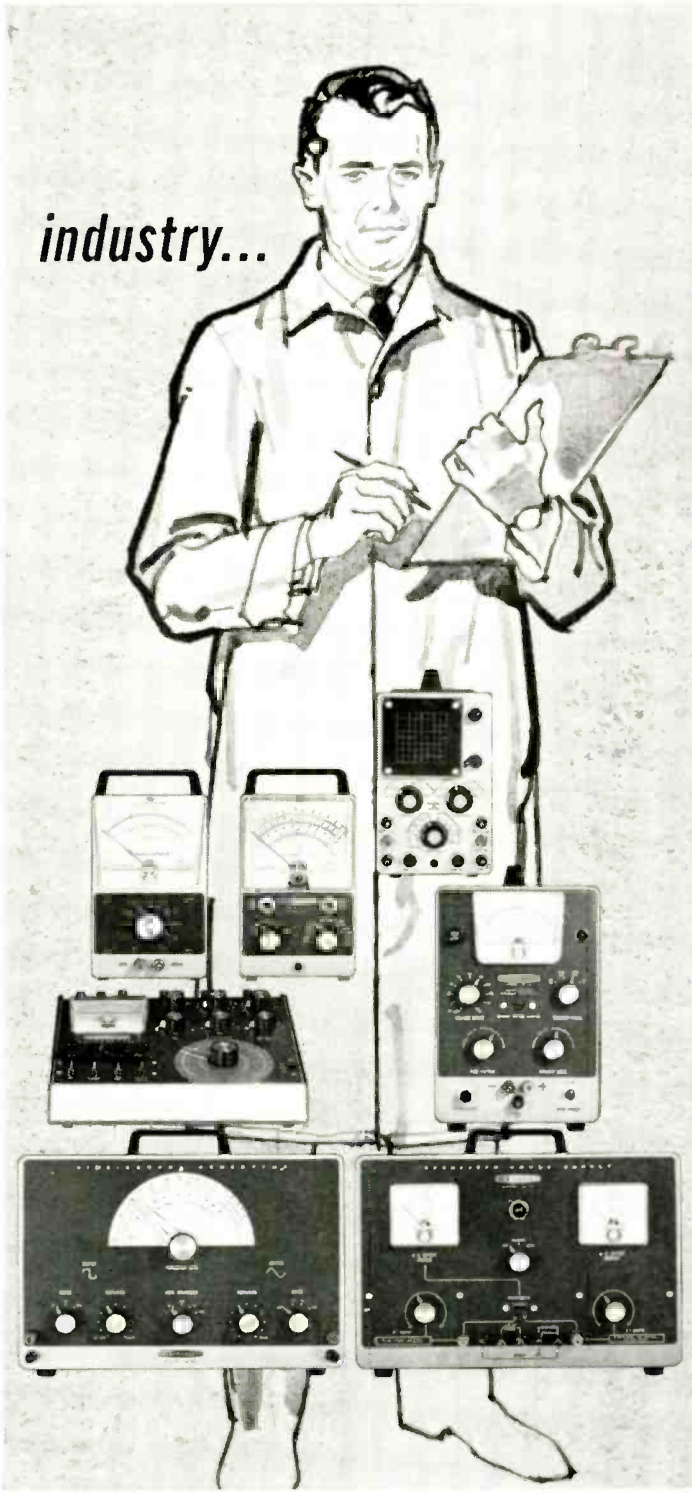
MODEL CS-3—(equipped with special elliptical hi-fi speakers and two tweeters for music and speech applications; tapered for use in clusters)

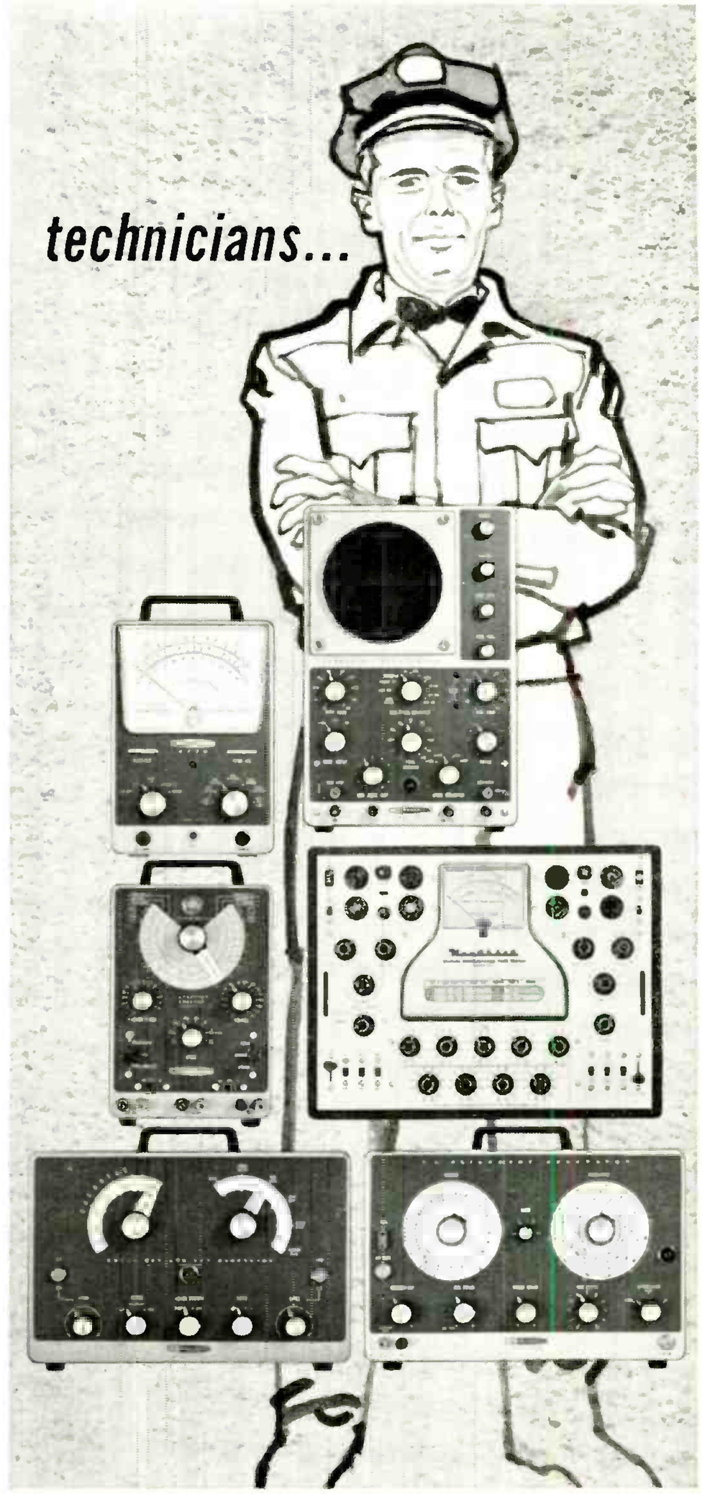
Frequency Range	150-10,000 cps
Power Capacity	25 watts
Impedance	16 ohms
Vertical Angle	22°
Horizontal Angle	120°
Dimensions	48" x 7½" x 8¾"
Shipping Weight	33 lbs.

For complete details, write: Desk S-2.

UNIVERSITY LOUDSPEAKERS
80 SOUTH KENSICO AVE., WHITE PLAINS, N.Y.
A Division of Ling-Temco-Vought, Inc.

CIRCLE NO. 164 ON READER SERVICE PAGE



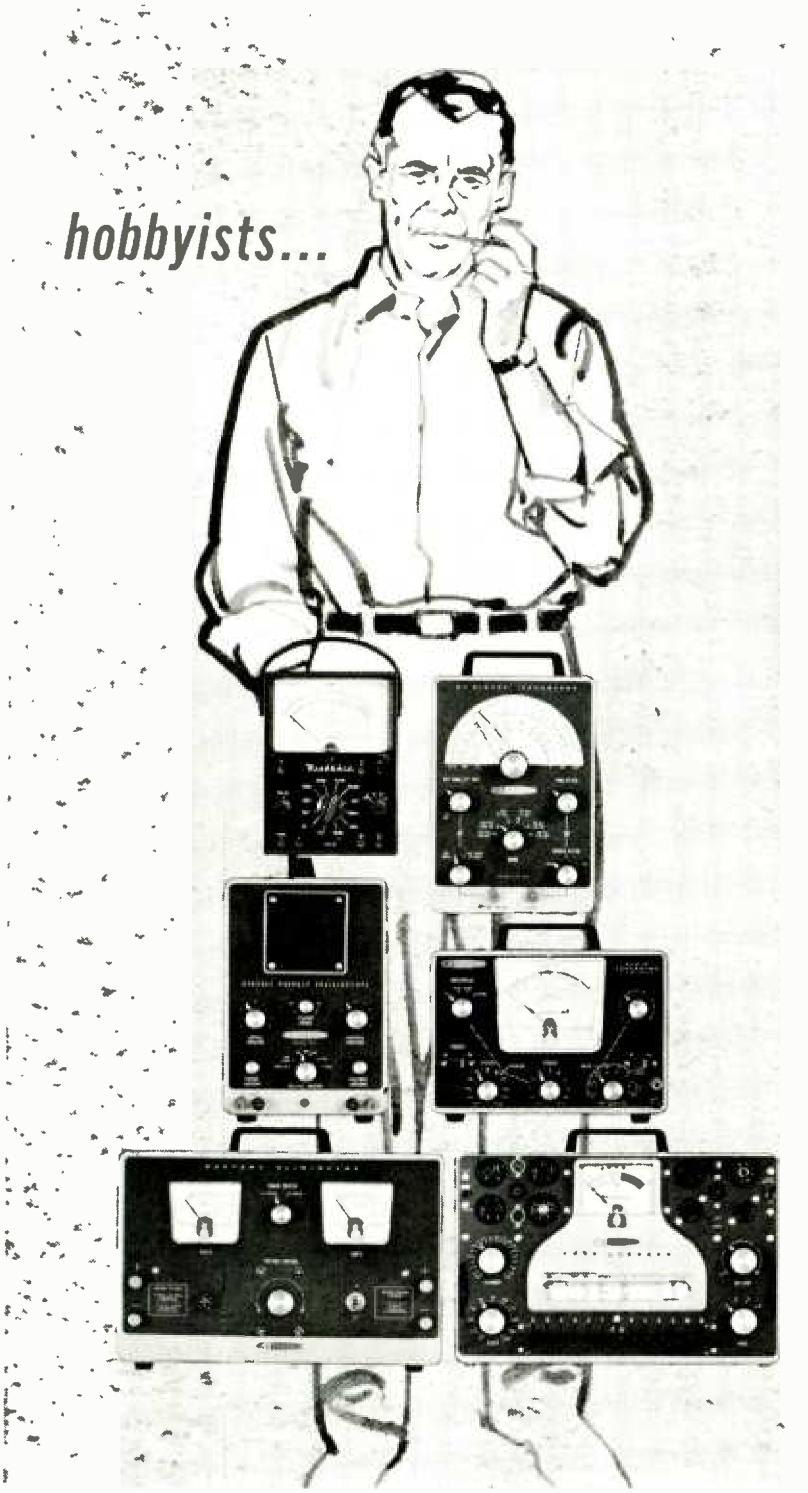


all find Heathkit® test equipment quality and

Industry Production and Design professionals put Heathkits to work in their factories and laboratories for high performance at low cost. Typical Heathkits used are: IO-10 3″ DC Oscilloscope, $79.95 . . . IM-11, world's largest selling Vacuum Tube Voltmeter, $24.95 . . . IG-82, Sine & Square Wave Generator, $51.95 . . . IP-32, Variable-Voltage Regulated Power Supply, $56.95 . . . IP-20, Hi-Current, All-Transistor, Regulated Power Supply, $72.95 . . . IM-30, Laboratory Transistor Tester, $54.88 . . . IM-21, Vacuum Tube Voltmeter for precision AC measurements, $33.95.

Technicians around the world put Heathkits on their service benches for rapid, precision measurements . . . complete trouble-shooting facilities at lowest cost. Typical Heathkits used are: IM-32, Service Bench Vacuum Tube Voltmeter, $32.95 . . . IO-12, Wide-Band 5″ Oscilloscope, $76.95 . . . TT-1A, Mutual Conductance Tube Tester, $149.95 . . . IG-62, Color Bar and Dot Generator for Color TV servicing, $64.95 . . . IG-52, TV Alignment Generator, $54.95 . . . IT-11, Deluxe Capacitor Checker to test capacitors of all types, $29.95 . . . See the complete line in the Heathkit Catalog.

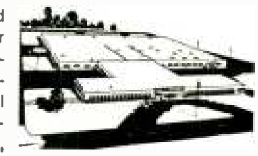
hobbyists...



economy stacks up best

Hobbyists of all kinds find Heathkit test equipment invaluable for pursuing their hobbies with refined techniques. Audiophiles, amateur radio operators, kit builders of all kinds use these Heathkits in their workshops: IO-21, General Purpose 3″ Oscilloscope, $49.95 . . . MM-1, Sensitive Volt-Ohm-Milliammeter for all-purpose measurements, $29.95 . . . IT-21, Tube Checker for fast tests of tubes of all types, $44.95 . . . IG-102, Radio Frequency Signal Generator, $27.95 . . . IG-72, Audio Signal Generator, $41.95 . . . IP-12, Low Ripple Battery Eliminator, $47.50.

Who is Heathkit?



Heathkit is the pioneer and world's largest manufacturer devoted exclusively to the design and manufacture of do-it-yourself electronic kits. All our efforts are aimed at creating more kits, better kits, easier-to-build kits.

What are Heathkits?

Heathkits are electronic equipment in un-assembled form. All parts are packaged in convenient groups and complete, easy-to-read, well-illustrated instruction manual tells you how to put them together. Heath offers over 250 kits from simple portable radios to big analog computers.

Who builds Heathkits?

Millions build Heathkits. People with absolutely no mechanical ability or knowledge of electronics as well as skilled electronic experts—all find value, economy, fun, relaxation, and pride of accomplishment in Heathkits. You can too.

Money Back Guarantee

Heath Company unconditionally guarantees that each Heathkit® product assembled in accordance with our easy-to-understand instruction manual must meet our published specifications for performance or your purchase price will be cheerfully refunded.

The famous Heathkit guarantee—This money back guarantee stands behind every Heathkit. It guarantees that you are getting equipment of the highest quality that will provide years of use and pleasure. Equipment second to none. Heathkit—world pioneer in the exciting hobby of kit building.

FREE 1963 Heathkit Catalog. Send for your free copy of this new Heathkit Catalog . . . it describes and illustrates the complete Heathkit Test Instrument line . . . units for every purpose . . . units of highest quality at lowest cost.

HEATHKIT® *by Daystrom*

HEATH COMPANY
Benton Harbor 15,
Michigan

☐ Please send my free 1963 Heathkit catalog

NAME____________________
ADDRESS____________________
CITY________________ZONE______
STATE____________________

19-Kc. FILTER

By THOMAS E. REAMER

Construction of a filter that enables you to use the 19-kc. pilot from a stereo broadcast as a frequency source for a multiplex signal generator.

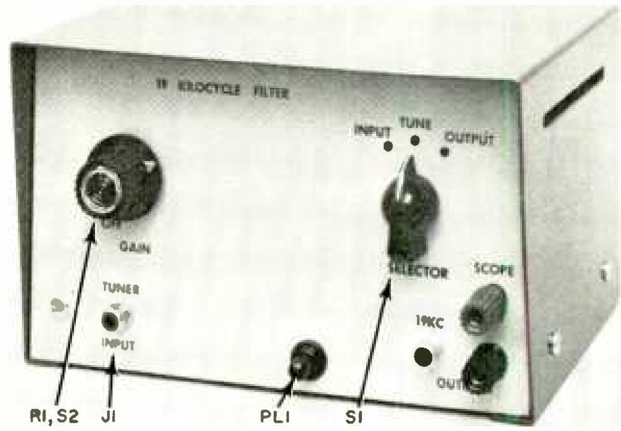


Fig. 2. Front view of author's filter shows location of controls.

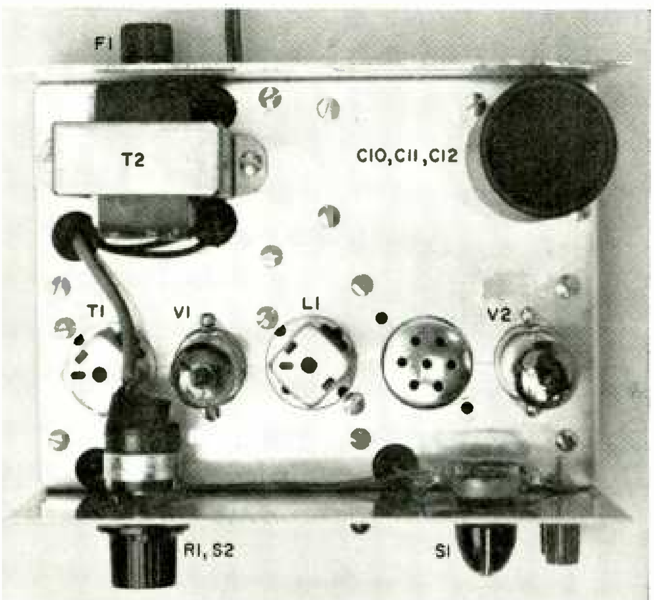


Fig. 1. Top view of chassis shows the arrangement of components.

A 19-kc. signal that meets the FCC's tolerance requirement of ± 2 cps must be provided for the correct alignment of multiplex adapters and multiplex circuitry when using the signal generator described on page 55.

An oscillator circuit with a close-tolerance 19-kc. crystal would meet the requirement, however, such crystals are often available only on special order and are somewhat expensive ($20 and up). A good solution to the problem at this time is to make use of the broadcast station's 19-kc. pilot carrier that is transmitted with an FM multiplex program. This 19-kc. pilot carrier frequency-modulates the main FM carrier by 8 to 10% and can easily be separated from it with a sharply tuned 19-kc. filter connected to the detector output of an FM tuner. A filter of this type was built by the author and is shown in Figs. 1 and 2.

Operation

The incoming signal of mixed frequencies is amplified by *V1A* (Fig. 5) and fed to a double-tuned transformer, *T1*. This transformer is normally used at 38 kc., but by selecting values for *C3* and *C4*, it will operate satisfactorily at 19 kc. The attenuation, at the grid of *V1B*, of frequencies other than 19 kc. is shown in curve *A* of Fig. 3. After *T1*, the signal is amplified by *V1B* and is fed to another tuned circuit, *L1*, *C8*. *L1* is designed for use at 19 kc.; it further attenuates the undesired frequencies as shown in *B* of Fig. 3. The output of *L1* goes to cathode-follower, *V2*. This particular tube (12BY7A) and its associated circuit have a gain of 0.97, which is quite high for a cathode-follower stage. The output from *V2* is routed to *J2 via S1*. A connection is also provided for viewing the signal on an oscilloscope. With *S1* at "Input," the output of the tuner can be observed. At the "Tune" position, the signal from the filter is sent to the oscilloscope only and not to *J2*. At "Output," the signal is connected to both the oscilloscope and *J2*. The separate "Tune" position is necessary as there is some feedback from the oscillator in the signal generator that would distort the signal and make sharp tuning difficult if it were done with *S1* in the "Output" position.

Resistor *R2* (Fig. 5) is in series with *R1* as it was found that the tuned circuits would sometimes break into oscillation when the resistance between the arm of *R1* and ground was less than 100,000 ohms. *R2* does not degrade operation as the gain control is normally operated at, or nearly its maximum position. The power supply is a conventional full-

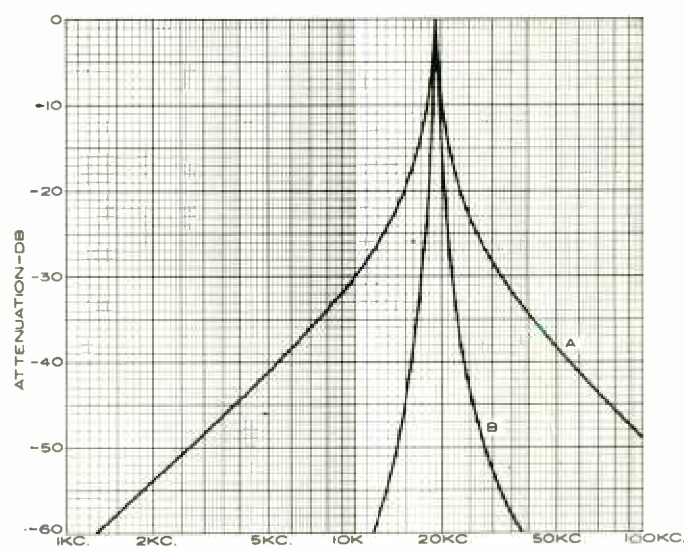
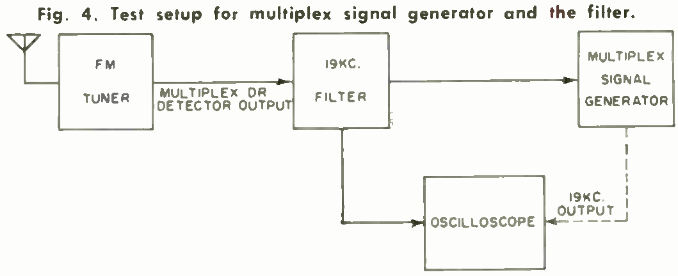
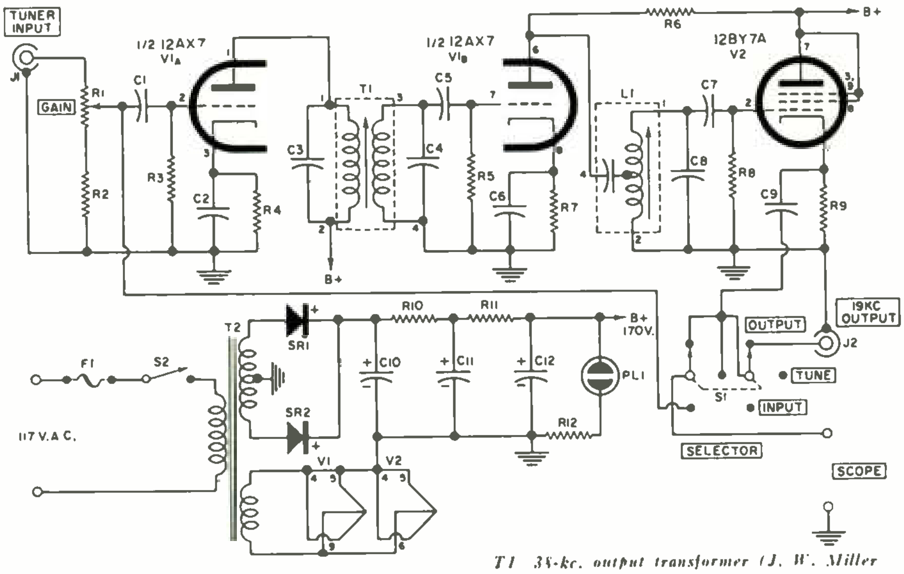


Fig. 3. Undesired-frequency attenuation at V1B (A) and at V2 (B).

Fig. 4. Test setup for multiplex signal generator and the filter.





R1 1 megohm linear-taper pot
R2,R6—100,000 ohm, ½ w. res.
R3,R5,R8—1 megohm, ½ w. res.
R4—1000 ohm, ½ w. res.
R7—680 ohm, ½ w. res.
R9—39,000 ohm, ½ w. res.
R10,R11—2500 ohm, 10 w. res.
R12—200,000 ohm, ½ w. res.
C1, C7, C9—.02 μf., 400 v. capacitor
C2,C6—.5 μf., 200 v. capacitor
C3,C4—.003 μf., 400 v., ± 5% mica capacitor
C5—430 μμf., 400 v. mica capacitor
C8—.01 μf., 400 v., ±5% mica capacitor
C10,C11,C12—20-20-20 μf., 450 v. elec. capacitor (Sprague TVL-3780 or equiv.)
T1 38-kc. output transformer (J. W. Miller 1355 or equiv.)
T2—Power trans. Pri: 117 v.; sec: 250 v., c.t. @ 25 ma., 6.3 v. @ 1 a. (Stancor PS8416 or equiv.)
L1—19-kc. locked-oscillator coil (J. W. Miller 1354 or equiv.)
SR1,SR2—Silicon diode, 750 ma., 600 p.i.v. (1N2071 or equiv.)
S1—2.p.3-pos. rotary switch
S2—S.p.s.t. switch on R1
F1—½ amp fuse
J1,J2—phono jack
PL1—NE-51 neon lamp or Dialco 249-7841-937 assembly (eliminate R12)
V1—12AX7 tube, V2—12BY7A tube

Fig. 5. Filter schematic. If this circuit is to be incorporated in the multiplex signal generator, its power supply may be omitted.

wave unregulated circuit. The filter is built in an *LMB* W-1A cabinet with the chassis moved down slightly to get more room above it; a new bottom plate was installed after the construction of the unit was completed.

The 19-kc. output signal from the filter is about 4.5-6 v. r.m.s., when it is connected to a tuner with a 0.2-2.0 v. output. The total gain of the filter is about 100 when measured with a clean 19-kc. input signal from an audio oscillator. As 1-3 v. r.m.s. is required to sync the oscillator in the multiplex signal generator, the output of the filter is more than adequate. The voltage data in the table was obtained with three FM multiplex stations in a metropolitan area. At low to moderate modulation levels, the 19-kc. output from the filter is very clean. At high modulation levels, some waveform distortion occurs but this *does not* have a detrimental effect on the 19-kc. output of the oscillator in the signal generator; that is, the generator oscillator output will be 19 kc. ±2 cps even though it isn't synced with a pure sine wave.

How It's Used

The block diagram in Fig. 4 shows the connections of the filter to the detector output of an FM tuner, the scope, and the multiplex signal generator. Set S1 to the "Tune" position and carefully tune an FM receiver, known to be in good working order, to a station broadcasting a multiplex program. Interstation noise will cause a low-level fuzzy 19-kc. signal to appear, but when the tuning is correct, the signal will be clean and of much greater amplitude. Initial peaking of the 19-kc. signal can be made by adjusting T1 and L1. When S1 is set to "Output," and the scope connection is transferred to the "19 Kc. Test" jack on the signal generator, the oscillator in the signal generator will be synced by the output from the filter and will meet the FCC tolerance requirement. ▲

Tuner and Filter Output Voltages for Three FM Multiplex Broadcast Stations

Station	Frequency (mc.)	Tuner output voltage range (r.m.s.)	19-kc. filter output voltage (r.m.s.)
A	94.9	0.2-1.5	6.2
B	101.3	0.3-2.0	6.1
C	104.5	0.4-2.0	4.6

Single Sideband Simplified

(*Continued from page 54*)

widely understood. And, by and large, the literature leaves too much to the imagination of the reader. They tell you that you must have a 90-degree audio phase shift in one place and a 90-degree r.f. phase shift in another. See Fig. 6. "And so at this point, dear reader, it must be obvious to you that there are two sets of sidebands and either the two uppers cancel and the two lowers add, or *vice versa*." Unfortunately most of the "dear readers" are not as clairvoyant as might be supposed. However, they put the thing together and it works. Now let's see what really does happen.

The Phasing Method

The audio phase shifter is designed in such a way that the modulation applied to one balanced modulator will occur 90 degrees in audio time later than that applied to the other tube. For example, at the instant that a 100% positive peak is occurring in one modulator the second one will be going through zero; 90 degrees later the first will be going through zero and the second will be at 100% positive; another 90 degrees later the first will be at 100% negative and the second will again be going through zero, and so on. The r.f. phase shift is such that the carriers introduced to the balanced modulators arrive 90 degrees in r.f. time out-of-phase.

Now, if we take this information and draw pictures of it, we will be able to see how one sideband is eliminated and the other retained. Fig. 7 represents conditions at several instants of time. Although we know that the carriers have been removed by the balanced modulators, they are included in parts A through D because they preserve our reference vector and make the explanation easier to follow.

Understanding is dependent on taking a certain instant of time and observing all of the things that are happening at that instant. Then we will take several other instants following the first.

Let us take the instant of time T when carrier "A" is modulated 100% positive (this is the same as Fig. 4H). This vector sum appears in Fig. 7A. In this case, we have drawn the "head" of the upper sideband vector U_1 connected to the "tail" of lower sideband vector L_1 in order to make it easier to visualize the total amplitude. Since carrier "B" is modulated 90 degrees later than "A," if the two carriers were in r.f. phase, it would appear as in Fig. 7B. But, carrier "B" has been shifted 90 degrees so it actually appears as in Fig. 7C at time equals T. If we take these two signals (7A and 7C) and combine them, we have the vector diagram shown in Fig. 7D.

Since the carriers are actually removed by the balanced modulators, the only sum we are really interested in (Fig. 7E) is the sum of the sidebands. So at time T we find that the upper sidebands of both carriers "A" and "B" are in the same direction and therefore add. The lower sidebands of carriers "A" and "B" are in opposite directions (180 degrees out-of-phase) and therefore cancel. At $T+45°$ (Fig. 7F) we find that upper sidebands of carriers "A" and "B" have both rotated 45 degrees counterclockwise and still add. By the same token, lower sidebands of carriers "A" and "B" have both rotated 45 degrees clockwise and still cancel. The same follows for $T+90°$ (Fig. 7G) or any other instant of time. So for all instants of time we have an upper sideband made up of the upper sidebands of both carriers and no lower sideband. If we reverse the connections on either audio line, the upper and lower sidebands would trade places and we would have a lower sideband and no upper sideband.

It is the belief of this author that a verbal description with any meaning is nearly impossible when it comes to describing the phasing method of producing SSB. A vector description instant by instant is the best way to show exactly how one sideband is eliminated and the other retained. So, if you are the proud possessor of an SSB rig that uses the phasing method, it is hoped that you now know what the designers were doing when they designed it. ▲

CLEANING SPEAKERS ON SMALL RADIOS

By C. R. ZINCK

BECAUSE OF their extreme portability, transistor radios get taken along everywhere, especially during outdoor fun in the summer. They will frequently come out second best after a day at the beach, because sand particles have lodged in the speaker assembly. One method has been found very useful for getting sand out.

Remove the speaker from the radio and connect it to the output of a small audio amplifier. Feed the output of an audio oscillator into the amplifier and vary the frequency until speaker resonance is reached, which will be indicated by maximum cone excursion. Keep oscillator output low at first, to make sure that the power rating of the speaker is not exceeded. With the tone applied as noted, turn the speaker with its cone facing downward and tap the magnet frame gently to dislodge the sand. ▲

We regret that "Mac's Electronics Service" could not be included in this issue. John Frye has been ill and we feel sure that many of our readers will want to join us in wishing him a speedy recovery. Hope to see Mac and Barney back next month.

CIRCLE NO. 144 ON READER SERVICE PAGE

Digital Readouts
(Continued from page 35)

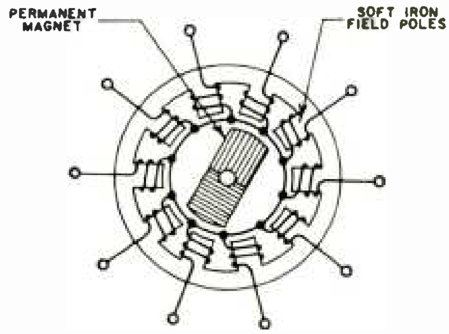


Fig. 10. Schematic of "Magneline" readout. Armature lines up with magnetized poles.

numbers are shown differently and the internal mechanical arrangement is different. Eleven electro-magnets are used in a vertical arrangement and the permanent magnet attached to the numeral drum is a bar mounted horizontally somewhat like a compass needle. The eleventh position is used in a patented circuit to eliminate the need for polarity reversal and to permit simpler driving circuitry.

Still another type of electro-mechanical readout is shown in Fig. 13. This consists of seven tiny rotary solenoids, individually actuated, that display seven lines forming the desired numeral. Each solenoid consists of a cylindrical permanent magnet that is rotated in the field of its coil. A small aluminum vane is cemented to the magnet so that the vane either appears in the window or moves out of sight. One model has a single coil and will only display the desired numeral while power is applied. Another model uses split wound coils and can be set with a pulse and then reset again with another pulse applied to the other half of the coil. *Allard Instrument Corp.* has a complete line of these readouts including alpha-numeric units which contain 14 coil assemblies capable of forming letters and numerals.

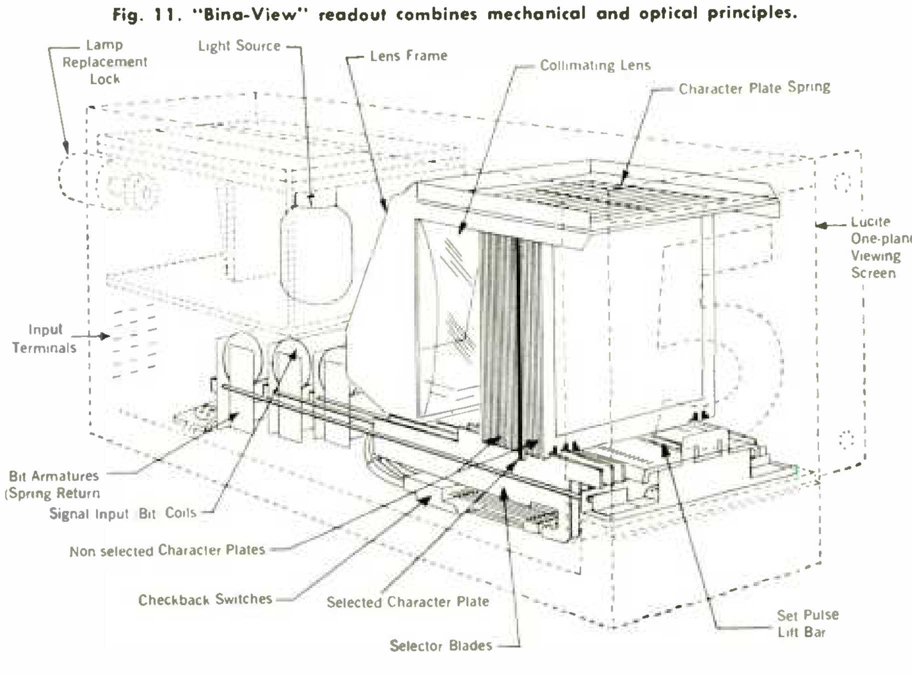
Mechanical/Optical Readouts

A readout which combines an interesting optical principle with an equally ingenious mechanical system is shown in Fig. 14. The optical principle is based on the use of a beam of collimated (parallel beams) light and a set of ten plates, each having a small checkboard raster

Fig. 12. A.C.E. is similar to "Magneline" except for different mechanical design.

and an open area the shape of the numeral. When the selected plate is positioned in a certain spot, only the light-forming numeral can pass through and project that character on the screen. To select the desired plate, four solenoids, corresponding to the four binary bits, each actuate a selector blade. The bottom of each numeral plate is notched so that only the desired plate can drop into the viewing position when the cor-

Fig. 11. "Bina-View" readout combines mechanical and optical principles.



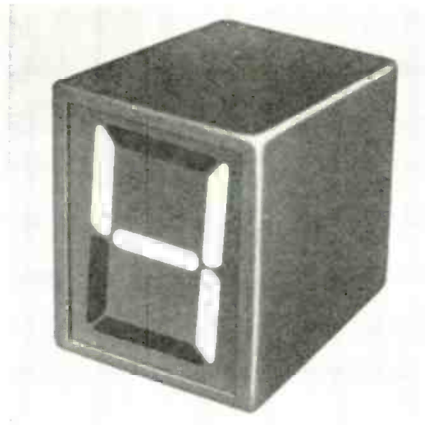


Fig. 13. Allard Instrument electro-mechanical readout uses seven rotary solenoids.

responding selector blades are actuated. Fig. 11 shows three of the solenoids and the selector blades attached to them. Running in the center under the numeral plates is a set bar which lifts all plates up, then allows the selected one to drop into the notched position. Each time a new number is to be displayed the selector blades are set first, the bar lifts all plates, and the selected one drops to display the number.

Only 100 milliwatts is required to set the selector solenoids, making transistor drive feasible. Decoding from binary to decimal is done by the selector blades and the notching combinations of the individual numeral plates. As an added feature in the *I.E.E., Inc.* "Bina-View" model, four sets of reed switches are used underneath the four selector blades to provide a status readout signal for the data processing equipment. This provides a memory because once a number is set in, the computing device can always read that number out through the four reed switches.

Servomechanisms, Inc. recently announced a 64-character readout whose operation is based on light interference.

Troubleshooting these types of readout may be very difficult because of their complexity. It is wiser to return them to the manufacturers for repair or replacement. ▲

Fig. 14. Checkerboard display produced by "Bina-View" readout shown cutaway in Fig. 11.

Multiplex Signal Generator

(*Continued from page* 58)

The 19-kc. oscillator, *V1A*, is the familiar circuit used in many matrix-type multiplex adapters. The output drives two 38-kc. series-connected tuned circuits, *T1* and *T2*. The second 38-kc. transformer, *T2*, lowers the amplitude variation of alternate peaks of the 38-kc. sine wave. The output is attenuated by *R3* and *R4* and fed to the control grid of *V2*.

The 19-kc. oscillator circuit may drift as much as ± 10 cps with variations in ambient temperature, consequently it must be locked, through the "19 Kc. Sync. In" input on the front panel, to a reference oscillator whose stability complies with the FCC frequency tolerance of 19 kc. ± 2 cps. Although a crystal-controlled oscillator could be built for this purpose, a less expensive (a 19-kc. crystal may cost $20 or more) solution at the present time is to use the 19-kc. pilot carrier transmitted with all FM multiplex broadcasts. This signal, which meets the FCC frequency tolerance requirement, can be obtained from an FM receiver tuned to a station broadcasting a multiplex program. The tuner output is amplified, filtered with a very sharply tuned 19-kc. bandpass filter, and connected to the "19 Kc. Sync. In" input. A filter for isolating the 19-kc. pilot carrier appears on page 62 in this issue. It can be built as a separate unit or incorporated in the signal generator.

The full-wave power supply employs an 0A2 voltage regulator tube to stabilize the B+. The 19-kc. and 1-kc. oscillator power is obtained from a decoupled section (*B2*) of the power-supply filter. A 6.3 v., 60 cps voltage is taken from the filament winding to modulate the right channel when S1 is in the "1 kc. Left, 60 cps Right" position. One side of the filament winding is grounded as pin 5 of V2 *must* be grounded.

Construction

The multiplex signal generator is built in an *LMB W-1C* cabinet with a 6" × 8½" built-in chassis. In the original layout space was left for an output meter. The installation of this meter was later found unnecessary as the output can be checked with a high-quality v.t.v.m. and an oscilloscope, as described in the section on application and use of the generator. The can of electrolytic capacitor *C32*, *C33*, *C35* is the only chassis ground. All ground connections should be made to points that connect to the can. A symmetrical layout of components associated with the 6JH8 tube is suggested to avoid unequal wiring capacitance. The author added capacitors *C17* and *C19* to improve the waveform symmetry at higher frequencies. The value and location of these capacitors were determined by trial and error and may have to be different in your unit.

Switch S1 provides an external-input normal, external-input reversed, and the internally generated audio signal for each channel. If a single-frequency external input signal is applied to the left channel binding posts, it may, for example, be quickly switched from left to right channels by moving S1 from the "Ext. Nor." position to the "Ext. Rev." position. Simultaneous dual inputs are fed to the correct channels when S1 is in the "Ext. Nor." position.

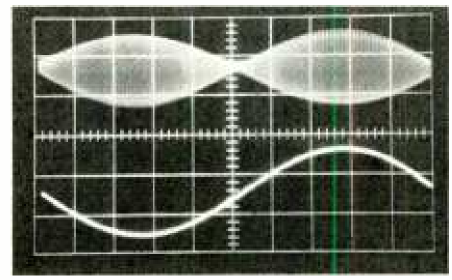


Fig. 9. Signal at E, Fig. 5. Positive or negative audio produces complete envelope.

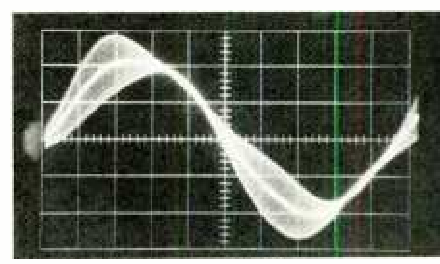


Fig. 10. One cycle of 19 kc. and left audio. Audio is in first and third quadrants.

Generator Alignment

When the unit is built, the 19-kc. and 38-kc. coils (*L1*,*T1*,*T2*,*T3*) will require

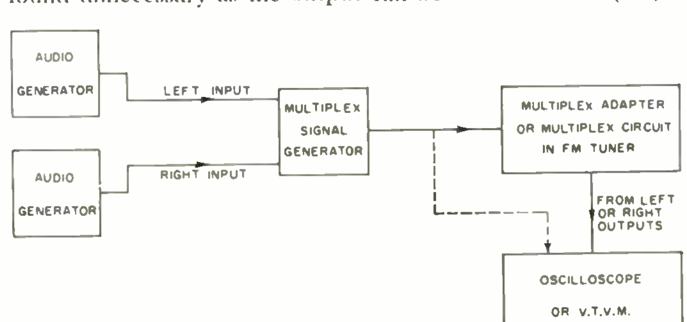


Fig. 11. Suggested test-equipment setup for checking multiplex adapters or multiplex circuitry in tuners or FM receivers.

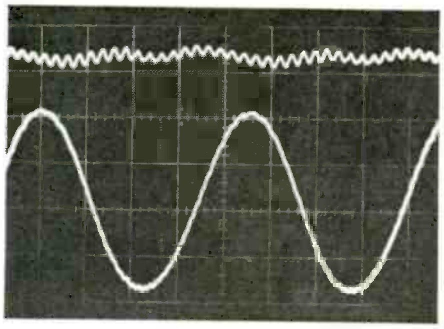


Fig. 12. R (top) and L (bottom) outputs of adapter; 1000 cps to generator left input.

touching up. Allow ten minutes for the unit to warm up then connect an oscilloscope to Lug 1 of $L1$. Apply an accurate 19-kc. signal to the "19 Kc. Sync. In" jack on the front panel. Adjust $L1$ from the *top* until jittering stops. Readjust $L1$ until it is in the center of the "stable-trace" region. An alternate method is to connect the vertical input of the scope to Lug 1 of $L1$ and the horizontal input of the scope to a source of an accurate 19-kc. signal. Adjust $L1$ until a 1:1 Lissajous pattern is obtained. (Note: The Lissajous pattern will vary from a single line inclined 45° to the right through an ellipse to a circle, through another ellipse, and to another single line inclined 45° to the left, due to the varying phase relationship between the signals.) Now connect the 38-kc. signal at Lug 3 of $T2$ to the vertical input of the scope and connect the 19-kc. signal at Lug 1 of $L1$ to the horizontal input of the scope. Adjust $T1$ and $T2$ until an approximate 2:1 Lissajous pattern is obtained. The next step is to connect the scope vertical input to Lug 3 of $T3$. Set the scope to internal sweep and adjust $T3$ for maximum amplitude.

Connect the scope to the output terminals of the generator, advance $R35$ ("Level") full clockwise, eliminate all 19 kc. by adjusting $R1$ on top of the chassis so its wiper arm is grounded, and adjust "Balance" control $R13$, for minimum output. The residual signal should be about 0.02 v. r.m.s. of 38 kc. Turn $S1$ to "1 Kc. Right" and adjust "Balance" control $R27$ to obtain the best composite waveform symmetry. With the oscilloscope adjusted to give a trace pattern identical to that shown in Fig. 1, lower-right photo, apply some 19-kc. pilot signal by means of $R1$ on the top of the chassis. Eight to ten per-cent of the total signal is the amount specified by the FCC. The photo in the lower left of Fig. 1 shows the composite output with 8-10% 19-kc. pilot added. Readjust the sweep of the oscilloscope until the lower semicircle of the composite signal fills the scope screen as in Fig. 7. Readjust $T1$ and $T2$ slightly until the trace appears exactly as in Fig. 7. It may be necessary to temporarily increase the 19-kc. signal to make the pattern more apparent.

An alternate method of adjustment was described by D. R. Bolgiano in the article "FM Stereo: A Broadcaster's Viewpoint" in the September, 1962 issue of ELECTRONICS WORLD. With this method, the 19-kc. signal should be increased somewhat by means of $R1$, the audio output removed, and one cycle of the 19-kc. signal displayed on the oscilloscope screen. The beginning of this pattern should be positive-going. Now apply a small amount of left-channel audio to the generator. Modulation of the 19-kc. signal should then appear principally in the first quadrant (0°-90°) and in the third quadrant (180°-270°) of the sine wave. (See Fig. 10.) Application of a right-input-only signal produces modulation of the 19-kc. sine wave principally in the second quadrant (90°-180°) and in the fourth quadrant (270°-360°). Slight adjustment of transformers $T1$ and $T2$ may be required to achieve this.

As a final check, connect the generator to a multiplex adapter known to be in exact alignment and confirm that a right-channel audio input to the generator results in a right-channel output from the adapter. The 19-kc. oscillator coil in some adapters must be adjusted exactly on frequency or the right- and left-channel outputs will be reversed.

How to Use the Generator

The signal generator may be used to check-out the operating characteristics of multiplex circuits such as frequency response, output level, and channel separation at various frequencies. A suggested test-equipment set-up is shown in Fig 11. The external audio generator is used in addition to the built-in audio generator in the multiplex generator. When a separate multiplex adapter is under test, a direct connection is made to it from the signal generator. Tuners with built-in multiplex circuits require generator connection at the input of the multiplex circuit. This point is determined by examination of the tuner schematic.

A generalized test procedure is as follows: With S1 in the "Ext. Nor." position, feed a 100-cps sine wave of 1-4-volt amplitude to the left input of the signal generator. The generator output is monitored on the scope for waveform symmetry and a v.t.v.m. is used to determine signal amplitude; 0.5 to 1.0 v. r.m.s. is usually specified. The generator should now be connected to the adapter and the signals at the left and right adapter outputs examined for waveform and signal level. The instructions supplied with the particular multiplex adapter should be followed. The 100-cps input to the generator should now be routed to the right-channel by moving S1 to the "Ext. Rev" and the multiplex adapter outputs for both channels should be observed and the signal levels recorded. The system outputs at 1 kc. and 400 cps for both left and right generator inputs and left and right multiplex adapter outputs should be obtained and recorded. Channel separation in db should also be calculated and recorded. For quick checking of multiplex adapters, the built-in 1-kc. oscillator is very useful. The combined 1-kc. and 60-cps signal inputs also may be used, but in general, a single sine-wave input to alternate generator channels is the more useful procedure. The 19-kc. output on the front panel is used for touching up adapters with a built-in 19-kc. oscillator.

Test Results

The characteristics of a well-designed transistorized multiplex adapter were measured with this signal generator. With the internally generated 1-kc. sine wave fed to the left input of the generator, the right- and left-channel outputs of the adapter were observed on a dual-trace oscilloscope (Fig. 12). Suppression of the unwanted channel is very good although some 19 kc. is visible in the upper trace. Test results on the same adapter at two audio frequencies are given in Table 2. Channel separation is particularly good at 400 cycles. ▲

Table 2—Multiplex Adapter Performance

Freq. cps	Generator Input v. r.m.s.		Adapter Output v. r.m.s.		Channel Sep. db.
	L	R	L	R	
400	0.5	—	.72	.045	24
400	—	0.5	.062	.75	22
1000	0.5	—	.62	.060	21
1000	—	0.5	.052	.52	20

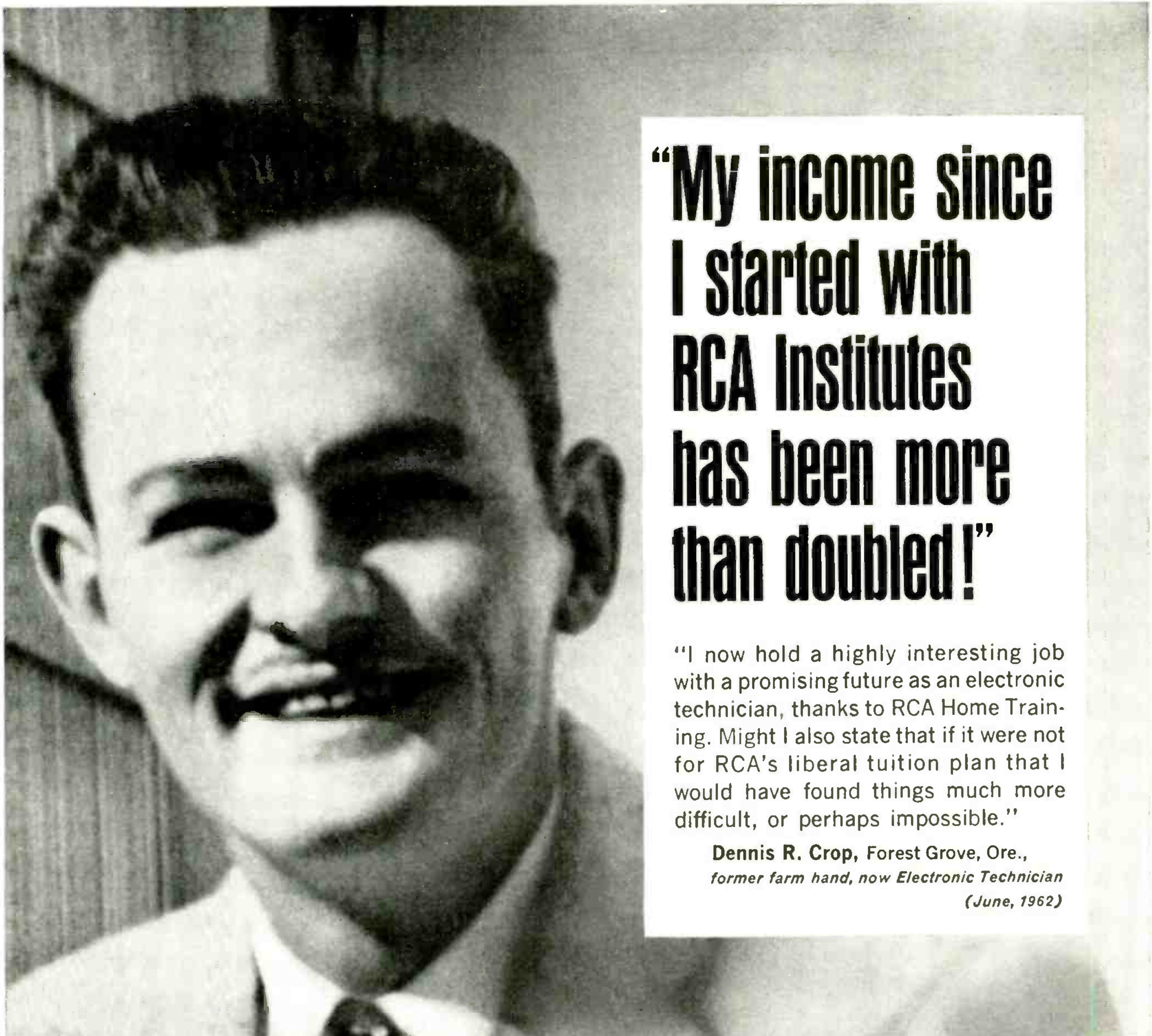
EXTENDING ZINC-CARBON BATTERY LIFE

By JOHN POTTER SHIELDS

COMMON zinc-carbon batteries are a handy source of power for transistor circuits. Unfortunately, the internal resistance of these batteries can become rather large long before they are completely exhausted. As a result, positive feedback may occur in a multi-stage amplifier because signals from several stages will appear in-phase across the battery's internal resistance. The effect is the same as if a resistor were connected in series with one of the battery terminals.

A high-value electrolytic capacitor (250 μf. or greater) connected directly across the battery terminals will provide a low-impedance shunt for a.c. signals and will offset the battery resistance. The d.c. working voltage of the capacitor should equal or exceed the battery voltage.

Obviously the capacitor will not correct for the drop in battery voltage when a load is applied but it will enable you to squeeze a bit more life out of a battery and at the same time it will just possibly clear up an elusive feedback problem. ▲



"My income since I started with RCA Institutes has been more than doubled!"

"I now hold a highly interesting job with a promising future as an electronic technician, thanks to RCA Home Training. Might I also state that if it were not for RCA's liberal tuition plan that I would have found things much more difficult, or perhaps impossible."

Dennis R. Crop, Forest Grove, Ore.,
former farm hand, now Electronic Technician
(June, 1962)

"RCA Home Training has given me the necessary background to pass the required tests for my present position."

"You are to be commended on the excellent content and study material of your courses. By going into electronic theory a little bit 'deeper', your Electronics Fundamentals Course far exceeds many other courses that try to cram too many different phases of electronics into one short course."

Robert David Regina, Marienville, Pa., *(July, 1962)*
former mechanic, now Test Maintenance Technician

"I Began Servicing radio and TV sets after four weeks of your Home Training Course."

"I selected RCA Training after investigating other popular courses and found them inadequate. I believe RCA Home Training is the most informative and most advanced course in the home study field . . . The whole thing from beginning to end is laid out clearly and in a fascinating manner and is so interesting that I was always eager to try the next step . . ."

Clarence Reneau, Dandridge, Tenn., *(June, 1962)*
former electrician, now self-employed Radio-TV Technician

Actual statements made by RCA Institutes graduates.

RCA Home Training can start *you* on an Electronics Career now!

RCA INSTITUTES, INC. Dept. EW-23

A Service of Radio Corporation of America,
350 West 4th St., New York 14, N. Y.
Pacific Electric Bldg., 610 S. Main St.,
Los Angeles 14, Calif.

The Most Trusted Name in Electronics

The dramatic success stories reported here are just a few of the many actual case histories on file at RCA Institutes, proving that the world of electronics offers you one of the fastest ways to a profitable career and a secure future. Today, more than ever before, RCA Institutes Home Training can be your key to a successful tomorrow.

COMPLETE SELECTION OF HOME TRAINING COURSES. RCA gives you a wide selection of electronics courses to choose from, including:

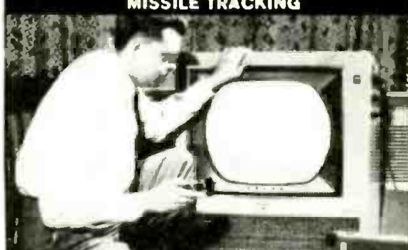
- Electronic Fundamentals
- TV Servicing
- Color TV
- Communications Electronics
- Automation Electronics
- Computer Programming
- Transistors
- Electronic Drafting

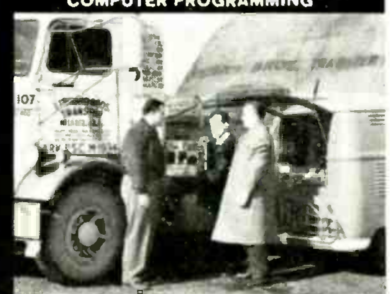
You get prime quality equipment to keep and use on the job, and all kits furnished are complete in every respect.

LIBERAL TUITION PLAN. In addition, RCA has the most liberal tuition plan; you pay only for lessons as you order them and have no long term obligations. Investigate this great opportunity now—from RCA—the name that means dependability, integrity, and scientific advance. Take the step that can mean a successful career now! Send for the free RCA Home Training catalog!


MISSILE TRACKING


COMPUTER PROGRAMMING


RADIO-TV REPAIR


INDUSTRIAL COMMUNICATIONS

CLASSROOM TRAINING. No previous technical training required for admission. You are eligible even if you haven't completed High School.

RCA also offers you classroom training of the highest caliber if you prefer to build your electronics career at one of the convenient locations throughout the country. At RCA Institutes, Inc., Resident Schools in New York City and Los Angeles, and at RCA Technical Institute in Cherry Hill near Camden, N. J., you can prepare for a rewarding position in the exciting field of electronics.

Coeducational Day and Evening Courses are available. You can prepare for a profitable career in electronics while continuing with your normal full-time or part-time employment. Classes start at regular intervals throughout the year.

FREE PLACEMENT SERVICE. RCA graduates may take advantage of the free placement service offered to them. A recent Resident School class had 92% of the graduates who used the FREE Placement Service accepted by important electronic companies . . . and had one or more jobs waiting for them on the day they graduated.

Check "Classroom Training" and information will be rushed to you.

SEND ATTACHED PRE-PAID POSTCARD FOR FREE ILLUSTRATED BOOK TODAY! SPECIFY HOME TRAINING OR CLASSROOM TRAINING!

TRANSISTORIZED WIRELESS INTERCOM

By L. M. DEZETTEL
Engineer, Allied Radio Corp.

Description of some of the unusual circuitry and its operation as utilized in a new "Knight-Kit" unit.

Each station measures only 8¼" x 5¾" x 3".

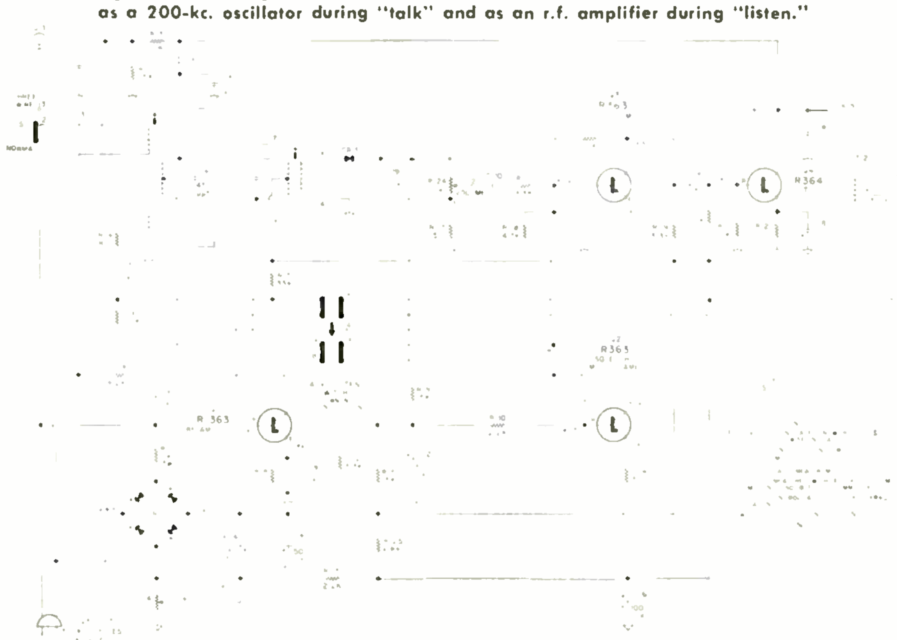
THE COMPLETE transistorization of "Knight-Kit's" new wireless intercom introduces some novel circuitry to the technician and significant advantages for the end user. One innovation —the absence of any "on-off" switch— is a notable departure from standard practice, while other design elements, like a new squelch system, represent an updating process from tube to transistor. The intercom relies on semiconductors to achieve the benefits of negligible power consumption and the cool operation desired in a continuous-service device.

Before discussing specific points, here is the general circuit lineup. Essentially, the transistor intercom functions like its tube counterpart in that the device is a transceiver capable of sending and receiving intelligence over the house wiring. As shown in the schematic (Fig. 1), four transistors comprise the basic complement. When the "Talk-Listen" switch S_2 is on "Talk," all stages are connected for transmitting. The voice enters loudspeaker LS_1 and is boosted by audio amplifiers Q_2, Q_3, and Q_4. Amplified audio is applied to the collector of Q_1, an r.f. oscillator which generates a carrier of approximately 200 kc., and modulation occurs. Output energy is applied to the power line inductively through the windings of special coil L_1.

When the "Talk-Listen" switch is in the "Listen" position, it re-arranges the circuit for receiving. Here, there is a departure from the tube-type intercom. Instead of applying the received signal directly to a detector stage, it drives transistor Q_1, now operating as an r.f. amplifier. This is the expedient which provides the unusually high sensitivity needed for weak-signal conditions. The effect is further heightened by transformer T_1, which peaks the output of the r.f. amplifier.

The separation of audio modulation from its r.f. carrier takes place in the crystal diode CR_1. Actually there is a

Fig. 1. Circuit diagram of wireless intercom. Notice that transistor Q_1 is used as a 200-kc. oscillator during "talk" and as an r.f. amplifier during "listen."



splitting at this point; part of the signal travels to the speaker after amplification in Q_3 and Q_4. The other portion is diverted for activation of the squelch circuit which keeps the intercom immune to annoying line noises and muted during no-signal conditions.

Operation of Squelch

Transistor Q_2, an audio amplifier during transmitting periods, is now connected as a squelch control stage. Its action is interesting since it typifies how a tube function is effectively performed by a transistor. Referring back to CR_1, the detector, it is apparent that rectification of an incoming signal creates a positive voltage at the diode's cathode, or output, terminal. Notice how this is applied to the base of squelch transistor Q_2, and appears only when a signal is received. The transistor utilizes this positive signal to switch audio amplifier Q_3 on or off.

To understand the sequence of events occurring at the squelch, it is best to consider first the normal bias conditions at Q_3, the amplifier to be controlled. Negative bias for the base of this stage is derived from the resistor divider network composed of R_{13} (from collector to base) and R_{18} (from base to ground). The resistance values are selected so the stage will behave as a conventional audio amplifier, its operating bias tapped from the negative leg of the power supply through the dividing network. Notice, however, that the squelch output is also tied into the base of Q_3. This is the lead running from Q_2 collector, through the "Talk-Listen" switch, and to the base of Q_3. It is in this circuit branch that bias control is exercised.

The action may be explained by observing the condition of the squelch transistor when no signal is impressed on its base. During this time its collector circuit conducts a steady, static current as determined by the setting of squelch pot R_1 (lower left in schematic). The direction of current flow through Q_2 acts to cancel part of Q_3's operating bias through their common connection described above. Loss of adequate bias on the base of Q_3 creates a cut-off condition and the intercom speaker remains quiet.

Circuit conditions change sharply when the squelch stage receives the positive signal from diode CR_1, whenever a message is received. Impressed with a positive bias, the static squelch current drops and the collector no longer exercises its cut-off effect on Q_3. Normal amplification takes place as bias resistors R_{13} and R_{18} can perform their voltage-dividing job unhindered by the clamping effect of the squelch.

Other Circuit Features

Other sections of the circuit point up the transistor's characteristic imprint. Most significant is the absence of an "on-off" switch. It reflects a design philosophy which evolved during early engineering stages. It was felt that the transistor's low power consumption could completely eliminate a disadvantage often encountered in intercoms—missing calls when the unit is turned off. With a full complement of transistors and the semiconductor power supply, this unit eliminates that problem. Total power consumption from the line is below 4 watts. Even at the residential rate of approximately 3 cents a kilowatt hour, the cost of continuous operation can be considered negligible.

As an added safeguard against missing calls, R_{17} is inserted between the volume control and ground to keep the volume control from being turned off completely. Although the pot's wiper may be rotated fully counterclockwise, R_{17} keeps it sufficiently above ground so some signal will reach the speaker, albeit low in level.

Hand in hand with low power consumption is another benefit which may be welcomed by the installer. The circuit is cool in operation which increases the number of mounting options. It may be placed in extremely small and confined areas without regard to ventilation or overheating. The compactness possible with transistorization results in a trim cabinet that lends itself to a variety of odd mounting locations. Of course, the "wireless" feature eliminates station-to-station interconnections and adds versatility. ▲

REPEAT FILAMENT "BREAKDOWN"

By DONALD J. PROVENCHER

IS THIS experience familiar? You replaced an octal-based tube—say a 5U4—in a TV set because the filament wasn't lit, and that seemed to take care of the matter. You were subsequently called back because the replacement also went dark. Perhaps you had to go through this cycle once more before realizing that the original defect was in the socket, not the tubes. If you don't remember such an experience with a 5U4, it may have occurred with some other type whose filament draws appreciable current, like a 6AX4, 6BQ6, or 6CD6.

Next time you run into filament trouble on such octal tubes, give the heater pins a simple, visual inspection. One or both of them may be discolored, and some solder may have run out of the pin. Such signs confirm a defective socket. For a temporary repair, the filament pins of the new tube can be crimped somewhat so that they will make good mechanical connection in the socket, until you can get the set into the shop for a replacement job.

Keeping this possibility in mind has been to our benefit because it reduces call-backs. It increases customer confidence. Besides, minimizing call-backs means more profit. This type of fault was checked for about a year before the tube and socket check was made a regular shop practice. ▲

UNIJUNCTION METRONOME

By JOHN F. CLEARY

Applications Engineering, Semiconductor Products Dept.
General Electric Company

Construction details on a simple metronome that is operated by a single unijunction transistor.

A METRONOME can be any contrivance for marking time as an aid to musical study and performance. The unijunction metronome to be described is one of the simpler electronic "contrivances" in that it uses the unique unijunction transistor to generate precision timing pulses. In fact, this is the only transistor used—or for that matter needed—in order to generate a distinct "metronomic tick" at the loudspeaker. An advantage of using the unijunction, or UJT as it is often called, is that the loudspeaker can be driven directly. No output transformer is needed.

The circuit of Fig. 1 can be powered either by a transformerless supply as shown or by a battery. Stability is excellent since the unijunction is known for and does possess high inherent stability. Beat rate is adjustable from below 42 beats per minute, a low *largo*, to slightly over 208 beats per minute, a high *presto*. Both limits can be extended simply by changing the emitter component values.

Circuit operation centers around the 2N2160 and is actually patterned after the basic unijunction transistor relaxation oscillator as used in most UJT applications. The circuit works as follows: applying voltage across R_3, R_4, R_5, and C_2 allows C_2 to charge. Since at the beginning of the operating cycle the unijunction emitter is reverse-biased and therefore nonconducting, a high impedance exists across C_2. As C_2 continues to charge, the emitter voltage increases exponentially and approaches the supply voltage level. At a point determined by the unijunction and called the "emitter peak point voltage," the emitter becomes forward-biased, presents a low impedance across C_2 causing it to "dump" its charge into base 1 (B_1) through the speaker voice coil. This results in a distinct "tick" from the speaker.

"Rate" pot R_4 provides for a slow or fast beat rate by controlling the charging time of C_2. Frequency is thus determined by the combination of R_4, C_2, and the supply voltage across the UJT. Resistor R_3 is selected to set the high beat rate limit while R_5 sets the low limit. By using a log-taper potentiometer for R_4, a well proportioned "rate" scale can be adjusted to any range desired. The photo shows a typical 42-208 beats-per-minute metronome scale spread over almost the total 270° range of R_4. The number of beats for the various tempi employed as calibration for the author's metronome are as follows:

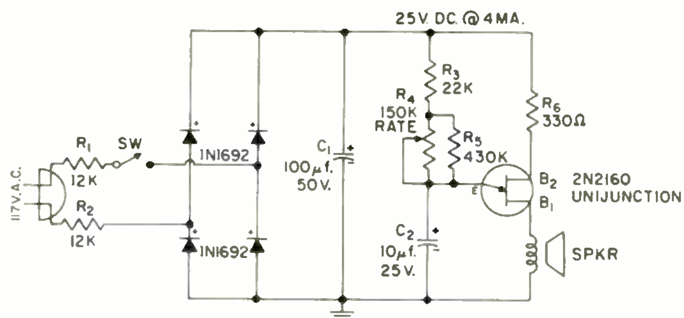
BEATS/MINUTE	TEMPO	BEATS/MINUTE	TEMPO
42-69	Largo	125-154	Andante
69-98	Larghetto	154-180	Allegro
98-125	Adagio	180-208	Presto

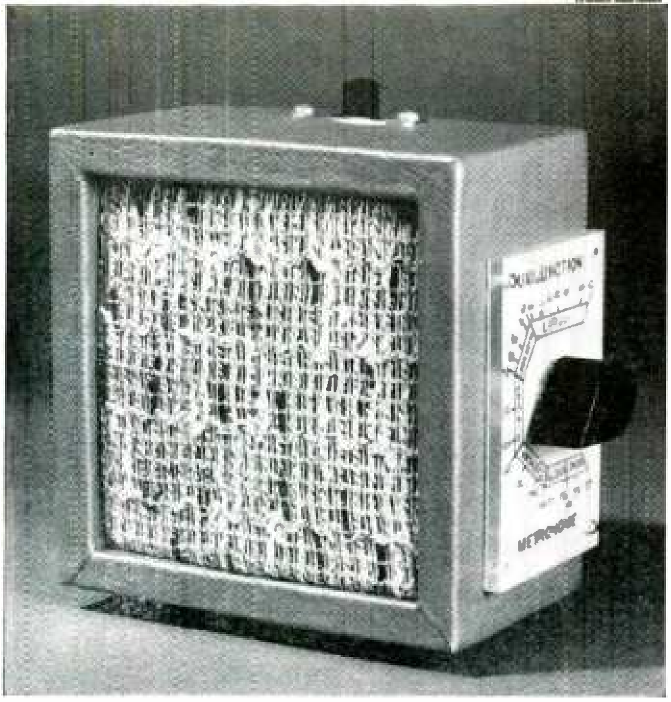
As with any transistor, the effects of temperature are ever present and must be compensated for by proper circuit design. R_6, when properly chosen, results in typical frequency stability from 0 C to 100 C of .25%.

The metronome described here uses a square framed 3½" *Utah* SP358 3-4 ohm loudspeaker containing a 1-ounce magnet. Any loudspeaker can be used, however, and the higher the efficiency of the speaker, the louder the tick.

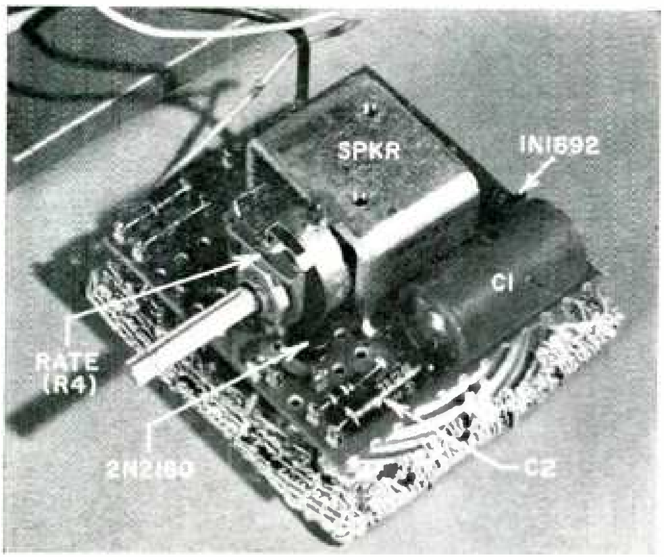
Four 1N1692 silicon rectifiers in a bridge-rectifier configuration and 100-µf. filter capacitor make up the power supply. Fed directly from the a.c. line, this arrangement supplies the required 25 volts at 4 ma. with sufficient regulation for good metronome stability. R_1 and R_2 act as voltage-dropping resistors as well as adding some degree of safety by limiting the total current drain to approximately 5 ma. under direct short-circuit conditions. By housing the circuit in an insulated box, additional protection is obtained against electric shock. An interesting feature of this power supply is that d.c. output voltage is not affected by a.c. line polarity. No matter which side of the a.c. line is short-circuited to ground, the d.c. output voltage remains unchanged.

Fig. 1. Complete circuit diagram of the unijunction metronome.





Wooden case, covered with plastic, is $4\frac{5}{16}$" square, $2\frac{1}{2}$" deep.



Components are mounted on perforated circuit board. The small loudspeaker is first covered with screening, then grille cloth.

Naturally, other power supply arrangements can be used. A $22\frac{1}{2}$-volt battery can replace the supply shown. Lower voltages can be used with decreased output and increased calibration error; in fact the UJT will continue to operate with as low as 3 volts applied in many instances. Should too high a supply voltage be applied, damage to the 2N2160 could occur.

Construction

The photos show construction quite clearly with the exception of the line resistors and three of the 1N1692 rectifiers, all hidden behind the speaker "U" frame. Two rectifiers are located on either side of the perforated insulation board for ease of mounting and wiring. The back of the speaker frame, as shown, protrudes through the square hole cut from the board and rides on the surrounding lip of the speaker frame. After cutting the board to size (slightly smaller than the over-all speaker measurement), measuring and cutting out the center opening, and mounting all components, the completed board is slipped onto the speaker frame and secured in place with contact cement. The bracket-supported R_4 is then soldered to the speaker frame for increased rigidity as can be seen in the photo showing the inside view of the unit.

A square of grille cloth and a square of aluminum window screening are cut about 1" larger than the speaker frame. Place the grille cloth on a flat surface, the screen on top of it, and the speaker—cone down—on top of the screen. By wrapping the excess material around the edge of the speaker frame the cone will be protected from damage. This method of covering the speaker requires no hardware and is self-supporting.

The cabinet shown in the photo is made from $\frac{3}{8}$" plywood and measures $2\frac{1}{2}$" deep x $4\frac{5}{16}$" square. The back is cut from $\frac{1}{8}$" hardboard and is glued in place. A shaft hole about $\frac{3}{8}$" in diameter—large enough to accommodate the shaft and allow the completed unit to be placed in the box snugly—is then carefully drilled in the side of the box. An additional power switch hole is made in the top of the cabinet and a power-line cord hole in the back.

In the photo showing the internal view of the metronome, note the two threaded holes located on the back of the speaker "U" frame. Two additional holes are carefully drilled in the cabinet back to match these holes which are then used to hold the speaker securely in place.

After all rough work is completed, the cabinet is then covered with a washable plastic material.

Should a battery be used to power the unit rather than a permanent power supply, cabinet dimensions must be changed accordingly. Since wiring is in no way critical, any type of cabinet or component arrangement can be used. The circuit could be built into a radio or amplifier, for example, to take advantage of the existing loudspeaker and power supply.

Calibration

Fairly accurate rate calibration will result by counting "ticks" against time. Using a stopwatch or a wristwatch sweep second hand, counting the number of ticks per 15 seconds and multiplying by 4 to obtain the "beat rate" per minute, will result in accurate dial calibration. This method works well for slow to medium beat rates but is more difficult at the faster rates. A second method is to compare the uncalibrated metronome with a calibrated metronome of known accuracy. Both methods are sufficiently accurate for musical purposes.

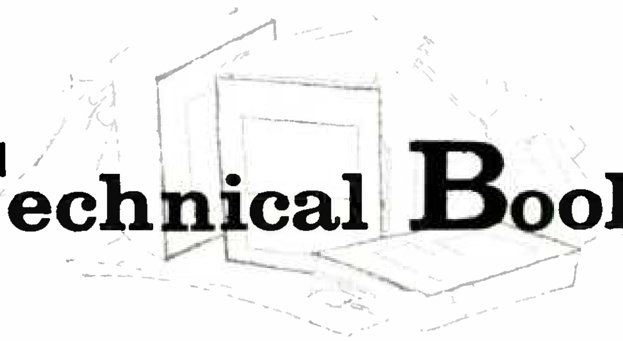
Precision dial calibration can be made by measuring pulse time across the speaker voice coil with an accurate scope or electronic counter. The metronome shown here was calibrated using a *Hewlett-Packard* Model 552B Electronic Counter connected directly across the speaker through a 200-μf. capacitor. All measurements were read off in milliseconds and converted to beat-rate by dividing 60,000 by time in milliseconds.

Conclusion

Should a louder "tick" be desired, the unijunction metronome will easily drive an audio amplifier. By replacing the loudspeaker with a 20- or 30-ohm resistor, positive driving pulses may be taken from base 1 (B_1). Negative pulses can be taken directly from 2 (B_2) simultaneously, if needed.

Pulse rate can be changed widely simply by replacing R_4 and C_2. Two to three minutes, and more, are possible between pulses in one extreme, while ten and less microseconds can be achieved at the opposite extreme.

Needless to say, the unijunction is one of the more unusual, yet simple, transistors among the many available today. The unijunction metronome is only one of many circuits possible with this transistor—and a simple one at that! ▲



Technical Books

"UNDERSTANDING TRANSFORMERS & COILS" by Edward J. Bukstein. Published by *Howard W. Sams & Co., Inc.*, Indianapolis. 91 pages. Price $1.95. Soft cover.

Despite the wide application of transformers, many of those encountering them daily are still vague about their function and operating principles. This basic text is designed to shed considerable light on the subject and does a good job of it. The author covers the properties of inductance and explains how it is measured and applied in electronic circuitry. Concepts of energy storage, counter e.m.f., time constant, self-inductance, mutual inductance, parallel and series inductors, inductive reactance, phase relationships, impedance, energy losses, and "Q" are all covered in detail and in easy-to-understand form.

Inductor construction and transformer principles are included, along with a chapter on measurement and testing, a glossary, and color code guide.

° ° °

"ELECTRONIC DRAFTING" by George Shiers. Published by *Prentice-Hall, Inc.*, Englewood Cliffs, N.J. 527 pages. Price $11.70.

This volume is designed not only for students and practicing draftsmen but also for all students in electronic engineering programs at all levels. The author feels that electronic engineers should be familiar with the problems and practices of electronic drafting even if he has no intention of setting pen to tracing paper.

There are 12 chapters devoted to instruments and materials, mechanical drawing, pictorial drawing, drafting practices, technical lettering, graphical symbols, block diagrams, schematic elements, schematic diagrams, components and assemblies, connection diagrams and printed circuits, graphs, charts and diagrams. The various points are covered by examples.

° ° °

"SINGLE SIDEBAND FOR THE RADIO AMATEUR" by Headquarters Staff. Published by *American Radio Relay League*, West Hartford, Conn. 222 pages. Price $2.00. Soft cover.

This is a comprehensive digest of SSB articles which have appeared in "QST" over a period of time—all carefully revised and expanded as required to conform to current practice. The text covers amateur sideband from its beginnings through the theory and practice of sideband generation, detection, modulation, linear amplifiers, and accessories to be found in the SSB station.

SSB operators will find this compact handbook a valuable and virtually complete reference work for their ham-shack libraries.

° ° °

"THE CONTROLLED RECTIFIER" compiled and published by *International Rectifier Corporation*, El Segundo, California. $2.50 by mail.

This is Volume I and covers the importance of the physical properties of controlled rectifiers and their effect in application. Written from the viewpoint of the controlled rectifier manufacturer, the text includes much information not normally available to the user.

The book is based on those device characteristics which can be observed and measured. The text covers structure and operation, static characteristics, dynamic characteristics, gate characteristics, thermal characteristics, cooling methods, and test procedures.

° ° °

"SEMICONDUCTOR RECTIFIER COMPONENTS GUIDE" compiled by Application Engineering Center. Published by *General Electric Company*, Rectifier Components Dept., Auburn, N.Y. 142 pages. Price 50 cents. Soft cover.

This is a second edition of a guide published for the power supply designer and provides a convenience reference for the selection of silicon, germanium, selenium, and copper oxide rectifier components and the design of rectifier circuits.

In addition to the text material, there are two valuable charts on rectifier selection and rectifier circuit constants. This new edition includes 27 additional pages of specification data.

° ° °

"AUTO RADIO MANUAL" compiled by Sams Staff. Published by *Howard W. Sams & Co., Inc.*, Indianapolis. 160 pages. $2.95. Soft cover. Vol. 15.

This is the latest volume in this publisher's continuing series of service data books covering auto radios. This volume includes some 42 different sets made by

American Motors, Automatic, Blaupunkt, Buick, Ford Granco, Mopar, Motorola, Oldsmobile, Pontiac, Stromberg-Carlson, Studebaker, and *Voxson.*

Each set is accompanied by a schematic, resistance charts, chassis photos, parts lists and replacement data, alignment information, and servicing hints and shortcuts.

° ° °

"MICROWAVE THEORY AND MEASUREMENTS" by Engineering Dept., Microwave Div., *Hewlett-Packard Co.* Published by *Prentice-Hall, Inc.*, Englewood Cliffs, N.J. 263 pages. Price $5.95. Soft cover.

This is a basic workbook for a course in microwave theory and measurements and is designed to fill the practical gaps left by the more theoretical texts. This volume is divided into four major sections involving introductory and background information, microwave theory, basic types of microwave measurements, while the fourth section contains fifteen experiments designed to familiarize the student with microwave equipment and the techniques employed in making microwave measurements.

Three appendices carry a glossary of microwave terms, microwave equipment data sheets, and a bibliography.

° ° °

"abc's of SYNCHROS & SERVOS" by Alan Andrews. Published by *Howard W. Sams & Co., Inc.*, Indianapolis. 92 pages. Price $1.95. Soft cover.

As the title implies this is a basic book for the student, hobbyist, and technician.

The author covers individual control systems, position transducers, synchros, modulators and demodulators, servo amplifiers, magnetic and rotary amplifiers, and actuators along with an analysis of complete systems.

Since servos are part and parcel of an impressive variety of electronic equipment ranging from remote-control TV tuners to missile guidance control systems, this book should attract a wide audience. ▲

Hi-Fi Loudspeaker Cones

(Continued from page 40)

Bass distortion is caused by three mechanical aberrations prevalent during large excursions: (1) non-linear electro-mechanical drive; (2) suspension non-linearity; and (3) non-linear flexular behavior of the woofer cone.

Long-Throw Woofers

"Long-throw" voice coils are designed to maintain a constant ratio between the flux lines and the voice-coil wire immersed in the field regardless of excursion. This can be accomplished in two ways. The most elegant solution is to provide a magnetic gap deep enough so that a narrow voice-coil winding cannot leave the flux field. However, if we contemplate perhaps one-inch (peak-to-peak) excursions, the gap depth required will necessitate a top plate thickness of about 1¼". This type of design although expensive is necessary when an extremely large voice-coil diameter is required. For example, a 4" voice coil wound to a 6-ohm d.c. resistance (a nominal 8-ohm impedance) will have an axial length of only ⅜".

The second and more economical solution involves a smaller voice-coil diameter wound to a longer axial length. The amount of wire in front of and behind the gap represents an insurance against any variation in the ratio between flux lines versus wire turns being cut during large excursions. (See Fig. 3.)

An examination of the disadvantages accruing from both techniques would reveal that they each sacrifice electromotive efficiency. In the narrow-coil/wide-gap case flux density is wasted over a part of the air gap that has no voice-coil wire immersed in it. In the long-coil/narrow-gap case the flux field is completely filled with wire but a percentage of the available winding represents a loss element. Specifically, the wire not in the flux field is analogous to a series resistor, thus influencing both efficiency and mechanical "Q" (damping). In addition, a voice coil with a long axial winding represents considerable additional moving-system mass.

The short-coil/long-gap avoids the effects of unequal distribution of the fringing-flux fields since the voice coil is always moving in a constant flux field. By contrast, some of the overhanging turns of the long-coil/short-gap woofer may cut fringing flux of unequal distribution. In practice, however, these effects may be minimized by compensating chamfering of the top plate. The primary advantage of the short-coil/long-gap system is for full-range speaker designs where a lightweight voice coil is essential for high-frequency radiation. In addition, the series resistor effect of overhanging turns is avoided. For compact enclosures these effects may prevent extension of the bass range due to excessive resonance damping.

The second problem associated with long-throw woofer design involves the mechanical linearity of the suspension springs associated with moving-coil loudspeakers. If we drew a graph representing the mechanical force required to displace the cone a given distance, we would find that it would not be linear with respect to distance: that is, a longer excursion would require greater force at the peak of each cycle. The linearity of any spring is a function of its size. The outer-edge suspension is usually more non-linear than the centering spider. This is because the distance from the clamp-edge on the basket to the fulcrum point where the cone body begins cannot be too large for acoustical reasons. The centering spider can be almost any dimension, consistent with adequate centering without any adverse acoustical effects.

As we have previously noted, the annulus is capable of exerting a considerable acoustical effect. One method of reducing the edge-hole effect due to the annulus anti-resonance, as well as providing a correct terminating acoustical impedance, is to provide an annulus made from a different material than the cone body itself. This allows a wide variation in materials and shapes.

The top photo on page 40 shows two designs made from impregnated cloth. The assembly on the left uses multiple folds of fabric deep enough to provide good linearity and acting not unlike an accordion bellows. The interstices of the fabric are sealed with a permanent viscous compound that also serves to damp out the edge-hole anti-resonance. The acoustical resistivity of this compound may cause a sound-pressure loss of about 2 db.

The roll-type edge suspension on the right provides a single rolling spring action which is about 30 per-cent more compliant than the bellows type. In addition it may be sealed with a compliant, but non-viscous compound that does not introduce any resistive losses. The compliance is so high in this suspension that the spider becomes the controlling spring element.

The third source of bass distortion involves the cone body itself. Obviously, any flexing movements of the cone subtracts from the acoustical output at low frequencies. A curved cone is deliberately designed to provide progressive decoupling, in order to control middle and high-frequency response. Unfortunately this decoupling action can also subtract from the bass output by permitting the outer sections of the cone to move independently of the area closest to the voice coil. A deep straight-sided cone seems admirably suited for execating the kind of pump-like movements we want but, it too, is subject to flexing along lines extending radially from the apex to the periphery of the cone. The extreme compliance of a roll-type suspension deprives the cone of support at the edge where these nodes form.

As we have also seen in Fig. 2 the ratio between voice-coil mass and cone mass affects both response and efficiency. (The optimum ratio exists when the voice coil and cone mass are about the same.) Thus an 1½″ voice coil wound to ¾″ to 1″ long axial length, and weighing about 12 grams should have a cone mass of about 12 grams. Conventional felting methods and mass distribution will produce some radial noding for a 10- or 12-inch cone of this weight. Let us consider the advantages of different felting methods or a different material entirely.

Polystyrene cones, with their high stiffness-to-mass ratio seem to be particularly intriguing. They may be formed to almost any shape and density. However, this writer has experienced unusual reflection characteristics related to the dissipation *versus* velocity characteristics of polystyrene woofer cones. While there is a whole gamut of materials to be considered which seem to offer advantages, the felted paper cone *can* be designed to outperform them all.

A sophisticated approach to conventional cone pulp stocks as well as felting methods can produce a cone of high rigidity and optimum mass. A re-distribution of this mass by means of graded density will yield a cone with more symmetrical structural configuration for any given mass.

The reconciliation of all these conflicting physical elements involves the closest cooperation between the speaker designer and the cone manufacturer. Certainly there are few precise and predictable answers. Much empirical trial-and-error work remains to be done in the field. ▲

LIVE-VS-RECORDED CONCERT

A LIVE-VERSUS-recorded concert was performed by the Fine Arts Quartet at Harvard University. During the performance, the musicians alternated their playing with the sound of their own tape, reproduced through a stereo playback system. The back-and-forth switching was done instantaneously, without losing the musical beat. It was frequently quite difficult to tell when the sound was coming from the musicians on stage or from the pair of Acoustic Research AR-3 loudspeakers directly behind the Quartet. The musicians feigned playing during some of the time that the tape was being played and quite a few in the audience of several hundred people were at a loss to know when they were hearing live or recorded sound. The only difference we could note was a very slight increase in the amount of reverberant sound when the members of the Quartet were actually playing on stage. ▲

Grid Current

(*Continued from page* 51)

$$\Delta I_b = G_m \Delta E_g, \text{ or } \Delta I_b = G_m R_g I_g,$$

where G_m is the transconductance of the tube under test, ΔE_g is the bias voltage change, R_g is the grid resistor, and I_g is the grid current. The solution, of course, is for grid current or I_g.

If the value of G_m is not known, grid current may be determined from the relationship, $\Delta E_g = R_g I_g$, with a somewhat different measurement technique. A voltmeter across a bias supply is used to note the bias change, ΔE_g.

First the grid resistor is shorted out and plate current is noted. Then the short circuit is opened. If negative grid current is present, an increase in plate current will now be noted. Bias is then increased until the initial plate current is re-established. The change in bias, observed with the voltmeter, needed to restore plate current (ΔE_g) is inserted in the last formula, which is then solved for I_g.

Identifying Grid Current

Measuring the amount of grid current does not necessarily establish which of the four types it is. Positive grid current, of course, can be verified by its polarity. The more difficult problem is to differentiate gas, grid-emission, and leakage current.

The amount of negative grid current caused by gas can be determined by remembering that the gas ions are the consequence of collisions between electrons and gas molecules. Therefore, if there is no electron current in the tube, there can be no gas ions and no gas current. The simplest way of cutting off the electron flow is to disconnect the cathode. Another method is to apply a high negative bias to the grid.

Since two or more types of negative grid current can be present simultaneously, some such current may still be present after gas current is interrupted. In fact, in some cases, there may be an increase. The remaining current is due to grid emission, leakage, or both.

Switching off or otherwise interrupting the heater will decrease grid emission almost as fast as the cathode (and therefore the grid) cools off. On the other hand, overheating the cathode (as by increasing heater voltage) will increase grid emission considerably.

Being resistive, leakage is little affected by temperature changes: its presence can usually be noted in a cold tube. Also reversing the polarity of applied voltages, while it will reverse the direction of leakage current, should not change its magnitude appreciably. In fact, this test should be performed only in a cold tube or one in which the cathode connection has been interrupted.

The particular characteristics of the various types of grid current discussed here can be noted in Fig. 2. Note, for example, that gas current is eliminated at about the same bias voltage at which plate current is cut off; *i.e.*, when bias is sufficiently negative to stop the electron beam. Also note the relative independence of grid-emission current of operating conditions (aside from temperature).

In general, manufacturers of modern tubes have managed to maintain the internal vacuum at a very high level. This has been achieved by careful processing of parts and the use of highly efficient getters. Such measures prevent significant gas current.

Grid emission is reduced by keeping the grid temperature low, and this is achieved with the use of materials on the grid that have good heat conductivity, or by plating the lateral wires with gold or silver.

Leakage results primarily from the deposition of material that has sublimated out of the cathode. Modern cathode materials, containing fewer impurities, have contributed to much lower leakage levels than were considered practical years ago.

Despite such advances, tube users may run into unusually demanding applications that require careful tube selection or compensation for undesired grid current. In such instances, the tests described here, based on manufacturing methods, can be used to determine the nature of grid current so that proper choice or compensation can be made. ▲

FAMOUS NAMES QUIZ

By JOE TERRA

A GREAT many principles, components, and phenomena are referred to by the names of the men who developed them. Can you match the names in the first column with the respective instruments, components, or principles listed in the second column? Check your answers on page 111.

1. Adcock	A. Antenna	10. Heaviside	J. Tube
2. Allstrom	B. Valve	11. Johnson	K. Earth
3. Ayrton	C. Enclosure	12. Klipsch	L. Shunt
4. Beverage	D. Disc	13. Lawrence	M. Base
5. Colpitts	E. Direction finder	14. Luxemburg	N. Layer
6. Edison	F. Series	15. Maxwell	O. Amplifier
7. Faraday	G. Bridge	16. Nipkow	P. Shield
8. Fleming	H. Relay	17. Wagner	Q. Noise
9. Fourier	I. Oscillator	18. Williamson	R. Effect

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. Place magazine address label here and print your new address below.

NEW ADDRESS:

NAME ______________________
PLEASE PRINT

ADDRESS ______________________

CITY __________ ZONE ____ STATE __________

MAIL COPIES TO NEW ADDRESS STARTING

WITH __________ ISSUE.

If you have any other questions about your subscription be sure to include your magazine address label when writing us.

Mail to: ELECTRONICS WORLD, 434 So. Wabash Avenue, Chicago 5, Illinois

Calendar of Events

JANUARY 22-26
Fourth Annual ERA National Convention. Sponsored by Electronic Representatives Association. Mark Hopkins Hotel, San Francisco. Details from ERA Headquarters, 600 South Michigan Ave., Chicago 5.

JANUARY 30-FEBRUARY 1
Fourth Winter Convention on Military Electronics. Sponsored by PGMIL and Los Angeles Section of IRE. Ambassador Hotel, Los Angeles, Calif. Program information from IRE Los Angeles Office, 1435 La Cienega Blvd.

FEBRUARY 8-10
1963 Pacific Electronic Trade Show (PETS). Sponsored by Association of Electronic Distributors. Shrine Exposition Hall, Los Angeles. Details from Association, 10480 National Blvd., Los Angeles 34. Att: Charlie Silvey, executive vice-president.

FEBRUARY 11-15
Third International Symposium on Quantum Electronics. Sponsored by IRE, SFER, ONR. Unesco Building & Parc de Exposition, Paris, France. Program details from Madame Cauchy, Secretaire, 7 rue de Madrid, Paris 8me, France.

FEBRUARY 20-22
International Solid State Circuits Conference. Sponsored by PGCT, AIEE, Philadelphia Section of IRE, University of Pennsylvania, Sheraton Hotel and University of Pennsylvania, Philadelphia. Program information from S. K. Ghandi, Philco Scientific Lab, Blue Bell, Pa.

MARCH 25-27
Convention on H.F. Communication. Sponsored by the Electronics Division of the Institution of Electrical Engineers. Program information from Secretary, IEE, Savoy Place, London, W.C. 2, England.

MARCH 25-28
IEEE International Convention. Sponsored by all Professional Groups of the IRE. Coliseum and Waldorf-Astoria Hotel, New York. Details from Dr. D. B. Sinclair, IRE Headquarters, 1 E. 79th St., New York 21, N.Y.

APRIL 10-11
Fourth Symposium on Engineering Aspects of Magnetohydrodynamics. Sponsored by PGNS, AIEE, IAS, University of California. Details from Julian L. Dunlap, Thermonuclear Exp. Div., Oak Ridge National Lab., Oak Ridge, Tenn.

APRIL 16-18
Cleveland Electronics Conference. Sponsored by IEEE, ISA, Cleveland Physics Society, Case Institute, and Western Reserve University. Hotel Sheraton, Cleveland. Details from Lapine Enterprises, 310 Hotel Manger, Cleveland 14, Ohio.

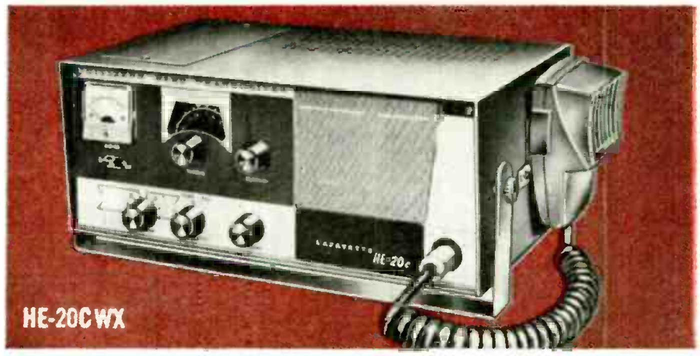
Symposium on Optical Masers. Sponsored by IRE, AIEE, Optical Society of America, U.S. Defense Research Agencies. Polytechnic Institute of Brooklyn, N.Y. Details from Jerome Fox, Polytechnic Institute of Brooklyn, 55 Johnson St., Brooklyn 1, N.Y.

APRIL 16-20
1963 British I.R.E. Convention. Sponsored by British Institution of Radio Engineers. University of Southampton. Information from I.R.E., 9 Bedford Square, London, W.C. 1, England. ▲

HE-20C DELUXE CITIZENS BAND TRANSCEIVER

Now Officially Approved For use in CANADA By Dept. of TRANSPORT Type Approval No. 169361029. Tops in CB world ■ 8 crystal controlled receive positions, 8 crystal controlled transmit positions ■ Tuneable over all 23 channels ■ Direct reading "S" meter indicates RF Power Output, Transmitter and Antenna Efficiency and Receiver "S" readings ■ Effective noise limiter ■ Built-in 12 or 6 volt power supply for mobile use. With crystals for channel 9.

No Money Down 109^{50}



4-TRACK STEREO TAPE DECK

99^{50} less case
No Money Down

Deluxe Professional Quality Built-in Transistorized Stereo Record/Play Preamps ■ Plays: 4-Track Stereo, 2-Track Stereo, and 4-Track Mono Tapes ■ Records: 4-Track Stereo or Mono and Sound-on-Sound ■ 2 Record Level Meters ■ Tape Index Counter ■ Automatic Stop at end of tape ■ 2 Speeds: 3¾ ips and 7½ ips ■ Frequency Response @ 7½ ips, 40-18,000 cps ■ Takes up to 7" reels.

49^{95}
No Money Down

DELUXE 4-BAND SHORTWAVE BROADCAST RECEIVER

■ Tunes 550 kc to 30mc in four bands — Hear Europe, ships at sea, planes and amateurs ■ Sensitive superheterodyne circuit ■ Built-in "S" meter ■ Electrical bandspread ■ Receives voice or code

LAFAYETTE FOR EYE-OPENING Values

33^{95} EACH
2 for 62^{90}
No Money Down

LAFAYETTE 10-TRANSISTOR CITIZENS BAND "WALKIE TALKIE"

50% more powerful—now with 10 transistors, plus diode, thermistor and extra RF stage ■ Transmits and receives up to 2 miles ■ Up to 50 hours battery life ■ Push-to-talk operation ■ Complete with leather case, earphone, antenna and batteries.

LAFAYETTE STEREO MULTIPLEX TUNERS

FM-AM STEREO MULTIPLEX TUNERS

89^{50} No Money Down

FM MULTIPLEX TUNER

76^{50}
No Money Down

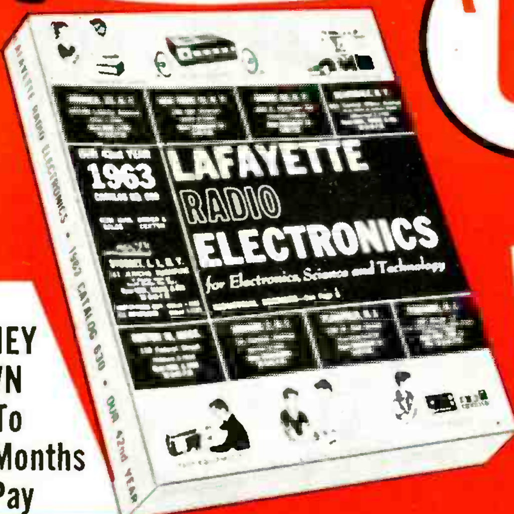
FEATURES OF BOTH LAFAYETTE TUNERS

Highest Quality Reception—Superb Styling! ■ Wide-band Design ■ Duplex 3-Gang tuning condenser provides tuned RF stage for greater sensitivity and selectivity ■ Built-in Multiplex with excellent separation ■ Sensitive tuning Meters ■ Variable AFC control ■ FM stereo Noise Filter ■ Smooth Flywheel Tuning.

FREE! FOR '63

LAFAYETTE RADIO ELECTRONICS

1963 CATALOG NO. 630
388 GIANT-SIZE PAGES —
The Largest Catalog in Our 42-Year History



NO MONEY DOWN Up To 24 Months To Pay

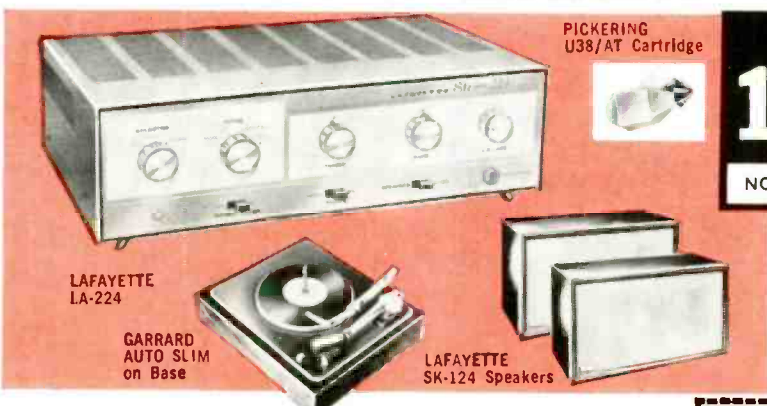
from the "WORLD'S HI-FI & ELECTRONICS SHOPPING CENTER"

WHEN YOU BUY AT LAFAYETTE, YOU GET THESE EXCLUSIVE BENEFITS

- OUTSTANDING LAFAYETTE KITS
- LOWEST PRICES
- 24-HOUR SERVICE

- **SATISFACTION GUARANTEED OR MONEY REFUNDED.** Use Lafayette's 30-Day FREE Home Trial.
- **LARGEST STOCK SELECTION.** If it's in Hi-Fi or Electronics, it's in the Lafayette Catalog.
- **NO MONEY DOWN.** Buy on time with Lafayette's Easy Pay Credit Plan, up to 24 months to pay.

TRUE, CUSTOM-MATCHED STEREO NEED NOT BE EXPENSIVE — *and isn't at Lafayette!*



ONLY 129.50
NO MONEY DOWN

YOU SAVE 49.30

A COMPLETE 24-WATT STEREO PHONO SYSTEM

Only at Lafayette could you find an outstanding, custom-matched stereo system at such an amazing low price. Compare components, compare performance, compare price—you'll choose Lafayette.

LS-225WXM Specify: Pickering Cartridge; wood base finish; Speaker System finish. Shpg. wt., 64 lbs. Net **129.50**

YOU GET THESE SYSTEM MATCHED COMPONENTS

Lafayette LA-224 24-Watt Stereo Amplifier	49.95
Garrard Autoslim 4-Speed Record Changer	39.50
Wood Base (Specify Walnut, Mhg. or Blonde)	3.95
Pickering U38/AT Diamond Needle Cartridge	46.50
2 Lafayette SK-124 2-Way Speaker Systems (Specify walnut or mahogany) @ 19.95 each	38.90
Regular Catalog Price	~~178.80~~

LAFAYETTE'S MAIL ORDER and SALES CENTER
SYOSSET, L. I., NEW YORK
111 Jericho Turnpike

OTHER LOCATIONS

NEW YORK, NEW YORK 100 6th Avenue	SCARSDALE, NEW YORK 691 Central (Park) Ave.	PARAMUS, NEW JERSEY 182 Route 17
JAMAICA, NEW YORK 165-08 Liberty Avenue	PLAINFIELD, NEW JERSEY 139 W. 2nd Street	BOSTON, MASS. 110 Federal Street
BRONX, NEW YORK 542 E. Fordham Rd.	NEWARK, NEW JERSEY 24 Central Avenue	NATICK, MASS. 1400 Worcester Street

MAIL THIS COUPON TODAY for YOUR FREE LAFAYETTE 630 CATALOG

Get One for a Friend Too

FREE!

388 GIANT SIZE PAGES

LAFAYETTE RADIO ELECTRONICS
Dept. RB-3-2, P.O. Box 10, Syosset, L.I., N.Y.

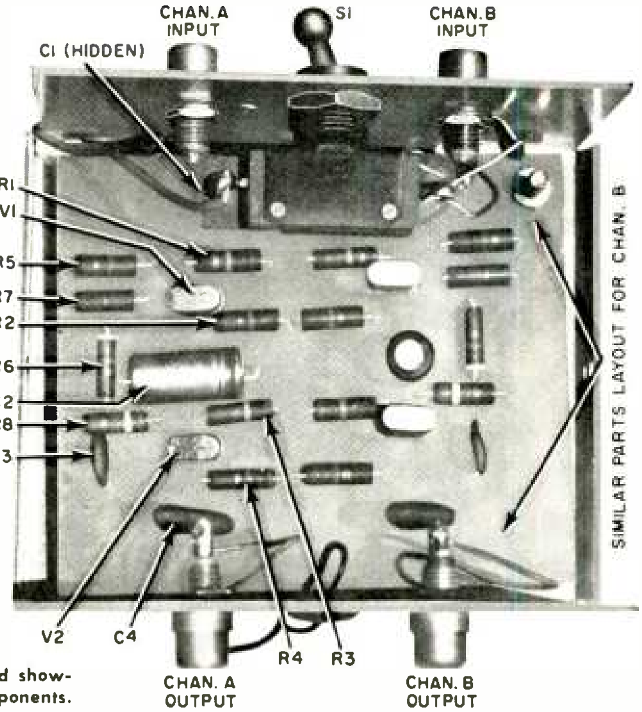
☐ Rush my FREE 388-page giant-size Lafayette Catalog
☐ Send me #................, Shipping charges collect.
I am enclosing ....

Name ....
Address ....
City .... Zone .... State ....
Friend's Name ....
Address ....
City .... Zone .... State ....

TAPE-DECK PREAMP

By DON M. WHERRY

Construction details on a transistorized playback preamp featuring high gain, low noise, and small size.



View of the top of the circuit board showing the arrangement of all the components.

WITH the growing popular acceptance of the tape recorder for stereo, many prospective customers have to decide whether to buy two full record-playback preamps or simply two units of the playback type. There is, however, a third alternative—you can build your own preamplifiers. If only the playback function is desired, this is amazingly simple and inexpensive.

This article describes such a preamplifier—a dual-channel, two-stage transistorized playback unit. The features of the preamplifier include: gain of 800 at 1 kc., ample to drive any power amplifier; over-all bass boost of 18 db; the use of only four inexpensive transistors; a low noise figure of 55 db below 1-millivolt input; and small size.

Fig. 1 shows the circuit schematic. The circuit is relatively straightforward, employing fixed gain and fixed bass boost by means of feedback from the collector of the output stage to the emitter of the input stage.

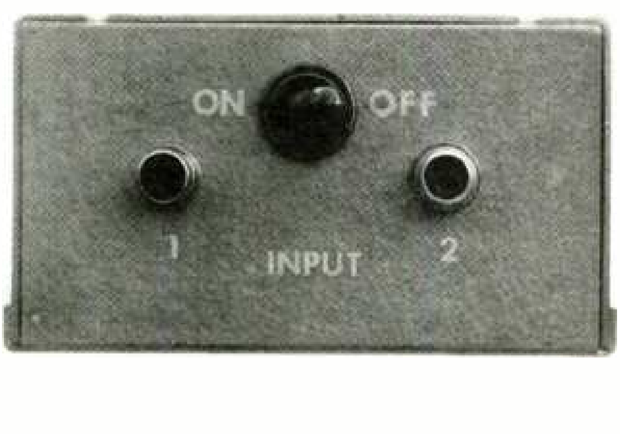
A word about this feedback value is in order. The output of a typical magnetic playback head rises with frequency to some fairly high value, above which output falls suddenly. Some heads will go out to higher frequencies than others and some of the newer heads will hold up a little better at the lower frequencies, but the general shape of the response is essentially the same for all heads. It is necessary, then, for your playback preamplifier to compensate for the head roll-off at the lower frequencies to present a flat response to the power amplifier.

Ideally, the preamplifier should have a response which is the exact opposite of the head's response curve. This would produce a flat output from the preamplifier into the main amplifier where additional tone compensation could be inserted to suit the listener's taste. In the case of the author's unit, adequate bass boost is provided to level out the playback head output at low frequencies only. The highs are taken care of by adjusting the tone controls of the main amplifier to suit.

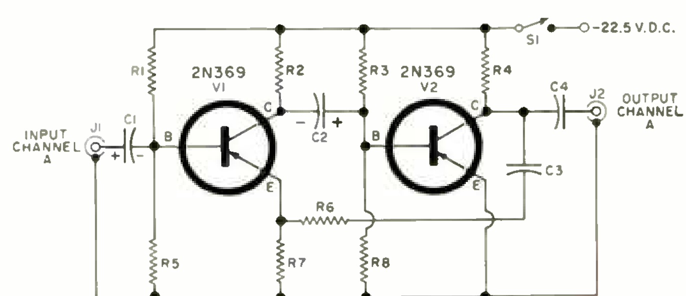
The exact equalization curve can be changed quite easily to suit individual needs by varying the values for R_6, R_7, and C_3. Resistor R_7 governs the over-all gain of the channel, both by altering the gain of the first stage and by changing the feedback voltage. The larger the resistance, the more feedback and the lower the net gain—and *vice versa*. Altering the value of R_6 will vary the feedback voltage only and can be used along with C_3 to set the shape, frequency, and total amount of low-frequency boost. The very high frequencies can be boosted by shunting R_7 with a suitable capacitor. However, this is not particularly important as the main amplifier can do this satisfactorily with its treble tone control.

The transistors are 2N369's manufactured by *Texas Instruments*. These operate very well in this circuit. They sell for around $1.75 each and are quite uniform, have a low noise figure, and fairly high gain.

In this circuit, as in all transistor circuits, correct base current (bias) is important. It probably would be well to tack R_1 and R_3 into the circuit temporarily until the unit is tried. This will



Front-panel view of the author's home-constructed four-transistor stereophonic tape-playback preamplifier unit.



R_1—510,000 ohm, ½ w. res.
R_2—22,000 ohm, ½ w. res.
R_3—910,000 ohm, ½ w. res.
R_4—62,000 ohm, ½ w. res.
R_5—10,000 ohm, ½ w. res.
R_6—91,000 ohm, ½ w. res.
R_7—200 ohm, ½ w. res.
R_8—3900 ohm, ½ w. res.
C_1, C_2—30 μf., 10 v. elec. capacitor
C_3—.001 μf. mica capacitor
C_4—.2 μf. ceramic capacitor
J_1, J_2—Phono jack
S_1—One-section of d.p.s.t. switch
V_1, V_2—2N369 transistor (see text)
Note: Duplicate the above for the second channel.

Fig. 1. Circuit diagram and parts listing for one of the two identical preamplifier channels that are required.

allow you to take them out and replace with other values in case there is a difference between your transistors and those used by the author. If other transistors are to be substituted for those specified in the parts list, it is suggested that R_1 and R_3 be omitted and one-megohm pots be temporarily wired into the circuit. These pots can then be adjusted for maximum output with no clipping of the audio sine wave. Once the correct settings are found, their values can be inserted into the circuit. The rest of the components should be satisfactory for any reasonable substitution.

The author's unit was built on a printed-circuit board. This construction method is not necessary but does have the advantage of providing solid construction, ease of component mounting, and small size.

One word of caution: be sure not to overheat the transistors when soldering the leads. It is good practice to hold the lead between the soldered connection and the transistor body with a pair of long-nose pliers which acts as a heat sink and protects the unit. The only thing left after the wiring and soldering are completed is to assemble the board in a box, connect up a 22.5-volt battery; and try it out. Be sure the battery is connected in the correct polarity. The current drain is very low, only 1.1 ma. per channel, so a small battery will last a long time.

Incidentally, the use of a battery will be a revelation to those of you who have worked long hours trying to eliminate the hum caused by ground loops in your audio equipment.

This unit will furnish adequate gain to bring up the 1-mv. output of your recorder head to some usable level. If you prefer less transistor hiss you can buy quieter types—but not for $1.75. The hiss is very low with these transistors, however, so it is no problem as is.

Don't try to use this unit with a crystal phono pickup as it has too low an input impedance and, in addition, will have very poor low-frequency characteristics. ▲

"You have a problem, McVeal. Your dog whistle changes channels on my TV."

The Electronic Antenna

(Continued from page 44)

impedances, no difference would be observable on the TV screen, whether the amplifier be mast-mounted or antenna-mounted. Likewise, since this very short piece of 300-ohm line is properly terminated with matching impedances at both ends, the amount of noise it can pick up is negligible and meaningless in the over-all system In fact, in most installations, the amplifier could be mounted on the mast several feet below the antenna without causing observable difference.

This, in turn, leads to the question of amplifiers designed specifically for a particular antenna. Mechanically, the amplifier can, of course, be designed for a particular antenna, such as having the plastic case of the amplifier act as the driver dipole terminal insulator. When this is done, however, removal of the amplifier for servicing leaves the dipole assembly without a support at its terminal point unless a special insulator is made available.

Under some circumstances, it might be desirable to design an amplifier electrically for a specific antenna. For example: an antenna that has good gain on all low-band channels except channel 4 could obviously benefit from an amplifier that has more gain on channel 4 than on the other channels. Likewise, if an antenna has some unusual terminal-impedance value, such as 1200 ohms, again an amplifier specially designed with an input impedance of 1200 ohms instead of 300 ohms would be desirable. However, if proper engineering techniques and design practices are used to produce an antenna having proper gain curve and impedance characteristics, there should be no reason why such an antenna would require a specially designed amplifier.

The choice of using an antenna with an amplifier, or simply a higher gain antenna, or a stacked array, is never a simple "rule-of-thumb" procedure. If noise pickup is our problem, its nature and location is of importance. If the difficulty is with transmission line pickup, it is entirely possible that simply using a shielded transmission line will satisfactorily correct the situation. In this case, a shielded line would present to the TV receiver a cleaner signal although, because of its greater attenuation or losses as compared to high-grade 300-ohm ribbon line. the level of the desired signal would be reduced. If this increased line loss reduces the desired signal to a level that is too low, a higher gain antenna or an amplifier, would of course be required. If increasing the gain of the antenna will provide sufficient additional signal, this undoubtedly is the most economical way of obtaining a satisfactory result. However, if very large increase in gain (such as 10 db or more) is required, then the addition of an amplifier is indicated as being more sensible. There are practical limitations on the size and cost of antennas intended to provide very large increases in gain.

If the source of local noise is such that most of the difficulty is being caused by noise picked up directly by the antenna, adding an amplifier will not improve the situation, as it would simply amplify the noise along with the desired signal, resulting in a higher signal level but the same offending signal-to-noise ratio. The problem then reverts to the antenna, which should have a narrower and more discriminating directivity pattern. Even though the very high db gain of an amplifier may be required because of extremely weak signal, in noisy locations it would be desirable to have a highly directional (and high-gain, since they go hand-in-hand) antenna to discriminate against the noise.

If one wishes to discriminate against atmospheric noises from above the antenna, or from other noise sources below the antenna, the stacking of two bays would be advisable, as this would increase gain primarily by narrowing the vertical-plane response pattern. In very weak signal areas with many local sources of noise, a satisfactory antenna installation may require the stacking of two bays of very high gain antennas, to produce the maximum discrimination against all undesirable signals, and also possible, an amplifier mounted near the antenna on the mast to supply the TV receiver with sufficient signal.

The problem can be summarized by the difference in engineering philosophy between the amplifier and a high-gain, highly directional antenna. The job of the booster, of course, is simply to amplify the signal presented to its input terminals and, at the same time, add as little noise as possible to the over-all system from its own inherent internal noises (determined by the signal-to-noise ratio of the amplifier itself). Also the design of the amplifier should be such that it is not prone to overloading or cross modulation from a strong, local signal. The function of the antenna, however, is to pick up a strong, clean signal for presentation to the input of either the amplifier or the TV set. Since the amplifier and/or TV receiver must operate on the signal delivered by the antenna, the choice of receiving antenna is of prime importance. It is the most critical component of the entire system, affecting the operation of all other components that follow it, including the amplifier. In fact, in many special situations, an antenna specifically designed to meet the particular local requirements may be indicated, whether an amplifier is used or not. ▲

ELECTRONIC CROSSWORDS

By LUTHER A. GOTWALD, JR.

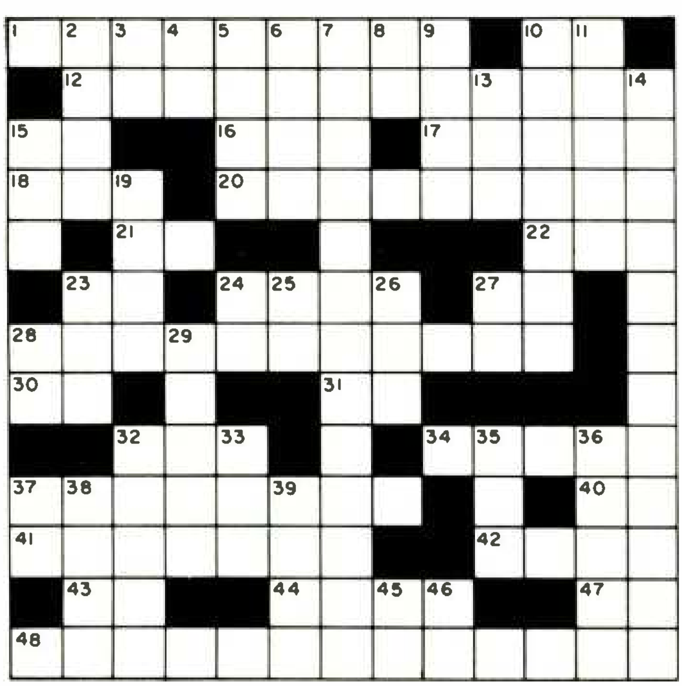
(*Answer on page* 111)

ACROSS

1. Geometric curves.
10. A Latin language (abbr.).
12. Flashing lights used to "freeze" motion.
15. A Chinese dialect.
16. Farm animal.
17. Stereo speakers are mounted like this.
18. Earth.
20. Part of the impedance of an a.c. circuit due to inductance and capacitance.
21. Pick______.
22. Fuel consumption rate (abbr.).
23. Type of speaker.
24. Moslem teacher.
27. Chemical ending.
28. Pickup used to modulate FM system.
30. Man's nickname.
31. Pronoun.
32. Professional "sound" group (abbr.).
34. Worthless things.
37. Induction-type pickup.
40. Preposition.
41. Another type of pickup.
42. Charles II's "Nell."
43. Again (prefix).
44. Shaded walk.
47. A chemical (abbr.).
48. Type of current produced by putting pressure on a crystal.

DOWN

2. God of war.
3. All the resistance in a circuit (schematic notation).
4. Belonging to (suffix).
5. Early atomic theorist.
6. Reed instrument.
7. Type of graph used in audio work.
8. While.
9. Cantankerous command.
10. A sparkling bit.
11. Food fish.
13. World War II agency.
14. Adds dimension to sound.
15. Turntable defect.
19. A jolt.
23. Attenuator.
24. Transformer output (abbr.).
25. Fifty-one (Rom. num.).
26. Girl's name (var.).
27. In the work mentioned (abbr.).
28. Engineering degree (abbr.).
29. Sphere of action.
32. Concede.
33. Institute for training ministers (abbr.).
35. It's usually housed in a ham shack.
36. Needles.
37. Inaudible frequency (abbr.).
38. Prefix meaning "air."
39. Period.
45. French article.
46. Tuned circuits (abbr.).



SIMPLE TRANSISTOR CHECKER

By A. J. MOLINARA

FIG. 1A is a schematic of a conventional small-signal transistor β checker. To measure the β you would adjust R_1 to obtain a value of base current, I_B, read on M_1. The collector current, I_C, is then noted on M_2. The β of the transistor is the ratio of the collector current to the base current ($\beta = I_C/I_B$). The author found that when the base current was varied to obtain different readings for current-gain measurements, there were instances when excessive base-input current caused a misleading gain figure.

With the circuit shown in Fig. 1B, this shortcoming was surmounted by fixing the base-input current at 20 μa., an optimum value for the general run of small-signal transistors. With the base current I_B held constant at 20 μa. (0.02 ma.) the current-gain formula becomes $\beta = I_C/0.02$, which equals $50I_C$. (All terms must be in the same units, *i.e.*, ma. or μa.) Therefore with a fixed base-input current of 20 μa., it is merely necessary to multiply the collector-current reading by 50 to determine β.

Complete Circuit

The tester shown in Fig. 2 uses a 1 ma. meter so a full-scale indication represents a transistor β of 50. To increase the range four times, the meter must be shunted to indicate four ma. full-scale. Then a full-scale reading will represent a transistor β of 200. An indication of .2 on the meter when operating in the ×50 range requires multiplying .2 × 50 = 10. The same .2 indication on the ×200 range requires multiplying .2 × 200 = 40.

To determine the value of the shunt, R_S, adjust a 5000-ohm pot, connected in series with a 0-1 ma. meter and a 1.5-v. battery, until the meter indicates 1 ma. Connect another pot in parallel with the meter and adjust it to reduce the meter indication to .25 ma. Measure the resistance of the shunt pot and buy or wind a resistor of the same value. To be sure that the value is correct, check a transistor on the ×50 range and then switch to the ×200 range. The gain figures should be the same. A transistor that indicates .8 on the ×50 range should indicate .2 on the ×200 range.

In Figs. 1B and 2 a 300,000-ohm resistor in the transistor base circuit fixes the base input current at 20 μa. The 2200-ohm resistor limits the collector current. S_3, in Fig. 2, determines gain or leakage (I_{CBO}) test. Normal I_{CBO} leakage should be below 5 μa. Transistors with a leakage current over 10 μa. are questionable. For a more accurate leakage-current reading, a microammeter may be used instead of a milliammeter. First take a reading with the milliammeter to make certain the current does not exceed the range of the microammeter. Be sure, too, that S_3 is in the leakage position. ▲

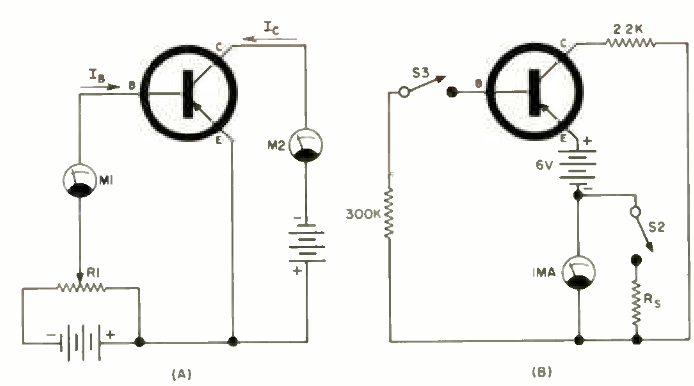
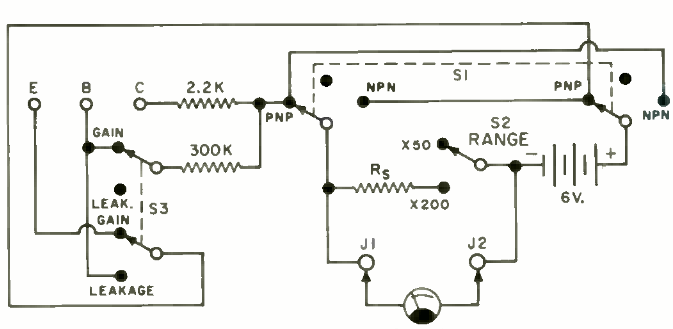


Fig. 1. (A) Conventional d.c.-beta test circuit. (B) Simpler circuit used by author.

Fig. 2. Checker measures gain to 200, and leakage of "n-p-n" and "p-n-p" transistors.



Radio & TV News

Events in the Service Industry

TEXT for this month's sermon: Intelligence is inborn, but wisdom must be learned.

With time, the service industry has come to bring riper insight to its standing problems, opening the way to more constructive remedies. Once all ills were caused by manufacturers, distributors, and sundowners. Such measures as licensing and selective buying would cure everything. Today the mentioned groups, although still recognized as factors, are not branded as pure and simple scapegoats with exclusive responsibility. And it is realized that the problems will not vanish miraculously when such magic wands as licensing are waved.

Consider, for example, a recent evaluation of the part-timer—who may learn to qualify for a license, if he has to. In an article entitled "Pool Your Resources . . . and Survive," NATESA spokesman Frank Moch points to an underlying factor: the trend to a shorter work week—as short as 25 hours in some industries today. The growing reserve of working people with time on their hands will feed the part-time pool, come what may from other directions.

He also takes a fresh look at manufacturer-controlled service, whether it be of the directly "captive" variety or in the form of an "extended warranty." There has been much talk over the fact that we have passed from an economy oriented toward goods to one oriented toward service. That is to say, slightly more than half of the consumer's dollars are spent on services right now, and the shift will continue from year to year. This means that big business, including TV set makers, will become increasingly interested in bidding for the money spent on services.

Plan for Action

Moch surveys some of the other problems in the same way. But the real point is that, if the economy is inevitably changing, the small shop must anticipate and adjust to reality.

Although it will mean the surrender of some traditional, "rugged individualism," his program nevertheless aims to preserve the basic individualism of small, private ownership. He feels that dealers should act in concert (obviously through such existing instruments as their associations), where separate action is fruitless.

Advertising is one area named. One shop has neither the resources nor the know-how to launch an effective campaign, particularly if it can expect to buck a company with a big budget in the future. Pooling resources will enable the hiring of specialists to devise effective campaigns, and consumer response to such ads could be divided on a geographical or other equitable basis.

Buying of parts can also be done in combination, although this does not necessarily mean bypassing of regular distributors, he points out. Larger purchases will mean better prices and will also encourage those distributors not competing with their dealer customers on the retail level.

Cooperation can also be extended to retailing TV and radio sets, which many service people have abandoned in the face of stiff price competition. Control of sales is an important asset in obtaining service work. Services can meet competition if they join hands for large-scale buying.

Centralized Service

Finally, the pooling of equipment and skill can produce perhaps the most important economy of all, without sacrificing the personalized but wasteful type of service, represented by the one- or two-man shop, that the public seems to prefer. Most bench work could be done in centralized shops, for example, where complete equipment and substantial parts inventories would be maintained. Economy would be made possible by the large volume of work.

Each dealer would still retain his own accounts and deal with them on an individual basis. The pooled facility would also take advantage of each man's specialty. If you are a wizard on the *Admiral* line, for example, you would concentrate on this brand no matter who brought the set in. On the other hand, if *Philco* sets are off your beaten path, the ones you run into would be tackled by another specialist.

The principle also extends to types of equipment other than radios and TV sets. Knowing little about tape recorders is no problem, if someone else in the "combine" can eat them alive. In fact, Moch suggests, the principle could extend to the type of diversification that evens out seasonal peaks and valleys.

He stops short of details at this point, however. Realizing the concept's newness, he chooses to go no further until he can get some feedback reaction. If opinion is favorable, he promises to carry the basic notion further. He also notes that he considers the "days of the industry as now constituted" quite limited, with some plan for the future becoming increasingly important.

More on this next month. ▲

EW Lab Tested

(Continued from page 20)

its versatility. Using the earphone, audible output could be obtained from inputs as low as 5 millivolts at 100 mc., modulated 30%. Even FM signals could be picked up near the tube envelopes in the multiplex and audio sections of receivers. The microwave demodulator yielded audible outputs at 1200 mc. at a −50 db level, corresponding to 0.7 millivolt, at 100% modulation.

Viewing the output on an oscilloscope, we were able to pick up the acoustic output of oscillating quartz crystals by touching the vibration pickup to the crystal case, at frequencies as high as 100 kc. The possible uses of this compact instrument are limitless, and surely go far beyond the usual signal-tracing techniques. It is ruggedly built and finely finished. The unit sells for $140. ▲

Citroen Model 660 Tape Recorder

For copy of manufacturer's brochure, circle No. 60 on coupon (page 15)

PORTABLE, battery-operated tape recorders have generally fallen into two price categories, one selling for about $20 and the other for several hundred dollars. The former is little more than a toy, lacking constant-speed capstan drives, and with such poor quality that even speech is often unintelligible. The latter, fully professional in quality, is too expensive for the average user.

The *Citroen* 660 represents an interesting compromise between these two extremes. It is light and portable, measuring only 7½" x 7" x 2½" and weighing 5½ pounds in its leather carrying case, and has many of the operating conveniences found on home tape recorders. The capstan drive has tape speeds of 1⅞ ips and 3¾ ips. The transistor amplifier and motor are powered from six penlite cells, installed in a removable cartridge. Unlike cheaper portable recorders, the 660 has a bias/erase oscillator, motor-driven rewind, a safety interlock for recording, and a tiny meter for monitoring recording level and battery voltage. It is beautifully finished in polished chrome and black wrinkle, and has a transparent window to allow inspection of the reels during operation.

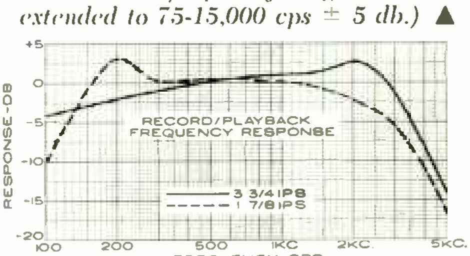
The recorder can accommodate 3" reels, which hold up to 600 feet of ½-mil tape. Being a half-track machine, it can record up to 2 hours on a reel at 1⅞ ips or 1 hour at 3¾ ips. The basic price of $149.50 includes the leather carrying case, batteries, microphone with remote-control switch, earphone, telephone pickup, take-up reel, and a reel of tape. An additional $39.50 buys an accessory kit including an adapter for powering the recorder from the cigarette lighter socket of a car, a foot-operated remote-control switch, and an a.c. power supply.

The 660 is not a high-fidelity recorder, and is not sold as such. Its chief usefulness would seem to be as a dictation machine, operating independently of power sources. A demonstration music tape supplied with the recorder produced highly listenable sound, comparable to that of a table model radio The two 2½" speakers produced more than adequate volume Voice recordings came out well, but the wow and flutter made music recording impractical

Since we didn't have a 300-foot reel of tape available, we wound some standard 1-mil tape on a 3" reel for our tests. The record/playback frequency response at 3¾ ips was ± 3 db from 100 to 3500 cps, and at 1⅞ ips was ± 3 db from 125 to 2500 cps. The signal-to-noise ratio was 58 db (there was no hum, of course, only a slight background hiss). At either tape speed, the wow was 1% and flutter was 0.25%. The flutter was at a low rate, producing an audible gargling sound more annoying than the numerical figure might suggest. Rewind time for the demonstration reel (presumably 300 feet) was 1 min., 40 sec.

As a means of writing voice letters, dictating, or taking verbal notes when a.c. power is not available, the 660 would seem to be quite satisfactory. Playback of pre-recorded 3¾-ips tapes, cut to fit 3" reels, can also be done if the music does not contain many sustained notes.

(Editor's Note: We have just been informed that the Model 660 is now being supplied with a 7½-ips conversion kit. With this addition and improvements in design, the manufacturer claims that the wow and flutter are less than .18% r.m.s. and that the frequency range has been extended to 75-15,000 cps ± 5 db.) ▲



Electric Shock—On Purpose

(Continued from page 32)

Defibrillator that is suitable for both closed- and open-chest resuscitation.

bly, including the mercury cells and other components, is potted in epoxy resin to prevent shifting of the components, strain on the connecting leads, and to keep out the body fluids which are electrically conductive and would cause short circuits. In addition, the assembly is encapsulated in a double shell of silicone rubber.

Implantation

The pacemaker is implanted in the subcutaneous abdominal tissues. Lead wires from the pacemaker are connected to a pair of electrodes buried in the myocardium (heart muscle) and held in place by sutures. As a safety feature, another set of leads is brought out from the pacemaker. This subcutaneous extension terminates slightly below the skin. In an emergency, a surgeon can make a small incision to reach the extension leads. In the event of failure of the internal pacemaker, an external unit can be connected to the exposed extension leads. In addition, an oscilloscope can be connected to these leads to determine whether the failure is in the pacemaker proper or in the heart electrodes or leads. Another emergency use of the extension leads is that they can be used to short out a current-limiting resistor in series with the pacemaker output. This increases the output current of the pacemaker to compensate for increased stimulation threshold due to increased electrode resistance.

The pacemaker ends of the electrodes terminate in stainless steel pins. These plug into jacks in the pacemaker and are held in place by setscrews. The jacks and setscrews are then covered with a coating of silicone rubber. Since the electrodes in the myocardium must "ride" with the movements of the heart, they are subjected to changing mechanical forces at a rate of approximately 30,000,000 cycles per year. The possibility of mechanical failure of the electrodes and lead wires is therefore an important factor in pacemaker design. Helical spring electrodes withstand material fatigue and breakage pressures far in excess of normal stresses. The conducting element is a continuous coil of platinum-iridium alloy of high corrosion resistance. The tips of the two electrodes are inserted into the left ventricle of the heart, about one centimeter apart, and are held in place by sutures passing through the myocardium.

Electronic Muscle Activator

The Theratronic (*Theratron Corp.*, St. Paul, Minn.) muscle stimulator eliminates the need of a lower leg brace for hemiplegic patients. In such patients the motor signal from the brain is lost as a result of cortical or peripheral nerve damage. For this reason, the lower leg muscles cannot contract as they should during a normal walking-cycle.

The activator is a pulse generator which simulates the *missing* motor signal from the brain, and these pulses are applied to electrodes on the patient's leg. Turned on and off by a heel switch in the shoe, the pulse generator causes contraction of the leg muscles at the proper time during the walking-cycle. This is illustrated in Fig. 9. As the heel is lifted, pressure is removed from the heel switch and the pulse generator turns on. Negative pulses, adjustable in the range of 20 to 80 volts, are now applied to the leg electrodes. As a result, the foot-lifting (dorsi-flexor) muscle is activated to produce the lift and carry-through motion of the leg. When the foot is set down, pressure is again applied to the heel switch and the pulse generator turns off. This artificial and correctly timed stimulation of the leg muscle eliminates the drag-and-shuffle gait of typical hemiplegic patients.

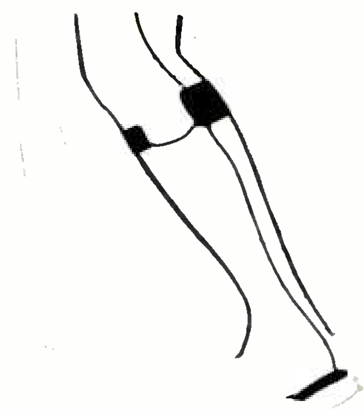


Fig. 9. Stimulator is worn on leg and is used to cause the leg muscle to contract at proper time for near-normal walking.

The complete muscle activator consists of the stimulator, battery pack, heel switch, pulse-applicator (active) electrode, and a reference electrode. The stimulator and the battery pack interlock to provide electrical coupling. This stimulator-battery assembly is fitted with belt loops and is contoured to fit the waist or upper leg. Total weight, including the electrodes and heel switch, is less than one pound. A re-energizer unit is available for recharging the nickel-cadmium battery pack. Charge life of the battery is approximately two weeks on the basis of 30 per-cent usage. For safety purposes, however, it is recommended that the battery be charged overnight once each week.

The stimulator output consists of negative pulses in the frequency range of 40 to 60 pulses per second. Pulse amplitude is adjustable from 20 to 80 volts, and output current is nominally 7 milliamperes. This output is applied to the patient through a pair of electrodes. The disposable electrodes are neutral colored for cosmetic effect and are flexible to conform to limb contours. An electrically conductive paste is applied to an absorbent pad on each electrode for improved contact. The smaller (active) electrode is placed over the motor point of the dorsi-flexor muscle, and the larger (reference) electrode is positioned over the gastrocnemius (calf) portion of the leg. These electrodes are held in place by an elastic cuff. By means of snap fasteners, the electrodes are connected to the stimulator and heel switch. This switch is enclosed in rubberized cork that can be trimmed to fit into the patient's shoe.

Aside from eliminating the need of a leg brace, the muscle activator has two important side-effects. It prevents atrophy of the muscle due to prolonged inactivity and it "re-educates" the muscle so that in some cases normal muscular control may be restored after a certain period of time.

Conclusion

Nearly two centuries have elapsed since Galvani's experiments with "animal electricity." Medical uses of electrical stimulation, however, are only now entering a phase of intensified research. In the field of surgery, for example, doctors have long hoped for the development of an electrical anesthetic that will be safe, quick-acting, and have little or no after-effect. Recently, promising results have been obtained with a 700-cps current passed through the head. (*Editor's Note: We are planning an article on electrical anesthesia for a forthcoming issue.*) Although future uses of electrical stimulation are difficult to foresee, it seems certain that many startling, curative, and life-prolonging techniques will come out of current research programs. ▲

Electromagnetic Delay Lines

(*Continued from page 49*)

the coding unit, it is necessary to develop a synchronizing key or code at the receiving end that will properly match the coded transmission. Fig. 13 shows a decoding circuit which utilizes a pulse-width discriminator to pass pulses of a predetermined width, and reject all narrower pulses. The input pulse is differentiated at the grid of V_1, forming a positive pip on the leading edge and a negative pip on the trailing edge. The pips, separated by a time lapse equal to the duration of the pulse, are coupled to a short-circuited delay line across the grid of V_2. The line is grounded on the other end so that a negative reflection of the positive pip appears at the grid. If the reflection coincides with the negative pip from the trailing edge of the input pulse, a high amplitude negative pip results from their summation. The output of V_2 is coupled to a pulse-forming circuit which is heavily biased to eliminate reaction to all but the high-amplitude signal developed above.

As the field grows and requirements become more stringent, additional types of delay lines will be developed for new applications. ▲

REDUCING IMPEDANCE OF SURPLUS EARPHONES

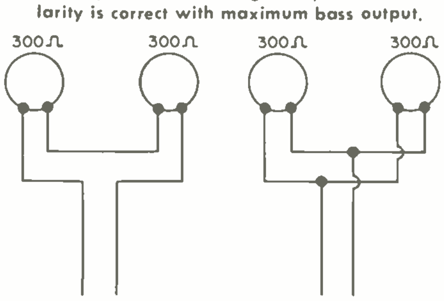
By ART TRAUFFER

FOR A NUMBER of years this publication has been carrying ads offering surplus 600-ohm headsets, and numerous surplus dealers list them in their catalogues. When it is desired to use these headsets in the outputs of short-wave or broadcast receivers, the 600-ohm headsets don't make too good a match to the 4-ohm, 6-ohm, or 8-ohm secondaries of the output transformers in the receivers.

As shown in Fig. 1A, these surplus 600-ohm headsets consist of two 300-ohm units connected in series to give 600 ohms. If you connect the two 300-ohm units in parallel, as shown in Fig. 1B, you will have a headset of 150 ohms impedance, which improves the match to the output transformer in your receiver.

The author has rewired his headsets using lightweight rubber or plastic lamp cord. Phone-cord tips or spade lugs were soldered to the leads as needed. ▲

Fig. 1. (A) Original series wiring and (B) modified parallel wiring. Observe polarity when re-wiring the phones. Polarity is correct with maximum bass output.



New Products and Literature

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

INDUSTRIAL TUBE TESTER

1 **The Hickok Electrical Instrument Company** is currently offering a new industrial and laboratory tube tester as the Model 539C.

Designed to test VR tubes, low-power thyratrons, 4-digit industrial types, as well as compac-

trons, novars, nuvistors, and 10-pin types, the instrument is designed to test tubes to handbook specifications with no elements paralleled.

The tester has provision for separate monitoring of plate current, through panel terminals facilitating matching or balancing of tubes. Non-standard tests can be performed using panel terminals to give access to grid, plate, cathode, and heater circuits.

TRANSMITTER-TYPE CAPACITORS

2 **Sprague Electric Co.** has announced the availability of a new type of large mica transmitter-type capacitor with the introduction of its cylindrical-body cast designs.

The new line, Types 375M, 380M, 385M, and 390M, are solid impregnant with the capacitor element embedded in a block of solid epoxy. This technique makes them leakproof, eliminates all air voids, and makes possible high insulation resistance, "Q", and voltage breakdown parameters.

ELECTRONIC PHONE SECRETARY

3 **Phone King Company** has introduced a new automatic push-button telephone answering machine which is fully transistorized and weighs only 22 pounds.

The new device is designed to be plugged into any standard outlet for instant use with any telephone handset. The unit answers the call with a personal greeting and simple instructions in the

owner's voice, records messages of any length in precise detail, and plays them back at the touch of the button. Special tapes record up to 2½ hours. A rugged, handsome carrying case permits safe and easy handling in the office, on trips, and in the home.

FLUORINATED CAPACITORS

4 **Cornell-Dubilier Electronics Division** has developed a new line of disc ceramic capacitors which are fluorinated to allow high-reliability operation up to 200 degrees C with no voltage derating.

The fluorination process increases the maximum operating temperature of the capacitor. The dielectric, barium titanate, is saturated thoroughly with a fluoride and at high temperatures a solid-state reaction takes place between the dielectric and its crystal matrix. The reaction of the fluorination electrically "hardens-in" material with respect to degradation. The units are glass encapsulated and, in addition, have silicone rubber jackets.

SENSITIVE PHOTOCONDUCTOR CELLS

5 **Sylvania Electric Products Inc.** has announced the availability of six high-sensitivity cadmium sulphide photoconductor cells for use in industrial control, furnace safety, and lighting applications.

The new units are of the T-4 (½-inch diameter) size and offer cell resistance from 750 through 16,000 ohms. The cell design features true hermetic sealed-in-glass construction and a visual indicator that responds if the envelope becomes damaged and moisture enters the compo-

nent. Back filling of the envelope with hydrogen during manufacture provides high dissipation and voltage safety factors.

ENGINEERING DRAWING DUPLICATION

6 **Copymation, Inc.** has introduced a new paper which copies engineering drawings simply by exposure to ultra-violet light. Called "UV-Dri," the paper needs no processing with liquid chemicals, gases, or heat to develop a sharp, permanent image, according to the company.

The paper can be used in all existing diazo machines of major makes. The special coating on the paper reacts to ultra-violet light shining through transparent or translucent originals or engineering drawings. Dark lines on originals show up white on the paper.

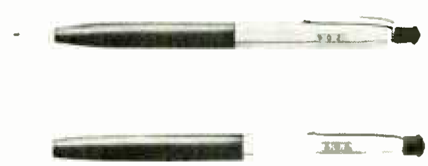
TV CAMERA KIT

7 **Craftsmen Instrument Labs. Inc.** has introduced a television camera in kit form designed especially for amateur TV stations, remote observation of hazardous operations, property protection, industrial and educational uses.

All major parts are pre-assembled on the chassis. Included in the kit are easy-to-follow step by step instructions. The basic kit does not include the vidicon tube and lens, which are available as accessory items.

POCKET MEASURING DEVICE

8 **Universal Writing Instruments Corporation** has recently introduced the "Perpetua," a pocket measuring device that is mounted in the barrel of a pen or pencil. Through a "window"



on the barrel, the complete, accurate measuring result, in inches and ¼ inches, automatically appears. In addition to meeting ordinary measuring requirements, the unit can be used to measure objects of any shape or size or configuration.

The company plans to market a metric model of the unit in the near future.

THERMAL WIRE STRIPPER

9 **Sentry Electronics, Inc.** is now marketing a new thermal wire stripper which the company claims eliminates the nicking of wire during stripping operations. There are no sharp edges nicking the wire as this specially designed heating element melts the wire covering and anneals the inner copper wire, making it more flexible and eliminating wire breakage.

The unit is available with variable tempera-

tures for Teflon, Formvar, Nyclad, vinyl, or other plastic coverings. The length of the wire to be stripped can also be regulated for production stripping.

TRANSISTORIZED TV CAMERAS

10 **General Electric Company** is now in production on two compact transistorized television cameras which have been developed for medium-priced closed-circuit TV systems.

The single-unit vidicon cameras, types TE-14

and TE-15, are available in ten different models. They will meet a wide range of applications in commercial, industrial, defense, medical, and educational use.

The circuits are completely transistorized with the exception of the vidicon pickup tube and a single subminiature tube in the video input section. Complete specifications are available from the company.

LOG-PERIODIC ANTENNAS

11 **JFD Electronics Corporation** has recently introduced a series of new TV antennas which offer high gain, sharp directivity, and constant impedance across the complete v.h.f. TV and FM bands.

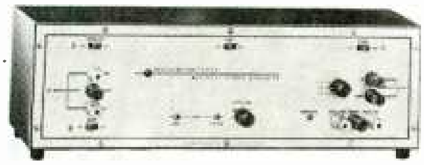
Based on the log-periodic principle developed by scientists at the University of Illinois and adapted for TV by the manufacturer, the new "LPV" antennas consist of an array of resonant "V" dipoles interconnected by transposed phasing harnesses, constituting a series of "cells." The size of each cell differs from the one before it by a logarithmic factor. Impedance is constant irrespective of frequency.

HI-FI—AUDIO PRODUCTS

MULTIPLEX SIGNAL GENERATOR

12 **Precision Apparatus Co., Inc.** has announced the addition of a stereo multiplex signal generator to its line of test equipment.

The Model E-490 is designed for rapid alignment and complete testing of the multiplex circuitry in all FM stereo receivers and multiplex adapters. Channel separation, channel balance, sync pull-in and hold-in range can easily be measured and adjusted. The controls provide for



generating the FCC-specified FM multiplex signal. A self-contained 1-kc. audio oscillator, or an external audio generator, may be switched to generate: left only, right only, and sum or difference signals. The pilot signal can be switched on or off, independent of the composite modulation.

INTEGRATED TUNER/AMP

13 **Bogen Communications Division** has recently introduced the Model RP230, a 30-watt FM-AM integrated stereo tuner/amplifier.

Frequency response is 20-20,000 cps ± 1 db and FM sensitivity is .85 μv. for 20 db of quieting. The unit features the company's "Stereo-Minder" indicator which lights when the station is broadcasting in FM stereo, electronic-eye tun-

ing, special tape recorder filter which eliminates beeps and whistles when recording off the air, and a brushed-gold panel. A walnut or metal enclosure is available at extra cost.

STEREO TAPE RECORDER

14 **Roberts Electronics, Inc.** has added the Model 1057 stereo tape recorder to its line of new units for 1963.

The new instrument offers four-track stereo and mono play, sound-on-sound recording in

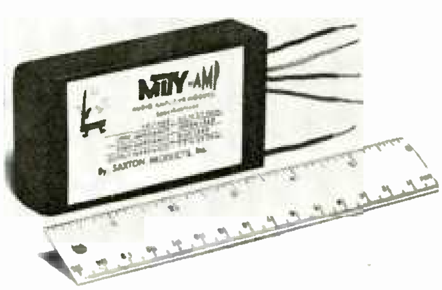
stereo, sound-with-sound, and sound-over-sound-microphone, and radio-phono mixing.

Other features include dual extended range stereo speakers, dual self-contained stereo power amplifiers, two easy-to-read vu meters for each channel, separate record buttons for each channel with record safety lock, preamp outputs, four stereo outputs, three-position speaker switch, automatic shut-off, edit lever, index counter, and automatic tape lifters. Tape speeds are 3.75 and 7.5 ips. A 15-ips accessory kit is available at no extra cost.

AUDIO AMPLIFIER MODULE

15 **Saxton Products Co.** is handling the U.S. distribution of the "Mity-Amp," a palm-sized 2 watt amplifier for a variety of audio applications.

Frequency response is 20-15,000 cps ± 2 db at the 1 watt level. Input voltage required to drive to full power is .5 volt while the input impedance is 45 ohms to 50,000 ohms. Output impedances of 3.2 to 45 ohms can be handled. Power requirements are 6 to 12 volts at 300 to



700 ma. Current is determined by the impedance of the voice coil.

The completely encapsulated unit measures 2" x 3½" x ⅞" and weighs 6 ounces.

MOBILE TV AUDIO PICKUP

16 **The MobilSound Corporation** is now marketing a mobile TV audio monitor which permits the audio portion of all v.h.f. TV programs to be received on the AM car radio.

Designed primarily for television station personnel, advertising agency men, and those in the entertainment business, this unit can also be used by laymen who hate to miss favorite TV programs just because they are away from their sets.

The "AudioMonitor" is transistorized, compact, and easy to install. It is designed to be used with 12-volt negative-ground automotive systems but can be used with other 12-volt systems by making a minor modification. Current drain is 1.4 amps at 12.6 volts. It measures 6" x 4" x 7".

INTEGRATED STEREO TUNER/AMP

17 **Kenwood Electronics** is handling the distribution of a new integrated stereo tuner/amplifier which is rated at 20 watts per channel at less than 1% harmonic distortion.

The Model KW-40 will handle AM, FM, and

FM multiplex program material and requires only the addition of a pair of speakers to function. The control center has inputs for a low-level magnetic stereo phono cartridge(as well as for high-level ceramic or crystal stereo cartridge) and provides RIAA phono equalization.

BUDGET-PRICED SPEAKER

18 **Electro-Voice, Inc.** has added a new budget-priced loudspeaker to its line of components as the MC8.

The first model in the firm's new "Michigan" line, the speaker features extra-slim styling, rugged die-cast frame, and edgewise-wound voice coil that provides 18% more efficiency than ordinary coils. Frequency response is 50-13,000 cps and the speaker will handle 12 watts program and 24 watts peak.

TRANSISTORIZED TAPE RECORDER

19 **North American Philips Company, Inc.** is now offering its "Continental 401," a four-track stereo record and playback tape recorder, completely transistorized, and featuring a new

fourth speed of 15/16 inch per second for up to 32 hours of recording on a standard 7" reel.

The circuit incorporates four AC107 transistors in its preamplifiers. A special magnetic head with a gap of only 0.0001 inch is said to be responsible for the extended high-frequency response of the unit even at lower speeds. Frequency response ± 3 db is: 60-16,000 cps at 7½ ips; 60-14,000 cps at 3¾ ips; 60-10,000 cps at 1⅞ ips; and 60-4500 cps at 15/16 ips.

TRANSISTORIZED STEREO AMP

20 **Allied Radio Corp.** is now offering a new easy-to-assemble, 32-watt transistorized stereo amplifier as its "Knight-Kit" KG-320.

Weighing only 7 pounds, the new amplifier

uses 14 transistors and 4 diodes. The unit has direct-coupled output with no output transformers or blocking capacitors. A special feature is the thermal feedback circuit which protects the output transistors from overload, acts as a fuse device for speakers, and helps to maintain circuit stability.

The amplifier has five pairs of stereo inputs including tape head; separate ganged bass and treble controls; printed-circuit construction; tape recorder outputs; two switched a.c. outlets; and stereo-mono switch.

WATERPROOF SPEAKERS

21 Racon Loudspeakers, Inc. has recently introduced two new loudspeaker models, the RL-10T and RO-25T. Exclusive features include a built-in line-matching transformer, molded Bakelite waterproof shielded terminal block in which

the transformer leads terminate, and immediate external choice of all impedance and power taps. The transformers used with these models are designed for the newer 25-volt lines as well as for the more usual 70-volt and constant-impedance lines. Detailed specifications are available on request.

24-WATT STEREO AMP

22 Lafayette Radio Electronics Corporation is currently introducing its Model LA-224WX 24-watt stereo amplifier, a moderately priced unit.

The new amplifier features a full range of control facilities, power output of 12 watts per channel, frequency response of 20-100,000 cps

± 1 db at 1 watt; harmonic distortion of less than 1% at 12 watts; and hum and noise −56 db on magnetic phono and −73 db on tuner.

The rear panel has a speaker impedance switch (8 or 16 ohms), hum adjust, and a.c. convenience outlet. The unit measures 12⅞" x 5⅛" x 8½" and is housed in a low silhouette cabinet.

CB-HAM-COMMUNICATIONS

ANTENNA FOR MOBILE CB

23 The Antenna Specialists Co. is now on the market with a new CB antenna which is being offered in cowl, deck, fender-mount, and trunk-mount versions.

The "Black Beauty" antenna features solid black Fiberglas sleeving which is specially processed to eliminate brittleness and cracking. The process also eliminates mottling and graying even after long service. The unit is center-loaded and is only 48" high. Mounting for the unit is supplied in contrasting chrome and black.

TRANSISTORIZED TWO-WAY RADIO

24 RCA Mobile Communication Products has recently introduced the "Super-Carfone," a two-way unit which is being offered in 30- and 60-watt versions.

(Continued on page 108)

you can have a career like this in space age electronics

SUPERVISING A FREQUENCY MEASUREMENT *in the Precision Measurement Equipment Laboratory at Vandenberg Air Force Base is CREI grad Robert N. Welch. He is a Philco TechRep Engineer and a Section Leader in the Laboratory.*

Take the first step today—send for free book that shows you how CREI can help you take advantage of today's opportunities.

JUST A FEW YEARS AGO Robert N. Welch had a routine job in electronics. He realized that progress was impossible without practical and up-to-date knowledge of advanced electronic engineering technology. Determined to prepare himself to meet industry requirements for career opportunities, he enrolled in a CREI Home Study Program. Today he is a Philco Corp. engineer with a responsible assignment in space age electronics at Vandenberg Air Force Base, launching site for intercontinental ballistic missiles.

YOU HAVE THE SAME OPPORTUNITY. CREI offers you, for study at home, a complete program in electronic engineering technology designed to equip you with the practical knowledge of electronic developments required for well-paying positions and put you on the level of specialization where men are most in demand.

YOU WILL FOLLOW THE FOOTSTEPS of the thousands of CREI men who hold positions as associate engineers, engineering aides, field engineers, project engineers and technical representatives. They work in every area of electronics from manufacturing to research in the aero-space program.

YOU CHOOSE FROM PROGRAMS covering every important field of electronics:

SERVOMECHANISMS • INSTRUMENTATION • RADAR • COMPUTERS • AERONAUTICAL AND NAVIGATIONAL • COMMUNICATIONS • AERO-SPACE • TELEVISION • AUTOMATION AND INDUSTRIAL ENGINEERING TECHNOLOGY • NUCLEAR ENGINEERING TECHNOLOGY

MR. WELCH PARTICIPATES *in a technical discussion with Charles R. Browning, Contract Manager, and Burl W. Bowman, Electrical Calibration and Repair Supervisor, in the Laboratory which Philco Corp. operates under contract to the Air Force.*

CALIBRATION OF PRECISION MEASURING EQUIPMENT *used in the missile program is performed in Mr. Welch's section of the Laboratory. He is shown making an adjustment on the oscillator which is used as a frequency standard in this important task.*

MR. WELCH HAS ENJOYED *promotions from Technician to Junior Engineer to Engineer since he enrolled in a CREI Program. Here he is greeted by his family as he returns to his pleasant home in Santa Maria, California at the end of the day.*

HIS FAMILY SHARES IN THE REWARDS *Mr. Welch has gained with the help of a CREI Home Study Program in Electronic Engineering Technology. He is shown reviewing the day's events with his wife JoAnn, and his children, Jeff and Lynn.*

YOU ARE GUIDED and assisted with personal attention from CREI's staff of experienced instructors. You study courses to which a number of leading engineers and scientists have made substantial contributions.

CREI EDUCATION IS RECOGNIZED by such large corporations as Pan American Airways, Federal Electric Corp., The Martin Co., Canadian Broadcasting Co. and Mackay Radio. They pay all or part of CREI tuition for their employees.

CREI HAS 35 YEARS OF EXPERIENCE in advanced technical education through home study. CREI has developed electronics courses for the Army Signal Corps, special radio technician courses for the Navy and group training programs for leading aviation and electronics companies. CREI also maintains a Residence School in Washington, D. C. and invites inquiries from high school graduates.

YOU CAN QUALIFY for a CREI Correspondence Program, if you have basic knowledge of radio or electronics and are a high school graduate or the equivalent. If you meet these qualifications, send for the FREE 1963 edition of our 58-page book describing CREI Programs and career opportunities in electronics. Use coupon provided, or write to:

THIRTY-FIFTH ANNIVERSARY CREI FOUNDED 1927

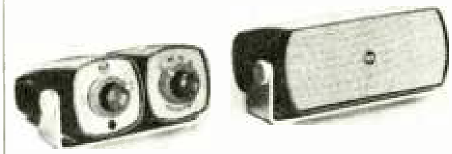
CREI *FOUNDED 1927*

THE CAPITOL RADIO ENGINEERING INSTITUTE
Department 1102-A, 3224 Sixteenth St., N.W.
Washington 10, D. C.

#39

(Continued from page 103)

The new model utilizes all-transistor receiver and power supply circuits plus maximum transistorization in the transmitter. One especially convenient feature is "instant transmission" which enables the user to have immediate com-



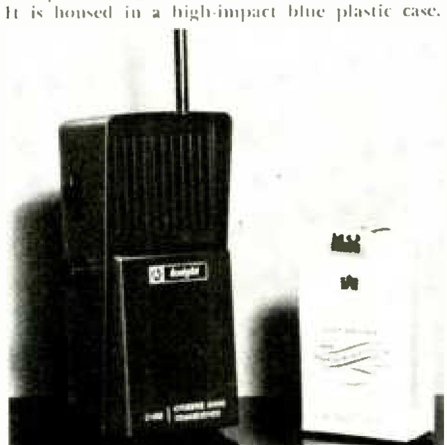
munication. The transmitter is normally off but automatically switches to full-power transmit without delay when the microphone is removed from its hang-up clip.

The unit is housed in a compact, functionally styled case that permits installation in a wide range of vehicle locations and modular design which provides easy access to circuits and components for inspection and servicing.

HAND-HELD RADIO

25 **Allied Radio Corporation** has introduced a low-cost, low-power all-transistor two-way unit for a variety of short-range communications applications.

The "Knight-Kit" C-100 is powered by a standard 9-volt miniature battery and features a rugged 3-transistor circuit. The transceiver, which has a built-in 2" speaker, is about twice the size of a pack of cigarettes and weighs only 9 ounces. It is housed in a high-impact blue plastic case.



Range is about a quarter of a mile. No license is required.

HELICAL ANTENNA

26 **Technical Appliance Corp.** is now offering a six-turn helical antenna designed for telemetry applications in the frequency range from 108 to 136 mc.

This antenna, which will also provide coverage from 90 to 150 mc., has a 3" o.d. aluminum shaft which affixes to a 6-foot diameter ground plane by means of a flange. The radiating helix is supported from the shaft by Fiberglas insulators and terminates in a dielectric housing mounted to the shaft. Connection is with an RG-7/U cable to a panel receptacle located on the ground plane.

MOBILE TRANSCEIVER

27 **Browning Laboratories, Inc.** is now marketing a new mobile CB transceiver, the Model M-523. The unit features 23-channel operation by means of a channel-selector switch. The transceiver measures 8" x 3" x 9" and can be used in cars, boats, and other vehicles.

Accessories for the Model M-523 include a transistorized "S" meter with illuminated dial, rear-deck speaker kit, and a.c. power supply for base-station applications.

TUBE FOR MOBILE GEAR

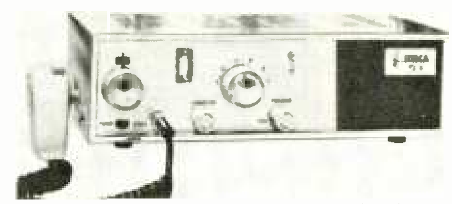
28 **RCA Electron Tube Division** has introduced a new beam power tube with "dark heater" for mobile communications and amateur radio transmitting applications.

Designated the **RCA-8032**, the tube may be used as an r.f. power amplifier and oscillator as well as an a.f. power amplifier and modulator in both mobile and fixed equipment. It contains a 13.5-volt heater that can be operated on a.c. or d.c.

The new tube provides 70 watts c.w. output (ICAS) at 60 mc. and 35 watts c.w. output (ICAS) at 175 mc.

CB TRANSCEIVER

29 **Utica Communications Corp.** is now marketing a new CB transceiver, the T & C II, which features 6-channel crystal-controlled transmit and receive, plus manual tuning of all CB



channels. The transmitting crystal socket is conveniently located on the front panel.

The dual-conversion superhet has a high gain stage for maximum sensitivity providing equal response on all 22 channels. The universal power supply provides 6 volts d.c., 12 volts d.c., and 110 volts a.c. for fast transfer from car or boat to home or office. The unit features a calibrated "S" meter with output power modulation indicator and auxiliary speaker terminal. The transceiver is supplied with one set of crystals.

CB TRANSCEIVER

30 **Globe-GC Electronics Company** has recently introduced the "Globe Master," an all-new deluxe CB transceiver unit.

The new model was designed to meet rigid CB requirements of the prospective commercial user as well as the buyer of CB for marine, home, and personal use. There are eleven crystal-controlled channels for transmitting, using fundamental type crystals. The receiving end features a dual-conversion superhet with a choice of eleven

crystal-controlled channels or tunable over all 22 channels.

Full technical specifications are available from the manufacturer.

U.H.F. MOBILE RADIO

31 **Communications Company, Inc.** has added a new u.h.f. AM two-way mobile radio to its line of communications equipment.

The Model 700 is designed for military airport vehicles requiring voice communications with control towers and planes in the vicinity of the airport. It is designed for single frequency crystal-controlled operation in the military range of 225 to 400 mc. The mobile unit for airport vehicles can be used interchangeably on vehicles having 6, 12, or 24 volt battery systems.

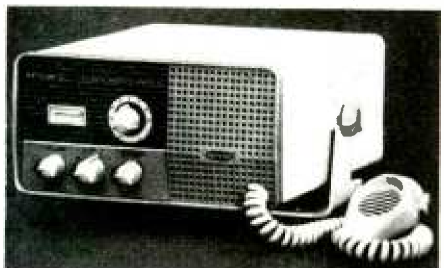
The unit consists of transmitter/receiver/power supply chassis and case, remote control head,

speaker assembly, military-type microphone, antenna, plus all necessary hardware and cabling for vehicle installation.

CB UNIT FOR MARINE USE

32 Raytheon Company is now offering a 10-channel CB unit, the "Raycom II," which has been especially designed for marine use.

The circuit features automatic volume control, a squelch circuit, and panel lights to signal when



power is on and when the transmitter is operating. The new CB unit is designed to operate from either 12 volts d.c. or 115 volts a.c.

It is compact and comes complete with bracket for bulkhead mounting.

SIX-CHANNEL CB UNIT

33 DeWald Radio has added the Model R 1050 to its line of equipment for CB service.

The new transceiver employs a nuvistor front

end for low noise. It also features a push-to-talk ceramic microphone, adjustable squelch, and full noise limiter. The unit comes complete with ceramic microphone, 1 transmitting and 1 receiving crystal, as well as a universal-type mobile mounting bracket.

MANUFACTURERS' LITERATURE

INDUSTRIAL COMPONENTS

34 Newark Electronics Corporation has issued a 511-page catalogue covering an extensive line of electronic components for the industrial market.

A complete product index plus a separate listing of manufacturers whose products are handled by the distributor make the catalogue especially useful. One innovation which will undoubtedly prove popular is the printing of stock numbers and prices of the various items in bold face type. This is helpful when checking tabulated listings with various model numbers.

"SOLID CIRCUIT" NETWORKS

35 Texas Instruments Incorporated has just published an 8-page brochure which explains its new "Master Slice" design approach to the production of economical, customized semiconductor networks.

The bulletin gives product features, design procedures, network flexibility, and typical variations possible with "Master Slice."

ADJUSTABLE SPEED CONTROLS

36 VecTrol Engineering, Inc. is offering copies of Technical Paper VTP-2 entitled "Versatile Adjustable Speed SCR Shunt Motor Drives" written by its engineering staff.

Some ten circuits for motor control, together with complete technical information on how to utilize them, both for adjustable speed control and for programmed speed control are given, using Sprague-VecTrol gate-driven silicon controlled rectifiers.

STOCK POWER RESISTORS

37 Ward Leonard Electric Co. has published an 8-page, 2-color catalogue describing its complete line of stock "Vitrohm" vitreous enamel wirewound power-type resistors for electronic and industrial applications.

Catalogue D130 lists the item, price, and dimensions on eight types of power resistors including axial lead, fixed, adjustable strip, disc, plaque, non-inductive, and intermittent duty. Mounting hardware data is also included.

TEST EQUIPMENT CATALOGUE

38 The Triplett Electrical Instrument Co. has published a concise 8-page catalogue which lists 25 major items of test equipment and their associated accessories. Included are v.o.m.'s, v.t.v.m.'s, tube and transistor analyzers, and many other instruments for the professional electronics man.

Photographs and complete detailed specifications accompany each major item listed.

DATA ON TEST EQUIPMENT

39 Precision Apparatus Co., Inc. has issued a 20-page booklet which provides complete details on a full line of test equipment.

In addition to specifications and prices, there are photographs and special feature listings on v.o.m.'s; v.t.v.m.'s; tube, transistor, and crystal diode testers; signal, sweep, audio, and color generators; R/C decades; oscilloscopes; capacitor testers; power supplies; and signal tracers.

HI-FI SPEAKERS

40 **Jensen Manufacturing Company** has just released a 24-page catalogue on "High Fidelity Loudspeakers for Stereo and Mono Listening."

In addition to providing complete technical and styling details on the firm's entire line of speakers and headphone equipment, the publication carries a discussion on "slim" speakers versus normal bookshelf size and comments on headphone listening for stereo.

COMPLETE SPEAKER LINE

41 **Quam-Nichols Company** has listed 110 different types of speakers in its new 8-page product catalogue.

Replacement speakers for every purse and purpose are listed, along with special types for particular audio applications. Audio transformers for use with the company's speakers are also listed in this publication.

HARD-TO-GET TUBES

42 **Unity Electronics, Inc.** has issued a 12-page booklet which lists an extensive line of hard-to-get tubes which this distributor is able to supply from stock as well as standard communications, entertainment, and industrial tubes.

The tubes are listed numerically with prices immediately adjacent. The booklet is punched for storing in a standard ring binder.

RESISTOR LINE

43 **Key Resistor Corporation** will supply copies of its new resistor catalogue upon request. Five data bulletins are included: these two-color sheets contain complete electrical and dimensional data, applications, and descriptions of the firm's new "Cold Mold" precision metal and carbon film resistors; the hermetically sealed, silicone-oil-filled precision carbon film units; and precision wirewound and microminiature wirewounds. Charts, graphs, and tables are included on each sheet.

TUBE INTERCHANGEABILITY

44 **Sylvania Electric Products Inc.** has published a new television picture tube interchangeability chart, including 54 of the firm's "universal" varieties which replace a total of 217 types.

The guide contains the type number of the tube to be replaced, the number of the Sylvania tube that replaces it, and a key to the information needed to effect the replacement. The guide can be used as a counter or wall chart or may be folded into pocket size.

STEREO/HI-FI COMPONENTS

45 **Grommes** has issued a 6-page folder which pictures and describes its "Custom Series" of stereo amplifiers, multiplex stereo tuners, and stereo receivers; its "E-Line Series" of tuners and amplifiers for stereo; plus mono tuner-amplifiers and amplifier, plus a multiplex stereo adapter. Performance specifications are listed concisely and in easy to use form.

TECHNICAL BOOKLIST

46 **Howard W. Sams & Co., Inc.** has issued a 40-page catalogue covering approximately 200 currently available books on electronics, TV, radio, audio, hi-fi, computers, electricity, and related modern technologies.

In addition to providing a brief description of the contents of each book, the catalogue carries a two-page subject index listing titles by categories.

SEMICONDUCTOR LISTING

47 **Bendix Semiconductor Division** has issued a four-page guide to its complete line of semiconductors. In concise tabular form, the publication lists parameters and other pertinent specifications on diffused alloy power transistors, military types, power varactor diodes, "p-n-p" alloy power transistors, "p-n-p" alloy high power transistors, "p-n-p" alloy medium power transistors, and diffused silicon power rectifiers.

HARNESS TYING SYSTEM

48 **The Thomas & Betts Co.** has issued a four-page folder which describes in detail its "Ty-Rap" system for tying, clamping, and identification of harnesses and wire bundles.

The new harness assembly method is based on adjustable cable ties and straps made of "Zytel" type 101 nylon which reduces fabrication time by 50% or more. With the associated accessories and tools described in the bulletin, any wire bundling, clamping, or identification job on diameters up to 4" can be performed at comparable savings in time.

FILM-RESISTOR WALL CHART

49 **Mepco, Inc.** has issued a wall chart listing MIL-R-10509-D specification summaries and environmental test limits for precision film resistors. The specification summary lists MIL styles with wattage ratings, tolerances, temperature coefficients, voltage, zero derating temperatures, and physical dimensions as spelled out in the MIL standard. The environmental test-limits chart lists the percentage change allowable under various conditions.

NOISE FIGURE DEFINED

50 **Hewlett-Packard Company** has issued Application Note No. 57 which defines noise figure and explains how it may be measured.

This 8-page publication states that the ultimate sensitivity of a detection system is determined by the noise presented to the system with the signal. In addition, any system will contribute noise to the signal in detection and amplification processes. Since the input noise presented with the signal cannot usually be controlled, the approach is to study, measure, and attempt to minimize the noise contribution of the system. Details on how this is done are outlined in the Note.

SPECIALIZED INSTRUMENTATION

51 **B & K Instruments, Inc.** has just published Catalogue ES-11 which lists and describes scores of instruments used in sound and vibration research and application, and in data analysis. The catalogue includes 24 types of instruments used in various applications ranging from specialized research-laboratory investigations of sound and vibration through testing of hearing aids and push-button production inspection of electric motors.

COIL CATALOGUE

52 **J. W. Miller Company** has announced publication of its General Catalogue No. 63 listing more than 1500 items including molded r.f. chokes, i.f. transformers, adjustable coils wound on stable ceramic and resinite materials, exact-replacement coils, and other related components.

Complete specifications are provided on all of the products with many of the components pictured as well.

ETV EQUIPMENT KIT

53 **General Electric Company** has issued a special kit containing detailed information on the firm's new educational television operating console as well as additional equipment needed for a complete system.

Included in the kit are a six-page technical brochure describing the console, a copy of a typical proposal for a complete ETV system, a capabilities brochure, composite specifications, a guide for estimating price, plus other data.

PIEZOELECTRIC CERAMICS

54 **Clevite Electronic Components** has issued a 12-page booklet entitled "Modern Piezoelectric Ceramics."

Illustrated with drawings, photographs, and graphs, the publication offers complete technical data on the firm's piezoelectric ceramics PZT-4, PZT-5, and Ceramic B. Charts and tables compare properties, illustrate basic actions, list available shapes, and provide useful reference guides to resonant frequencies and common MKS/English conversions.

CAPACITY OPERATED SWITCH

55 **Tung-Sol Electric Inc.** is offering a new technical brochure which describes its "Touch Control Switch," a capacity operated device that can be turned on and off with the touch of a finger. Circuitry is designed around a "p-n-p-n" semiconductor. Use of this solid-state device makes possible a reliable, low-cost, small-size unit for a wide range of operating conditions.

SPEAKER BULLETIN

56 **The R. T. Bozak Manufacturing Company** has released a technical bulletin on its Model CM-109-6 columnar speaker system. The bulletin lists applications, characteristics, performance specifications, installation data, and carries a frequency response curve.

STOCK PANEL METERS

57 **Simpson Electric Company** has just published a new 16-page brochure on stock panel meters. The publication lists over 1300 panel meters of various sizes, styles, types, and ranges—all carried in stock. Included are voltmeters, ammeters, microammeters in sizes from 1½" up through 6". Special application meters such as meter relays used in control devices, elapsed time meters, and segmental voltmeters plus a glossary of terms are also included. ▲

Answers to "Famous Names Quiz"

(Appearing on page 84)

1. E	7. P	13. J
2. H	8. B	14. R
3. L	9. F	15. G
4. A	10. N	16. D
5. I	11. Q	17. K
6. M	12. C	18. O

PHOTO CREDITS

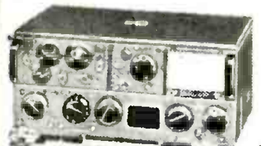
Page	Credit
16	H. H. Scott, Inc.
20	Don Bosco Corp.
30 (top), 31, 97	Medtronic Inc.
30 (bottom), 98	Therotron Corp.
33	Burroughs Corp.
34 (Fig. 2)	Non Linear Systems Inc.
34 (Fig. 3), 66 (Fig. 11), 67 (Fig. 14)	I.E.E., Inc.
34 (Fig. 4)	Teleregister Inc.
34 (Fig. 6)	I.D.E.A. Inc.
35 (Fig. 8)	Union Switch & Signal Corp.
35 (Fig. 9)	Potwin Corp.
39	Howley Products Co.
40 (bottom)	Sherwood Electronics
66 (Fig. 12)	A.C.E. Co.
67 (Fig. 13)	Allard Instrument Corp.
76	Allied Radio Corp.
78, 79	General Electric Company
96	Citroen

Answer to Electronic Crosswords

(Appearing on page 93)

P	A	R	A	B	O	L	A	S		S	P	
	S	T	R	O	B	O	S	C	O	P	E	S
W	U			H	O	G		A	P	A	R	T
O	R	B		R	E	A	C	T	A	N	C	E
W		U	P			R				G	H	R
	P	M		A	L	I	M		O	L		E
C	A	P	A	C	I	T	A	N	C	E		O
E	D		R			H	E					P
		A	E	S		M		T	R	A	S	H
M	A	G	N	E	T	I	C		I		T	O
C	E	R	A	M	I	C			G	W	Y	N
	R	E			M	A	L	L			L	I
P	I	E	Z	O	E	L	E	C	T	R	I	C

AN/ART-13 100-WATT XMTR



11 CHANNELS
200-1500 Kc
2 to 18.1 Mc

$69.50 exc. used

Complete with Tubes

Famous Collins Autotune Aircraft Transmitter. AM, CW, MCW. Quick change to any of ten preset channels or manual tuning. Speech amplifier/clipper uses carbon or magnetic mike. Highly stable, highly accurate VFO. Built in Xtal controlled calibrator. PP811s modulate 813 in final up to 90%, class "B." A Real "HOT" Ham buy at our low price! Orig. cost $1800.

AN/ART-13 XMTR as above. Like New .. $79.50
0-16 Low Freq. Osc. Coil for ART-13 .... 7.95
24V Dynamotor for ART-13 .... 11.95
Same as above less meter 39.50
We carry a complete line of spare parts for above.

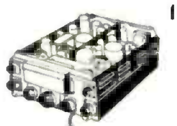
AN/APR-4 RECEIVER only. 38 to 4000 Mc in 5 tuning unit ranges. High precision lab instrument. Input 115 V60 cy. Like New $79.50
Tuning Units TN16, 17, 18 each $39.50
Tuning Unit TN19. Brand New $89.50
Tuning Unit TU54 .... $149.50

LIMITED QUANTITY SPECIALS!

BC-312 MOBILE RECEIVER 6 bands, 1500 Kc to 18 Mc. With Tubes and 14 V Dynamotor. Like New $79.50
BC-312 for AC operation $89.50
AN/APT-5 AIRBORNE RADAR SET, with tubes, Like New $49.50
AN/APT-5 BRAND NEW $69.50
POWER SUPPLY for AN/APT-5, complete, Brand New, for 80/115 V 400 to 2000 cycles $14.95

FAMOUS BC-645 TRANSCEIVER

15 Tubes 435 to 500 MC



BRAND NEW

Can be modified for 2-way communication, voice or code, on ham band 420-450 mc. citizens radio 460-470 mc. fixed and mobile 450-460 mc. television experimental 470-500 mc. 15 tubes (tubes alone worth more than sale price!): 4—7F7, 4—7H7, 2—7E6, 2—6F6, 2—955 and 1—WE-316A. Now covers 460 to 490 mc. Brand new BC-645 with tubes, less power supply in factory carton.

Shipping weight 25 lbs. SPECIAL! **$19.50**

PE-101C Dynamotor, 12/24V input $7.95
UHF Antenna Assembly 2.45
Complete Set of 10 Plugs 5.50
Control Box 2.25

SPECIAL "PACKAGE" OFFER:
BC-645 Transceiver, Dynamotor and all accessories above. COMPLETE, BRAND NEW. While Stocks Last $29.50

ARC-3 RECEIVER!

Complete with All Tubes Exc. Used **$19.95**
Like NEW .... $29.50.
Crystal-controlled 17-tube superhet, tunes from 100 to 156 MC., AM., on any 8 pre-selected channels. 28-volt DC power input. Tubes: 1-9002, 6-6AK5, 1-12SH7, 3-12SG7, 1-9001, 1-12H6, 2-12SN7, 1-12SL7, 1-12A6.
110 V A.C. Power Supply Kit for above 15.00
Factory Wired and Tested 19.95

ARC-3 TRANSMITTER

Companion unit for above, tunes 100 to 156 MC on any 8 pre-selected channels. 9 tubes, crystal controlled, provides tone and voice modulation. 28V DC Power input. Complete with all Tubes: 3-6V6, 2-832A, 1-12SH7, 1-6J5, 2-6L6. Exc. Used ....Only **$18.95**
Like new condition $28.50
ARC-3 PUSHBUTTON CONTROL BOX $5.95

ACCESSORIES for BC-603, 683 RECEIVERS

EXTRA SET OF 10 TUBES FOR ABOVE brand new in original boxes $3.95

12 or 24V Dynamotor for Above. Exc. Used $4.25 ....Brand New $5.50

AC POWER SUPPLY FOR BC603, 683
Interchangeable, replaces dynamotor. Has On-Off switch. NO RECVR. CHANGE NEEDED. Provides 220 VDC @ 80 Ma. 24VAC @ 2 Amps $12.95

Complete 240-page Technical Manual for BC-603, 604 .... $3.15

BC-604 TRANSMITTER—Companion unit for BC-603 Rcvr. above. With all tubes. BRAND NEW $8.95
4-Section Antenna for BC-604, 684 Transmitters. Complete with mounting base. BRAND NEW .. $4.95
We carry a complete line of spare parts for above.

APN-1 FM TRANSMITTER-RECEIVER

420 to 460 Mc Aircraft Radio altimeter equipment. Tubes: 4-955, 3-12SJ7, 4-12SH7, 2-12H6, 1-VR150; Complete with tubes, brand new **$11.95**
APN-1 Exc. used, like new $8.95

AN/ARR-2 RECEIVER 234-258 Mc., UHF tunable receiver, including 11 tubes: 3-6AK5, 1-12A6, 7-9001. BRAND NEW, with tubes $8.88
Used, with tubes $5.95

ARC-5/T-23 TRANSMITTER 100-150 Mc., Includes tubes: 2-832A, 2-1625. BRAND NEW, with tubes $21.50
Excellent Used, less tubes $5.95

ARC-5/R-28 RECEIVER, 2-meter superhet, 100 to 156 Mc in 4 crystal channels, complete with 10 tubes. BRAND NEW, with tubes $26.50
Excellent Used, with tubes $23.50

BC1206-C BEACON RECEIVER 195 to 420 Kc, 135 Kc. IF, works on 24V DC. Complete with 5 tubes. Size: 4x4x6". Wt. 4 lbs. BRAND NEW, with tubes $9.99
Brand New, less tubes $5.95
Used, with tubes $5.95   Used less tubes $2.95

IMPORTERS—EXPORTERS of ELECTRONIC EQUIPMENT

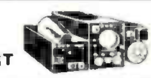
We specialize in the export of military surplus electronic equipment:

- All at LOWEST PREVAILING PRICES.
- In addition to items shown on this page, we have in stock or can obtain for export customers, military electronic equipment made for World War II, Korean War, and later.
- IF YOU DON'T SEE WHAT YOU WANT HERE, WRITE US YOUR NEEDS. INQUIRIES WELCOMED.
- All packing and shipping is made directly from our own warehouse in NYC to give you substantial savings in handling costs!

SEND FOR LATEST FREE G & G BULLETIN OF SURPLUS MILITARY ELECTRONIC EQUIPMENT.

LORAN APN-4

FINE QUALITY NAVIGATIONAL EQUIPMENT

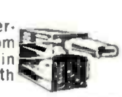


Determine exact geographic position of your boat or plane. Indicator and receiver complete with all tubes and crystal.
INDICATOR ID-6B/APN-4, and RECEIVER R-9B/APN-4, complete with tubes Exc. used $49.50
Receiver-Indicator as above, BRAND NEW $88.50
Shock Mount for above $2.95

INVERTER POWER SUPPLY for Loran. Made by Eclipse—Pioneer Div. INPUT: 24 V DC @ 75 A. OUTPUT: 115 V AC @ 10.5 Amps. 800 cycles. Complete with two connecting plugs BRAND NEW $49.50

12-Volt Inverter Power Supply, Like New. P.U.R.
We carry a complete line of spare parts for above.

LORAN R-65/APN-9 RECEIVER & INDICATOR

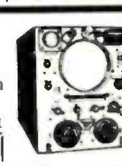


Used in ships and aircraft. Determines position by radio signals from known xmitters. Accurate to within 1% of distance. Complete with tubes and crystal. Exc. used.
Value $1200.00. Our Price $79.50
Used, less tubes, crystal and visor, but with 3BP1 C.R. tube $29.50

INVERTER POWER SUPPLY. INPUT: 24 V DC. OUTPUT: 115 V AC. 800 cy. BRAND NEW $49.50

12-Volt Inverter Power Supply, Like New ... P.U.R.
Shock Mount for above $2.95
Circuit diagram and connecting plugs available.
We carry a complete line of spare parts for above.

LORAN APN/4 OSCILLOSCOPE



Easily converted for use on radio-TV service bench.
LIKE NEW! Less tubes, but including 5" Scope, type 5CPI only **$14.50**

BENDIX DIRECTION FINDERS

For commercial navigation on boats.
MN26Y 150-325 Kc; 325-695 Kc; 3-4.7 Mc. Complete with tubes, dynamotor. BRAND NEW $19.50
MN28Y Receiver Control Box .... $ 4.95
MN26C Receiver 150-1500 Kc continuous tuning with 12 tubes and dynamotor. Used... 18.95
MN26C Receiver as above, BRAND NEW 27.50
MN20E Rotatable Loop for above 4.95
MN52 Azimuth Control Box 2.95

SCR-274 COMMAND EQUIPMENT

ALL COMPLETE WITH TUBES

Type	Description	Used	Like NEW
BC-453	Receiver 190-550 KC	$12.95	$14.95
BC-454	Receiver 3-6 Mc	12.45	17.95
BC-455	Receiver 6-9 Mc	11.50	13.95
1.5 to 3 Mc.	Receiver Brand New		$17.95

110 Volt AC Power Supply Kit, for all 274-N and ARC-5 Receivers. Complete with metal case. Instructions $8.95
Factory wired, tested, ready to operate .. $12.50
SPLINED TUNING KNOB for 274-N and ARC-5 RECEIVERS. Fits BC-453, BC-454 and others Only 49c

2.1 to 3 Mc. Transmitter, Brand New $12.95
BC-457 TRANSMITTER—4-5.3 Mc. complete with all tubes and crystal, BRAND NEW.. $9.75
Like New $7.95
BC-458 TRANSMITTER—5.3 to 7 Mc. Complete with all tubes and crystal.
BRAND NEW $10.95
Like New $7.95
T19 TRANSMITTER ¾ m.c. complete with all tubes and crystal. Exc. Used $9.95
BC-696 TRANSMITTER 3-4 Mc Complete with All Tubes & Crystal. Like New $11.95
BC-456 Modulator .... USED 3.45 NEW 5.95
MD7 Modulator, Like New $9.95
ALL ACCESSORIES AVAILABLE FOR ABOVE

SCHEMATIC DIAGRAMS For most equipment on this page, each 65c

Please include 25% Deposit with order—Balance C.O.D., or Remittance in Full. 50c Handling Charges on all orders under $5.00. All shipments F.O.B. Our Warehouse, N.Y.C. All Merchandise subject to Prior Sale and Price Change.

G & G RADIO SUPPLY CO.

Telephone: CO 7-4605
77 Leonard St.   New York 13, N. Y.

TEST EQUIPMENT IE-36. Provides trouble-shooting tests of SCR-522A and SCR-542A sets: Starting & stopping mechanisms, channel selection circuits, switching etc. Complete with instruction manual. In sturdy carrying case. BRAND NEW $8.95

LM FREQUENCY METER

Crystal calibrated modulated. Heterodyne. 125 Kc to 20,000 Kc With Calibration book. Complete. Like New $58.50

BC-906 FREQ. METER—SPECIAL

Cavity type 145 to 235 Mc. Complete with antenna. Manual and original calibration charts included. BRAND NEW. OUR LOW PRICE ... $11.88

BC-221 FREQUENCY METER

SPECIAL BUY! This excellent frequency standard is equipped with original calibration charts, and has ranges from 125 Kc to 20,000 Kc with crystal check points in all ranges. Excel. Used with original Calibration Book, Crystal, and all tables—LIKE NEW!
Unmodulated ... $72.50   Modulated $99.50
BC-221 1000 Kc Crystal Brand New $8.95

TS-16/APN TEST SET

For aligning and calibration of radio altimeters. May be used to check calibration of count or circuits and modulator sweep freq. and bandwidth of transmitter. Audio-oscillator range: 340 to 7250 cycles. 24 V.D.C. input. Complete with tubes, connecting cables, instruction summary. BRAND NEW $14.50

TEST SET TS-175/U. Portable crystal controlled heterodyne type unit used in field testing of CW or MCW RF Transmitters and Signal Generators. Range 85 to 1000 Mc. Power requirements: 6V DC and 135 VDC. Exc. Cond. $169.50
TEST SET TS-174/U Frequency Meter similar to above but for 20 to 250 Mc. Power input 3.5V DC and 121.5 V DC. Exc. Cond. ... $169.50
TS-170/ARN-5 TEST OSCILLATOR, portable, battery-operated, crystal controlled, for frequencies: 332.6 Mc., 338.6 Mc., and 335 Mc. Power input 1.5 VDC and 90 VDC. Less Batteries. Exc. Cond. $22.50

SCR-625 MINE DETECTOR

Complete portable outfit in original packing, with all accessories. Brand New **$27.50**

APR-1 Navy VHF-UHF radar search Receiver. 80 Mc to 950 Mc in 2 bands. BRAND NEW $79.50
TUNING UNITS for above: TN1, TN2, TN3, BRAND NEW, each $39.50

CITIZENS' BAND CRYSTALS
All 23 Channels, made for us by America's Leading Crystal Manufacturer. Specify make and model number of CB equipment. Any channel, for RECEIVE or TRANSMIT. Each $2.95
Shipped Postpaid in Lots of 3 or More

EE-8 ARMY FIELD PHONES
Excellent Condition, checked out, perfect working order, complete with all parts. Each $12.95

TG-34A CODE KEYER. Self-contained automatic unit for code practice tapes from 5 to 25 words per minute. Like New, tested $26.50
Set of 14 Reels Army Code Practice Lessons. Brand New .... P.U.R.

WE Mercury Relay SPDT. 4500-ohm coil with 24 V Heater. WE #D-171584 (275-D) BRAND NEW $2.95

MICROPHONES Checked Out, Perfect

Model	Description	EXC. USED	BRAND NEW
T-17D	Carbon Hand Mike	$4.45	$7.95
RS-38	Navy Type Carbon Hand Mike	3.95	5.75

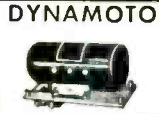
HEADPHONES Checked Out, Perfect

Model	Description	Excellent Used	BRAND NEW
HS-23	High Impedance	$2.49	$4.75
HS-33	Low Impedance	2.69	4.95
HS-30	Low Imp. (featherwt.)	.90	1.65
H-16/U	High Imp. (2 units)	3.75	7.95

TELEPHONICS—600 ohm Low Impedance HEADSETS. BRAND NEW, PER PAIR $3.25
CD-307A Cords, with PL55 plug and JK26 Jack .99
Earphone Cushions for above—pair .... .50

MOBILE-MARINE DYNAMOTOR

Model DM35



Input 12V DC. Output: 625 V DC @ 225 Ma. for press-to-talk intermittent operation. Shpg. wt. 14 lbs.
BRAND NEW **$14.95**

OTHER DYNAMOTOR VALUES:

Type	Input	Output	Excellent Used	BRAND NEW
DM-32A	28V 1.1A	250V .05A	2.45	4.45
DM-33A	28V 5A 28V 7A	575V .16A 540V .25A	1.95	4.45
DM-34D	12V 2A	220V .080A	4.15	5.50
DM-36	28V 1.4A	220V .080A	1.95	2.95
DM-53A	28V 1.4A	220V .080A	3.75	5.45
PE-73C	28V 20A	1000V .350A	8.95	14.95
PE-86	28V 1.25A	250V .050A	2.75	3.85

DM-42A DYNAMOTOR. Input 12 V DC @ 39 Amps. Output 515 V DC @ 215 Ma. and 1030 V DC @ 260 Ma. Wt. 38 lbs. BRAND NEW, each $6.95
DM-37 DYNAMOTOR. Input 25.5 V DC @ 9.2 A. Output 625 V DC @ 225 Ma. BRAND NEW. Each $3.25

CARTER GENEMOTOR

INPUT: 5.9 V DC @ 32 Amps.
OUTPUT: 405 V DC @ .270 Amps.
BRAND NEW, special $8.95

2 VOLT BATTERY "PACKAGE"

1—2V, 20 Amp. Hr. Willard Storage Battery, Model #20-2, 3" x 4" x 5½" high $2.79
1—2V, 7 prong Synchronous Plug-in Vibrator 1.49
1—Quart Bottle Electrolyte (for 2 cells) 1.45
ALL BRAND NEW! Combination Price $5.45

WILLARD 6-VOLT MIDGET STORAGE BATTERY

3 Amp. Hour. BRAND NEW. 3⅝" x 1-13/16" x 2⅜". Uses Standard Electrolyte .... Only $2.95

ELECTRONICS MARKET PLACE

RATE: 60¢ per word. Minimum 10 words. April issue closes February 5th. Send order and remittance to: ELECTRONICS WORLD. One Park Ave., N. Y. C. 16. N. Y.

ELECTRONICS ENGINEERING AND INSTRUCTION

USED Correspondence Courses and Books sold and rented. Money back guarantee. Catalog Free. (Courses Bought.) Lee Mountain. Pisgah. Alabama.

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.

FCC LICENSE in six weeks. First class radio telephone. Results guaranteed. Elkins Radio School, 2603C. Inwood. Dallas, Texas.

"DRAFTING, Reading Blueprints, Schematics. Send $2.00 first lesson. complete home course $25.00. Prior, Inc., 23-09 169 Street, Whitestone 57, New York."

SLIDE Rule-Selfteaching Method. 8 inch Bamboo Rule; Manual With Step-by-Step Illustrative Problems. Practice Exercises and Answers—only $3.95 Postpaid. No COD. ALSYNCO. Dept EW-1. 171 So Main, Natick. Mass.

ENGINEERING and Art Degrees earned through home study. Electronics, mechanical, liberal arts, major accounting. When writing specify course desired. Pacific International College of Arts & Sciences, primarily a correspondence school. Resident classes also available. 5719-C Santa Monica Blvd., Hollywood 38, California.

FOR SALE

TV Tuners—Rebuilt or Exchanged $9.95 complete—all types - fast, guaranteed service. Send tuner with all parts to: L. A. Tuner Exchange. 4611 West Jefferson Blvd., Los Angeles 16. California

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 Corp., 512 Broadway, New York 12N, N. Y.

DIAGRAMS for repairing radios $1.00. Television $2.00. Give make, model. Diagram Service, Box 672-E. Hartford 1, Conn

GOVERNMENT Surplus Receivers, Transmitters, Snooperscopes, Parabolic Reflectors, Picture Catalog 10¢. Meshna, Malden 48. Mass.

CONVERT any television to sensitive, big-screen oscilloscope. Only minor changes required. No electronic experience necessary. Illustrated plans, $2.00. Relco, Box 10563, Houston 18, Texas

INVESTIGATORS, free brochure. latest subminiature electronic listening devices. Ace Electronics, 11500J NW 7th Ave., Miami 50. Florida.

BEFORE you buy receiving tubes, test equipment. Hi-fi components, kits. parts. etc. . . . send for your 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., 461 Jericho Turnpike, Mineola. N. Y.

SUPERSENSITIVE directional microphone picks up faint sounds at 300 feet. Detects sound through ordinary walls. Easily built for $7.00. No electronic experience necessary. Illustrated plans, $2.00. Dee Company, Box 7263-D, Houston 8. Texas.

TV TUNERS rebuilt or exchanged, $9.95. Fast, guaranteed. Complete crystal alignment. Valley Tuners. 18530 Parthenia. Northridge. Calif.

FREE Catalog—name brand tubes 65% discount. phono needles 80% or more discount, phono cartridges. picture tubes 75¢ inch, parts. parts kits, silicon and selenium rectifiers. transmitting tubes, 7" T.V. test tube $6.99, imported batteries, tube testers etc. Want to swap or sell tube inventory? Send us your offering. Arcturus Electronics Corp., Dept. Z.D., 502 22nd St., Union City, N.J.

AUTO Radios AM/FM/MB/SW Metravox. Blaupunkt, Motorola Custom Fit Foreign-Domestic Cars. Low Prices. Park Terrace Radio. 4975 Bway. New York, N.Y.

Save dollars on radio. TV-tubes. parts at less than manufacturer's cost. 100% guaranteed. No rebrands, pulls. Request Bargain Bulletin. United Radio 1000-W. Newark, N.J.

$115 Self-Service Console Type Tube Testers Brand New, Original Cartons. $40 F.O.B. Dorn, 3303 Lambert Ave. N.W. Canton 8. Ohio.

TRANSISTORIZED Products import catalog, $1.00. Intercontinental, CPO 1717, Tokyo. Japan.

NEW. transistor computer plans. programming manuals: analog $4.95 Eight digital $5.50 guaranteed. Tesla. PO Box 11275. Phoenix 17, Arizona.

SURPLUS Electronics. Free catalog. Saratoga Surplus, Round Lake. New York.

TRANS-NITION. Electronic Egnition. Components, Kits, Coils. Special 260/1 coil. Manual $8.50. Anderson Engineering. Wrentham, Mass.

WANTED

WANTED: Collins. Hammarlund Receivers SP-600. 51J, R-390A. R-388. Teletype, Kleinschmidt. Cash. or trade. Alltronics-Howard, Box 19, Boston 1, Mass. (Richmond 2-0048

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 such as G.R.H.P., AN UPM prefix. Also want commercial Ham Receivers and Transmitters. For a Fair Deal write: Barry Electronics Corp., 512 Broadway, New York 12. N. Y. (Walker 5-7000).

QUICKSILVER. Platinum, Silver. Gold. Ores Analyzed. Free Circular. Mercury Terminal, Norwood, Massachusetts

ARMY Sets or Parts—GRC—PRC—FRR/URR—TCC—SB—SCR—Send Listings—Quick Cash. Anker Electronics, 1617 So. Main St., Box 26, Wilkes-Barre, Pa.

TAPE AND RECORDERS

TAPE Recorders, HI-FI Components. Sleep Learning Equipment. Tapes. Unusual Values. Free Catalog. Dressner, 1523 EW Jericho Turnpike, New Hyde Park 10, N.Y.

RENT Stereo Tapes—over 2,500 Different—all major labels -free catalog. Stereo-Parti, 811-G, Centinela Ave . Inglewood 3. California

SELF-Hypnosis. New concept teaches you quickly by tape or LP-record. Free literature. McKinley Publishers, Dept. T6. Box 3038. San Bernardino. California.

SAVE 30% Stereo music on tape. Free bargain catalog/blank tape recorders norelco speakers. Saxitone, 1776 Columbia Road. Washington. D.C

4/TR Stereo Tapes — bought. sold. rented. traded! Bargain closeouts! Catalog, COLUMBIA, 9651 Foxbury, Rivera. California.

HIGH-FIDELITY

DISGUSTED with "Hi" Hi-Fi Prices? Unusual Discounts On Your High Fidelity Requirements. Write. Key Electronics, 120 Liberty St., New York 6, N. Y. DI6-4191.

PRICES? The Best! Factory-sealed Hi-Fi Components? Yes! Send for free catalog. Audion, 25T Oxford Road, Massapequa. N.Y.

RECORDERS. Components! Free wholesale catalogue! Carston 125-R. East 88. N.Y.C. 28.

INDUCTORS for Crossover Networks, 118 types in stock. Send for brochure. C & M Coils, P.O. Drawer 1147. Huntsville. Ala.

LOW. LOW quotes: all components and recorders. Hi-Fi, Roslyn 9. Penna.

WRITE for our low quotation on components, recorders. Hi-Fidelity Supply. 2817-YC Third. N.Y.C. 55.

Mello Monster Folded Horn. From designer now a 12" enclosure. Also popular 8". Plans $2.00 each. Roald E. Dybvig, 2754 Xenwood Ave., St. Louis Park 16, Minnesota.

REPAIRS AND SERVICING

TV TUNERS REBUILT AND ALIGNED per original factory specifications using xyal controlled equipment only $9.50. 24 hour service for unmutilated units. Ship complete tubes or write for free mailing kit and dealer brochure. J W ELECTRONICS. P.O. Box 51A. Bloomington Indiana

METER Repairs—All Make and Models. Bigelow Electronics. Bluffton. Ohio.

YOUR ad will be read by more than 200,000 readers when placed in this space. For information on how to place a classified ad in this section, write: Martin Lincoln, ELECTRONICS WORLD. One Park Ave., N.Y 16, N.Y.

RECORDS

RARE 78 s. State Category. Write Record-Lists, P.O. Box 2122. Riverside. Calif.

HELP WANTED

EARN Extra money selling advertising book matches. Free Samples furnished. Matchcorp, Dept. MD-13. Chicago 32. Ill.

GOVERNMENT SURPLUS

JEEPS $278. Airplanes $159, Boats $7.88, generators $2.68, typewriters $8.79. are typical government surplus sale prices. Buy 10,001 items wholesale, direct. Full details. 627 locations and procedure, only $1.00. Surplus. Box 177-C33. Abbottstown. Penna.

U.S. GOVERNMENT SURPLUS—Jeeps, $264.00; radios. $2.53; guns. typewriters; cameras; tools: thousands of items. Fabulously low surplus prices. Complete information sent immediately. Send $1.00 to: Surplus, P.O. Box 50512. Dept. R. New Orleans 50, Louisiana.

FREE. Valuable War Surplus Bargain Information. Box 8ZD. Thomasville. Penna.

SHOPPING GUIDE CLASSIFIED

A HANDY GUIDE TO PRODUCTS, NOT NECESSARILY ELECTRONIC, BUT OF WIDE GENERAL INTEREST.

STAMPS AND COINS

SMASHING collection free. Includes triangles. early United States. rockets. sports. British colonies high value pictorials. etc. Complete collection plus big illustrated magazine. all free. Send 10¢ for postage. Gray Stamp Co., Dept. Z2. Toronto. Canada.

FREE Mint British Colonials from Maldives. Solomon Islands. Pahang. St. Christopher. Nevis. Sarawak, Cayman Islands. Gilbert Ellice. Free with approvals. Viking, Great Neck 50, N. Y.

BUSINESS OPPORTUNITIES

I Made $40,000.00 Year by Mail Order! Helped others make money! Start with $10.00—Free Proof. Torrey, Box 3566-N. Oklahoma City 6. Oklahoma.

ASSEMBLE artificial lures at home for stores. Materials supplied free. Profitable! Write: Lures. Ft. Walton Beach 1, Florida.

PUBLISH your book! Join our successful authors: publicity advertising promotion. beautiful books. All subjects invited. Send for free appraisal and detailed booklet. Carlton Press, Dept. ZDB, 84 Fifth Avenue. N.Y.C. 11.

INVESTIGATE Accidents—Earn $750 to $1,000 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-2. 6801 Hillcrest. Dallas 5, Texas.

$100 weekly possible. Complete mailing lists and address envelopes for advertisers. Home—spare time. Particulars free. National Service, 81, Knickerbocker Station. New York City.

ELECTRONICS Manufacturer offer engineering and/or production facilities. Tax exemption permits tremendous savings. Write, Milles Engineering. Las Marias, Puerto Rico.

PHOTOGRAPHY-FILM, EQUIPMENT, SERVICES

SCIENCE Bargains -Request Free Giant Catalog "CJ"—144 pages—Astronomical Telescopes, Microscopes. Lenses. Binoculars. Kits. Parts. War surplus bargains. Edmund Scientific Co., Barrington, New Jersey.

MEDICAL FILM—Adults only—"Childbirth," one reel, 8mm $7.50; 16mm $14.95. International W, Greenvale, L.I.. New York.

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 7021. Dept e.g.. Lexington. Kentucky.

MISCELLANEOUS

AUTHORS! Learn how to have your book published. promoted. distributed FREE booklet "ZD." Vantage. 120 West 31 St.. New York 1.

GET Repeat Business! Use 2-color adhesive advertising labels on your products and installations. Free Samples! Bestmart. Box 12303-B, Cincinnati 12, Ohio.

HYPNOTIZE Unnoticed. quickly. effortlessly. or refund! Thousands satisfied! $2, Timner, Box 244, Cedarburg. Wisc.

SEND ELECTRONICS WORLD EVERY MONTH

name ____________

address ____________

city ____________ zone ______

state ____________

Check one: ☐ 3 years for $12

☐ 2 years for $9 ☐ 1 year for $5

In the U.S., and possessions.

☐ Payment enclosed ☐ Bill me

Foreign rates: Canada and Pan American Union countries, add .50 per year; all other foreign countries, add $1.00 per year.

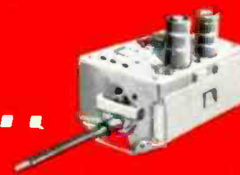
☐ New ☐ Renewal

Mail to: ELECTRONICS WORLD
Dept. 6851, 434 S. Wabash Ave.
Chicago 5, Ill.

ELECTRONICS WORLD FEBRUARY 1963
ADVERTISERS INDEX

Printed in U.S.A.

Standard Made It...



STANDARD CAN FIX IT BEST

$11.50 Plus Parts . . . $13.50 Maximum Total Cost

FREE *Specially designed shipping cartons to prevent damage in transit*

6 Months GUARANTEE

Only BRAND NEW PARTS Used · 48 Hour Service on All STANDARD Tuners · Latest Testing Techniques Assure Proper Alignment · $3.00 Defective Tuner Trade-in Allowance Against a New STANDARD Replacement Tuner Carrying a 12 MONTH GUARANTEE

IN TV IT'S *Standard*

STANDARD has maintained uniform mounting centers for the last 13 years. Over 50% of the TV sets in existence today have STANDARD tuners—in the case of most other tuners one of the 8 STANDARD replacement models can be easily adapted or will fit directly in place of these units. All STANDARD replacement tuners carry a 12 Month Guarantee.

SEE YOUR AUTHORIZED STANDARD DISTRIBUTOR

MORE PROFIT FOR THE SERVICE DEALER · GREATER CUSTOMER SATISFACTION GUARANTEED BY THE WORLD'S LARGEST TV TUNER MANUFACTURER

standard kollsman INDUSTRIES INC.

FORMERLY STANDARD COIL PRODUCTS CO., INC., MELROSE PARK, ILLINOIS

CIRCLE NO. 147 ON READER SERVICE CARD

An important message to electronic technicians . . .

RCA invites you to

PUT YOURSELF IN THE COLOR PICTURE

Color television today is a 300-million-dollar-a-year business—and the fastest growing segment of the home entertainment industry.

Color TV programming is at an all-time high. If you still limit yourself to black-and-white servicing, you put yourself in the same position as the village blacksmith who considered automobiles a fad.

Leading manufacturers are now turning out color TV sets with the color picture tube developed by RCA. Servicing these sets means big and highly profitable business, but it requires special skills, knowledge, equipment and parts. What are you doing to take advantage of this great new business opportunity?

To the public, *color TV means RCA!* It was RCA who conceived and pioneered the compatible color system in universal use.

How can you climb on the color bandwagon? Associate your business strongly with the prestige and customer acceptance of the recognized pioneer of color TV. See your authorized RCA distributor; stock and advertise RCA tubes and associated products for color. Isn't it time you started seeing yourself in color?

RCA ELECTRON TUBE DIVISION, HARRISON, N.J.

THE MOST TRUSTED NAME IN TELEVISION