Electronics World

SEPTEMBER, 1968
60 CENTS

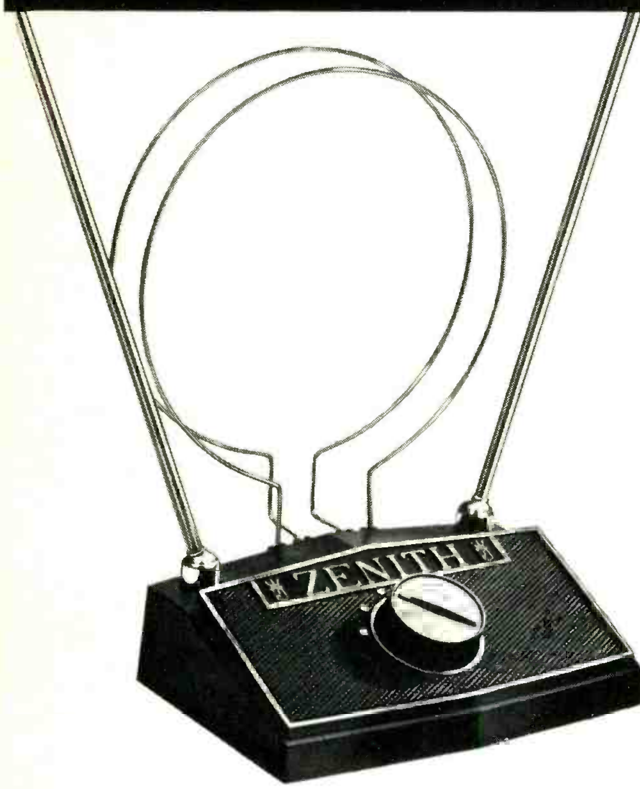
HOW TO FLY TO THE MOON AND GET THERE
ELECTRONIC INTRUSION ALARMS
IC DECIMAL COUNTING TECHNIQUES

PHOTO-CONDUCTIVE DEVICES

Includes Practical Circuit Applications

For better TV reception and better business...

sell Zenith Wavemagnet® Indoor TV Antennas!



Make your customers happier . . . with high-performance Wavemagnet antennas. Zenith-designed for sensitive TV reception in color or B/W. Telescopic dipoles, fully adjustable. Six-position selector switch for optimum reception on each channel. Handsome base of high-impact molded styrene. Individually packaged for attractive sales display.

Order Zenith TV Antennas and Accessories from your Zenith Distributor.

Deluxe All-Channel
Part No. 973-56
Two full-size UHF loops develop high front-to-back ratios equal to many outdoor antennas.

Economy All-Channel
Part No. 973-55.

VHF only
Part No. 973-58.

Exciting Surprises
for You—
and Your Family!
Fun for all!
Get the details
at your Zenith
Distributor's
Parts Department.

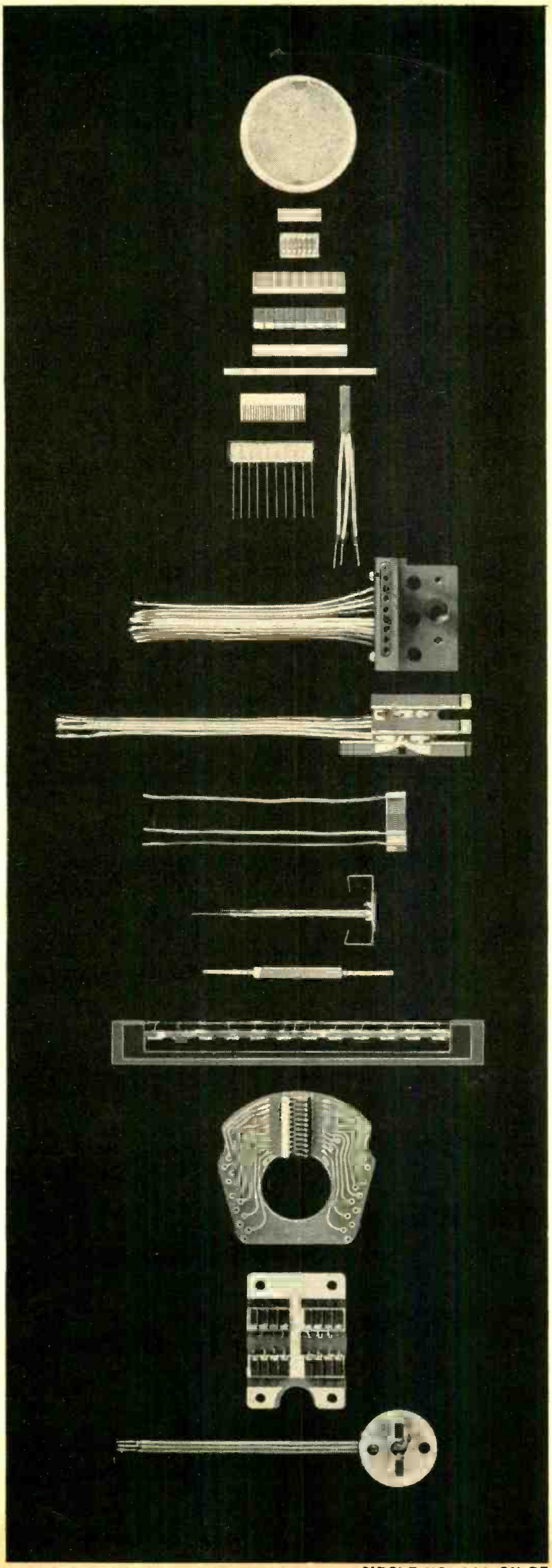
FIFTIETH ANNIVERSARY 1918 50 1968 — 50 YEARS OF LEADERSHIP THROUGH QUALITY

BEST YEAR YET TO SELL THE BEST

ZENITH®

The quality goes in before the name goes on

CIRCLE NO. 86 ON READER SERVICE CARD



You Supply the Light — Centralab Optoelectronic Devices Will Control:

object counters • punched tape readers • card readers • position indicators • object orienting equipment • liquid level indicators • optomechanical programmers • analog to digital converters • recognition equipment • precision motor speed • film sound track pickups • automatic illumination • TV automatic brightness • exposure meter and aperture • burglar alarms and security systems • doors • infrared detectors • X-ray • ultraviolet • flame failure detectors • smoke and fire detectors

Consult Centralab in the early stages of your design to see how photovoltaic, photoconductive and photoemissive sensors can be used. You'll be assured of a degree of control not possible through other methods. Centralab has experience in all the areas listed above and our devices feature advanced designs and fabrication techniques developed as the world's largest producer of solar cells. If Centralab is there during the planning stages, we can lighten your load.

For more information and a comprehensive catalog on our optoelectronic devices, write Centralab Application Engineering Today.

CENTRALAB
Electronics Division
GLOBE-UNION INC
5757 NORTH GREEN BAY AVENUE
MILWAUKEE, WISCONSIN 53201

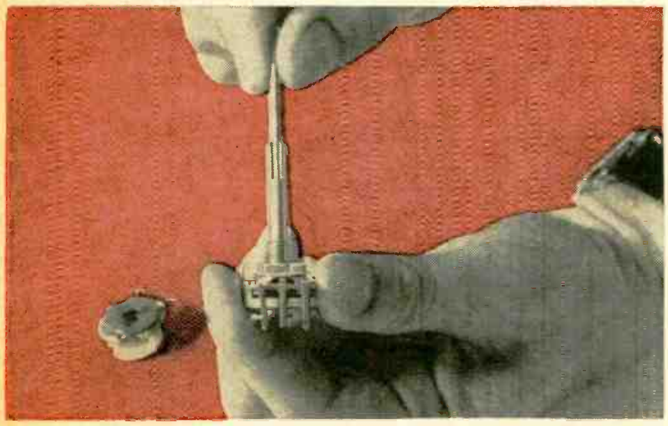
M-6830

CIRCLE NO. 119 ON READER SERVICE CARD

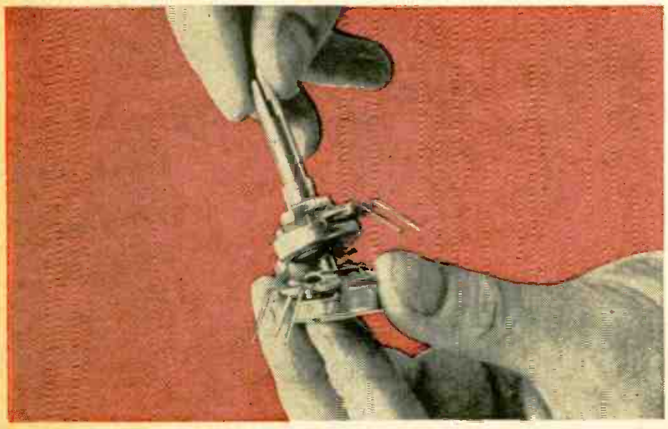
MALLORY Tips for Technicians

Do-it-yourself stereo clutch controls

First, squeeze the end tines of the outer shaft together (the tines on the end of the shaft that go into the control) with a pair of pliers, until the tines just touch. Then insert the outer shaft into the front control section.



Next, insert the inner control shaft through the outer shaft from the front. You'll have to apply some pressure to force the inner shaft through the squeezed tines of the outer shaft. As you do this, the outer shaft will lock in place in the front control section.



Now push the inner shaft through the front control far enough so you can slide the rear control section in place on the shaft. Finally, attach the rear control section and snap it into place.

Many stereo sets use a dual volume control which lets you adjust volume of both channels either together or separately. As in most dual controls, there's an inner and outer shaft linked to the front and rear control sections. By means of separate knobs, you can adjust each channel simply by holding one knob and rotating the other . . . and this is how you adjust right and left balance. These controls have an extra feature: there's a friction clutch that ties the two shafts together. So once you set the balance the way you want it, you can turn just one knob and raise or lower both channels together.

When you need to replace one of these clutch controls, you may find that an exact replacement may be tough to locate. Rather than go to the delay and cost of ordering from the manufacturer, you can get the job done quickly and economically by one visit to your Mallory distributor. He'll have the parts you need in his Sta-Loc® Control cabinet. They're all standard Sta-Loc parts. It's what you do to them that's special.

And what have you got? A friction clutch dual control, tailor-made for stereo. Friction between inner and outer shafts will make both controls move when either knob is turned—or either knob can be turned separately while you hold the other.

This is just one of the many time-saving tricks you can do with the Sta-Loc Controls components immediately available from your Mallory Distributor. See him for all your replacement parts requirements. Or write Mallory Distributor Products Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.

DON'T FORGET TO ASK 'EM *"What else needs fixing?"*

THIS MONTH'S COVER shows a number of photoconductive cells manufactured by Clairex, RCA, and Raytheon. Most of these employ cadmium sulfide (CdS) or cadmium selenide (CdSe) as their active material whose resistance changes upon the presence of light. By using different electrode geometries, including interdigitated types, changes in cell resistance and operating voltage can be produced. The cell at the lower right has been reproduced at about twice actual size to show the interdigitated structure. Four of the units shown (the ones with 4 and 6 leads) include their own incandescent or neon lamp light sources. For further details on photoconductive cells, refer to our lead article on page 23. . . . Photo: L. Heicklen Studios.

Electronics World

SEPTEMBER 1968 VOL. 80, No. 3

CONTENTS

MONTHLY FEATURES

Electronics World: Published monthly by Ziff-Davis Publishing Company at 307 North Michigan Ave., Chicago, Illinois 60601. One year subscription $6.00. Second Class Postage paid at Chicago, Illinois and at additional mailing offices. Subscription service and Forms 3579: Portland Place, Boulder, Colorado 80302.

One of a series of brief discussions by Electro-Voice engineers

THE NEW LOOK IN MULTICELLS

LARRY SALZWEDEL
Loudspeaker Product Engineer

The improvement of a product does not always come from the discovery of a radical new design concept. In many cases, careful attention to the details of construction plus the application of modern materials and techniques can offer benefits of appreciable magnitude.

A case in point the new Electro-Voice multicellular horn, Model M253. In general, its shape and sound characteristics are familiar, and represent no major departure from accepted design parameters. But detail points of construction offer a significant improvement in performance. One obvious difference is the die cast aluminum throat coupler, included with each horn assembly. This coupler is threaded to accept any standard P.A. driver, thus increasing the driver options possible when designing a sound system using the horn.

Because multicellular horns are by nature bulky and heavy, a concentrated effort was made to reduce the mass of the assembly, while improving its acoustic properties. It was found that the wall thickness of the steel horn sections could be reduced .003" by utilizing stressed wall sections, plus the addition of a special damping compound to the entire outer surface of the horn.

The walls of each horn section are assembled in jigs that establish the desired stress. 16 locking tabs at each junction of wall surfaces insure that the stress is maintained after assembly. This clamping action reduces resonances that can noticeably affect the smoothness of the frequency response characteristics of the horn.

The asphaltic-base damping compound is applied to the outer horn surfaces to further reduce any tendency of the assembly to resonate, without adding substantially to the mass of the horn. Modern cements also seal each wall junction to eliminate the possibility of acoustical leaks at any point of the horn.

The result of the application of these modern materials and construction techniques is a reduction in distortion, improved transient response, and a smoother curve with fewer large peaks or dips in response. The polar pattern is also somewhat more uniform since the wall surfaces of the horn do not radiate any appreciable acoustic energy, even at high signal levels.

In addition, the horn is easier to install due to a reduction in weight of about 10% compared to traditional construction techniques. Installation is also made easier by the design and inclusion of universal mounting brackets that eliminate the need to fabricate special mountings at the site. While the new Model M253 E-V multicellular horn cannot lay claim to any major design "breakthroughs" the net effect of the many detail improvements has been the creation of a more effective tool for sound reinforcement.

For reprints of other discussions in this series, or technical data on any E-V product, write: ELECTRO-VOICE, INC., Dept. 983N 629 Cecil St., Buchanan, Michigan 49107

Electro-Voice
A SUBSIDIARY OF GULTON INDUSTRIES, INC.

CIRCLE NO. 112 ON READER SERVICE CARD

COMING NEXT MONTH

SPECIAL ISSUE:

Shielded Cables and Connectors

Need shielded wire? Or a connector? Articles in our Special Issue discuss some of the more popular coaxial and multi-conductor shielded cables and connectors and highlight a few of the problems shielding causes engineers. John Holland and Tore Anderson of Amphenol cover cable standardization and coax connector types; Filtron's Saul Berstein and Martin Mirsky show engineers the right way to ground circuits; high-frequency cables are covered by Times Wire's Al Kushner; while low-frequency (below 100 kHz) cables are examined by Belden's Bob Sharp. L. Kehl and J. Grove of Amphenol's Industrial Division give pointers on mating connectors and cables.

AIRPORT GROUND CONTROL
Many airports are becoming so large and busy that it's possible for a ground controller to lose a plane right on the taxiways. This article tells why and gives a possible solution.

ELECTRONIC INTRUSION ALARMS
Part 2 of this two-part story discusses microwave burglar alarms which the author contends provide excellent over-all protection. Units made by Radar Devices are used as examples.

VIDEO TAPE RECORDERS
A directory of the most popular video tape recorders on the market giving their specifications and cost. The following brands will be included: Apeco, Ampex, Bell & Howell, Concord, Craig, G-E, Panasonic, Phillips, Revere-Mincom, Shibaden, and Sony.

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

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
Senior Vice President

Philip Sine
Financial Vice President

Walter S. Mills, Jr.
Vice President, Circulation

Stanley R. Greenfield
Vice President, Marketing

Phillip T. Heffernan
Vice President, Electronics Division

Frank Pomerantz
Vice President, Creative Services

Arthur W. Butzow
Vice President, Production

Edward D. Muhlfeld
Vice President, Aviation Division

Irwin Robinson
Vice President, Travel Division

Furman Hebb
Administrative Vice President

George Morrissey
Vice President

Sydney H. Rogers
Vice President

Editorial and Executive Offices
One Park Avenue
New York, New York 10016 212 679-7200

NEW YORK OFFICE 212 679-7200
Joseph E. Halloran

MIDWESTERN OFFICE
307 North Michigan Avenue
Chicago, Illinois 60601 312 726-0892
Midwestern Advertising Manager, Robert J. Ur

WESTERN OFFICE
9025 Wilshire Boulevard
Beverly Hills, California 90211
213 CRestview 4-0265; BRadshaw 2-1161
Western Advertising Manager, Bud Dean

JAPAN: James Yagi Ishikawa Mansion,
#4, Sakuragaoka Shibuya-ku, Tokyo 462-2911-3

CIRCULATION OFFICE
Portland Place, Boulder, Colorado 80302

Member Audit Bureau of Circulations

Radio & TV News • Radio News • Radio-Electronic Engineering Trademarks Reg. U.S. Pat. Off.
SUBSCRIPTION SERVICE: Forms 3579 and all subscription correspondence should be addressed to Electronics World, Circulation Department, Portland Place, Boulder, Colorado 80302. Please allow at least six weeks for change of address. Include your old address, as well as new—enclosing if possible an address label from a recent issue.
EDITORIAL CONTRIBUTIONS must be accompanied by return postage and will be handled with reasonable care: however publisher assumes no responsibility for return or safety of art work, photographs, or manuscripts.
ELECTRONICS WORLD (September, 1968, Vol. 80, No. 3). Published monthly at 307 North Michigan Avenue. Chicago, Illinois 60601, by Ziff-Davis Publishing Company—also the publishers of Airline Management and Marketing, Boating, Business & Commercial Aviation, Car and Driver, Cycle, Flying, HiFi/Stereo Review, Modern Bride, Popular Electronics, Popular Photography, Skiing, Skiing Area News, and Skiing Trade News. (Travel Weekly is published by Robinson Publications, Inc., a subsidiary of Ziff-Davis Publishing Company.) One year subscription rate for U.S., U.S. Possessions, and Canada, $6.00; all other countries, $7.00. 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.

Radio & Television news

By FOREST H. BELT / Contributing Editor

CATV Has No Copyright Liability

Because cable-TV companies operate essentially as receiving systems, the U.S. Supreme Court decided that they don't have to pay copyright fees or royalties for material picked up off the air from TV stations. The Court took the view that CATV systems do not actually perform the programs, but are merely a link in receiving and distributing the signals for home viewers. The broadcasters, however, who originate (and thus "perform") the material, do pay royalties to copyright holders.

This interesting interpretation seems to hinge on what constitutes "performing". It would seem that the minute a CATV operator uses his own programming, be it film, tape, or live, he is no longer just a receiver and distributor of signals, but is instead a "wirecaster." A portion of his operation is then similar to broadcasting, at least insofar as copyrighted material is concerned. The ruling doesn't cover that eventuality.

The Court's decision is only one episode in the long, drawn-out battle to control CATV. It was implied that by next year Congress is expected to step in and provide copyright protection for material used on CATV. How far this might go isn't at all clear; it could cover all programs carried by a system, or only those fed to the wire as system originations. In either case, system owners are relieved that they won't now be liable for royalties on programs carried in the past.

Another stumbling block has thus been pulled out of the path of CATV expansion, which incidentally hasn't suffered very much from past restrictions. With judicial and legislative opinions leaning in favor of wired-TV reception systems, the specter of a totally wired TV system for the nation shadows broadcasters ever more ominously.

National Communications Policy

The clamor for a special cabinet-level Department of Communications is getting noisier. Surprising news like that of the two recent Supreme Court decisions on CATV (that the FCC can regulate it and that CATV has no copyright liability for off-the-air programs it carries) stir plenty of controversy. More fuel for the flame is added by land-mobile communications operators who covet that portion of the spectrum now allocated to television broadcasting. Also badgering broadcasters, and those who must oversee the fantastic disarray of communications services that exists and is developing, is the prospect of either nationwide wired-TV distribution and equally the curtailing possibility of direct satellite-to-home broadcasting. A nationwide test of pay-TV is also being pushed, again by *Zenith*.

So far, the wheel that squeaks loudest, and at the most effective pitch, gets grease. With first this wheel and then that one making the squawks, the country's total communications situation is approaching a somewhat muddled state. The key consideration has to be: what is—to quote the Communications Act of 1934—the "public interest, convenience, and necessity"? One industry leader suggests completely eliminating the FCC and replacing it with, instead of one super-agency, three separate agencies: one handling spectrum allocations, one handling rates and tariffs of common carriers, and one handling most of the other activity now administered by the FCC.

Whatever the means, almost no one disagrees that a broad statement concerning our communications needs and goals is at the top of the list of needs. Television, radio, cable TV, or whatever—our system of home entertainment and information depends on what is decided in the next year or two. The future of communications in this country should be well coordinated and considered most objectively instead of thrown together by the piecemeal wishes of so many vested interests.

Color-TV X-Rays . . Not Any More

Within the next two years, said the U.S. Public Health Service earlier this year, new color-TV sets will be free from any measurable x-radiation. We reported one step a couple of months ago—the solid-state high-voltage rectifier in 1969 *Motorola* color receivers. Now there's another device for the same purpose. *Atlantic Semiconductors, Inc.* of Asbury Park, N.J. makes a voltage multiplier to take the place of both rectifier and regulator tubes in high-voltage supplies. The device is solid-state, and occupies only a fraction of the space of a conventional high-voltage section. Even the bulky flyback transformer can be reduced to a mere yoke-matching device or eliminated entirely.

Speaking of x-rays from color sets, we have seen newspaper and trade ads selling so-called x-ray detectors with which the customer can monitor his TV set for x-rays. The "kit" consists of a few strips of film which are attached to the set for a few days, then returned to the advertiser to develop. For several reasons, the Post Office Department and the Federal Radiation Commission have been asked to investigate the ads. There are many possible fallacies to this means of trying to detect x-radiation, not to mention that such testing is needless. It has been proven adequately that a competent service technician can replace any suspect regulator or rectifier and reduce the high-voltage setting to normal—thus eliminating even the likelihood of x-radiation. (Don't forget, it's only color sets that ever had a problem in the first place—a fact overlooked by some in connection with this "check your own TV" idea.)

Copper vs Aluminum

As reported in last month's "Flashes in the Big Picture", the long copper strike caused electronic-wire users to seriously consider the qualities of aluminum wire. Hardly was the copper strike over, however, than labor-trouble rumblings become audible among aluminum companies. Strikes of serious duration could affect capacitors, shielding, etc. as well as wire. In any case, aluminum prices are bound to increase—indeed, they already have at some companies.

Flattest of the Flat

One of the most unorthodox working versions of a thin-screen TV set was on display in New York a short time ago. This one, shown by *Sharp Electronics*, has a picture tube only 2 inches thick.

The one we saw is only a prototype, but it's like nothing we've seen before. The picture tube, which is remote from the chassis, is flat enough to hang on the wall in true picture-frame fashion—something long hoped-for by decorator-designers in the home-entertainment field. But here is the real surprise: It shows a picture on the back as well as on the front! It could be placed in a room divider and watched from both sides.

Sharp didn't give us details of structure, but a few things were discernible. The screen size is about 12 diagonal inches, and about 2 inches from front to back. A small "neck" extends downward from the bottom, like the handle of a ping-pong paddle, yet not nearly so large. The beam seems to be deflected by a wiring "harness" wrapped around the periphery of the screen, although we couldn't verify this. The picture is excellent, although raster linearity was not too good. A spokesman for *Sharp* says that sets using the new picture tube won't be available for at least another year or two, however.

And Littlest of the Little

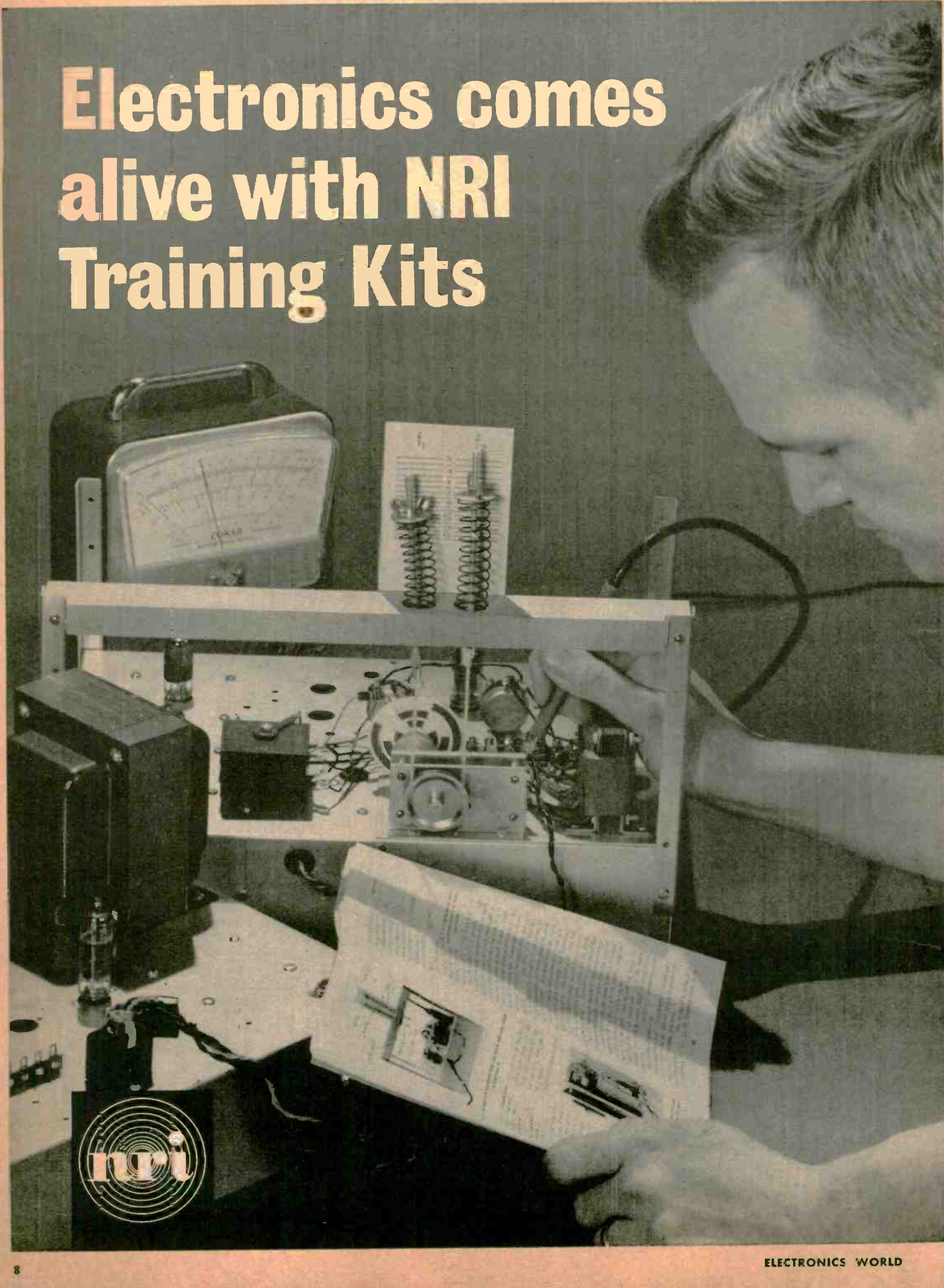
A wristwatch radio from *Matsushita (Panasonic)* has some interesting characteristics besides being so tiny. It uses integrated circuits, of the thick-film variety. Tuning is with a pair of variable-capacitance semiconductor diodes. However, the little device is not yet in production, and no schedule is given.

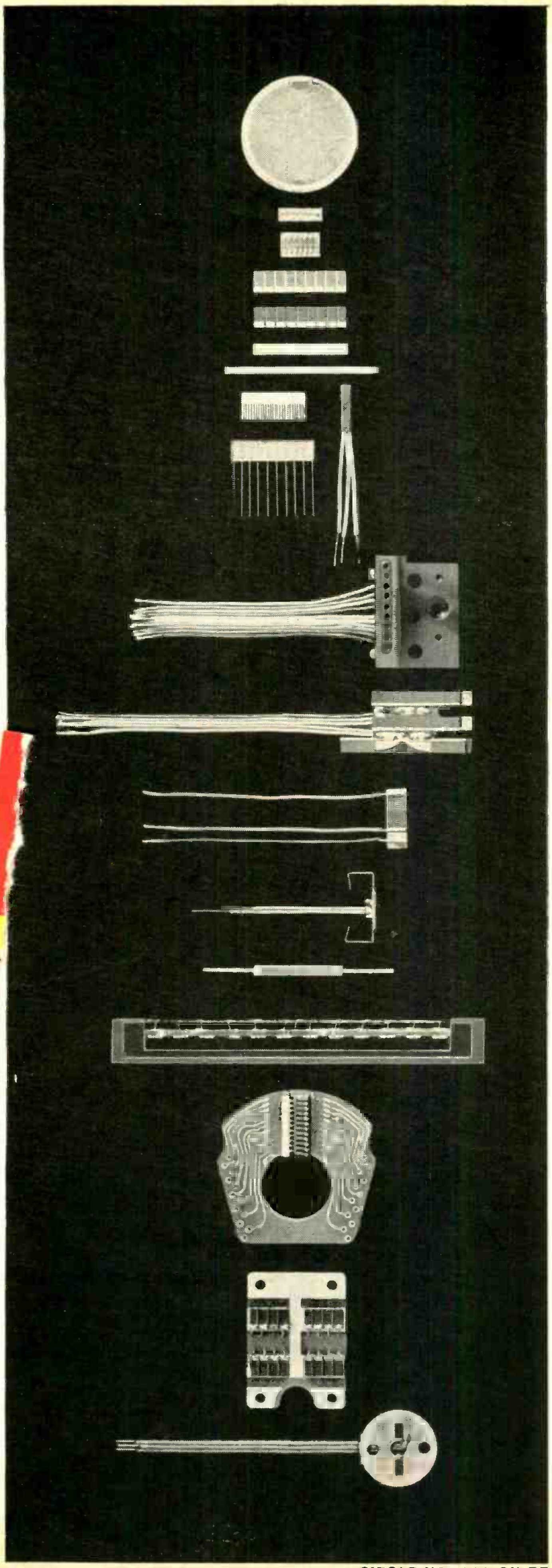
The same company has a pocket-size TV set that also uses hybrid IC's—eight of them. *Panasonic* expects to have this set available by spring of 1969, priced (they hope) at slightly over $100.00.

Another step toward color tinyvision exists in the thick-film IC announced by *Plessey Microelectronics Co.*, of London, England. The IC combines color demodulators and amplifiers and supplies enough R, G, and B drive to feed large-screen pix tubes. In the U.S., *Fairchild* developed a similar integrated circuit last year, but it hasn't appeared yet in a commercial chassis.

Flashes in the Big Picture

One executive of *RCA Victor Records* is worried that cassettes may spell the doom for disc records, and is looking for a way to prevent taping music off radio . . . Tiny "hip pocket" records, 4 inches in diameter and playing at either 45 or 33 r/min, are getting a big push from *Symphonic;* offers special portable players, tiny combinations, even a TV-phono combo wrapped around 3-inch mini-TV, to play them on; one merchandising concept is vending machines to dispense records for 50 cents each . . . Warranty extensions are turning into sizable flap; seems dealers are complaining about no-pay labor, as we predicted. . . . New name in color-TV field: *Broadmoor Industries*, of Des Plaines, Ill., selling a 15-inch portable; could be called hybrid, since ad copy claims one (!) transistor . . . Sales prediction of entire consumer portion of electronics industry is $5 billion this year . . . Over $2 billion of this is television. ▲


Electronics comes alive with NRI Training Kits
nri



You Supply the Light — Centralab Optoelectronic Devices Will Control:

object counters • punched tape readers • card readers • position indicators • object orienting equipment • liquid level indicators • optomechanical programmers • analog to digital converters • recognition equipment • precision motor speed • film sound track pickups • automatic illumination • TV automatic brightness • exposure meter and aperture • burglar alarms and security systems • doors • infrared detectors • X-ray • ultraviolet • flame failure detectors • smoke and fire detectors

Consult Centralab in the early stages of your design to see how photovoltaic, photoconductive and photoemissive sensors can be used. You'll be assured of a degree of control not possible through other methods. Centralab has experience in all the areas listed above and our devices feature advanced designs and fabrication techniques developed as the world's largest producer of solar cells. If Centralab is there during the planning stages, we can lighten your load.

For more information and a comprehensive catalog on our optoelectronic devices, write Centralab Application Engineering Today.

CENTRALAB
Electronics Division
GLOBE-UNION INC
5757 NORTH GREEN BAY AVENUE
MILWAUKEE, WISCONSIN 53201

M-6830

CIRCLE NO. 119 ON READER SERVICE CARD

Electronics World

SEPTEMBER 1968 VOL. 80, No. 3

THIS MONTH'S COVER shows a number of photoconductive cells manufactured by Clairex, RCA, and Raytheon. Most of these employ cadmium sulfide (CdS) or cadmium selenide (CdSe) as their active material whose resistance changes upon the presence of light. By using different electrode geometries, including interdigitated types, changes in cell resistance and operating voltage can be produced. The cell at the lower right has been reproduced at about twice actual size to show the interdigitated structure. Four of the units shown (the ones with 4 and 6 leads) include their own incandescent or neon lamp light sources. For further details on photoconductive cells, refer to our lead article on page 23. . . . Photo: L. Heicklen Studios.

CONTENTS

MONTHLY FEATURES

Publisher
PHILLIP T. HEFFERNAN

Editor
WM. A. STOCKLIN

Technical Editor
MILTON S. SNITZER

Associate Editors
W. J. EVANZIA
P. B. HOEFER

Contributing Editors
WALTER H. BUCHSBAUM
Prof. ARTHUR H. SEIDMAN
FOREST H. BELT

Art Editor
EUGENE F. LANDINO

Art and Drafting
J. A. GOLANEK

Advertising Manager
JOSEPH E. HALLORAN

Advertising Service Manager
ARDYS C. MORAN

Associate Publisher
LARRY SPORN

Electronics World: Published monthly by Ziff-Davis Publishing Company at 307 North Michigan Ave., Chicago, Illinois 60601. One year subscription $6.00. Second Class Postage paid at Chicago, Illinois and at additional mailing offices. Subscription service and Forms 3579: Portland Place, Boulder, Colorado 80302.

COMING NEXT MONTH

SPECIAL ISSUE:

Shielded Cables and Connectors

Need shielded wire? Or a connector? Articles in our Special Issue discuss some of the more popular coaxial and multi-conductor shielded cables and connectors and highlight a few of the problems shielding causes engineers. John Holland and Tore Anderson of Amphenol cover cable standardization and coax connector types; Filtron's Saul Berstein and Martin Mirsky show engineers the right way to ground circuits; high-frequency cables are covered by Times Wire's Al Kushner; while low-frequency (below 100 kHz) cables are examined by Belden's Bob Sharp. L. Kehl and J. Grove of Amphenol's Industrial Division give pointers on mating connectors and cables.

AIRPORT GROUND CONTROL
Many airports are becoming so large and busy that it's possible for a ground controller to lose a plane right on the taxiways. This article tells why and gives a possible solution.

ELECTRONIC INTRUSION ALARMS
Part 2 of this two-part story discusses microwave burglar alarms which the author contends provide excellent over-all protection. Units made by Radar Devices are used as examples.

VIDEO TAPE RECORDERS
A directory of the most popular video tape recorders on the market giving their specifications and cost. The following brands will be included: Apeco, Ampex, Bell & Howell, Concord, Craig, G-E, Panasonic, Phillips, Revere-Mincom, Shibaden, and Sony.

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

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
Senior Vice President

Philip Sine
Financial Vice President

Walter S. Mills, Jr.
Vice President, Circulation

Stanley R. Greenfield
Vice President, Marketing

Phillip T. Heffernan
Vice President, Electronics Division

Frank Pomerantz
Vice President, Creative Services

Arthur W. Butzow
Vice President, Production

Edward D. Muhlfeld
Vice President, Aviation Division

Irwin Robinson
Vice President, Travel Division

Furman Hebb
Administrative Vice President

George Morrissey
Vice President

Sydney H. Rogers
Vice President

Editorial and Executive Offices
One Park Avenue
New York, New York 10016 212 679-7200

NEW YORK OFFICE 212 679-7200
Joseph E. Halloran

MIDWESTERN OFFICE
307 North Michigan Avenue
Chicago, Illinois 60601 312 726-0892
Midwestern Advertising Manager, Robert J. Ur

WESTERN OFFICE
9025 Wilshire Boulevard
Beverly Hills, California 90211
213 CRestview 4-0265; BRadshaw 2-1161
Western Advertising Manager, Bud Dean

JAPAN: James Yagi Ishikawa Mansion,
#4, Sakuragaoka Shibuya-ku, Tokyo 462-2911-3

CIRCULATION OFFICE
Portland Place, Boulder, Colorado 80302

Member Audit Bureau of Circulations

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

SUBSCRIPTION SERVICE; Forms 3579 and all subscription correspondence should be addressed to Electronics World, Circulation Department, Portland Place, Boulder, Colorado 80302. Please allow at least six weeks for change of address. Include your old address, as well as new—enclosing if possible an address label from a recent issue.

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

ELECTRONICS WORLD (September, 1968, Vol. 80, No. 3). Published monthly at 307 North Michigan Avenue, Chicago, Illinois 60601, by Ziff-Davis Publishing Company—also the publishers of Airline Management and Marketing, Boating, Business & Commercial Aviation, Car and Driver, Cycle, Flying, HiFi/Stereo Review, Modern Bride, Popular Electronics, Popular Photography, Skiing, Skiing Area News, and Skiing Trade News. (Travel Weekly is published by Robinson Publications, Inc., a subsidiary of Ziff-Davis Publishing Company.) One year subscription rate for U.S., U.S. Possessions, and Canada, $6.00; all other countries, $7.00. 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.

Radio & Television news

By FOREST H. BELT / Contributing Editor

CATV Has No Copyright Liability

Because cable-TV companies operate essentially as receiving systems, the U.S. Supreme Court decided that they don't have to pay copyright fees or royalties for material picked up off the air from TV stations. The Court took the view that CATV systems do not actually perform the programs, but are merely a link in receiving and distributing the signals for home viewers. The broadcasters, however, who originate (and thus "perform") the material, do pay royalties to copyright holders.

This interesting interpretation seems to hinge on what constitutes "performing". It would seem that the minute a CATV operator uses his own programming, be it film, tape, or live, he is no longer just a receiver and distributor of signals, but is instead a "wirecaster." A portion of his operation is then similar to broadcasting, at least insofar as copyrighted material is concerned. The ruling doesn't cover that eventuality.

The Court's decision is only one episode in the long, drawn-out battle to control CATV. It was implied that by next year Congress is expected to step in and provide copyright protection for material used on CATV. How far this might go isn't at all clear; it could cover all programs carried by a system, or only those fed to the wire as system originations. In either case, system owners are relieved that they won't now be liable for royalties on programs carried in the past.

Another stumbling block has thus been pulled out of the path of CATV expansion, which incidentally hasn't suffered very much from past restrictions. With judicial and legislative opinions leaning in favor of wired-TV reception systems, the specter of a totally wired TV system for the nation shadows broadcasters ever more ominously.

National Communications Policy

The clamor for a special cabinet-level Department of Communications is getting noisier. Surprising news like that of the two recent Supreme Court decisions on CATV (that the FCC can regulate it and that CATV has no copyright liability for off-the-air programs it carries) stir plenty of controversy. More fuel for the flame is added by land-mobile communications operators who covet that portion of the spectrum now allocated to television broadcasting. Also badgering broadcasters, and those who must oversee the fantastic disarray of communications services that exists and is developing, is the prospect of either nationwide wired-TV distribution and equally the curtailing possibility of direct satellite-to-home broadcasting. A nationwide test of pay-TV is also being pushed, again by *Zenith*.

So far, the wheel that squeaks loudest, and at the most effective pitch, gets grease. With first this wheel and then that one making the squawks, the country's total communications situation is approaching a somewhat muddled state. The key consideration has to be: what is—to quote the Communications Act of 1934—the "public interest, convenience, and necessity"? One industry leader suggests completely eliminating the FCC and replacing it with, instead of one super-agency, three separate agencies: one handling spectrum allocations, one handling rates and tariffs of common carriers, and one handling most of the other activity now administered by the FCC.

Whatever the means, almost no one disagrees that a broad statement concerning our communications needs and goals is at the top of the list of needs. Television, radio, cable TV, or whatever—our system of home entertainment and information depends on what is decided in the next year or two. The future of communications in this country should be well coordinated and considered most objectively instead of thrown together by the piecemeal wishes of so many vested interests.

Color-TV X-Rays . . Not Any More

Within the next two years, said the U.S. Public Health Service earlier this year, new color-TV sets will be free from any measurable x-radiation. We reported one step a couple of months ago—the solid-state high-voltage rectifier in 1969 *Motorola* color receivers. Now there's another device for the same purpose. *Atlantic Semiconductors, Inc.* of Asbury Park, N.J. makes a voltage multiplier to take the place of both rectifier and regulator tubes in high-voltage supplies. The device is solid-state, and occupies only a fraction of the space of a conventional high-voltage section. Even the bulky flyback transformer can be reduced to a mere yoke-matching device or eliminated entirely.

Speaking of x-rays from color sets, we have seen newspaper and trade ads selling so-called x-ray detectors with which the customer can monitor his TV set for x-rays. The "kit" consists of a few strips of film which are attached to the set for a few days, then returned to the advertiser to develop. For several reasons, the Post Office Department and the Federal Radiation Commission have been asked to investigate the ads. There are many possible fallacies to this means of trying to detect x-radiation, not to mention that such testing is needless. It has been proven adequately that a competent service technician can replace any suspect regulator or rectifier and reduce the high-voltage setting to normal —thus eliminating even the likelihood of x-radiation. (Don't forget, it's only color sets that ever had a problem in the first place—a fact overlooked by some in connection with this "check your own TV" idea.)

Copper vs Aluminum

As reported in last month's "Flashes in the Big Picture", the long copper strike caused electronic-wire users to seriously consider the qualities of aluminum wire. Hardly was the copper strike over, however, than labor-trouble rumblings become audible among aluminum companies. Strikes of serious duration could affect capacitors, shielding, etc. as well as wire. In any case, aluminum prices are bound to increase—indeed, they already have at some companies.

Flattest of the Flat

One of the most unorthodox working versions of a thin-screen TV set was on display in New York a short time ago. This one, shown by *Sharp Electronics*, has a picture tube only 2 inches thick.

The one we saw is only a prototype, but it's like nothing we've seen before. The picture tube, which is remote from the chassis, is flat enough to hang on the wall in true picture-frame fashion—something long hoped-for by decorator-designers in the home-entertainment field. But here is the real surprise: It shows a picture on the back as well as on the front! It could be placed in a room divider and watched from both sides.

Sharp didn't give us details of structure, but a few things were discernible. The screen size is about 12 diagonal inches, and about 2 inches from front to back. A small "neck" extends downward from the bottom, like the handle of a ping-pong paddle, yet not nearly so large. The beam seems to be deflected by a wiring "harness" wrapped around the periphery of the screen, although we couldn't verify this. The picture is excellent, although raster linearity was not too good. A spokesman for *Sharp* says that sets using the new picture tube won't be available for at least another year or two, however.

And Littlest of the Little

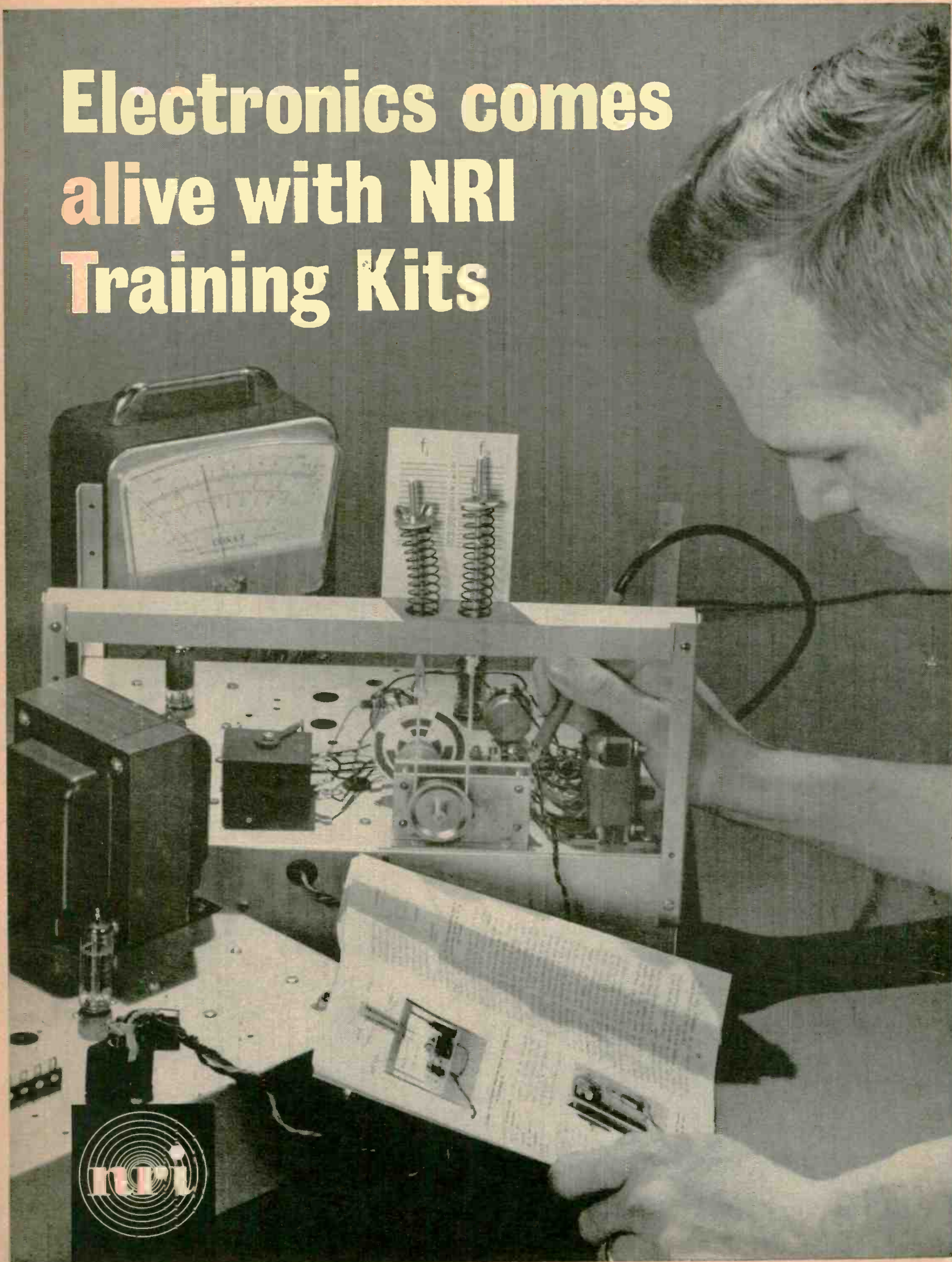
A wristwatch radio from *Matsushita (Panasonic)* has some interesting characteristics besides being so tiny. It uses integrated circuits, of the thick-film variety. Tuning is with a pair of variable-capacitance semiconductor diodes. However, the little device is not yet in production, and no schedule is given.

The same company has a pocket-size TV set that also uses hybrid IC's—eight of them. *Panasonic* expects to have this set available by spring of 1969, priced (they hope) at slightly over $100.00.

Another step toward color tinyvision exists in the thick-film IC announced by *Plessey Microelectronics Co.*, of London, England. The IC combines color demodulators and amplifiers and supplies enough R, G, and B drive to feed large-screen pix tubes. In the U.S., *Fairchild* developed a similar integrated circuit last year, but it hasn't appeared yet in a commercial chassis.

Flashes in the Big Picture

One executive of *RCA Victor Records* is worried that cassettes may spell the doom for disc records, and is looking for a way to prevent taping music off radio . . . Tiny "hip pocket" records, 4 inches in diameter and playing at either 45 or 33 r/min, are getting a big push from *Symphonic;* offers special portable players, tiny combinations, even a TV-phono combo wrapped around 3-inch mini-TV, to play them on; one merchandising concept is vending machines to dispense records for 50 cents each . . . Warranty extensions are turning into sizable flap; seems dealers are complaining about no-pay labor, as we predicted. . . . New name in color-TV field: *Broadmoor Industries*, of Des Plaines, Ill., selling a 15-inch portable; could be called hybrid, since ad copy claims one (!) transistor . . . Sales prediction of entire consumer portion of electronics industry is $5 billion this year . . . Over $2 billion of this is television. ▲



Electronics comes
alive with NRI
Training Kits

NTS...THE FIRST HOME STUDY SCHOOL TO OFFER LIVE EXPERIMENTS WITH INTEGRATED CIRCUIT KITS

You build a computer sub-system using the new, revolutionary integrated circuits. Each one, smaller than a dime, contains the equivalent of 15 resistors and 27 transistors.

And your kits come to you at no extra cost. These kits are the foundation of the exclusive *Project-Method* home study system...developed in our giant resident school and proven effective for thousands of men like yourself.

With Project-Method, all your kits are carefully integrated with lesson material. Our servicing and communication kits are *real* equipment—not school-designed versions for training only. As you work on each of the projects, you soon realize that even the most complicated circuits and components are easy to understand. You learn *how* they work. You learn *why* they work.

NTS Project-Method is a practical-experience approach to learning. The approach that works *best!* An all-theory training program can be hard to understand — difficult to remember. More than ever before you need the practical experience that comes from working with real circuits and components to make your training stick.

NTS SENDS YOU KITS TO BUILD THESE IMPORTANT ELECTRONICS UNITS!

- 25″ COLOR TV
- 21″ BLACK & WHITE TV
- SOLID-STATE RADIO
- AM-SW TWIN-SPEAKER RADIO
- TUBE-TESTER
- TRANSCEIVER
- COMPU-TRAINER®
- VTVM
- SIGNAL GENERATOR
- 5″ OSCILLOSCOPE

See them all illustrated in the new NTS Color Catalog.

CLASSROOM TRAINING AT LOS ANGELES: You can take classroom training at Los Angeles in sunny California. NTS occupies a city block with over a million dollars in facilities devoted exclusively to technical training. Check box in coupon.

NATIONAL TECHNICAL SCHOOLS

WORLD-WIDE TRAINING SINCE 1905

4000 So. Figueroa Street, Los Angeles, Calif. 90037

APPROVED FOR VETERANS

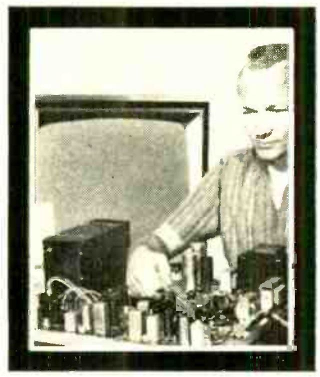
Accredited Member: National Home Study Council
Accredited Member: National Association of Trade and Technical Schools

◀COMMUNICATIONS

This transceiver is included in Communications courses. You build it. With it, you easily prepare for the F.C.C. license exam. You become a fully-trained man in communications, where career opportunities are unlimited.

25″ COLOR TV▼

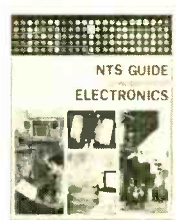
Included in Color TV Servicing Courses. With it you advance yourself into this profitable field of servicing work. Color is the future of television, you can be in on it with NTS training.



YOUR OPPORTUNITY IS NOW

New ideas, new inventions, are opening whole new fields of opportunity. The electronic industry is still the fastest growing field in the U.S. There's a bigger, better place in it for the man who trains today. So, whatever your goals are — advanced color TV servicing, broadcasting, F.C.C. license, computers, or industrial controls, NTS has a a highly professional course to meet your needs.

GET THE FACTS! SEE ALL NEW COURSES AND KITS OFFERED IN THE NEW NTS COLOR CATALOG. SEND THE CARD OR COUPON TODAY!



There's no obligation. You enroll by mail. No salesman will call.

DEPT. 240-98

NATIONAL TECHNICAL SCHOOLS
4000 S. Figueroa St., Los Angeles, Calif. 90037
Please rush Free Color Catalog and Sample Lesson, plus information on field checked below. No obligation.

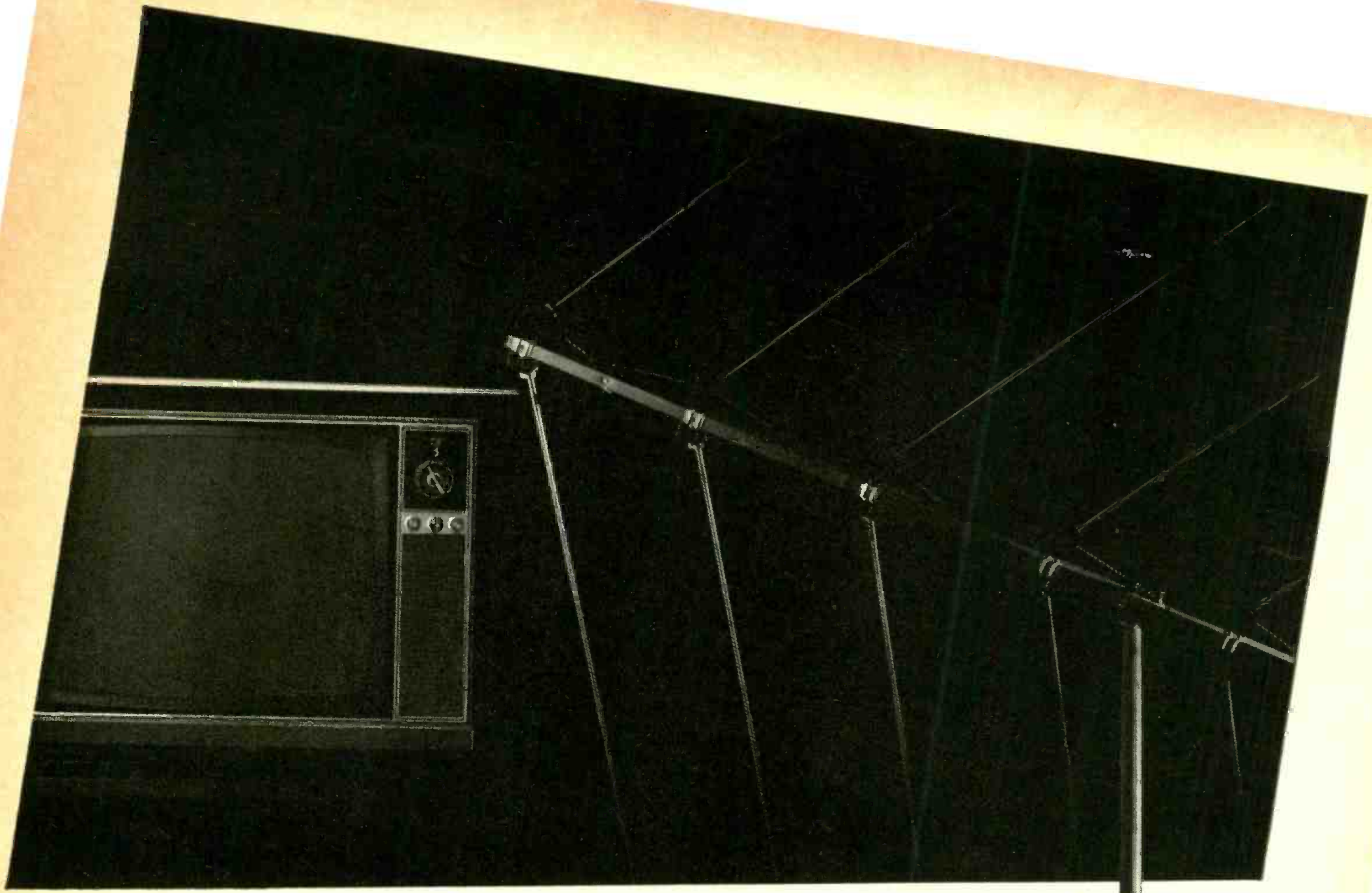
- ☐ MASTER COURSE IN COLOR TV SERVICING
- ☐ COLOR TV SERVICING
- ☐ MASTER COURSE IN TV & RADIO SERVICING
- ☐ MASTER COURSE IN ELECTRONIC COMMUNICATIONS
- ☐ PRACTICAL TV & RADIO SERVICING
- ☐ FCC LICENSE COURSE
- ☐ INDUSTRIAL & COMPUTER ELECTRONICS
- ☐ STEREO, HI FI & SOUND SYSTEMS
- ☐ BASIC ELECTRONICS

NAME ______________ AGE ______

ADDRESS ______________

CITY ______________ STATE ______________ ZIP ______

☐ Check if interested in Veteran Training under new G.I. Bill.
☐ Check if interested ONLY in Classroom Training at Los Angeles.



Step up...Lead-in Loud and Clear with Belden

TV lead-in. Belden makes all kinds. Indoor, outdoor, for color and black and white reception. All have one thing in common: for price and performance you won't find better lead-in anywhere. They provide a picture-perfect link between antenna and set. Since no two installations are alike, Belden gives the right choice for every situation. But don't skimp on your lead-in. Step up . . . choose one that gets the most out of the customer's overall investment. One that will delight the eye and ear with quality reception. For the absolute best, check out 8285 and 8290: the Color Twins. You won't find anything comparable for all-channel black and white as well as living color. Your Belden Distributor has all the facts. Talk to him today. Belden Corporation, P.O. Box 5070-A, Chicago, Illinois 60680.

*Belden Trademark, and Belden U. S. Pat. 2,814,666

Shielded/Low Loss/All Channel—8290 (For color in congested areas)

All Channel/Low Loss—8285 (For color in uncongested fringe areas)

Celluline*—8275

Weldohm®—8230

8225

Indoor—8226

Coax—8228

don't forget
to ask them
what else needs
fixing?

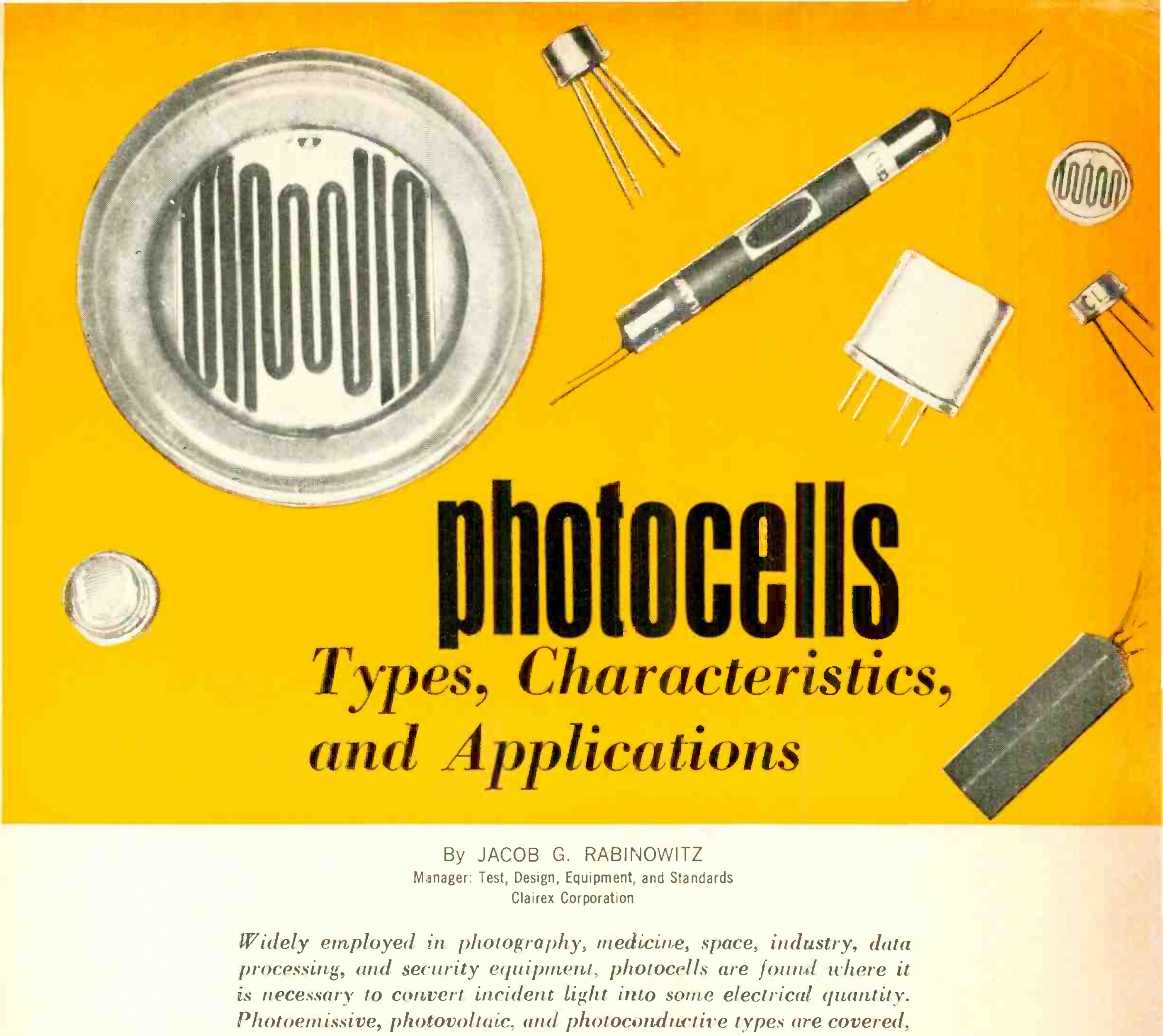
...the
missing link
in perfect
picture reception

BELDEN

BELDEN CORPORATION
P.O. Box 5070-A • Chicago, Ill. 60680 • Phone 312-378-1000

B-5-7A

CIRCLE NO. 121 ON READER SERVICE CARD



photocells
Types, Characteristics, and Applications

By JACOB G. RABINOWITZ
Manager: Test, Design, Equipment, and Standards
Clairex Corporation

Widely employed in photography, medicine, space, industry, data processing, and security equipment, photocells are found where it is necessary to convert incident light into some electrical quantity. Photoemissive, photovoltaic, and photoconductive types are covered, and a number of practical circuit applications and designs are given.

PHOTOCELLS are transducers that convert incident light into some electrical quantity or into a variation of some electrical property. These cells are now used in a wide range of applications, some of which will be covered here.

In photography, cells made of cadmium sulfide and cadmium selenide are sensitive enough to measure the low light levels usable with today's fast lenses and films. They serve as sensors in the burgeoning number of automatic-exposure cameras. In the darkroom, they analyze black-and-white negatives for exposure and paper grade, and color negatives for exposure and color balance. In automatic-focusing slide projectors, cells sense slide position and servo the lens for optimum focus. In electronic flash units, a cell controls the light output in accordance with light reflected from the subject during the actual flash duration.

Medical electronics utilizes photocells in such diverse instruments as oximeters (for blood-oxygen measurement), pulse readers, flame photometers (for analysis of sodium, potassium, and calcium in body fluids), and drop counters (in transfusions and intravenous feeding or medication).

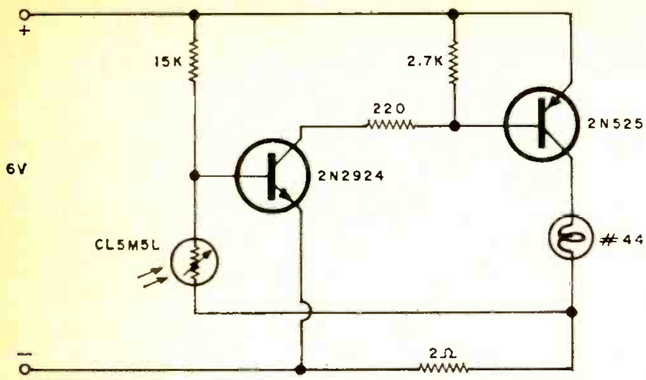
In space, photocells have been steering the Ranger, Surveyor, and Mariner space vehicles. Other cells serve to protect sensitive photomultipliers from direct exposure to the sun by actuating capping shutters when required. In Mariner 4, a photocell turned the cameras on when Mars posed for its pictures.

Industry uses many cells in such applications as automated weighing machines, process-control equipment, automatic warehousing using conveyor routing, counting and most recently in interface equipment between on-line computers and process-control equipment. Inspection equipment uses cells to examine containers for fullness and correct labeling.

The vending-machine industry uses cells for such diverse purposes as examination of dollar bills for authenticity (in bill changers), verification of coin usage, and sensing product delivery.

The electronic data processing industry uses cells to read perforated tape and cards and to control magnetic-tape transports. In analog computers, cells serve as primary elements in simplified multiplier circuits.

Security applications include the familiar beam-breaker burglar alarm, and also the smoke detector and flame and explosion detector.



A battery-operated night light (or a masthead light) that goes on when it gets dark. Circuit is a modified complementary Schmitt trigger in which the transistors conduct heavily when photocell resistance exceeds about 1500 ohms. During day, when cell resistance drops below 500 ohms, both transistors turn off and battery drain is limited to 400 μA.

In communications, cells serve as components in attenuator, level control, and transmitter drive control functions.

In music, photocells are used to generate effects such as vibrato, tremolo, and percussion in electronic organs and guitar amplifiers. Some of the earliest electronic organs generated the tones photoelectrically with tone wheels and photcells.

The principal types of photoelectric sensors that are in wide use are: the photoemissive, the photovoltaic, and the photoconductive types.

Photoemissive Types

Photoemissive types are either vacuum or gas-filled tubes with a cathode consisting of an alkali-metal-coated silver plate and an anode consisting of a wire structure positioned so as not to obstruct the cathode's view.

The energy required to release an electron from the cathode coating is called the "work function." When electromagnetic radiation with a photon energy greater than this work function impinges on the cathode surface, an electron is emitted for each photon. A positive potential applied to the anode collects the emitted electrons. When the anode potential is high enough to eliminate any space charge around the cathode, the vacuum photoemissive cell is an excellent linear sensor of light energy.

Cell sensitivity is low but frequency response, or speed, is excellent. It is limited only by electron transit time between the electrodes and their capacitance and inductance. A photoemissive tube is a constant-current source; hence, it is quite well-suited to high-impedance, voltage-sensitive amplifiers.

The short wavelength limit of such tubes is usually set by the tube envelope. The usual glass envelopes cut off (become opaque) somewhat below 4000Å, which is in the ultraviolet region. Special glass or quartz envelopes are used to extend tube sensitivity to below 2000Å.

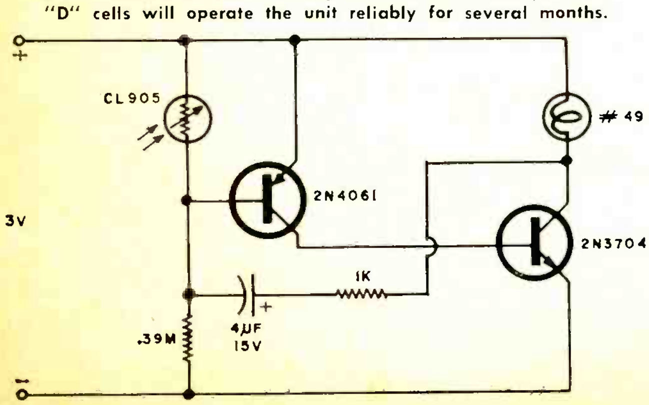
The sensitivity of photoemissive tubes may be increased if low-pressure gas is substituted for the vacuum. With sufficient anode potential, primary photo-electrons acquire sufficient velocity to ionize molecules of the gas and generate additional electrons and ions. This increases tube current for the same amount of light intensity (gains are 5 to 10).

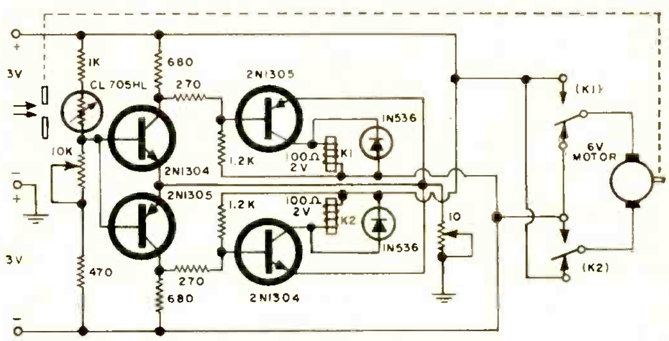
This increased sensivity is at the expense of linearity and response time, however. Part of the output current is carried by heavier, and therefore slower, ions. Moreover, ionization and recombination are not instantaneous.

While response time of vacuum phototubes is measured in nanoseconds, the gas-filled tubes have response times of many microseconds. Gas-filled photoemissive tubes, with some high-frequency boost in the circuitry, have served the sound-movie industry over the past 40 years.

Photomultipliers are vacuum photoemissive tubes which incorporate internal amplification *via* an intermediate series of secondary electron-emitter dynodes between the photocathode and the anode. The primary photo-electrons generated by the light are electrostatically focused and accelerated by a potential difference toward a sensitized metal dynode. In impinging upon this surface, each primary photo-electron generates a number of secondary electrons. These, in turn, are focused and accelerated, liberating additional electrons at other dynodes.

Type of battery-operated blinking night light that flashes when it gets dark. Flash rate is about 50 per minute and lamp brightness is adequate for drawing attention to hazard in dark. Pulsing ceases in light when cell resistance drops below 10,000 ohms and battery drain is less than 75 μA. Two "D" cells will operate the unit reliably for several months.





Photoelectric servo employed for aperture or illumination control. Circuit consists of two complementary Schmitt triggers driven by voltage divider consisting of photocell and its load resistors. When cell resistance is lower than load, upper trigger turns on and motor decreases aperture by moving shutter until photocell resistance equals load, at which time upper Schmitt turns off. When cell resistance is larger than load, lower trigger is actuated, motor then opens aperture. Input pot adjusts illumination, output pot controls dead band.

The current amplification is dependent upon good focus and the inter-dynode voltages. A typical photomultiplier offers gains beyond 2×10^6 at 100 V per dynode.

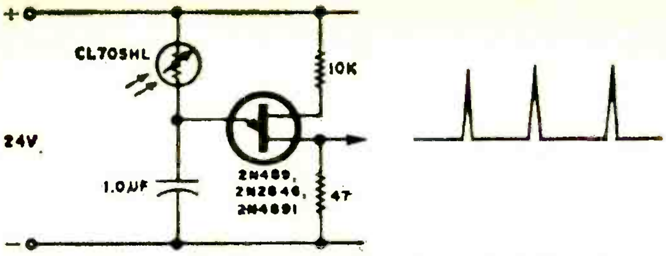
Photomultipliers have excellent linearity and wide frequency response. Applications include very low light level measurement, automatic astronomical devices (star trackers), and the generation of television video signals from movie film using the flying-spot technique.

Television camera tubes of the iconoscope and image orthicon types are photoemissive tubes in which an optical image is projected upon a mosaic cathode which is scanned by an electron beam to generate the video signal.

Infrared viewing tubes (sniperscopes) are near-infrared sensitive photoemissive tubes in which an IR optical image is projected upon the cathode. The emitted electrons are accelerated and focused onto a fluorescent screen where they produce a visible picture of the IR image incident upon the photocathode.

Photovoltaic Cells

Barrier-layer, photovoltaic (solar) cells, and photodiodes



An analog-to-digital converter that changes light intensity to pulses whose repetition rate varies with amount of light. For telemetering light level pulse rate may be transmitted directly or as modulation on a carrier. If pulses must be counted by a vacuum-tube circuit lacking a preamp, replace 47-ohm resistor with 3 to 8-ohm secondary winding of audio output transformer. Primary winding drives decade counter.

are of the self-generating type of photosensitive device. These include the selenium cell; the more recent silicon solar cell; and silicon, germanium, gallium arsenide, and indium antimonide photodiodes. Their operation depends on a junction or barrier layer across which a potential is generated upon the incidence of light.

Selenium cells have been used for the past 35 years or more in such devices as portable light meters for photography and illumination measurement. Their advantages in such applications are circuit simplicity (requiring only cell and meter) and the fact that they require no external source of power.

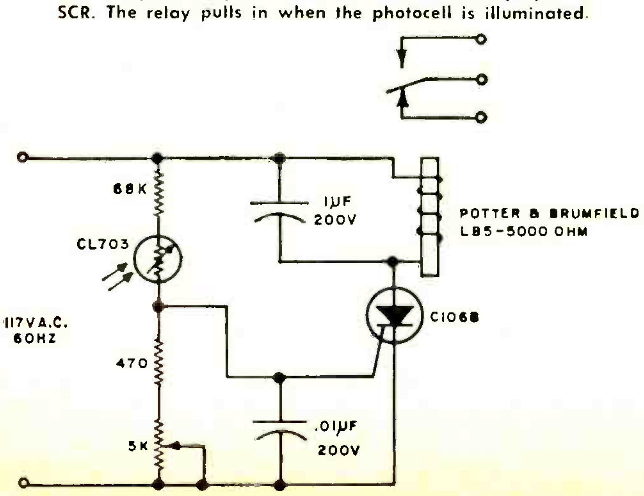
Selenium cells consist of a thin layer of selenium between an iron plate and a transparent front electrode. Such cells may be fabricated in sheets of considerable size when high sensitivity units are required. One commercially available unit approaches a ping-pong paddle in area.

The open-circuit output voltage of photovoltaic cells varies logarithmically with the incident illumination to a maximum of approximately half a volt. The short-circuit output current is quite linear with illumination. The cell response curve may thus be tailored by choice of meter or circuit resistance.

Photovoltaic cells generate power. The conversion efficiency of silicon solar cells is several times greater than that of selenium and therefore these have served as primary power sources in space vehicles.

The spectral response peaks of available photovoltaic devices range from approximately 5600 Å for selenium to 5 microns (50,000 Å) for indium antimonide (*InSb*). Operating *InSb* cells at liquid nitrogen temperatures improves their useful sensitivity and such cells are commonly fabricated into dewar- (vacuum-bottle) type envelopes to permit efficient cooling. These devices find their principal application in military detection and IR-mapping devices and most recently in the thermal mapping of integrated circuits.

A line-operated photoelectric control that employs an SCR. The relay pulls in when the photocell is illuminated.



Due to the low voltage output and variable impedance of photovoltaic devices, their output proved difficult to amplify before the advent of the transistor. Therefore, cells were almost invariably operated directly into indicating meters or less often into very sensitive relays.

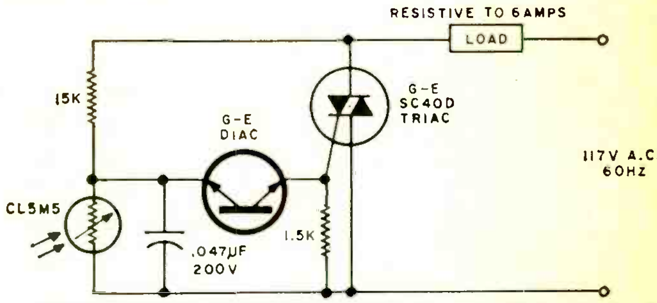
The concurrent development of silicon cells and transistors has broadened their field of applicability. Silicon cells are used in sound-movie projectors and in computer hardware such as tape and card readers.

The response time of silicon cells is in the microsecond range. Recently, silicon devices with response times in the nanosecond and even picosecond range have been announced for use in detection of wide-band multi-channel modulated laser signals.

Photoconductive Cells

Photoconductive cells are photosensitive devices whose response to incident radiation or illumination is a change in their electrical conductivity or resistance. (When the cells are dark, their resistance is high; when they are illuminated, their resistance is low.) These cells are also referred to as photoresistive types. This category includes both single and polycrystalline and both junction-type and bulk devices.

When junction-type photovoltaic cells are back-biased (potential applied to the non-conducting direction of the



CAN USE RCA-40431 IN PLACE OF BOTH SEMICONDUCTORS (OMIT 1.5K RES.)

Light-controlled triac used to operate high-current load. When cell is illuminated, triac turns off the power to load.

junction), the diode leakage current is a function of incident radiation. This current is not linear with the amount of applied voltage and is not linear with incident illumination. Response time is in the microsecond range and the effective sensitivity of very small junction units (such as are required for card and tape readers) is greater in the photoconductive mode than in the photovoltaic.

The sensitivity of silicon photodiodes is quite low. Data is generally listed for high light levels (hundreds of footcandles). Such levels are not difficult to achieve in applications where the light source and cell are quite close.

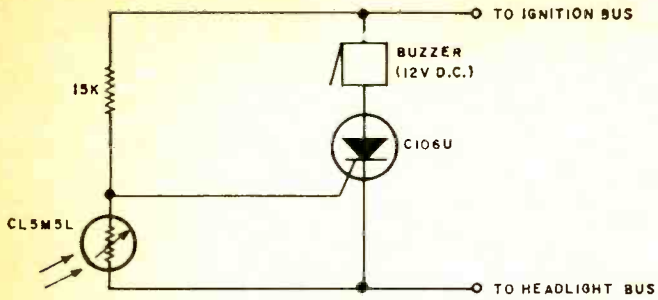
The output current of photodiodes may be amplified integrally if the diode is made one junction of a transistor, thus forming a phototransistor. By applying IC techniques, photo-Darlingtons have become available in which the photodiode is integrated into a Darlington transistor pair. The photo-Darlington provides both respectable sensitivity and sufficient output current capability to operate a relay directly.

Phototransistors are slower than photodiodes; photo-Darlingtons slower yet, although response times remain below a millisecond.

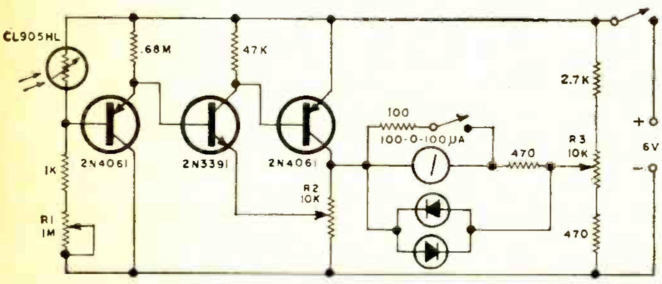
Non-junction or bulk-type photoconductive cells have been made from selenium, silicon, lead sulfide, thallium sulfide, zinc oxide, cadmium sulfide, and cadmium selenide.

While selenium photoconductive cells were among the earliest, they are presently used only in Xerographic copying equipment. Zinc oxide, in the form of a coating on paper, serves the same purpose in similar equipment.

Thallium sulfide and lead sulfide cells are primarily near-infrared sensitive devices with spectral sensitivity peaks near 9000 Å and 25,000 Å (2.5 microns) respectively. The dark (leakage) resistance of these cells is rather low, often



Auto headlight "off" alarm that sounds buzzer until headlights are turned on. Mount cell on windshield facing out. If buzzer sounds too early, increase resistor value. Circuit shown for negative ground. For positive ground, interchange connections.



Circuit diagram of a very sensitive low-level photometer circuit suitable for measurements or comparisons over extremely wide range of light levels and with controls especially suitable for use as a darkroom easel photometer. R1 may be calibrated in exposure time, R2 in paper contrast grade or filter number, and R3 in relative paper speed. To use, first preset R3 for the paper being used. With the R2 wiper at the collector of the 2N4061, set cell in darkest shadow area (brightest area on easel) and center meter with R1. Read exposure time in seconds from setting of R1. With cell in highlight area (darkest) adjust R2 for balance and read paper grade or filter number from the setting of pot R2.

below one megohm, but their speed of response makes them useful in detecting modulated radiation. Such cells have been used in sound-movie reproduction. Lead sulfide cells serve as sensors in IR heat-seeking missiles.

Our discussion here is devoted mainly to bulk-type photoconductive cells whose active material is cadmium sulfide (*CdS*) and cadmium selenide (*CdSe*). With only minor exceptions, present production and availability are limited to polycrystalline devices. Single-crystal cadmium sulfide cells exhibit additional useful sensitivity to energetic particles (such as *alpha* and *beta* radiation) and to x- and *gamma* rays. However, fabrication difficulties have virtually halted their production.

The doping of the sensitive materials and their fabrication into cell elements are highly proprietary processes. Cell elements are generally thin layers of photosensitive material on a ceramic substrate (alumina is commonly used) with metallic electrodes either on this layer or under it. At least one manufacturer fabricates cell elements of compacted sensitive material. Device packaging ranges from simple plastic dip coatings and castings to hermetically sealed all-glass and metal-glass units.

The photosensitive material used determines the intrinsic properties of the device. These include: spectral sensitivity, resistivity, slope, speed of response, temperature dependence, and magnitude of light-history effects (fatigue, memory, hysteresis).

The diposition of the electrodes upon (or under) the layer sensitive material allows cell conductance to be set to a specified light level. Cell resistance is then determined by electrode geometry. For a lower resistance cell, the gap between the electrodes is decreased and/or electrode length is increased. Low resistance and efficient utilization of element area are achieved by interdigitating the electrodes.

It might appear that the best cell is the one with the lowest possible resistance. However, lowest resistance is accompanied by narrowest electrode gaps and therefore limited voltage capability without risk of breakdown. Nor does lowest resistance invariably lead to highest effective sensitivity since, as cell resistance decreases, allowable power dissipation is approached at lower voltages.

The spectral response of a photocell is usually presented as a curve of relative output *versus* wavelength for constant energy input at each wavelength. Both the peak wavelength and the shape of the response curve are influenced by many factors. These include dopants and surface impurities, but also such purely physical characteristics as particle size and layer thickness. Thus, different manufacturers' products exhibit different response curves for nominally similar material cells.

Cadmium sulfide cells usually have peak response at about 5150 Å. Cadmium selenide peaks at 7350 Å. By mixing the sulfide and the selenide (cadmium sulfo-selenide cells), cells are fabricated with peak response at any desired wavelength between 5150 Å and 7350 Å.

The steady-state sensitivity of cadmium sulfide and selenide cells approaches that of photomultipliers. However, response times are orders of magnitude longer (milliseconds *vs* nanoseconds).

Cell speed is a function of the incident light level. Cells respond faster to higher light levels. The relationship is approximately square-root: to double the speed of response requires four times the light level.

In common with other light sensors, cells exhibit a light-history effect (fatigue, memory, hysteresis): present cell characteristics depend upon the cell's previous light exposure history. After exposure to a high light level, cells exhibit lower conductance but higher slope. Exposure to low levels, or darkness, leads to higher conductance and lower slope.

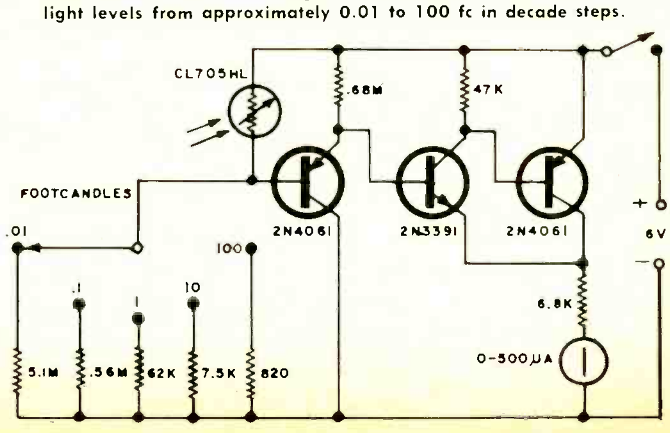
The phenomenon is totally reversible. Exposure history is cumulative and acquired rather slowly. Thus, momentary exposure to any level, or darkness, has little effect on a cell's response curve.

Temperature, too, affects cell performance. Selenide cells exhibit a negative temperature coefficient of conductance. (Cell resistance increases with temperature.) The temperature coefficient for sulfide units is much smaller and may be positive or negative depending on doping, fabrication, and light level.

Cells are spectrally selective; that is, cell output depends not only on the intensity of the incident light but also on its spectral composition. The spectral response curve describes this characteristic for monochromatic radiation. However, for applications involving illumination and photography, a derived characteristic, the color-temperature response, may be more useful. This is the plot of cell output at constant illumination, as the color temperature of the illuminant is varied.

A cell whose response curve is identical with that of the human eye would have a constant (*Continued on page* 76)

Sensitive indicating photometer schematic diagram. The cell load resistors shown will give full-scale meter readings for light levels from approximately 0.01 to 100 fc in decade steps.



BANDWIDTH REQUIREMENTS FOR FM

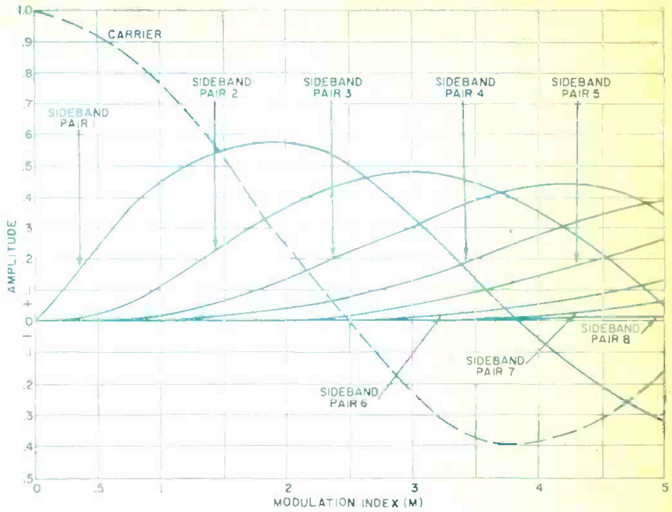


Fig. 1. Bessel-function curves showing sideband pairs in FM.

By use of Bessel functions, we find that an FM receiver must have a bandwidth in excess of the widely quoted figure of 2 × 75 kHz, or 150 kHz. For stereo, requirements are more severe.

MANY persons are very confused about the bandwidth requirements for FM receivers. They find that although a high-fidelity FM transmitter may deviate only ±75 kHz, the receiver bandpass must be greater than the 150 kHz swing of the station. Should the receiver bandpass be 200 kHz, 220 kHz, or 250 kHz, and why? Are the bandpass requirements the same for a stereo receiver as for a mono one?

One of the reasons why explanations have been lacking is that it is difficult to explain frequency modulation rigorously without using Bessel functions. These are used in the solution of differential equations. It is true that some types of Bessel functions are very difficult to use, but those applied to frequency modulation can be handled by anyone who is able to add and subtract.

Modulation Index

The *modulation index (M)* of an FM broadcast is defined as: *M(modulation index)=frequency deviation/highest audio modulation frequency*. The radio frequency being modulated may be ignored. All that is required is the deviation, which in the case of a mono FM station is 75 kHz and the audio frequency, which would be 15 kHz. The modulation index for this transmission is: $M = (75 \text{ kHz}/15 \text{ kHz}) = 5$.

Fig. 1 shows a number of Bessel function curves with the horizontal axis calibrated in M units and the vertical axis calibrated in units of relative amplitude. The amplitude of the unmodulated carrier is shown as 1 unit at the top of the vertical axis. The dashed curve shows how the carrier level changes with different values of M. The solid curves show how the level of the sideband pairs changes with different values of M. The portions of the curves shown below the horizontal zero axis mean a change of polarity.

In order to find the required receiver bandwidth from the curves, the sideband pairs are counted on the vertical M lines. On the $5M$ line there are 8 pairs of sidebands, the dashed line of the carrier should not be counted. *Bandwidth = sideband pairs × 2 × audio frequency*. In the case of the mono FM broadcast station mentioned earlier: *receiver bandwidth*=8 × 2 × 15 kHz or 240 kHz.

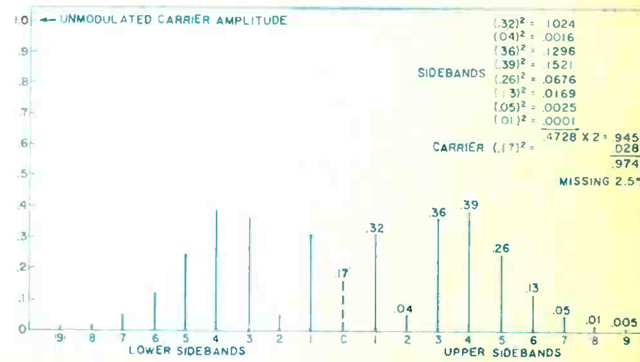
The curves show that there is no carrier at $2.5M$; this point is called a Bessel null. The curves also show that the amplitude of the sideband pairs decreases as the modulation index, M, increases: at $2M$ the highest amplitude is 0.57 and at $4M$ the highest is 0.43. Fig. 1 is limited to a modulation index of 5 because, although the sideband pairs decrease in amplitude with an increase in M, more pairs appear and the curves would be difficult to use. At $10M$ there are 14 pairs of sidebands, at $100M$, 100 pairs.

Receiver Bandwidth

From the information in Fig. 1 it is possible to construct Fig. 2A, which shows the spectrum of the transmission from the FM broadcast station. Any sideband pair with an amplitude of 0.01 (1%) or less is not used since it would contribute such a small amount to the recovered audio. Since the amplitude of sideband pair 8 is also quite small, bandwidth may be reduced from 240 kHz given previously to a value of 7 × 2 × 15 kHz = 210 kHz. If this is done, however, the loss in the recovered audio is often greater than was anticipated because the slope of the selectivity curve which eliminates sideband pair number 8 will cause a phase change and amplitude loss in sideband pairs 7 and 6 as well. Therefore, a quality FM receiver requires a bandpass of 240 kHz with perhaps a minimum of 220 kHz.

Since it is not practical to draw curves of Bessel functions using large M numbers, it is necessary to get all the information from Bessel-function tables. It is then only necessary to count the values about 0.01 in (*Continued on page* 61)

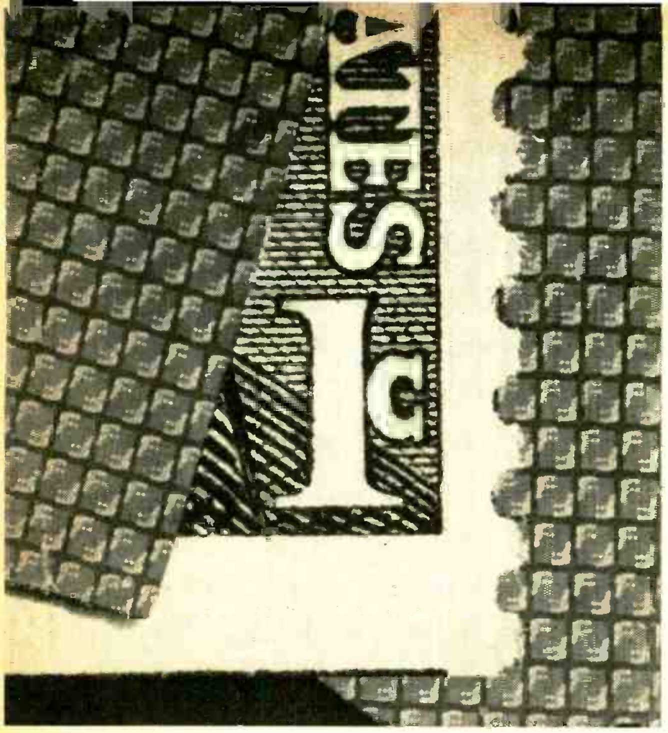
Fig. 2. (A) Spectrum of FM broadcast station with a 75-kHz deviation, 15-kHz highest audio modulating frequency, and an M of 5. (Note: amplitudes are given to only two significant figures and this accounts for portion of the missing 2.5% of total power. (B) Significant sideband pairs for various M's.



(A)

MODULATION INDEX (M)	.5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	30	40	50	75	100
NUMBER OF SIDEBAND PAIRS	2	3	4	6	7	8	9	9	11	13	14	15	16	16	18	19	19	20	21	22	23	35	45	56	81	100

(B)

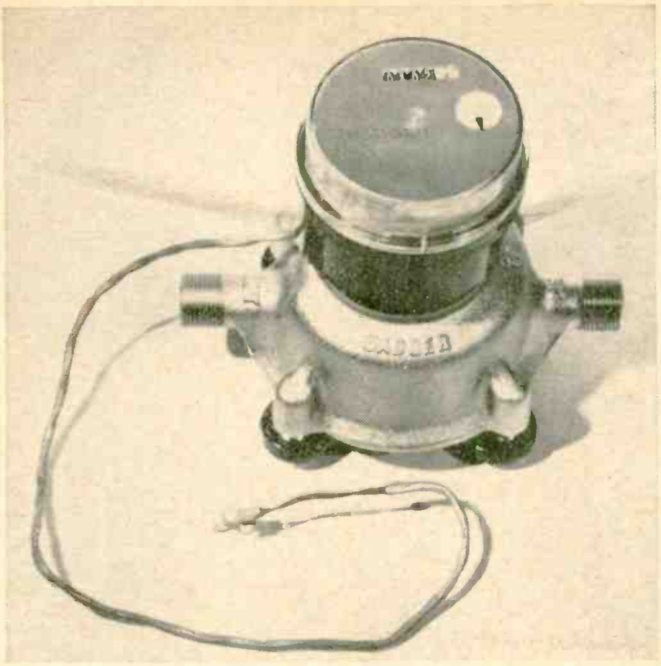


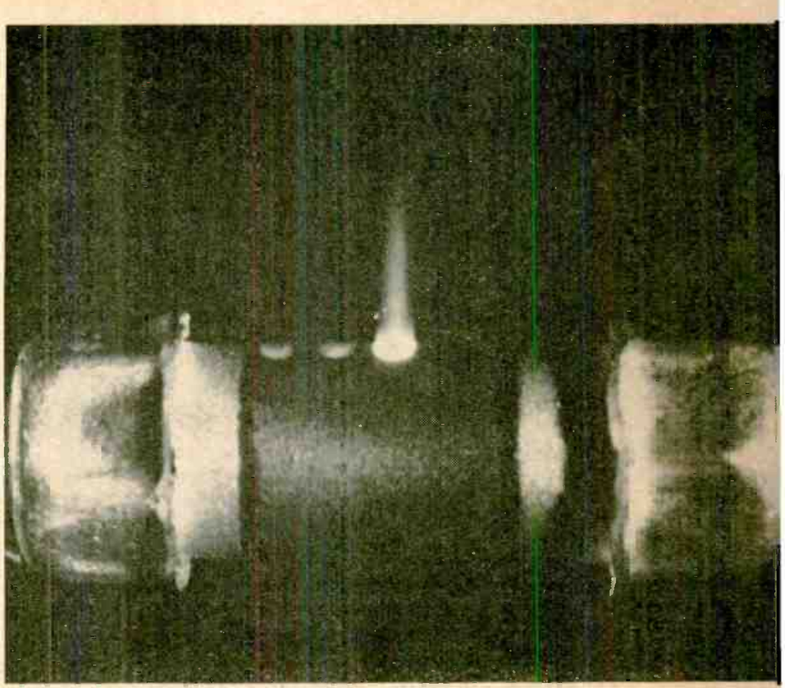
RECENT DEVELOPMENTS IN ELECTRONICS

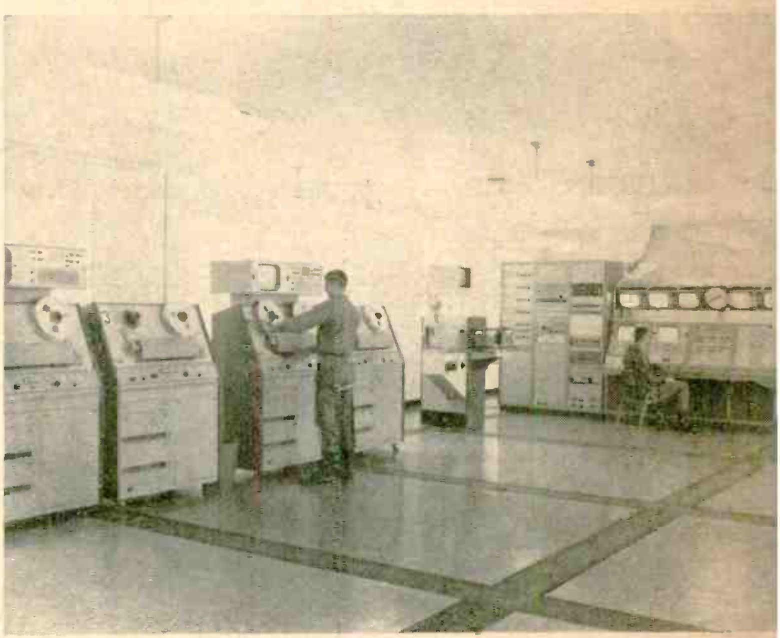
A Million Components per Square Inch. (Top left) New techniques for integrated-circuit fabrication can provide circuit arrays containing up to 100,000 bipolar-transistor logic gates per square inch of silicon. This is close to a million transistors and resistors per square inch. This density of components is from five to ten times greater than is obtainable with conventional IC manufacturing techniques. Each little square visible through a single stamp perforation hole contains 672 transistors and resistors. The circuits, developed at Bell Telephone Laboratories, operate at voltages of 2 volts and under. They use very thin epitaxial layers only about one micron (about 40 millionth of an inch) thick rather than the usual 5 to 7 micron thick layers. The thin epitaxial layers allow a reduction in the spacing between separate elements. By using narrower "stripe" widths and spacings of only about 2 to 3 microns, the size of the elements have themselves been reduced considerably.

Starlight Scope Sees in the Dark. (Center) The Department of Defense recently took security wraps off several tactical night-vision devices that have been used in Vietnam. The devices have been declassified so that the equipment could have wider use. Unlike the old Sniperscope with its infrared light source that might be detected by the enemy, the new scopes use image intensifiers and are completely passive in nature. No matter how dark an area might be, moonlight, starlight, or even faint skyglow produces a small amount of light that may be completely imperceptible to the naked eye, but with enough intensification, will result in a visible display. The image-intensifier tubes in these night-vision devices have a brightness gain of 40,000. They consist of three stages with photoemissive cathode surface at one end and a fluorescent phosphor screen at the other. An electron lens is used between cathode and screen. Curved fiber-optic faceplates are used between the three stages and at input and output ends, where the intensified image is viewed. The smallest scope can be mounted atop a rifle as shown in the photo. The small cylindrical device above the scope contains a battery-operated inverter that delivers 15 kV to each of the image intensifier's three stages, for a total of 45 kV accelerating potential. The battery, a small mercury type, has a life of about 70-100 hours. These night-vision devices grew out of a $20 million R & D contract. Current cost of the smallest scope is about $2000 each, larger versions run about $5000. Companies participating in the program are: Varo, Electro-Optical Systems, Machlett Laboratories, RCA, and ITT.

New Circulating-Liquid Laser. (Left) The development of an experimental laser system which uses a circulating liquid as the light-producing material was announced by GT&E Labs. The system is said to be the first successful application of circulating rather than stationary liquid in a laser. By using the new technique, light pulses can be produced at much faster rates and the pulses can be directed with more precision.







Meter Readings via Phone Lines. (Top left) Here is how the water meter in your home might look if it were equipped with a new automatic meter-reading and billing system produced by Badger Meter Mfg. Co. The encoder atop the water (or electric or gas) meter converts changing meter readings into changes in frequency of an oscillator. This signal is then put onto the phone lines upon command from the local utility company. In the utility billing office, the meter readings are fed into a computer which can prepare customer statements.

Resistor Trimming by Laser. (Top right) This carbon resistor is having its resistance changed a prescribed amount by the action of a laser beam. The beam goes right through the glass encapsulation and burns away a small amount of the deposited carbon resistance material. This new manufacturing technique is being used in Western Electric's Merrimack Valley Works, Massachusetts. It has resulted in cost and time savings as well as more closely controlled resistance values.

Video Tape for Army Training. (Center) Two technicians at Fort Ord, California operate the television control center from which educational and training tapes are played to Army recruits. Video tapes produced at one of five production centers throughout the country are played back at Fort Ord and 24 other TV installations in the Continental Army Command (CONARC) network. This network is said to be the largest and most sophisticated closed-circuit instruction TV system in the world, with more than 4.8 million viewers reached annually. Ampex broadcast video tape recorders are being used in system.

Computer-Controlled Traffic Lights. (Below right) New York City has been trying unsuccessfully for a couple of years to get a computer-controlled traffic system off the ground. Bugged with non-delivery or improperly operating equipment, N. Y. might look at Houston, Tex. Here an IBM data acquisition and control system operates traffic lights on the Gulf Freeway access ramps to smooth out traffic flow at peak hours. A closed-circuit TV system displays the results. Since the system has been put into operation, traffic volume actually has increased 10 percent, yet speeds have gone up approximately 30 percent, and rush-hour accidents have been cut nearly in half.

In the application of linear microelectronics to high-fidelity system design, their acceptance depends upon how much. . . .

IC Op Amps Boost Audio Circuit Performance

By SIDNEY L. SILVER

AT first glance, the monolithic or fully integrated circuit, in which all the active and passive components share a common silicon substrate, appears to offer a simple, reliable approach to audio circuit design. Owing to the extremely small physical separation of components within the silicon chip, these devices are more immune to temperature variations than their discrete component counterparts. The close spacing of components also reduces the possibility of stray electrical pickup.

Unfortunately, it is impossible to adjust these devices to meet certain circuit requirements and there are just a few types of circuit components available in a restricted range of component values. In addition, the performance requirements of many audio systems make total integration unfeasible. Although portions of an audio system can easily be implemented with integrated circuits, several critical sections are not compatible with monolithic fabrication. These include transformers, inductors, variable resistors and capacitors, and special zener or reference diodes which cannot be made by the standard diffusion process.

An alternate approach to monolithic design is the hybrid circuit, which combines the reliability of monolithic devices with the precision and flexibility of thin-film and thick-film technology. In the hybrid circuit, independent monolithic wafers are electrically interconnected by special bonding techniques, together with selected conventional micro-components. These devices, which are hermetically sealed in a high-density package, can more readily withstand environmental stresses, such as thermal shock and electromagnetic radiation, which might impair circuit function.

At the present state of the art, however, it is desirable to design audio circuits around standard commercially available microcircuits, and include external discrete components wherever they are needed. By this means, the discrete portions of the circuit permit the utilization of a wide range of complex circuit arrangements to provide complete flexibility of the operating function. The discrete components, in effect, modify the functional performance of standard off-the-shelf linear integrated circuits to achieve optimum results in a particular audio application.

Basic Configurations

Integrated operational amplifiers are ideally suited to function as basic building blocks in the construction of a wide variety of circuits in the audio-frequency range. Essentially, IC op amps selected for audio applications are general-purpose, high-gain, direct-coupled amplifiers which have a sufficient amount of negative feedback to achieve the desired gain stability, and an adequate current and voltage output for a specific design. An additional requirement is that any error currents or voltages introduced by changes in the amplifier's characteristics with ambient temperature, loading, or supply-voltage variations, be smaller than the noise and distortion levels which can be tolerated. For accuracy, the amplifiers are designed with differential input stages that easily match the characteristics of individual transistors diffused on the same chip.

In general, audio circuits employing op amps can be connected in two ways; the inverting and the noninverting modes. As shown in Figs. 1A and 1B, the connections differ only in the manner in which the input signal and the feedback are applied to the amplifier. The minus ($-$) and plus ($+$) designations on the input terminals indicate the inverting and noninverting terminals, respectively. In both arrangements, the components Z_i and Z_f are shown as resistive elements, although in many frequency-shaping applications they may represent complex impedances.

Fig. 1A is a simplified diagram of the inverting-type amplifier in which the input signal is fed to the ($-$) terminal *via* the input impedance Z_i, so that the output voltage is 180° out-of-phase with respect to the input. The feedback loop is connected to the same terminal *via* impedance Z_f, and the ($+$) terminal is normally connected to ground.

In this configuration, the driving source effectively "sees" Z_i as the input impedance since the negative feedback loop formed with Z_f creates a virtual ground at the ($-$) terminal, commonly called the summing point. Thus, any increase in current developed at the input develops a voltage across Z_f which opposes the input change. The accuracy of this action is controlled by the open loop, or intrinsic, gain of the amplifier which, in turn, regulates the degree to which the ($-$) terminal can be driven toward a null. Since the input current and voltage offsets are assumed to be small, the output voltage is substantially the voltage appearing across the feedback network. The closed-loop gain figure, or transfer function, for an inverting amplifier can thus be approximated by the equation: $e_o/e_i = -Z_f/Z_i$. The negative sign signifies phase inversion of e_o with respect to e_i. Gain figures much greater (or smaller) than unity may be obtained by proper choice of Z_f and Z_i.

It's important that the open-loop input impedance, which refers to the complex impedance across the input terminals without feedback, be greater than Z_i. But, if Z_i is too high, the closed-loop gain will be attenuated and the signal-to-noise ratio reduced. This limits the usefulness of the inverting amplifier in audio work, especially when it's necessary to amplify signals originating from a very large source impedance. Since Z_f is effectively in parallel with the load impedance R_L, the total amplifier current is the sum of the currents through both impedances. If the amplifier is to operate linearly these currents must be kept below its maximum current rating.

In the noninverting amplifier shown in Fig. 1B, the input signal is fed directly to the ($+$) terminal so that the output is in-phase with respect to the input signal. Here the feedback circuit is provided by a simple voltage divider (formed by Z_f and Z_i) which is connected back to the ($-$) terminal. Since virtually no feedback current flows into the ($-$) or ($+$) terminals, the closed-loop input impedance is primarily set by the amplifier's common-mode input impedance.

The latter parameter refers to the open-loop input impedance between the (+) input terminal and ground.

Ideally, the gains from each input terminal to the output would be equal and opposite, so that no output voltage would be produced when both inputs have the same phase and potential. In practice, however, due to component variations in the differential amplifier stages, the output is never balanced at zero. Under these conditions, there is an apparent error in the null voltage (common-mode error) which is considered to be an undesirable signal source in series with one of the input terminals. Since these error voltages effectively disappear when one of the input terminals is grounded, common-mode effects do not exist in the inverting configuration. To indicate the degree of circuit balance of the differential amplifier stages, the term, common-mode rejection ratio (CMRR) is introduced. This parameter expresses the ratio of amplifier gain due to differential signals, to amplifier gain caused by common-mode signals. For example, if a 1-millivolt normal-mode signal creates an output of 10 volts and a 1-mV common-mode signal causes an output of 10 mV, the CMRR is equal to 1000:1 (60 dB).

The noninverting amplifier is particularly useful in audio work since the large input impedance developed by the feedback arrangement permits the amplification of signals from high source impedances, and hence the attainment of high signal-to-noise ratios. A high input impedance is present even with low values of Z_f and Z_i. The result is that high-accuracies can be achieved with resistors selected for best stability instead of absolute value. Closed-loop gain for the noninverting configuration can be approximated by: $e_o/e_i = 1 + Z_f/Z_i$. This equation indicates that voltage gain values are greater than unity.

Flat Amplifiers

To illustrate how integrated circuits can simplify audio system design, a number of practical amplifier configurations are given, which utilize either the *Fairchild* μA709 or the *National* LM709 operational amplifier as the basic building block. The 709 is a general-purpose amplifier characterized by high gain, low offset voltage, low power consumption and a large output signal swing under load. Furthermore, it displays exceptional temperature stability and will operate over a wide range of supply voltages.

The microphone preamplifier in Fig. 2A operates in the noninverting mode and has a bandwidth flat to within ±0.25 dB from 20 to 20,000 Hz. The circuit is terminated in 600 ohms because this is the nominal impedance used in many audio applications involving lines, equalizers, and attenuators. Voltage gain of the op amp can be determined from the ratio: $(R_i + R_f)/R_i = (1\text{ k} + 100\text{ k})/1\text{k} = 101$. Assuming that the input transformer is ideal (it is lossless), the step-up ratio provides a gain of 8. Hence the circuit yields an over-all voltage gain of 808 (approximately 58 dB).

Since the preamp is designed for a transformer-coupled input, the secondary provides a d.c. path for the base current of the input stage, between the (+) terminal and ground. Any d.c. offset voltage developed at the input, however, may drive the amplifier into saturation unless a substantial amount of d.c. degenerative feedback is employed. This feedback is obtained by inserting capacitor *C*1 in series with shunt feedback resistor R_i. The result is high d.c. output stability. At audio frequencies, *C*1 is virtually a short circuit providing negative feedback in proportion to the $(R_i + R_f)/R_i$ ratio. For d.c., however, *C*1 is effectively an open circuit producing a much larger amount of d.c. feedback so that the closed-loop d.c. gain is unity.

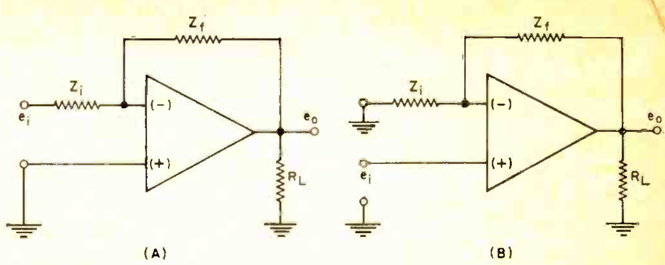


Fig. 1. Operational amplifiers in audio circuits can be connected in two ways. The inverting mode (A) and noninverting mode (B) differ in manner in which input signal and feedback are applied.

In the transition period between d.c. and the audio frequencies, *C*1 shapes the low-frequency roll-off characteristic, and therefore must be sufficiently large to make the feedback (and hence the gain) constant across the audio spectrum. Since polarized electrolytic capacitors in a.c. circuits do not act linearly toward a.c. when low d.c. voltages are present, *C*1 should be a high-quality, non-polarized type, such as a solid tantalum capacitor.

The natural response of the 709 integrated circuit is limited by internal capacitances. Therefore, stabilization is achieved by shaping the gain-phase characteristics with external frequency compensation networks. The design of these networks depends mainly upon the open-loop gain, frequency response, and the impedance at the compensation terminals of the amplifier. Owing to the high gain of the 709, two compensation networks are used to achieve good stability with any amount of feedback. To obtain the necessary roll-off characteristic, a series network, *R*1-*C*2 provides an interstage negative feedback loop and capacitor *C*3 forms an additional feedback loop around the output stage of the amplifier to give the required compensation. Using the design techniques previously described, a 40-dB line amplifier (Fig. 2B) can easily be constructed.

In many practical applications, more than one input signal is required to feed the IC op amp. The inverting amplifier in Fig. 2C makes an excellent mixing amplifier in which any number of input signals can be coupled to the (−) input terminal with essentially complete isolation between each signal channel. Mixing action is possible because each input signal contributes to the total current (summed) at the virtual ground between feedback resistor R_f and the input terminal. Thus interaction or cross coupling does not occur. The summed currents flow through R_f and generate a voltage drop which appears as output voltage across R_L.

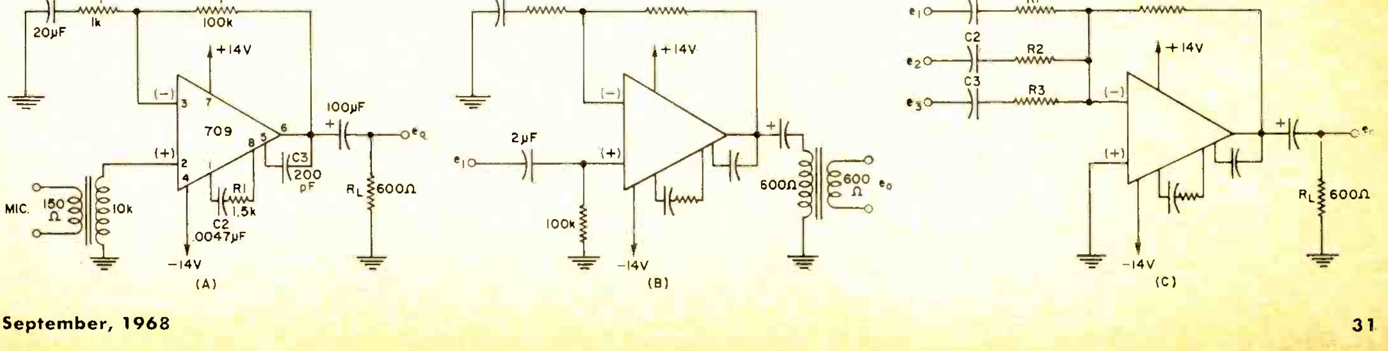


Fig. 2. The microphone amplifier (A) operates in the noninverting mode and its band is flat from 20 to 20,000 Hz. The 40-dB line amplifier (B) uses same circuit design. If more than one input signal is needed, mixing circuit (C) may be used.

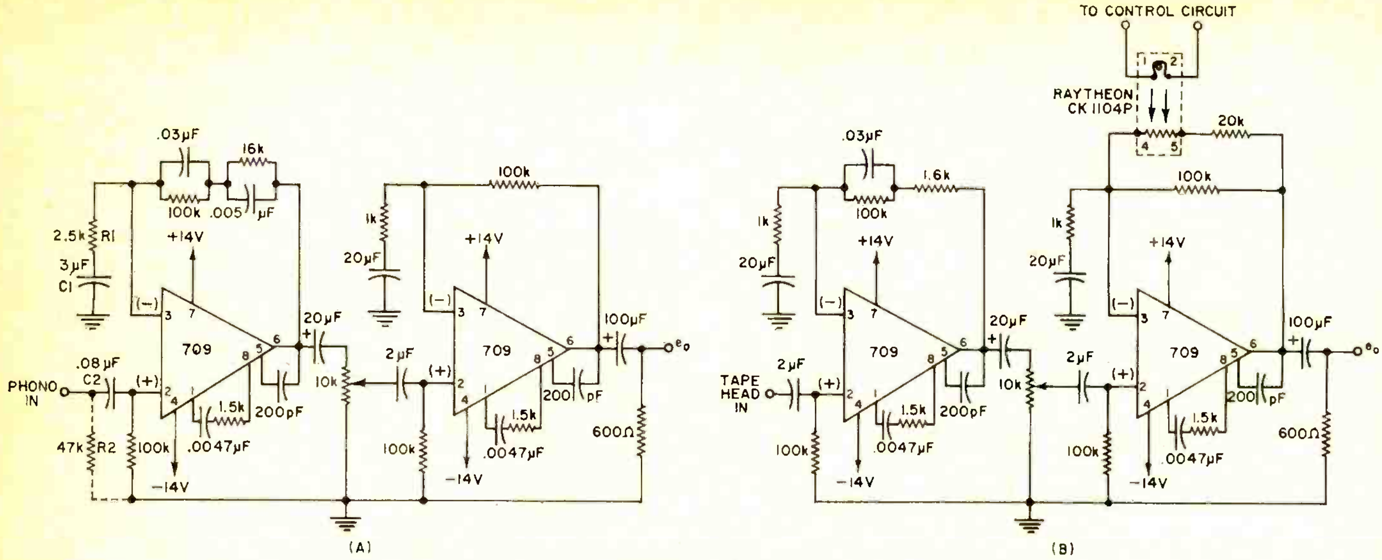


Fig. 3. RC networks in the feedback of the magnetic phono cartridge amplifier (A) compensates for the RIAA characteristic. In the other amplifier circuit (B), gain is remotely contolled by a light which varies resistance of a photoresistive element.

When each of the input resistors is equal to R_f, the circuit acts as a highly accurate one-to-one inverter. Under these conditions, the output voltage e_o may be calculated by adding each source voltage. When the input resistors are identical, and differ in value from R_f, the output voltage may be expressed by the equation: $e_o = -R_f(e1 + e2 + e3)/R1$. In other applications, the individual input resistors may be arbitrarily "weighted" or scaled before the mixing process so that each input "sees" a different value input resistor as the input impedance. The voltage output may then be obtained by the equation: $e_o = -R_f(e1/R1 + e2/R2 + e3/R3)$. In each case, the time constants formed by $C1$-$C2$-$C3$ in series with their respective input resistors are large enough to maintain the desired low-frequency response.

Frequency-Selective Amplifiers

By inserting the appropriate reactive elements in the negative feedback loop of an op amp, the normally flat wide-band response can easily be shaped to provide highly stable equalizers. Fig. 3A, for example, shows the circuitry of a preamplifier designed to work with a magnetic phono cartridge. Here the proper RC networks are inserted in the feedback loop of the first amplifier to compensate for the standard RIAA recording characteristics. The second amplifier has a flat response and is merely used to boost the input signal to line level.

The preamp requires a 6-mV input at 1 kHz to obtain a 4-dBm reference output level. Noise level is 80 dB below the reference level, and the total harmonic distortion at 1 kHz is within 0.25%. To minimize low-frequency noise and transients the circuit rejects signals below 20 Hz. The two time constants formed by $R1$-$C1$ and $R2$-$C2$ combine to produce a 12-dB-per-octave attenuation below the cut-off frequency.

The circuit of Fig. 3B shows a tape playback preamplifier in which NAB equalization provides a flat output (±1 dB) from 20 to 20,000 Hz. An input signal of 3 mV at 700 Hz gives a 4-dBm output reference. In this circuit, gain is remotely controlled by an electro-optical method, operating on the principle of a controlled light source acting on a photoresistive element. Here a variation in the input to the light source causes a corresponding change in the photocell resistance which alters the effective feedback resistance of the amplifier. This technique provides completely noise-free control of gain since no electrical connection exists between the control source and the signal circuit.

Fig. 4 shows a tone-control circuit which provides approximately 20 dB of boost or attenuation at the low and high frequencies. In this circuit, the op amp functions as a

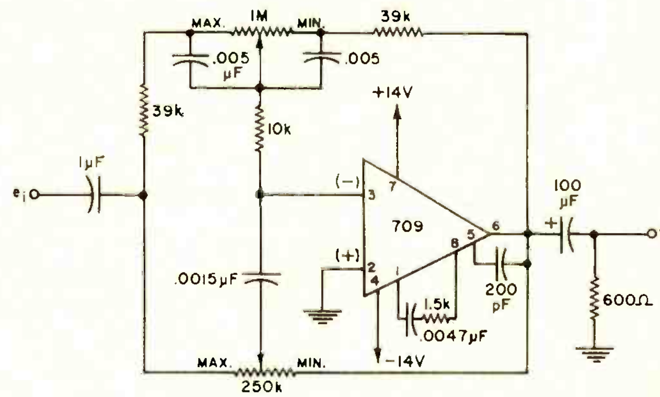
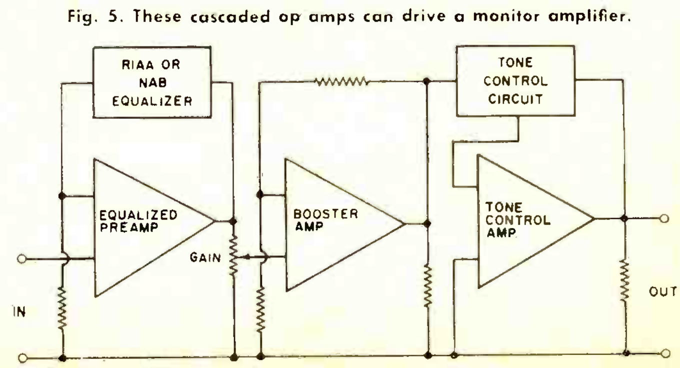


Fig. 4. Tone-control circuit in this amplifier provides about 20 dB of boost or attenuation at low and high audio frequencies.

unity gain inverter when both tone-control pots are set at mid position. When the pots are adjusted to maximum position, a feedback ratio, and thus a gain, of 10/1 (or 20 dB boost) is obtained at 50 Hz and 15 kHz. Setting the pots to minimum position provides a feedback ratio of 1/10 (or 20 dB cut) at the same frequency limits. In each case, the circuit parameters in the frequency-sensitive feedback loop are selected so that unity gain is maintained at the 1-kHz reference point (when the pots are in maximum or minimum position). Fig. 5 is a simplified block diagram of a complete preamplifier system that is used to drive a monitor amplifier.

Recently, *Radiation Inc.* has introduced the type RA-909 operational amplifier which can be employed as a direct replacement for the type 709, and requires no external compensation networks. ▲

Fig. 5. These cascaded op amps can drive a monitor amplifier.



HOW TO FLY TO THE MOON AND GET THERE

Mosaic of 212 pictures of moon taken by Surveyor VII's TV camera forms panoramic view of highlands about 18 miles north of crater Tycho.

By LEONARD H. DAVIDS / Hughes Aircraft Co.

Guidance systems which control spacecraft trajectories are complex devices. Here is how inertial, celestial, and radio guidance is used to aim spacecraft at the moon.

HOW do you guide a spacecraft from earth to the moon . . . or Mars? We've known how it could be done (theoretically) ever since Johannes Kepler, the German astronomer, developed his laws of planetary motion in the 17th century, but it was only about ten years ago that we became technically capable of doing it. Actually, it's the marriage of precise orbital dynamic equations with existing technological capabilities that has created a special field of engineering—spacecraft guidance and control—and pushed us, and the Russians, upward and onward in a race to the moon.

It's easy to see the problems associated with guiding a spacecraft from earth to the moon, neighboring planets, or planetary satellites if we use the Surveyor spacecraft as an example. During the earth-to-moon flight, there are three guidance phases separated by periods of coasting. The first is the injection guidance phase in which the spacecraft is put into an elliptical or hyperbolic trajectory relative to earth (with the exception of station keeping, this is the only guidance usually required for near-earth satellites). The second phase is the midcourse guidance phase in which injection guidance errors are corrected so that the trajectory errors fall within the terminal guidance capabilities. The final phase is concerned with guiding the spacecraft through either a fly-by (current Mars and Venus probes), orbital-injection (Lunar Orbiter), or soft-landing (Surveyor) modes. Of course, there are combinations and variations of these general mission types such as the Ranger with its hard-impact landing or the proposed Voyager spacecraft to Mars which includes both an orbiting vehicle and a soft lander.

All guidance systems, irrespective of type, must be capable of determining vehicle attitude, vehicle velocity and position, and time. If the vehicle's velocity and position are determined by on-board accelerometers having an inertial attitude reference, the guidance system is usually classified as inertial. If ground-based radio tracking and on-board celestial sensors are used to determine the vehicle's position and velocity, then it has a combination celestial-radio guidance system. For the Surveyor missions, the injection guidance system on the Centaur launch vehicle was inertial. The mid-course guidance system could be classified as a combination of all three since the spacecraft's initial position and velocity were determined from radio tracking, an on-board accelerometer measured and controlled the actual velocity correction. The spacecraft's terminal phase is radio guided with its initial conditions determined by a combination of earth-based radio tracking and an on-board radar sensor. During the powered portion of the terminal flight phase, on-board radars measured both velocity and position relative to the moon's surface. These classifications are, of course, subject to various interpretations, but are important because they give an indication of guidance system mechanization.

The spacecraft's control system is tied in closely with the guidance system and has the job of executing the guidance commands. These commands can be in the form of accelerations or attitude maneuvers. Functional elements of the control system can be, and usually are, part of the inertial guidance system. The accelerometer, which is used as a source of velocity and position information, may also be used as the main reference source to control vehicle acceleration. The gyros also serve the two main functions; they provide a fixed inertial attitude reference for the ac-

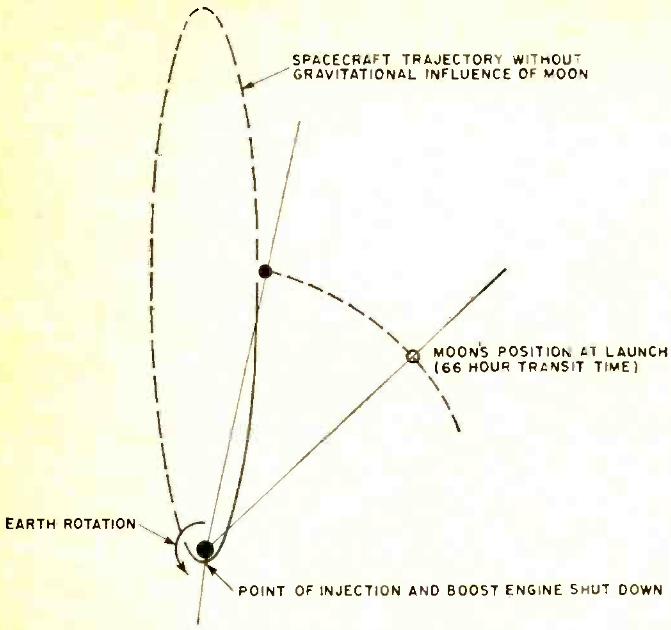


Fig. 1. It takes about 66 hours for the moon and a spacecraft traveling initially at 25,000 m.p.h. to run into each other.

celerometers, and a reference for vehicle attitude stabilization.

Injection Guidance and Control

With the exception of the Gemini and Apollo spacecraft, which contain backup systems, the boost vehicle guidance system is separate from the spacecraft. Its job is to place the spacecraft on a trajectory sufficiently close to the target so that the spacecraft's midcourse guidance equipment can correct the injection errors. The magnitude of the injection errors is important because they influence how much propellant the spaceship must carry.

It takes about 66 hours for the moon and spacecraft to run into each other. Fig. 1 shows how it is done. If a spaceship were launched normally, and the moon did not "get in its way," it would go into an elliptical orbit about the earth. By the time the spacecraft has reached the vicinity of the moon, it has slowed from a velocity of approximately 25,000 miles-per-hour to 2200 mi/h. These speeds correspond to a nominal earth-to-moon transit time of 66 hours and, since the moon's orbital velocity is 2300 mi/h, the concept of their running into each other is easily understood.

"Shooting" spacecraft at the moon is really quite sophisticated. The heart of the system is the inertial platform which is suspended by three, or perhaps four, gimbal axes, each axis having a servo torquing drive motor capable of rotating the gimbal on command.

Fig. 2 diagrams a 3-degree of freedom, 3-axis stable platform of the type used for many space shots. A 4-gimbal system is better, but the additional weight and complexity of the extra gimbal is undesirable. The problem with a 3-gimbal system is that a condition called "gimbal lock" can develop. This condition occurs when the vehicle rotates about the middle gimbal axis (approximately 90°) in such a way as to make the outer gimbal parallel with the inner gimbal axis. Now if the vehicle rotates about an axis perpendicular to the outer gimbal plane, there isn't a gimbal axis available to absorb the effects of the rotation and the platform is pulled from its reference plane. In practice, the problem is avoided because the vehicle's trajectory is fixed and the inertial unit can be aligned on the launch pad so that all rotations occur about the inner gimbal axis.

As the craft maneuvers through space, the stable platform's gyroscope can sense angular rotation in any of three orthogonal directions. These errors in platform attitude are fed back as commands to the gimbal torquing motors which try to return the platform to its original position. The most common gyro used for this purpose is the single-degree of freedom "integrating" gyro (Fig. 3). If this gyro's case is rotated about its X input axis at a rate ω, the output θ is described by the equation: $\theta/\omega = (H/C)/S(\tau S + 1)$, where S indicates an integration and $(\tau S + 1)$ is the dynamic lag. Therefore, in the steady-state condition, the output θ is the integral of the input angular rate ω. Removing the dynamics from the equation, it becomes $\theta/\theta_i = H/C$, where θ_i is the input angle, H is the rotor's angular momentum, and C is its viscous friction coefficient.

In addition to the gyros, the platform contains three extremely accurate accelerometers that measure the slightest acceleration of the booster in any of three orthogonal directions. Their outputs are fed to a computer which keeps a running account of the spacecraft's velocity and position in three-dimensional space. Using pre-programmed guidance equations, the computer compares the ship's actual position and velocity with that which is desired, and modifies the booster steering commands to null out differences.

Fig. 4 diagrams the Surveyor's launch phase. Immediately after liftoff the vehicle is rotated so that its pitch axis is perpendicular to the trajectory plane. Following the roll maneuver, the vehicle is programmed through a pitch maneuver in what is called a "gravity turn." The initial "kick angle" of this maneuver fixes the profile that must be followed while the booster remains in the earth's atmosphere.

At the end of the initial liftoff period, the equation which describes the vehicle's velocity is: $v = c \ln R - g\,(t_b - t_0)$, where R, the mass ratio, is defined by the ratio of the ve-

Fig. 2. A 3-degree of freedom 3-axis stable platform.

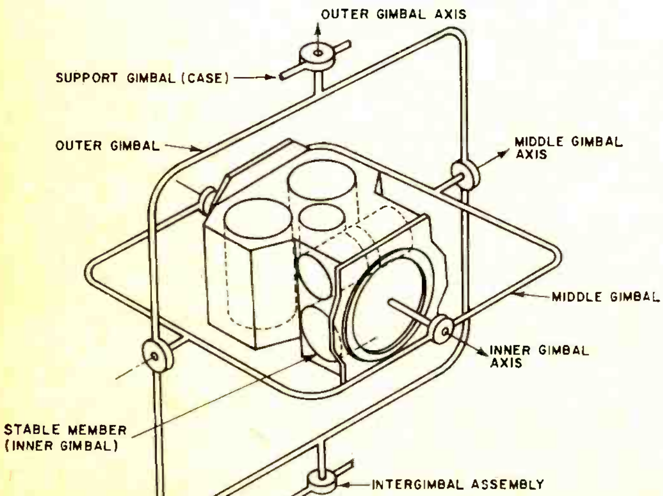
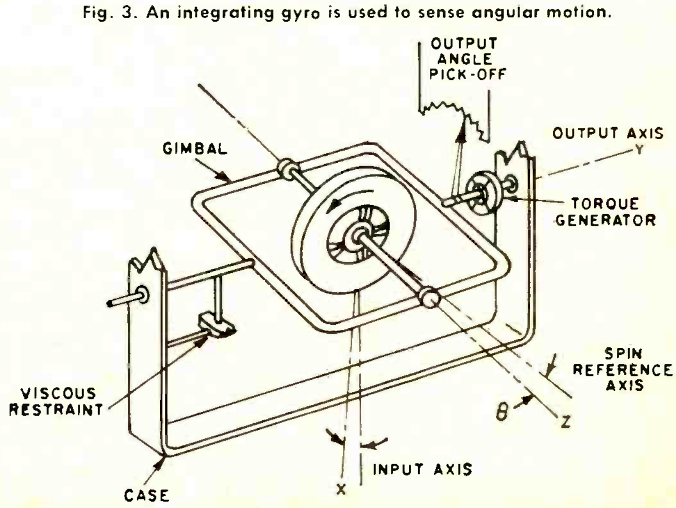


Fig. 3. An integrating gyro is used to sense angular motion.



hicle's launch weight, M_0, to its weight at end of this phase, M_b, and where c equals the propulsion system performance parameter and g is the earth's gravitational constant.

During the programmed pitch maneuver, the pitch rate is controlled so that the vehicle follows a zero angle of attack, that is, the vehicle's longitudinal axis is aligned to the velocity vector. This flight profile minimizes aerodynamic structural drag and rocket engine inefficiency due to atmospheric pressure and "g" losses. The "g" loss term [g (t_0-t_b) in the previous velocity equation] is subtracted from the thrust acceleration term while the vehicle is in vertical flight. By rotating the thrust acceleration vector, the effect of the "g" loss is minimized and the earth's rotational velocity is added to the final injection velocity.

After the booster engine has been jettisoned, the pitchover program is terminated and the steering commands are initiated by the guidance system. These commands are based on the inertial measurements of the vehicle's position and velocity and the desired injection conditions. After the Atlas sustainer rocket cuts off, the high-performance Centaur engines are ignited and the final injection velocity is achieved in what is called a direct ascent trajectory. The Centaur boost phase is divided into two parts. The first engine burn places the spacecraft in a low orbit approximately 90 miles high, then it is allowed to coast to the injection point at which time the engines are re-ignited and the final injection velocity is achieved. This method of injection is called a parking orbit trajectory.

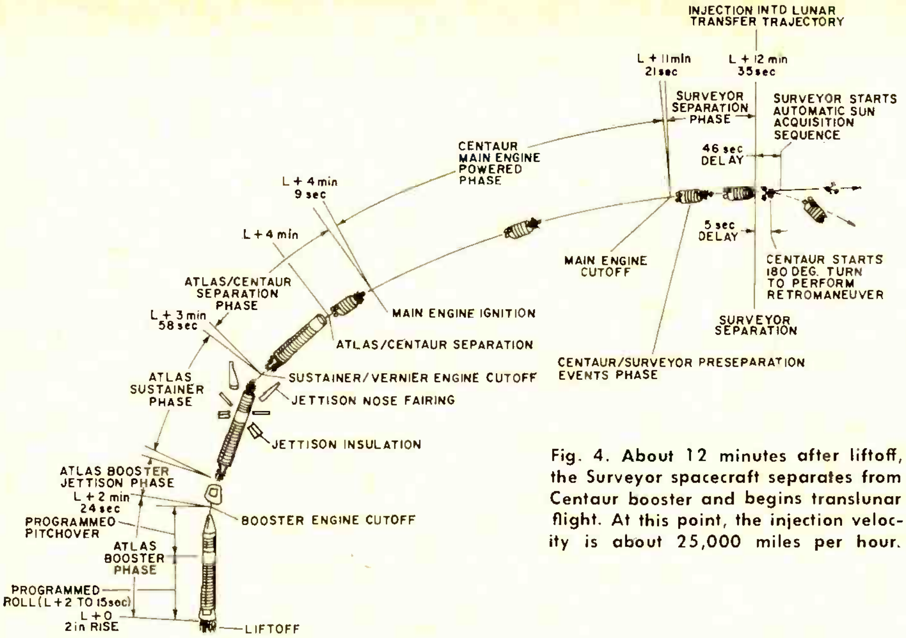


Fig. 4. About 12 minutes after liftoff, the Surveyor spacecraft separates from Centaur booster and begins translunar flight. At this point, the injection velocity is about 25,000 miles per hour.

Launch Windows

You can't launch a space vehicle any time you want to. The allowable times are commonly called "launch windows" and, depending on the mission, these "windows" can occur daily, monthly, yearly, or a combination of all three. If we study the geometry of Fig. 1, we can see some of the restrictions of the daily launch window. Note that at touch down, the injection point is approximately 180° away from the earth-moon line. This angle is fixed by the transit time and has to be held fairly constant. And since the trajectory arc from liftoff to the injection point is fixed, this limits the position of the launch pad relative to the earth-moon line. Since the launch pad passes through this desired point once a day, this is a daily launch window. The length of the daily launch window can be increased (in time) by placing the vehicle in a parking orbit and allowing it to coast with engines off to the injection point where the engines are re-ignited. If the length of the coast arc is varied, the position of the launch pad relative to the injection point is varied and the liftoff time is increased. The Apollo launch system will theoretically eliminate the daily launch window by placing the space capsule in an orbit with unrestricted coast arc. Thus the spacecraft will pass the injection point every two hours.

Monthly launch windows are limited by conditions at the landing site. Since the Surveyor spacecraft was not designed for lunar night survivability, it had to land during the morning hours of the lunar day to assure maximum operating time. The monthly launch window is eight days long and the lunar day 13 days long. Thus, there are five operational days on the moon. (The term "monthly launch window" is a misnomer, the constraint is really tied to a lunar day which just happens to be approximately one month in length.)

"Yearly launch windows" arise from a desire to minimize injection energy requirements or, in other words, to have a maximum payload for a fixed size booster. As an example, launch times to Mars occur at an approximate two-year interval.

Vehicular Controls

Vehicle control functions are limited to controlling attitude and initiating engine cutoff as commanded by the guidance computer. Acceleration due to thrust is not controlled since the booster engine(s) is usually fixed thrustwise. Abnormal thrust must be compensated by modified steering commands or engine cutoff time, or both. Pitch and yaw control is provided by gimbaling the main engine, while roll control is maintained with either small auxiliary engines or by gimbaling the main engines when more than one is used.

Both radio command guidance and inertial guidance systems have been used with success. However, in the present state of hardware development, it appears that the inertial system is best. The ascendancy of inertial guidance probably can be explained by the simple fact that inertial injection accuracies are more than adequate for most missions and the system does not require the ground support of radio command guidance systems. To prove this point, one may consider the Surveyor missions in which all seven injections were completely successful. To correct injection errors, the spacecraft was required to expend an average of less than 3

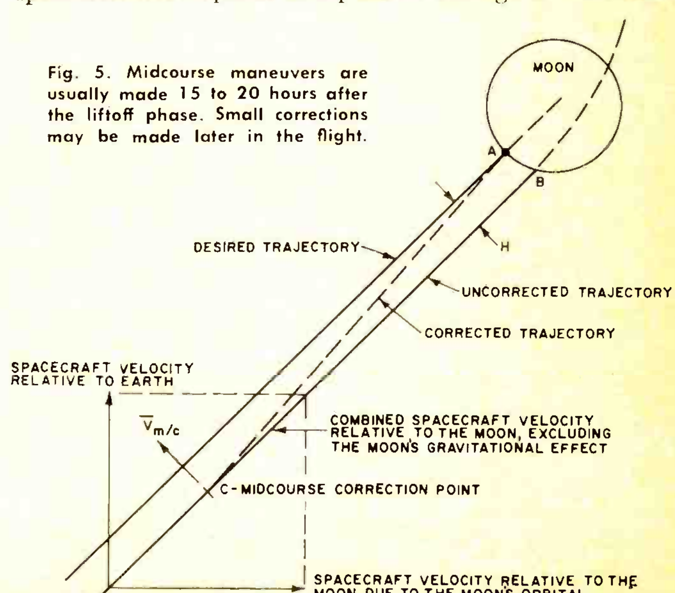


Fig. 5. Midcourse maneuvers are usually made 15 to 20 hours after the liftoff phase. Small corrections may be made later in the flight.

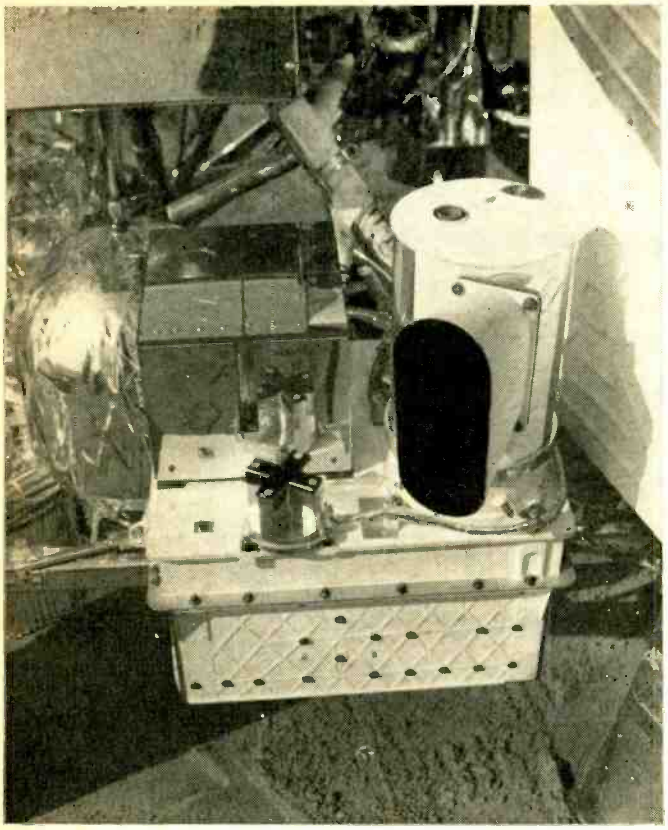


Fig. 6. Cylindrical object with dark opening (right) is part of the sensor which controls the spacecraft's attitude with reference to the star Canopus. Flight control electronics are in the white box in the lower portion of the unit and the polished rectangular container behind the sun sensor contains the inertial reference unit which senses pitch roll and yaw.

pounds of propellant (maximum was less than 6 lbs for the third spacecraft). The significance of these numbers becomes clear when they are compared to the 1430 pounds of propellant carried by the spacecraft.

Midcourse Guidance and Control

The midcourse guidance system corrects injection errors and compensates for other known deviations in the total system performance.

Examine Fig. 5. If the outward velocity of the spacecraft (relative to earth) is combined with the orbital velocity of the moon, the result is the spacecraft velocity relative to the moon. Assume that the desired trajectory passes through point A, but due to injection errors the actual trajectory (if left uncorrected) passes through point B, then if the spacecraft is at point C when the midcourse maneuver is performed, a velocity correction in the direction of $\overline{V}_{m/c}$ will cause the trajectory to follow the dotted line. If T is the time from the midcourse point to the terminal phase, and H is the distance that the trajectory must be corrected, then $\overline{V}_{m/c}=H/T$. In like manner, if it is desired to arrive at the moon earlier or later than the prestated time of arrival, velocity changes may be made toward or away from the moon. These corrections do not change the ultimate destination, but only the time of arrival.

The importance of midcourse guidance is perhaps best illustrated by an event which occurred during the fifth Surveyor flight. During the mission, the propulsion pressurization system developed a leak which dropped the supply pressure to less than one-third its normal value. Through use of extensive midcourse corrections, the terminal conditions were altered and the spacecraft landed as planned.

This event also points out the extent to which "man is in the loop" in guidance of unmanned spacecraft. Generally, the guidance is ground based, and radio tracking determines the spacecraft's position and velocity prior to the terminal descent. Only during the brief terminal phase must guidance equations be automated on-board the craft.

To properly execute guidance commands during the midcourse and terminal phases, the spacecraft must have means for controlling its attitude accurately, and either controlling or measuring its acceleration. Usually, the attitude control occurs in two phases. The first applies to the coast period in which the spacecraft is allowed to "free-fall" and the only forces acting on it are gravitational forces. During this period, the vehicle must be held in a stable and constant attitude so that temperatures inside the spacecraft will stay reasonably constant and scientific instruments, engineering sensors, and navigational equipment can be pointed in the correct direction.

On the Surveyor spacecraft, attitude was controlled by a cold gas nitrogen system with small thrusters located on the landing gear legs. These small thrusters (0.05-lb thrust) are pulsed "on" and "off". The prime attitude reference sources are the star Canopus, located in the southern hemisphere, and the sun. With special optical sensors and gas jets, the axis of the spacecraft can be accurately pointed in the direction of these celestial bodies to provide an accurate and nearly inertial reference. During this period, the on-board inertial system, composed of three integrating gyros rigidly aligned to the spacecraft axis ("strapped-down inertial system") serve as an attitude stabilizer rather than a prime reference. The optical sensors, gyros, and associated electronics are shown in Fig. 6. The strapped-down inertial system is very similar to the fixed inertial platform, if the entire spacecraft to which the gyros are mounted is considered as the platform. Since the spacecraft is free to rotate in any direction, it is the equivalent of the gimbal rings with no possibility of gimbal lock and the small gas jets act as the torque motors in maintaining a fixed inertial attitude. However, the similarity ends when the spacecraft is rotated since the accelerometer, also rigidly mounted to the spacecraft, rotates away from its initial position. Thus to rotate the spacecraft away from the sun and Canopus for the purpose of either performing a midcourse maneuver or preparing for the terminal phase, the attitude reference is switched from the optical to the inertial system. Under this condition, the spacecraft's attitude is held fixed except for "drift" errors in the gyros or an intentional change in the gyros' reference. To perform pitch maneuvers using an inertial platform, a spacecraft is rotated by gas jet or rocket engine until the gimbal angle sensor on the pitch axis reaches the desired value. In the strapped-down system, the same maneuver is accomplished by torquing the pitch gyro inertial wheel at a known angular rate for a time proportional to the desired angular change. As the wheel is torqued, an error output is generated between the gyro case and wheel. This signal is used to activate the gas jets which the spacecraft uses to achieve the angular rate of the torqued inertial wheel.

Once the spacecraft has been reoriented in the desired direction, corrections in trajectory may be made by firing the three vernier engines. These engines are placed symmetrically around the center of the spacecraft and are individually controlled.

Midcourse guidance errors for the seven Surveyor spacecraft are summarized in Table 1. Of the five spacecraft that successfully soft-landed, four of their landing sites were determined from high-resolution Lunar Orbiter photographs. Spacecraft V landed outside of the area of high-resolution photographs due to large midcourse errors and could not be pinpointed. As noted in Table 1, the predicted landing accuracy prior to the midcourse maneuver, is a combination of execution errors and uncertainty in the uncorrected trajectory. Errors in the earth-based tracking data used to determine the uncorrected trajectory transforms directly into errors in the corrected trajectory. The prime source of data used to determine Surveyor's trajectory was the vehicle's

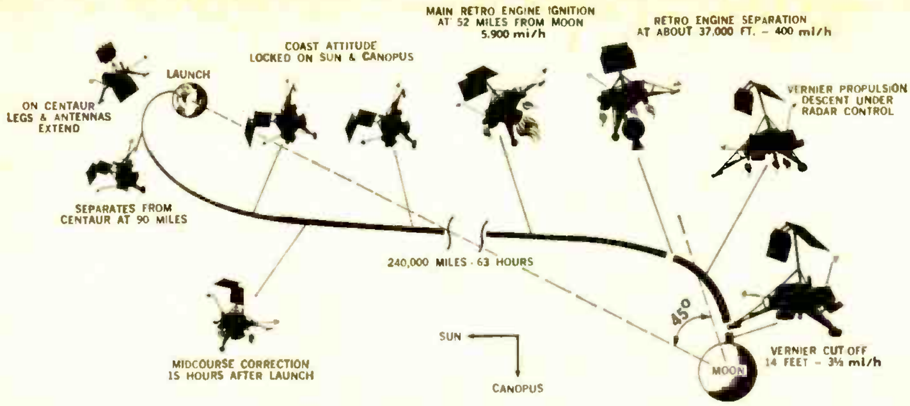


Fig. 7. The landing approach used by the Surveyor vehicle to set it on the moon.

velocity as determined by the doppler shift in the radio communications signal. Software not hardware limits the precision of trajectories computed from doppler data.

Terminal Guidance and Control

The Surveyor terminal guidance system was designed to be both simple and reliable without redundant hardware. For example, this system does not employ the relatively complex stabilized inertial platform or a thrust termination system which depends on a highly accurate integrating accelerometer. The same task is performed by simple strapped-down integrating gyros and a solid-propellant engine. The larger errors associated with this simpler system are a major problem during the descent phase. The soft landing task is controlled by an on-board radar.

Fig. 7 shows the direct landing approach used by Surveyor. The total velocity relative to the moon's surface is obtained by combining the outward velocity of the spacecraft (in its elliptical orbit relative to earth) and the orbital velocity of the moon. Since both of these velocity components are of the same relative magnitude, the combined velocity vector is at an angle of approximately 45 degrees with the earth's direction. Depending on the position of the spacecraft relative to this velocity vector passing through the moon's center, it will land at different points on the moon's surface at an incidence angle proportional to the displacement. Thus, when the spacecraft follows a trajectory which passes through the moon's center, the problem of soft landing is simply the method of reducing the approach velocity from its maximum value of 6000 mi/h to zero at the moon's surface. This is much like racing toward a brick wall at 100 mi/h and trying to decide when to put on the brakes so you won't dent your bumper or your head.

Therefore, the spacecraft's initial position and velocity must be known precisely. To minimize complexity, maximum reliance was placed on earth-based tracking. Accurate knowledge of both the moon's and spacecraft's velocity enabled calculation of the velocity direction to better than 0.1 degree and the absolute velocity magnitude to better than 1 mi/h. However, the tracking system could not pinpoint the spacecraft's position relative to the moon's surface to within 3 miles at best and this big an error would cause the spacecraft to have a velocity of 250 mi/h when it reached the moon's surface.

Table 1. Surveyor guidance errors.

SURVEYOR SPACECRAFT	PRE-MIDCOURSE LANDING UNCERTAINTY, 99%, Miles			FINAL LANDING ERROR, Miles
	Expected Error of Execution	Track. Uncertainty	Total RSS*	
I	18.3	10.7	21.2	12.0
II	12.3	26.5	29.2	[1]
III	4.4	6.8	8.1	1.7
IV	5.6	2.3	6.0	5.4[2]
V	6.0	97.1	97.3	19.0[3]
VI	5.4	8.1	9.7	6.2
VII	18.7	36.0	40.7	1.0

Notes: [1]One vernier engine malfunctioned during the midcourse maneuver, resulting in mission failure. [2]Signal from spacecraft abruptly stopped during main retro descent phase with no warning. Landing error, assuming it did land, is based on ground-based tracking. [3]Landing error also based on tracking rather than Lunar Orbiter photographs.
*The total of statistical errors is the square root of the sum of the squares.

To solve this problem, a pulse-type radar was installed on the spacecraft. It measures the transit time of the radar pulse from the spacecraft to the moon's surface and back again and gives a signal when the landing vehicle is about 60 miles above the moon's surface. This type of sensor reduced the uncertainty in the spacecraft's actual position to about 0.2 mile.

The final problem is to determine the spacecraft's attitude so that it can be aligned with the velocity vector. Again, the same on-board optical sensors during the midcourse and coast phases are used to establish an inertial reference system and spacecraft control is switched to the gyro inertial reference system. Using ground-based computers and guidance equations, the necessary attitude maneuvers are computed and transmitted to the spacecraft for execution. Sequential maneuvers about two axes are required to align the thrust axis. A third attitude maneuver about the thrust axis is usually performed to optimize the earth-spacecraft communications link by pointing the transmitting antenna at the earth and to maximize performance of the landing radar. After this final maneuver, power is applied to the marking radar and the high-thrust, solid-propellant engine (main retro) is ignited when the range or altitude reaches a predetermined value.

The main retro engine brakes the spacecraft from 6000 mi/h to approximately 350 mi/h while the inertial reference system maintains a fixed attitude. The three small vernier engines used to maintain attitude control during this period are then throttled down to minimum thrust after the main retro firing has ceased. During this period, on-board radars start measuring both range to the surface and velocity. By comparing these parameters in a simple analog computer, the exact point at which the engines must be up-throttled to successfully soft-land may be computed. In this manner, uncertainties in ignition altitude and main retro performance are cancelled by making sure that the nominal coast distance from retro eject to the high vernier thrust is larger than the uncertainties. On the Surveyor, only 10 to 15 lbs of extra propellant was needed to accommodate the main retro phase dispersions.

During the final descent phase (starting at 350 mi/h nominally), both velocity and altitude are continually measured and the thrust is modulated to insure the correct conditions at touch down. It is during this period that the inertial attitude system serves as a stabilization reference while the radar velocity sensor is used to maintain the thrust axis alignment. *(Continued on page 78)*

super sound system

Speakers mounted on side of Air Force Cessna observation plane broadcast psych-warfare messages to enemy.

By FRED BIELER / University Sound, LTV Ling Altec, Inc.

Psychological warfare planes must dodge bullets as they broadcast to enemy troops. A new audio system lets them fly out of range.

THE job of piloting a psychological warfare plane in Vietnam is an extremely dangerous one. The psych-warfare planes which fly over enemy lines and broadcast messages are constantly the target of small arms fire from the ground because the power amplifiers on board the light aircraft are bulky and heavy and have such low output that the planes are forced to fly at 3000 feet or below to broadcast their messages. This altitude is well within range of small arms ground fire.

What the Air Force needed was a speaker/amplifier combination that would be capable of being heard clearly on the ground from a mile or so in the air. While this is not quite beyond small arms range, this altitude reduces the effectiveness of such ordnance. Many manufacturers, and the Air Force, considered the job almost impossible because of the plane's weight and space limitations and the power that would be required for high audibility coverage from that altitude.

Sounds from the Sky

A speaker/amplifier system called the SA-1800C, manufactured by *University Sound*, was developed to do the job. With a system capacity of 1800 watts and a highly efficient directional trumpet, the SA-1800C is capable of broadcasting audible messages to the ground from a height of almost two miles, twice that of the Air Force's most optimistic requirement and considerably more than three times the best previous performance level.

The speaker assembly is a Model B-24PT 1800-watt unit, an improved version of a speaker developed in the early 1950's for psychological warfare use during the Korean conflict. During that conflict, such speaker systems were mounted in the bomb-bay sections of B-26 medium bombers. The power capacity of the original B-24 speakers was limited to 720 watts by the driver units available at the time—they had a 30-watt capacity.

The current B-24PT loudspeaker system is composed of a compact, die-cast horn and multiple-driver throat assembly using 24 ultra-high-efficiency compression drivers with a capacity of 75 watts r.m.s. each. The driver units are *University* Model ID-75's in an 8-ohm configuration. The high power handling capacity and efficiency of these compression-loaded ID-75's was made possible by several technological breakthroughs. A carefully designed concave-convex phenolic diaphragm completely eliminates diaphragm break-up, a former cause of distortion and a loss of efficiency. Another high power nemesis, heat buildup, was handled by using new materials in the voice coil. Experiments showed that temperatures in the voice-coil area could reach over 450° F in operation. The use of H-class, high-temperature-film voice-coil formers and wire now permits the voice-coil temperatures to reach 1700° F without breakdown, far beyond the heat levels expected to be reached during actual broadcasting.

The 24 drivers are wired in six arrays of four drivers each. The impedance of each array is 2 ohms and an ideal match for the low-impedance transistorized amplifiers. The 1800-watt r.m.s. speaker is amazingly compact, measuring 24″ × 22″ × 19″ and weighing only 75 pounds, less drivers. The weight increases to only 171 pounds when the 24 drivers are added. The speaker dispersion is 90° high by 45° wide and frequency response is from 200 to 7000 Hz.

The amplifier section of the system consists of an 1800-watt bank of three newly developed, solid-state, 600-watt amplifiers in parallel, a remote-control panel, and a distribution panel. The convection-cooled amplifiers measure a compact 8″ × 6¾″ × 10⅞″ each and a three-bank, 1800-watt assembly will fit into a space measuring only 12″ high × 28″ wide × 15″ deep. The amazingly light (only 11.3 pounds each), fully transistorized amplifiers operate at an efficiency factor of 70%. Interconnecting cables are used so that each amplifier may be separately installed remote from one another within cable limitations, or they may be installed in banks of two or three. This is of prime importance in light aircraft configurations, where available space is at a premium.

Interconnection of the three amplifiers is made through prefabricated cables to the distribution panel which serves as a junction box for the remote-control panel. The distribution panel also provides isolation and coupling facilities for operation of the three 600-watt amplifiers from a common low-level input. Three transformers provide isolation and three high-current d.c. contactors are used to apply operating power to the three amplifiers.

A transistorized voltage regulator supplies 12 volts d.c. to the remote-control unit at 0.7 amp to operate an optional tape recorder. The power input for the system, 28 volts d.c. at 90 amps, is fed directly to the distribution panel and then distributed to the three 600-watt amplifiers.

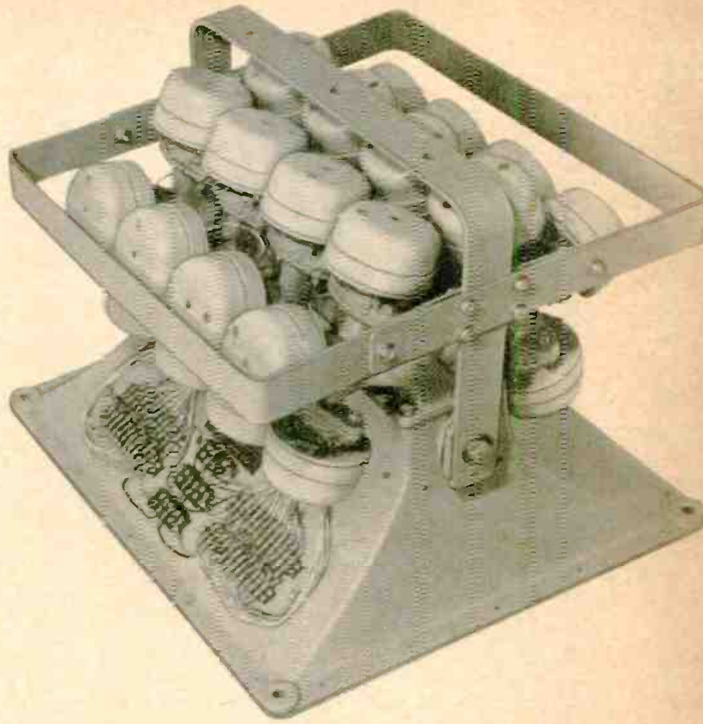
The remote-control unit contains all connections, controls, and indicators needed to operate the system as an integral part of a vehicular or airborne system or from a remote position. The panel controls include a system power switch, a microphone volume control, a tape recorder volume control, plus three vu meters to indicate the power output of each of the three amplifiers and three pilot lights to indicate d.c. power to the three amplifiers. The remote-control box also contains separate inputs for a microphone and tape recorder.

Multiple Uses

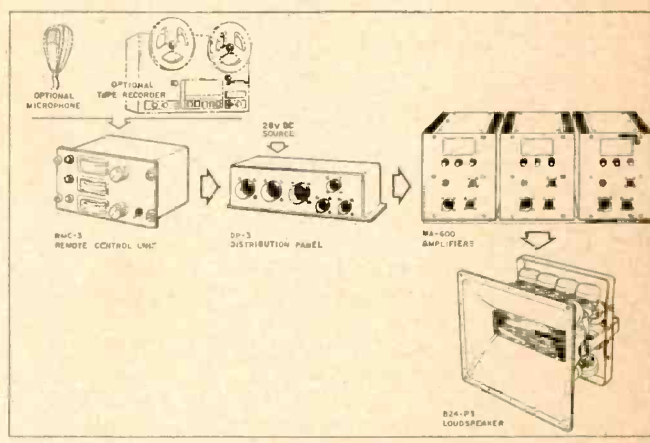
In Vietnam, the SA-1800C super-high-power sound system has been mounted on the side of *Cessna* "Super Sky Master" aircraft. A number of these light two-engine planes were modified by the Air Force to provide a platform for the speaker/amplifier. They carry a crew of two—a pilot/navigator and a sound-systems operator.

In addition to its use for psychological warfare in Vietnam, the new speaker/amplifier is suited to many other applications. For example, it can be used for voice and sound projection wherever extreme noise levels exist or where extreme depth and penetration of sound are required over long distances or large areas. Primary applications are: air-to-ground or ground-to-air and ship-to-ship or ship-to-shore. Other possible uses include mobile installations in vehicles for combat areas, and fire and police control applications in civil riot areas.

The SA-1800C is probably the most powerful speaker/amplifier combination in the world. It is capable of putting out signals measuring in excess of 148 dB at four feet. This equates to a sound pressure level of over 80 dB (equivalent to the sound level in a noisy factory assembly area), at a distance of two miles. ▲

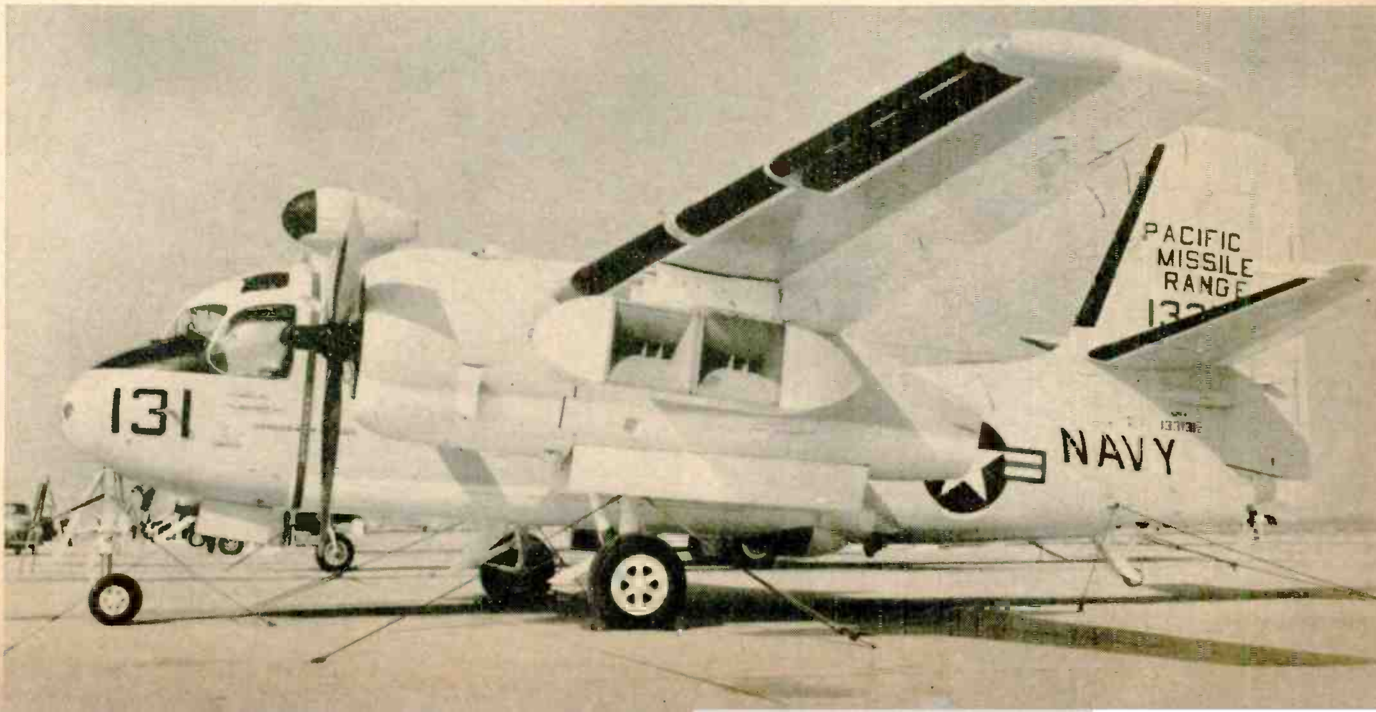


Multiple-driver throat assembly pushes 1800 watts out of die-cast horn. The sound can be heard two miles away.



Sound system operator can work the entire speaker-amplifier system from a remote-control panel in the pilot cabin.

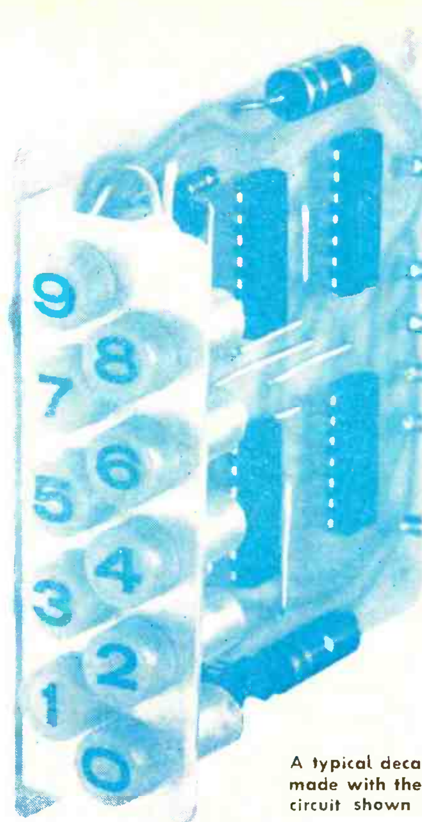
Navy planes use the SA-1800C sound system to turn ships away from missile impact area at Pacific test range.



IC Decimal Counting Techniques

By DONALD E. LANCASTER

IC's have made complex digital counter circuits simpler and less expensive than those made with discrete or mechanical components. Here are several practical schemes which can be used to time events.



A typical decade counter made with the biquinary circuit shown in Fig. 8.

RECENTLY, we've seen how digital integrated circuits have opened the doors to a wide variety of new applications. One of the most important of these new uses is decimal counting and readout circuits; typically, event and frequency counters, digital voltmeters and multimeters, electronic clocks, calculators, computers, and so forth. IC's have made these circuit designs simpler and lower in cost than older tube and solid-state versions, and significantly faster, smaller, and more reliable than mechanical or gas-tube counting techniques.

A basic problem common to all these applications is: to *count* an input signal by one's up to nine; *decode* each counter state; *indicate* each digit; *carry* a pulse to the next stage every time there is a count of 9 + 1; and, finally, provide a *reset* capability that allows the counter to be put into the "0" state at the beginning of a measurement.

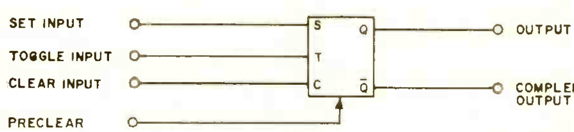
We do not have an integrated circuit that will single-handedly do all these tasks, while simultaneously lighting up a large numeral on its case. We must make use of several integrated circuits in combination with a conventional readout. But, depending upon the readout and the speed with which we must operate, the cost, legibility, and visibility factors, we have a wide choice of decade counting schemes. Let's look at some of the more popular techniques, and see just how they may be put to use.

The Building Block: The JK Flip-Flop

The basic building block of all counting systems is some device that has *two* possible states, "on" and "off". With few exceptions, the basic building block is a JK flip-flop, a circuit that is somewhat similar to the older types of flip-flops (self-steering bistable multivibrators or Eccles-Jordan circuits), but far more versatile and lower in cost. Several of these flip-flops can be tied together to achieve a system capable of many states. For example, if we connect them as divide-by-two circuits so that the outputs run 1, 2, 4, 8, 16, 32. . . . we obtain a binary divider chain or binary counter. By modifying the count procedure, we can generate several different decimal counting techniques. Or, we might choose to connect the flip-flops in a different manner, perhaps as a "bucket brigade" lining them up so that they pass on a count under command. This is called a shift register and if we connect the output of the register back to its own input, we have a ring counter and several more possibilities for decimal counting.

Fig. 1 gives us a closer look at a typical JK flip-flop. Notice

Fig. 1. (A) JK flip-flops form basic building block of many decimal counters. The table (B) shows counter state at the instant of toggle. Diagrams in (C) and (D) show the proper connections for a binary divider and for shift register.



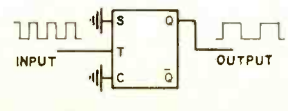
NOTE: EACH FLIP-FLOP ALSO REQUIRES B+ AND ⏚. THESE CONNECTIONS ARE USUALLY NOT SHOWN ON LOGIC DIAGRAMS

(A)

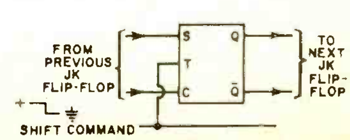
TABLE APPLIES TO:
µL923
MC723P
1/2 MC791
RTL TYPES, ETC.

IF THE SET INPUT IS	AND THE CLEAR INPUT IS	AND THE TOGGLE IS	THE OUTPUT WILL
⏚	⏚	+ ⏚	CHANGE TO THE OTHER STATE
⏚	+	+ ⏚	GO TO THE ⏚ STATE
+	⏚	+ ⏚	GO TO THE + STATE
+	+	+ ⏚	DO NOT CHANGE STATE

(B)



(C)



(D)

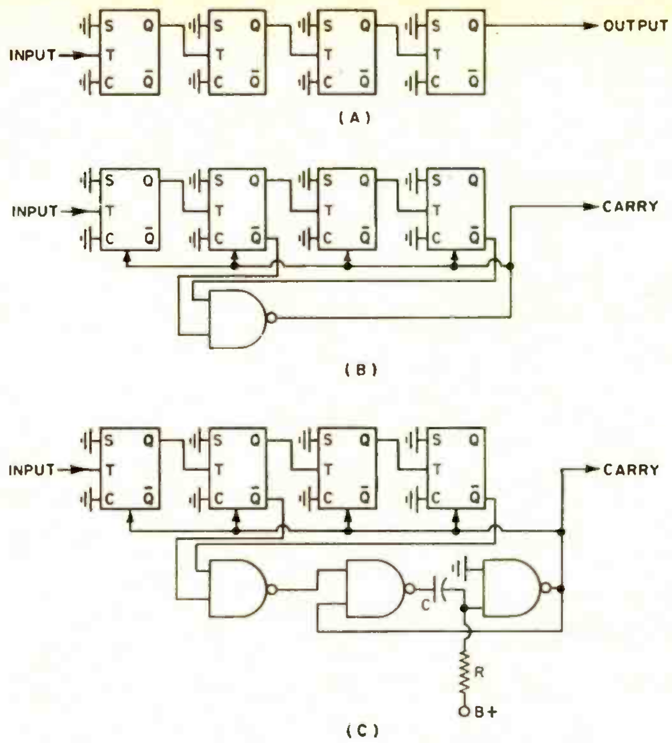


Fig. 2. (A) Four flip-flops count 0 to 15 in a 1-2-4-8 binary divider chain. A "nand" gate (B) can be used to detect state "10" and preclear counter to "0". One method of eliminating preclear difficulty is to use circuit connections as shown in (C).

that there are two outputs, the Q output and the *Q* output. These outputs are complementary because one output is "+" and the other is at ground. Under certain combinations of inputs, the output can be made to change state, with the positive output going to ground, and the grounded output going positive.

There are two groups of inputs, the Set, Toggle, and Clear inputs and, off in a class by itself, the Preclear input.

The Preclear input is normally grounded. If the Preclear input were made positive, the JK flip-flop would immediately go into the state in which the Q output is grounded and the Q output is "+", if it were not there already. This happens regardless of the status of the other inputs. Thus, the Preclear input must be used to "empty" a counter or register, making the readout indicate zero.

The other three inputs are always used together and, depending upon their input voltages, can make the JK flip-flop change state, go into one of the two possible output states, or do nothing. The key to the operation is the Toggle input. The flip-flop cannot change state except during the instant the Toggle input abruptly changes from a positive to a grounded condition. To operate the flip-flop, we first apply voltages to the Set and Clear inputs (this is called conditioning) and then we toggle the flip-flop by causing the Toggle input to suddenly change from a positive to a grounded condition.

Specifically, a JK flip-flop made with RTL digital IC's obeys the following laws: if the Set input is grounded and the Clear input is grounded, the flip-flop will change to the other state upon a negative-going Toggle transition; if the Set input is "+" and the Clear input is grounded, the flip-flop will go into the state in which the Q output is "+" upon a negative-going Toggle transition; if the Set input is grounded and the Clear input is made "+", the flip-flop will go into the state in which the Q output is grounded upon a negative-going Toggle transition; if the Set input is made "+" and the Clear input is made "+", nothing happens when a negative-going Toggle transition occurs.

Thus, to design a binary divider, we simply ground the Set and Clear inputs (Fig. 1C). Note that the output goes from "+" to ground only on every other negative toggle transition (in between, it goes from ground to "+") and we have a divide-by-two circuit. The next stage divides by two again so it only responds to every second Toggle negative transition, and its output has a negative transition only once every four Toggle transitions. The next stage divides by eight; the next by sixteen; and so on. By observing the state of each binary divider, we can see how many Toggle negative transitions have taken place since we last Precleared the counter. In practice, we feed input pulses to the binary divider and the fall time of each input pulse toggles the divider chain. Thus we can easily count the number of input pulses by simply observing the state of the binary divider.

Another way to use the JK flip-flop is shown in Fig. 1D. Here we have built a shift register by connecting each JK output directly to the Set and Clear inputs of the next flip-flop. All toggle inputs are connected in parallel and operated synchronously. Upon every negative toggle transition, the state of each flip-flop is passed on to the next and so on down the line. An automatic time-delay circuit is built into each JK flip-flop to prevent the states from being transferred more than one stage each command.

Together, these two basic JK flip-flop interconnections form the basis for the majority of our decimal counting methods.

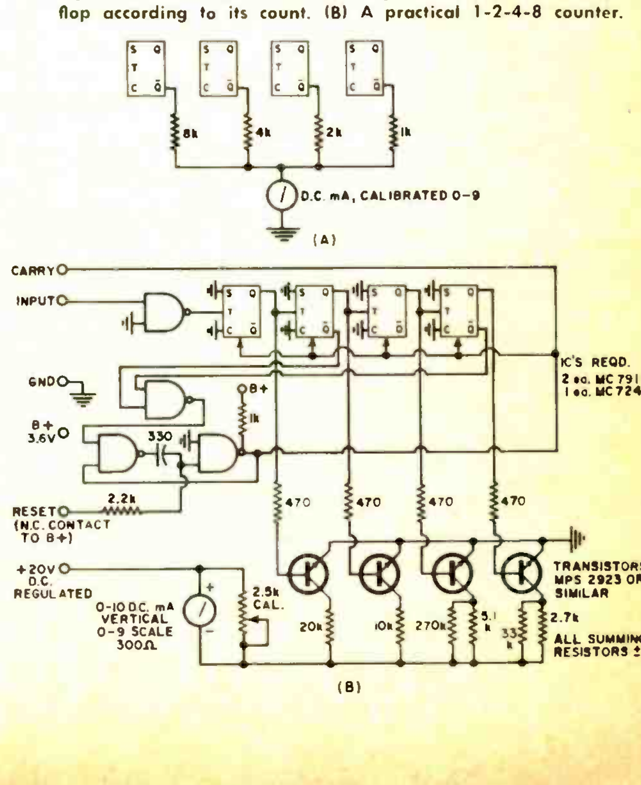
With many popular IC logic lines, the Toggle input must switch once per input pulse (in less than 100 nanosec). Thus, when counting low frequencies, the input signals must be squared to have a fall time of less than 100 ns. This is most often done with a pulse shaper. This is particularly important with RTL-type circuits.

The 1, 2, 4, 8 Counter

Fig. 2A shows how four JK flip-flops may be connected as a binary divider with sixteen possible states. If we decoded each state, we would count from 0 to 15. But if, as in Fig. 2B, we add a circuit called a *nand* gate to detect the presence of the eleventh state (count "10") and immediately preclear the counter, the binary divider could never get past the tenth state (count "9") and we would have a decade counter.

This is how that circuit operates. The tenth state is the first time, starting with count zero, that both the *Q* output and the second and fourth flip-flops are simultaneously grounded. The *nand* gate detects the grounding and pro-

Fig. 3. (A) Analog current summing circuit weighs each flip-flop according to its count. (B) A practical 1-2-4-8 counter.



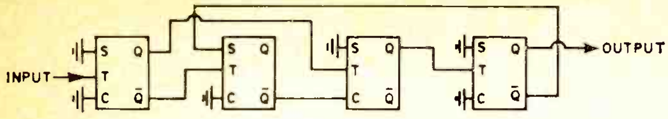


Fig. 4. Although low in cost, this modulo-10 minimum hardware circuit is difficult to decode so it is used only for scaling.

duces a positive output which preclears the entire binary divider to zero. This circuit usually works but there can be a problem. Suppose either the first or third flip-flop is a bit slow in preclearing. The *nand* gate will not detect a coincidental grounding and the counter can preset to some number other than zero. To overcome this problem, we can add a monostable multivibrator which provides a constant-width preclear pulse.

There is also a decoding problem. Ten four-input *nand* gates can be used to detect each state and produce discrete outputs for the individual counts 0, 1, 2, 3, ... 8, and 9. And by fancy circuit techniques, we can even cut down on the number of inputs many of the gates require. But this is rather expensive, especially if RTL integrated circuitry is used and additional buffers to increase drive capability are required.

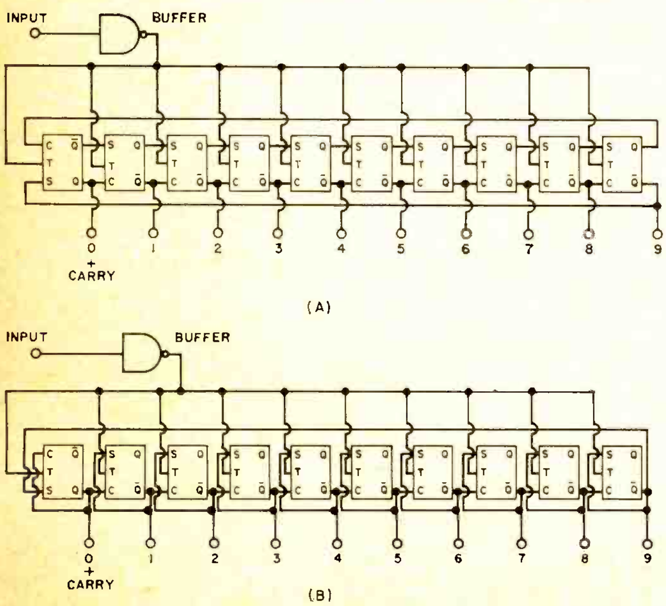
In its most inexpensive form, the 1, 2, 4, 8 counter is best used with a meter or analog readout, as suggested in Fig. 3A. Here we add 8000, 4000, 2000, and 1000 ohm resistors to the output of each JK flip-flop and measure the total current through a milliammeter calibrated from 0 through 9. Using these resistors a flip-flop counting by eight produces eight times the current of a flip-flop counting by one, the *sum* of all the currents will equal the count stored in the 1, 2, 4, 8 counter.

Problems arise in the simple circuit of Fig. 3A due to the voltage drop across the meter and temperature and supply variations. A practical form is shown in Fig. 3B which uses a higher voltage-regulated meter supply, four driver transistors, and a calibration potentiometer.

Modulo-10 Minimum Hardware

The Set and Clear inputs on a JK flip-flop are in themselves gates and we can add feedback directly to the binary divider without any extra parts and inhibit counts 11 through 16. If we do this, the modulo-10 minimum hardware circuit of Fig. 4 results. This circuit is very useful when we want to scale an input by ten, without decoding and indicating the

Fig. 5. The 10-bit shift register (A) is analogous to a 10-position stepping relay. An alternate form (B) offers easier PC layout and corrects errors. Both require six IC packages.



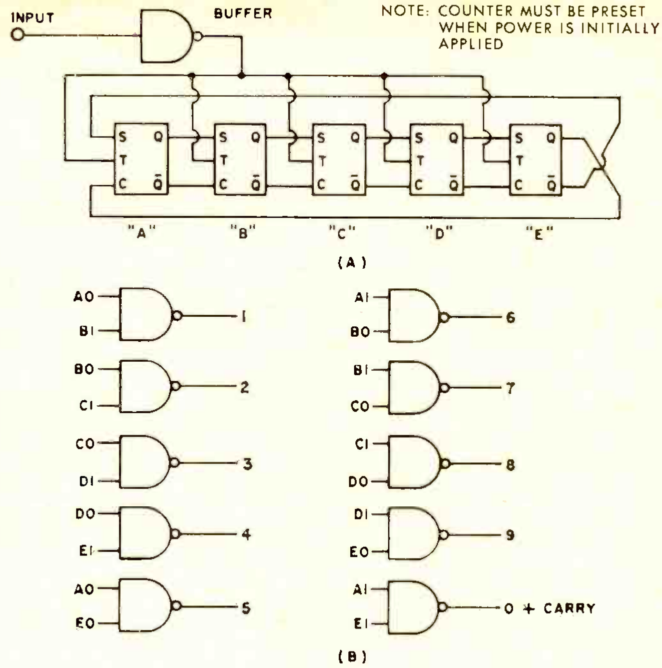


Fig. 6. (A) Walking ring counter must be preset when power is applied. (B) Ten 2-input "nand" gates may be used as inputs.

intermediate states. For instance, a modulo-10 can be used to bring a 50-MHz signal down to 5 MHz where it can easily be counted with RTL circuits. This costs far less than building a 50-MHz counter. It can also be used in counters that require precise time gates of 1, 10, 100, and 1000 milliseconds.

The 10-Bit Shift Register

By using more flip-flops, we can build a self-decoding counter. A 10-bit shift register, like that in Fig. 5A, can be used. Note that the first flip-flop is inverted which allows the counter to be preset to a 1000000000 state. The first negative toggle transition shifts the "1" one place to the right and produces a 0100000000 state. Each successive transition shifts the "1" one more place to the right, generating a sequence: 0010000000, 0001000000, and so on. We have a ten-state counter that requires no decoding. However, the output signals are at a low level so they must be amplified.

We can also change the circuit around a bit and make sure each register turns itself back to zero after it passes on the "1". Thus the register can be "self-correcting" and it lessens the chances of another "1" getting into the counter by way of a noise pulse or something similar. A buffer is normally added to the input to allow the input signals to simultaneously drive the ten parallel Toggle inputs. The details are shown in Fig. 5B.

Both these circuits have a problem not found in the 1-2-4-8 and the modulo-10 circuits. If either of these circuits ever gets into a wrong or disallowed state, it only takes few counts to get it back on the right track.

This is not true of the 10-bit shift register. When power is applied, or perhaps when a noise transient arrives, the 10-bit register can go into any one of 1024 possible states. Of these only ten are legitimate.

There are several ways to correct this. The easiest is to reset the counter every time power is applied or, if possible, immediately before each use. A second possibility is to use the presence of a "1" in the first counter to generate a brief pulse that automatically forces every other counter into the zero state. This requires another IC, a capacitor, and maybe a resistor.

We can fold a 10-bit shift register over on itself and design a decimal counter that requires only five JK flip-flops and ten two-input *nand* gates for a decoded output. The

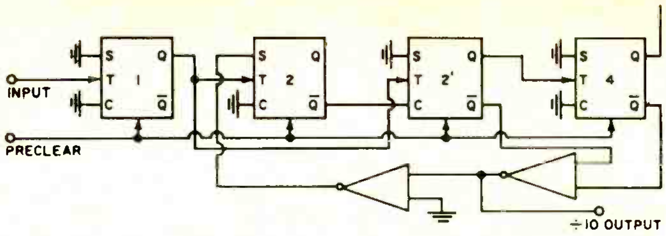


Fig. 7. In a biquinary counter, the first flip-flop divides by two. With help of two gates, other JK's divide by five.

cost will be slightly less than the 10-bit register and an output square wave at 1/10th the input frequency is available. The walking ring counter (Fig. 6) has advantages at higher speeds since only one flip-flop changes with each negative toggle transition. This is the way it works. When the counter is precleared to the 00000 state, a negative-going toggle transition will advance it to the 10000 state. The "1" comes about as a result of the crossed wires between output and input. Each succeeding input pulse generates the sequence 11000, 11100, 11110, 11111, 01111, 00111, 00011, 00001, and finally 00000. Each state is unique and decodable by a two-input gate. Transistors are required to drive the readout lamps.

Once again, there is a disallowed state problem. This particular counter can get into 32 states—of which 10 are legitimate. For example, if the counter goes into a 10101 state, on the next toggle it will go to 01010, and on the next one, right back to 10101. Thus we have a modulo-2 counter instead of a modulo-10. Worse yet, the decoding process gets mixed up and several counts at a time can appear as outputs.

But we can reset the counter to zero when power is applied or before each count is made, or both. If we must have absolutely "fail-safe" operation, we can watch for the coincidence of zeroes in the first and fifth flip-flops and use this coincidence to force flip-flops 2, 3, and 4 into the zero state. This automatically clears the counter regardless of what state it is in.

The Biquinary Counter

There is yet another way to divide by ten. Simply divide by two first, and then by five. This somewhat subtle approach is called biquinary counting and has some unique advantages. A biquinary counter needs only four JK flip-flops and with certain forms of readout, only four decoding operations are required to produce all ten counter states. This extreme economy of parts is possible only if the display can be "bent" properly to fit the counter. For a biquinary counter to be practical, both ends of the readout must be available and, usually, only visual outputs may be conveniently obtained.

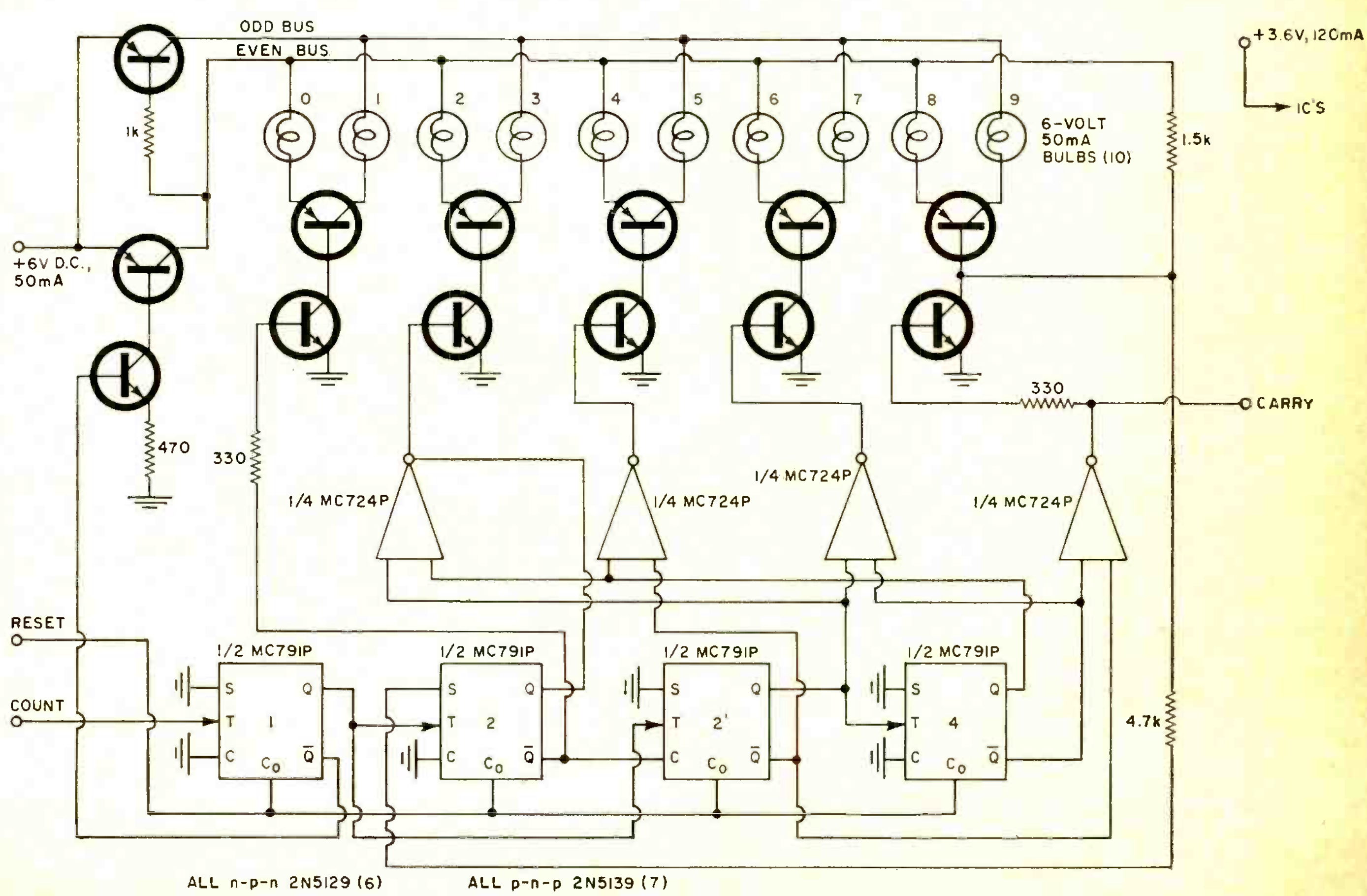
Fig. 7 shows the basic biquinary decade counter. The first flip-flop divides by 2, while the remaining three flip-flops divide by five. This particular decade counter is weighted in a 1-2-2'-4 manner.

If we added a meter readout in a circuit similar to Fig. 3, we would need two less gates, two less resistors, and one less capacitor. The resistors would be weighted 1-2-2-4 instead of 1-2-4-8 which eliminates one resistor value and makes the jump between counts 7 and 8 less drastic.

Fig. 8 shows a complete decimal counter, decoder, driver, and readout using a biquinary counter and a staggered 0-9 incandescent display. This particular circuit uses RTL integrated circuits and is useful from d.c. to beyond 8 MHz.

The outstanding features of the biquinary counter are low cost and the ease with which it can drive either an incandescent display or a special biquinary Nixie indicator. If we were to look at the counter waveforms, we would see that we have three decoded outputs: an even-odd output, a "0" or a "1" output, and an "8" (*Continued on page 70*)

Fig. 8. This biquinary counter—including decoder, driver, and readout—can be built for $10.90 per decade in kit form.



Electronic Intrusion Alarms PART 1

A security console of this type enables one guard to watch one or 100 buildings without leaving his post. Alarm printer (center) raps out what is wrong and when; digital display at left flashes identification code telling where trouble is. Lights at right report progress of any roving guard patrols.

By LON CANTOR

American industry is spending over $250 million a year for plant protection but burglars are currently stealing over $1 billion a year. Electronics is being enlisted to turn the tide of this losing battle. The various types of alarms and their operating principles are covered in this two-part article.

Editor's Note: Part 1 of this two-part article emphasizes audio and ultrasonic intrusion alarms. These are manufactured by such companies as Honeywell, ADT, Euphonics, and Kidde. Next month, Part 2 will cover microwave r.f. intrusion alarms, such as the one made by Radar Devices. We will also include a complete directory listing of intrusion-alarm manufacturers, along with their addresses so that further details can be obtained on their particular products.

CRIME in the streets is making headlines today, but crime in stores, offices, warehouses, factories, schools, and public buildings has become a billion-dollar "business." American industry has increased plant protection expenditures to more than $250 million per year, but is still fighting a losing battle. Burglars currently steal over $1 billion per year. And losses due to vandalism and sabotage multiply these losses many times.

The average burglary nets the thief only a couple of hundred dollars, but he often causes thousands of dollars worth of damage.

Since police forces are understaffed and overworked, the number of burglaries continues to rise rapidly each year. In the face of the high cost of manpower, industry and public officials are turning more and more toward electronics to cope with the problem.

Properly used, electronic intrusion alarms can thwart any burglar. Basically, they work in three ways:

1. They frighten burglars away. Burglars tend to look for easy marks. Since they don't understand electronics, they tend to steer clear of buildings known to be protected by electronic intrusion alarms.

2. They turn on the lights and/or make a loud noise (siren, horn, or bell) to frighten the burglar away.

3. They ring an alarm in police headquarters. The burglar goes on about his business, without knowing he has been detected, and the police apprehend him.

Types of Intrusion Alarms

The most common method of keeping out burglars, of course, is to lock the doors and windows. Unfortunately, most burglars are quite adept at opening locked doors, especially if inadequate locks are used. If a good lock stops him, the determined burglar can probably get into most buildings through the windows.

To prevent this, switches are sometimes connected to all doors and windows. Opening the door or window opens a switch that opens a relay. The relay, in turn, closes a contact that activates an alarm.

Conducting tape and thin wires are used in the same way, but these devices really don't give experienced burglars much trouble. They simply short out the switch, tape, or wire with a jumper wire, and go to work.

Vibration detectors (Fig. 1A) are a good way to protect specific objects, such as safes and file cabinets. The vibration detector is taped or glued to the object it protects. Then, if that object is touched even gently or moved even slightly, an alarm is sounded. Any tampering with the detector, of course, sounds the alarm. An advantage of the vibration detector is that unlike some more sophisticated systems, it can be used in noisy, heavy traffic areas.

Similar to the vibration detector is the capacitance detector made by *Honeywell*, *Kidde*, and *ADT*. The capacitance detector uses a very unstable oscillator connected to an external antenna loop. The antenna loop is actually made up, in part, by the objects to be protected, as shown in Fig. 2. Anyone nearing the "antenna" changes its capacitance. This change in capacitance is detected by a Wheatstone-bridge circuit and used to sound the alarm. Some capacitance detectors react to anyone going near the protected object, while others require that the object actually be touched.

Another similar device is the "electronic fence" made by *Honeywell*, *ADT*, and *Mosler*. The "fence" is simply a wire which carries current and radiates an electromagnetic field. When the burglar comes within three feet of the wire, the field is changed enough to sound the alarm.

Photoelectric systems are marketed by *ADT*, *Ademco*, *Kidde*, and *Honeywell*. They work on the same principle that opens supermarket doors. A light source is beamed into a photocell; when the beam is broken, the alarm is set off.

Visible light systems are very easily spotted and thwarted. Infrared and ultraviolet light sources are much better, but experienced burglars can often spot the faint radiation glow, with or without a special filter.

Some of the best photoelectric security systems use a flickering beam, modulated in a predetermined interruption sequence. This sequence may be established electronically or mechanically, using a spinning disc.

Another type of photoelectric system uses a very sensitive light meter. This meter is set to normal room lighting. Then, any change in lighting sets off the alarm. If the room is normally dark, the burglar is detected as soon as he lights a match or shines a flashlight. If the room is normally light, the burglar's shadow will then trigger the burglar alarm.

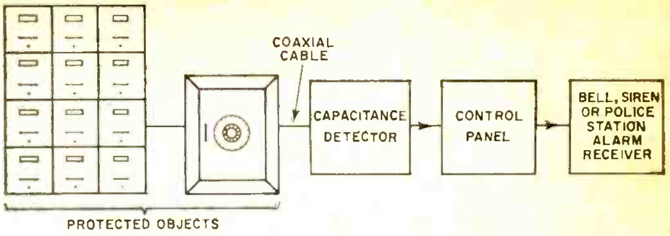


Fig. 2. Capacitance detector connected to safe, file cabinets.

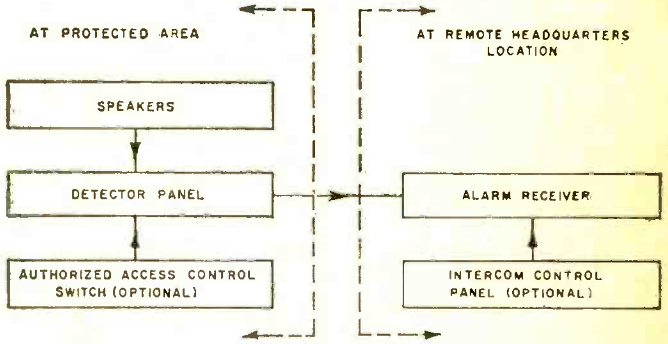


Fig. 3. Diagram of a typical audio intrusion alarm system.

Audio Alarms

The intrusion alarms discussed so far are quite simple. More sophisticated are the audio types. There are two basic types of audio intrusion alarms. The first is a very sensitive microphone system that sounds the alarm when it hears something unusual. The second uses sonic or ultrasonic waves to detect motion by the doppler effect.

Microphone-type audio detection systems are made by *Honeywell*, *ADT*, *Alarmtronics*, and *Mosler*. Figs. 1B and 1C show two types of audio detectors. These are actually loudspeakers used as pickup devices. Fig. 3 shows how these units would be used in a typical system.

The audio detectors, which act as sensitive microphones, pick up all sounds and send them to the control panel. Sensitivity can be set to detect even very faint sounds, but too much sensitivity causes false alarms. The *Honeywell* system has a built-in discriminator that triggers the alarm only if it hears a number of disturbances within a relatively short time. Further, this system cancels sounds that are not associated with burglary, like passing trains.

However, audio systems can often be triggered by thun-

Fig. 1. (A) Vibration detector closes circuit when object to which it is attached is moved. (B) Horn-type p.a. loudspeaker and (C) cone-type loudspeaker mounted in a metal case are employed as detectors in audio intrusion alarms described.

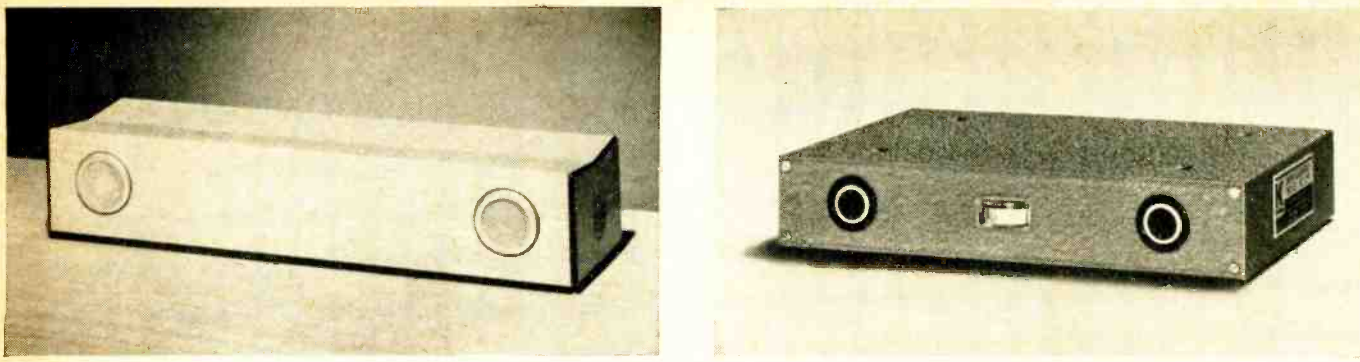


Fig. 4. (Left) Euphonics and (right) Kidde ultrasonic intrusion alarms. The two transducers may be seen on front panels of the units.

der or passing traffic. They are relatively inexpensive, but they cannot be used in areas with high noise levels.

Audio Motion Detectors

Audio motion detectors generate their own sound waves, which permeate the area to be covered and are then reflected back into the unit. They are made by *Kidde, Euphonics, ADT,* and *Honeywell.*

The *Euphonics* and *Kidde* units (Fig. 4), like most others, use ultrasonic sound waves. Ultrasonic waves are generated by one transducer and received by another.

A solid-state oscillator in the unit provides the signal to drive the transducer and also supplies a reference signal for the detector in the receiver circuit. The ultrasonic waves bounce off walls, furniture, floors, and ceilings to form a fixed pattern of standing waves. The detector compares the transmitted signal with the standing-wave pattern and is balanced to sense any changes in phase.

When a burglar enters the room, his motion—no matter how slow—causes a shift in the phase of the ultrasonic waves due to the doppler effect. Reacting to this phase shift, the detector actuates a relay which sounds the alarm.

Units are ideally located two to six feet above the floor, on a table, desk, counter, or shelf. Range is adjustable to a maximum of about 12 feet.

The unit provides jacks for two types of alarm devices, generally lights and a bell or siren. Typically, the lights go on immediately and the bell clangs 20 seconds later. This combination of light and sound is calculated to frighten the burglar away.

A block diagram of the *Euphonics* alarm is shown in Fig. 5 while Fig. 6 is a block diagram of the more elaborate *Kidde* unit, which will be described below. (*Editor's Note: Most of the manufacturers in this field are very security-conscious about giving any detailed information or complete schematic diagrams of their products. Hence, readers should not waste time trying to obtain such information either from us or from the manufacturers.*)

Completely solid-state, the *Kidde* master control can accommodate up to 24 pairs of transmitters and receivers, to protect an area of up to 12,000 square feet.

The oscillator generates a 19.2-kHz signal, tunable by means of a ferrite plunger which can be screwdriver-adjusted from outside the case. The balanced output of the oscillator is fed into a push-pull power amplifier comprising two symmetrical Darlington stages. The output of the power amplifier goes directly to remotely located transmitter(s).

The transmitter transducer fills the area with ultrasonic waves, which are picked up by the receiver. This signal is then amplified by the high-frequency amplifier and sent to the phase detector. In order to accommodate up to 24 receiver transducers in parallel, the input to the high-frequency amplifier is deliberately mismatched.

Notice from the block diagram that the oscillator also sends a 19.2-kHz reference signal to the phase detector. This reference signal is taken directly from the oscillator, rather than the output stage, to avoid any introduction of noise through the transducer lines.

It is the job of the phase detector to compare the received signal with the reference signal. The output of the high-frequency amplifier consists of the amplified input signal superimposed on the collector voltage of a transistor. The received signal contains a certain percentage of phase-modulation components due to the doppler effect. This signal is compared with the 19.2-kHz reference signal direct from the oscillator. Any phase shift between the two signals produces an a.c. component from the phase detector that will follow the doppler modulation of the incoming signal.

The high-frequency filter eliminates the 19.2-kHz signal, passing only the low-frequency (doppler signal) component. This component is then amplified by the low-frequency amplifier.

At this point, the output of the low-frequency amplifier is separated into two distinct channels. One channel amplifies signals around 5 Hz and the other handles signals around 35 Hz. The 35-Hz channel am- (*Continued on page* 86)

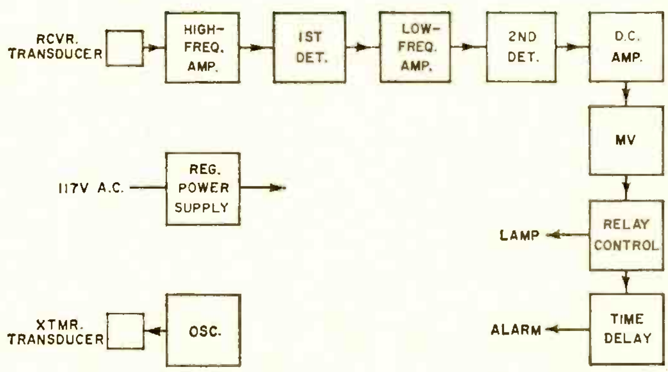
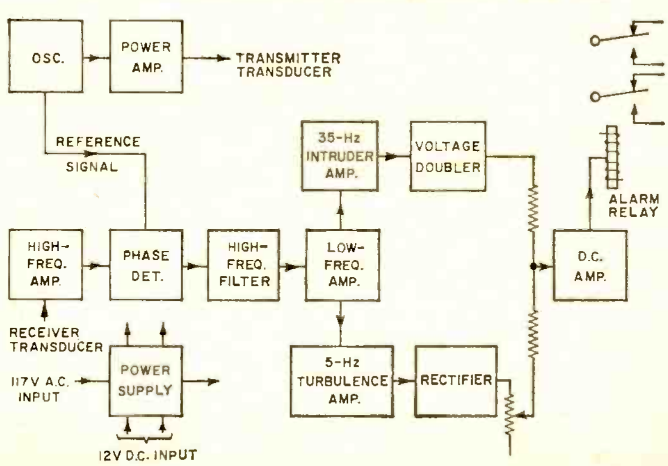
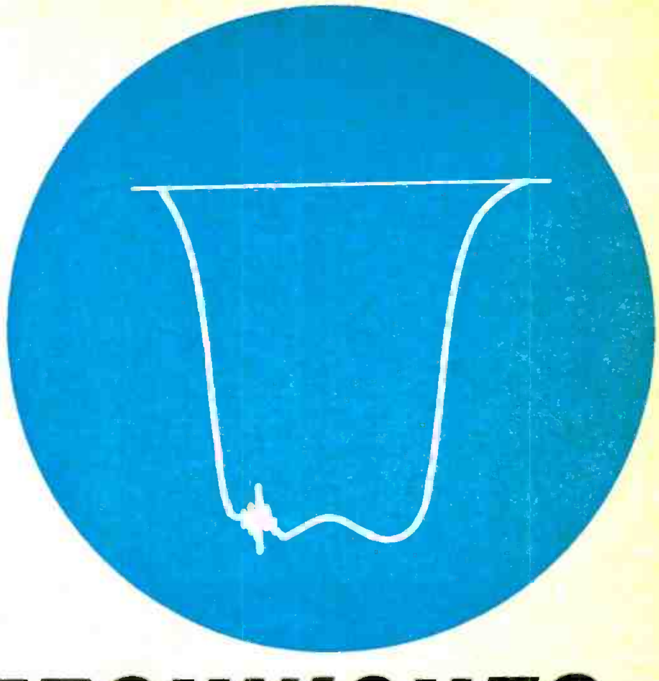


Fig. 5. The Euphonics intrusion alarm operates in the range 24 kHz to 42 kHz. Note similarity to ordinary broadcast set.

Fig. 6. The Kidde intrusion alarm operates on 19.2 kHz.



TV



ALIGNMENT TECHNIQUES

PART 2. The Procedure

By FOREST H. BELT / Contributing Editor

The principles of alignment and the proper procedure to follow in order to adjust the r.f. and i.f. coils, transformers, and traps in a TV set.

IN Part 1 (last month's issue), you found out that one holdback to TV alignment was a misunderstanding of test equipment. In that article, you learned what the equipment is like and what each instrument is used for.

Now, to the other holdback—the procedure itself. Manufacturers' service data for television sets almost always includes alignment instructions. However, there is no elaboration nor any help if things don't go just right. First, let's examine the principles of alignment. If you know what alignment is all about, that's a solid foundation from which to interpret the instructions for almost any TV set.

The I. F. Response Curve

Consider Fig. 1, a typical i. f. strip. The diagram is simplified, but it shows the stages and adjustments in a black-and-white i. f. section.

Each tuned circuit responds best to one frequency. If you draw a graph of how *L*3, for example, responds to signal voltages at various frequencies, it looks like Fig. 2A. At around 43 MHz, the response is very weak. As the frequency goes higher, response improves, until at 45.2 MHz it reaches a peak. Beyond that, it drops off again, until there is none beyond 46 MHz. All frequencies above 46 and below 43 MHz are shut out.

Some of the tuned circuits in Fig. 1 are traps. This means they reject a specific frequency and accept or pass all others. Fig. 2B shows the response of adjacent-channel sound trap *L*4. Frequencies above and below 47.25 MHz are okay, but frequencies near the center are blocked.

Fig. 1. Traps and tuning adjustments in typical i.f. strip.

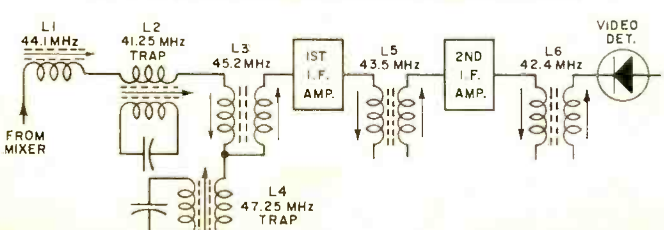
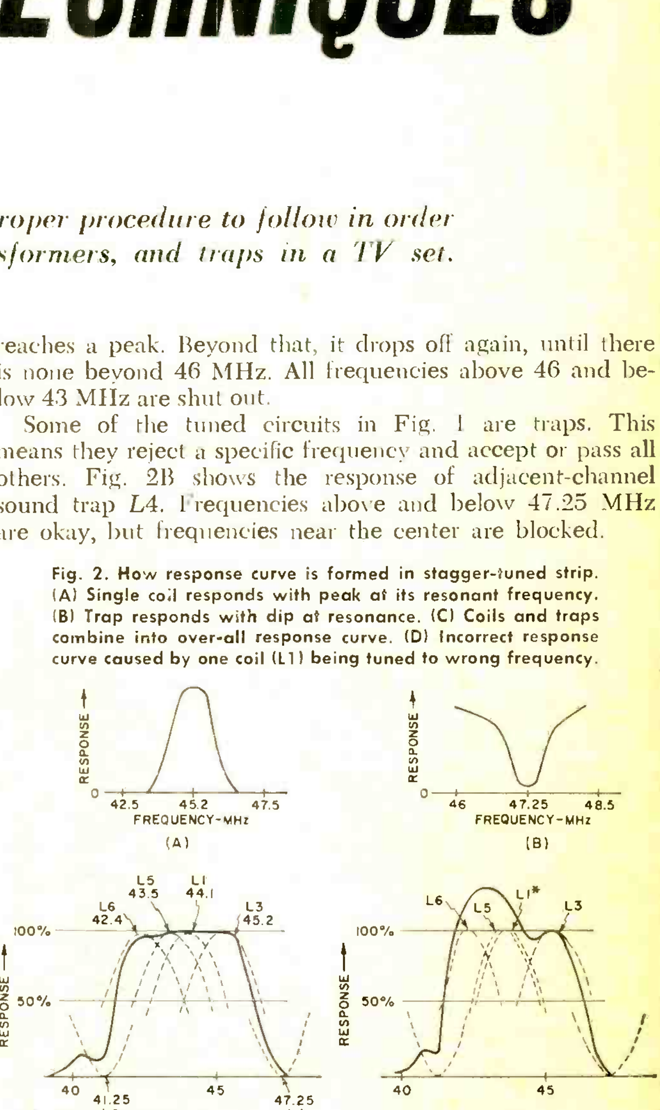


Fig. 2. How response curve is formed in stagger-tuned strip. (A) Single coil responds with peak at its resonant frequency. (B) Trap responds with dip at resonance. (C) Coils and traps combine into over-all response curve. (D) Incorrect response curve caused by one coil (L1) being tuned to wrong frequency.



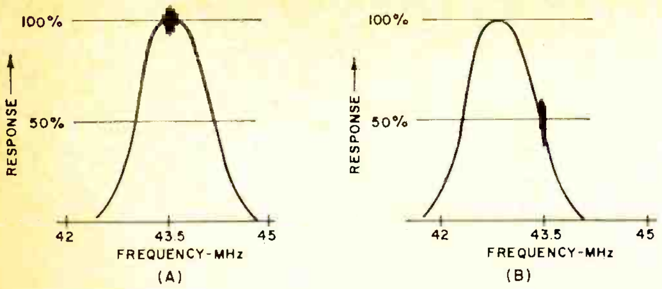


Fig. 3. Marker stays in same place because it is fixed by the generator (A). In (B) mistuning has changed position of curve.

Now look at Fig. 2C. This is a composite response graph for all the tuned circuits in Fig. 1. Each curve is labeled. They are combined, and the response of the entire i. f. strip is as shown by the heavy solid line. This is why a stagger-tuned i. f. system shows a broad response to a wide band of frequencies. The traps, as you can see, make the sides of the i. f. response curve—the skirts—rather steep.

If you think about it, you can see how moving any one of the tuned circuits off-frequency could upset the shape of the over-all curve. Fig. 2D shows an example. The tuning of $L1$ has changed—the equivalent of misalignment. With its peak shifted downward in frequency, the combination response curve takes a different shape. Imagine how crazy the over-all curve would look if all the coils were at wrong frequencies.

The purpose of alignment is to make sure each tuned circuit is at its correct frequency. Any number of things can cause a coil to drift out of alignment. A moment's examination of the i. f. response curve, with a scope and sweep generator, can tell you if something is wrong. That's why it's such a good idea to keep these instruments warmed up. You can run a quick response curve whenever you have the slightest inkling of trouble.

A Way of Thinking

Misunderstandings about TV alignment often arise because of the way a technician thinks about it. There is a common fallacy that must be explained away.

Take a look at the response curve in Fig. 3A. It is produced by a sweep generator set near the frequency of the coil. A marker generator signal, exactly at the coil's supposed peak frequency, is mixed with the sweep signal. Both are fed through the tuned circuit, demodulated, and fed to a scope. Once that marker frequency is set, its position on the curve tells whether the coil is properly tuned or not. In Fig. 3A, the coil's response peak is exactly at the 43.5-MHz marker. Looking at it the wrong way—a popular fallacy which leads to misunderstanding—you could say that the marker is at the top of the curve. The *right way* is to say *the peak of the curve is at the marker.*

Take a look at Fig. 3B. The marker is still where it was, at 43.5 MHz. However, the peak of the curve has been shifted sideways in frequency by retuning the coil. In misleading terms, it would ordinarily be stated: the marker has moved to halfway down one side of the curve. Although this is how it looks as you watch the scope, the right way to state it is: the curve has moved sideways and shows only 50% response at the marker frequency.

In television alignment, you must make the i. f. response conform to a shape that places specified marker frequencies at certain points on the curve. You can't let yourself think of the curve as stationary and the markers as movable, although it appears this way on the scope. Exactly the opposite is true. You set the markers at specified frequencies (with the r. f. generator dial) and you move and reshape the curve to suit them (by re-tuning the i. f. coils). When a marker is not in the proper position, you alter the curve (tune the coils) until it is. If you understand this principle, you can approach the alignment procedure more confidently.

The alignment instructions in TV service data tell you to adjust certain coils, with this or that input connection from the sweep generator. The same step shows marker positions at perhaps four different points on the i. f. curve. With most marker generators you can get only one marker at a time, so you set the marker generator dial for the first one. Then you tune the coil for that marker until the curve is highest at that point. Keep in mind that the full i. f. curve may not be peaked there, because all the other coils affect the curve too. Nevertheless, what you do is raise the curve to maximum height *at that particular frequency point.*

Then go to the next adjustment. Change the dial of the marker generator to whatever frequency is associated with that coil. The marker is now at some new place on the curve. Tune that coil until the curve *at that particular point* is as high as it will go. Again, this may not be the highest point on the curve; you are simply making *this point* as high as you can with this one adjustment.

When you have finished, the over-all curve will be close to what the manufacturer suggests. The curve is the correct shape and is positioned so that each marker you set up with the r. f. generator falls at its correct level and position.

Suppose the receiver whose i. f. section is shown in Fig. 1 arrives on your bench looking smeared, and not tuning right. You run a quick response-curve check, and it looks like Fig. 4A. The manufacturer suggests it should look like Fig. 4B. You look at a single marker—the 45.75-MHz marker. The curve is obviously out of position with respect to that particular marker (Fig. 4A). That marker should be halfway up the right skirt (Fig. 4B). (We have flopped the curves over in this drawing as this will be their normal appearance at the anode output of the video detector.) The set needs alignment.

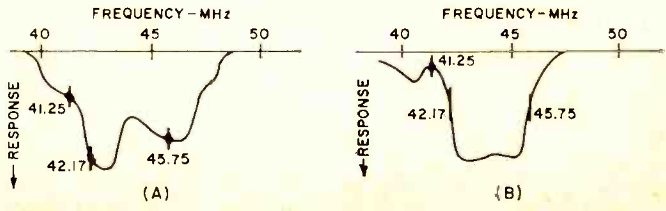
There are two stages in a complete alignment job. Both are quick and easy, provided your instruments are already set up—and they should be. The first is *prealignment.* Sometimes absolutely necessary with sets that are badly messed up, prealignment is so quick and simple you can start with it anyway. The second stage is *sweep alignment.* If you follow the steps outlined here, both phases rarely take more than a half-hour in all.

Prealignment Procedure

To overcome the normal effect of the a. g. c. circuit, set manufacturers suggest a certain d. c. voltage be connected to the a. g. c. line. This is called *clamping* the a. g. c. It's the first step in prealignment. Batteries can be used, or a low-impedance d. c. supply. Some generators have a bias supply built right in. Commercial bias supplies are available with two or three outputs. In a few sets, you bias the tuner with one voltage and the i. f. stages with another.

The next step is to kill the horizontal sweep. There are several ways, but the simplest is to pull the horizontal output tube from its socket. If the tube heater is part of a series string, just unsolder the cathode connection. With the output tube disabled, the "B+" supply becomes higher than it should. A 5000-ohm, 25-watt resistor connected across the proper power-supply point will add enough load to make up for the missing tube. The manufacturer's alignment instructions tell you where to connect the resistor. Killing the hori-

Fig. 4. (A) Poorly aligned set displays this response curve. (B) Normal response curve; each marker is in proper position.



zontal sweep eliminates interference in the curve on the scope.

You use only your v. t. v. m. and r. f. signal generator for prealignment. Connect the generator to the mixer test point on the tuner, and the v. t. v. m. to the video detector output. Set the v. t. v. m. polarity, and turn its range switch to 10 volts. Occasionally, you'll have to switch to a higher range, but not too often.

The first adjustment is to preset all the traps. The schematic diagram ordinarily shows trap frequencies; if not, the alignment instructions do.

The first trap in Fig. 1 is *L*2. Its frequency is 41.25 MHz, so that's where you set the generator dial. Turn the output control high enough to force a reading on the v. t. v. m. If the trap is close to its proper frequency, the reading may be quite low. You may have to turn the generator way up. If it's far off frequency, the reading may be above 10 volts. Your goal is to make the meter indication as low as possible by adjusting the slug in the trap coil. When the reading is low, turn the generator output up some more, so you are sure you have dipped through the absolute minimum for that frequency.

Next, do the same for trap *L*4. Its frequency is 47.25 MHz so that's where you set the generator. Again, push enough signal through the trap to cause a meter reading, and then tune the trap for an absolute minimum.

Follow this procedure for any other traps. Then go back over each one again, setting the generator to the exact trap frequency and tuning the slug for precise minimum. Keep in mind that some trap coils are wound on the same form with i. f. coils which you will adjust later. Be sure you turn the correct slug. The manufacturer's alignment data tells you whether to turn the top or bottom slug when you're setting the trap. If they don't call the coil a trap, you'll know that it is when you are instructed to adjust it for *minimum* response.

Next, preset all the other coils in the i. f. strip. Too often their frequencies are not labeled in the schematic. Notice in the alignment instructions which marker frequency is supposed to be used with which adjustment. From that you can work out for yourself which coils are for which frequencies. The sequence shown in Fig. 1 is common in monochrome receivers. However, you can't depend on this every time. Check the service manual.

The major difference between this step and prealigning the traps is that you use as little generator signal as you possibly can and still get a v. t. v. m. reading. A good rule of thumb is to use no more signal than is necessary to get a 1.5- or 2-volt d. c. reading from the video detector. And, of course, the adjustments are for *maximum* readings.

Start from the video detector and work toward the front end. In Fig. 1, align *L*6 first. The frequency for this coil wasn't on the schematic, so it was determined from the alignment data. It is 42.4 MHz. Set the r. f. generator for that frequency. Turn up the output control only enough to get a meter reading, and then adjust the slug for maximum. If the reading obtained is too high, reduce the output of the signal generator.

Continue with the other coils. Set the generator to the proper frequency for each, use enough r. f. signal to cause a meter reading, and then peak the coil for maximum. As you did with the traps, go over the entire group a second time.

This whole prealignment procedure seldom takes more than 10 minutes. What's important, you have brought the set pretty close to accurate alignment. Many technicians stop at this point and get away with it. The untrained eye and ear may not recognize that the set is still out of alignment. A customer may not notice the still-degraded picture.

However, the job is not done right until the set performs normally. In a color set, it would be a definite mistake to stop after prealignment. Color signals need the full bandwidth of the i. f. strip. Therefore, go on to the rest of the job —the sweep alignment.

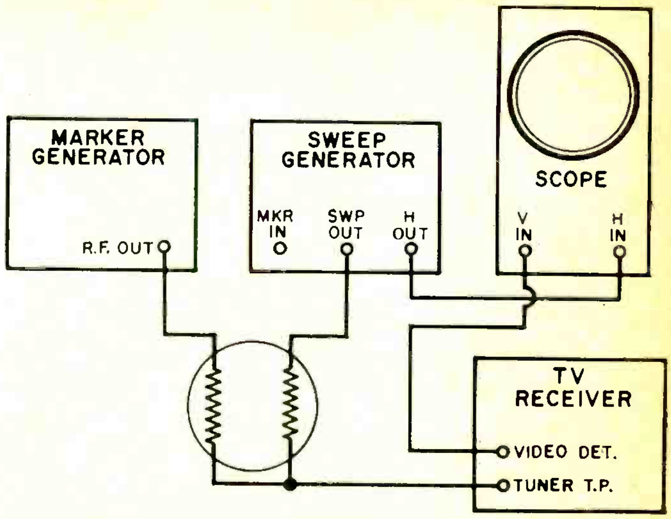


Fig. 5. Equipment connections for television alignment. You should keep all instruments warmed up for immediate use.

Sweep Alignment Problems

Fig. 5 shows the sweep generator, scope, and marker generator connections for running a sweep-response curve of the TV receiver. Use whatever input gimmick or jigs are suggested by the set manufacturer. Many of them are interchangeable. Use the resistive device to mix the marker and sweep signals. If you use a marker adder, connect it as was shown in Fig. 7C of Part 1.

For sweep alignment, you'd best study manufacturers' instructions. Each set is slightly different. Now that you understand the true relationship between the marker and the response curve, interpreting the instructions is easy. Nevertheless, problems do arise. Instead of repeating exact instructions, we'll explain away some of the troubles you may get into trying to follow them.

The question often arises: How can I tell from a sweep curve that I'm peaking a coil at the right frequency? Here's how. Set the marker generator to the intended frequency. Make sure you can see it on the response curve. Twist the Horizontal Position knob of your scope until the marker is situated on the vertical line of the graticule. With that line as your guide, tune the slug of the coil and watch the curve—only at the marker—move up and down along that line. No matter what a coil does to the over-all shape of the curve, it is peaked when the little marker squiggle is farthest up the guide line. It doesn't matter where on the curve the marker is; it can even be on one of the skirts.

You can use this technique with traps, too. Instead of tuning for uppermost movement of the curve at the marker point, you tune for downward movement. When you get a trap closely aligned, it may be hard to see the marker. This is because the trap is doing its job—blotting out that frequency. As a practical matter, once you've prealigned the traps, you'll probably not bother them again.

There's another common problem. Technicians sometimes go off on a haphazard tangent twiddling the slugs, trying to make the curve look as it should. There's a more scientific way. The secret is to figure out what frequencies are messed up.

Suppose, for example, an i. f. response curve looks like the one in Fig. 6. This one has an unnatural dip at the left side, and you don't know which coil is causing it. You can find out. Tune your marker generator back and forth until the marker is down in that dip. Read the frequency from the generator dial. Then look at the schematic or alignment instructions and see what coil most affects that frequency.

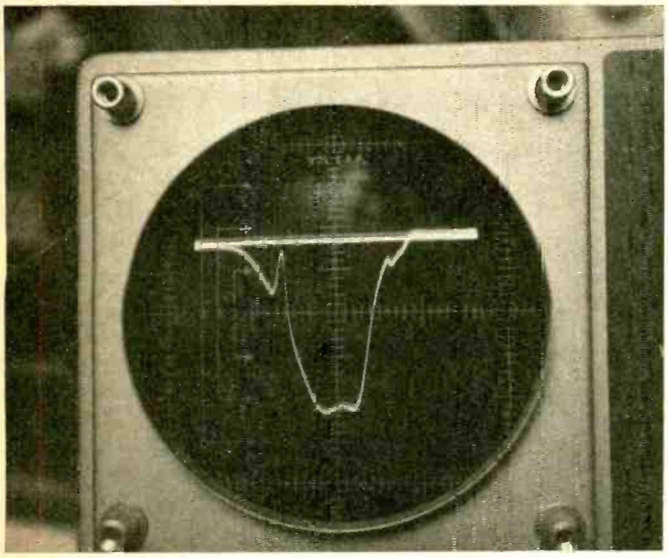


Fig. 6. Dip at left side of this curve is unnatural. If you can decide which coil is causing it, you can effect a cure easily.

That coil may be defective, or its bypass capacitor might be at fault. Or, the coil may simply be off-frequency.

The same reasoning would work if the curve has a hump. Just tune the r. f. generator until the marker falls at the point in question and notice its frequency. That gives you a clue as to which slug can help correct the shape.

Speaking of humps, sometimes you'll find that some other slug has been mistuned to the frequency that's over-peaked. There's an example of this in Fig. 2D; *L1* is almost at the same frequency as *L5*. If retuning the coil that normally affects a frequency doesn't straighten out the curve, look elsewhere. Usually, troubles of this extent mean you should prealign. If a coil or one of its associated parts is faulty, you will also be unable to prealign it. If mistuning is the only trouble, prealignment will practically cure it.

Fig. 7 illustrates several symptoms of trouble in your sweep-alignment setup. In Fig. 7A, the outline of a sync pulse indicates you are picking up station signal along with the sweep-generator signal. The sync pulse may creep around the trace. The deep fuzziness signifies that you also forgot to kill the horizontal sweep; horizontal pulses are modulating the response curve.

Fig. 7B shows faint horizontal pulses in the curve, without the station signal. Don't kill the horizontal sweep by disabling the horizontal oscillator; lack of drive can burn up the output tube. Likewise, don't just pull off the output plate cap; you'll exceed the screen-grid dissipation ability of the output tube.

Fig. 7C also shows the curve modulated by station signal, but with the sweep killed. You can set the channel selector for u. h. f. and tune to a blank spot near the high end; that will eliminate station interference.

Fig. 7D is a normal response curve, except that the phasing control on the scope or on the generator is set wrong. You can see it because the blanking control is also not turned on. The right procedure is to leave the blanking off until you've adjusted phase, then turn it on. The blanking establishes a "base-line"—as you can see in Fig. 7E, a normal sweep curve.

Editor's Note: Speaking of phasing, sometimes the sweep curve is displayed with the frequency increasing from left right, other times, from right to left. It all depends on the phasing of the 60-Hz sweep signals used by the scope and the sweep generator. Often, by merely reversing the a. c. plug of one of these instruments, you can get the curve to display frequencies which increase from left to right. In this way, you can match the display shown in most manufacturers' service data.

Fig. 7F shows how the curve can be distorted by too much marker signal. The curve would be the same as the one in Fig. 7E if it weren't for the marker swamping the tuned circuits. The cure is to reduce marker generator output.

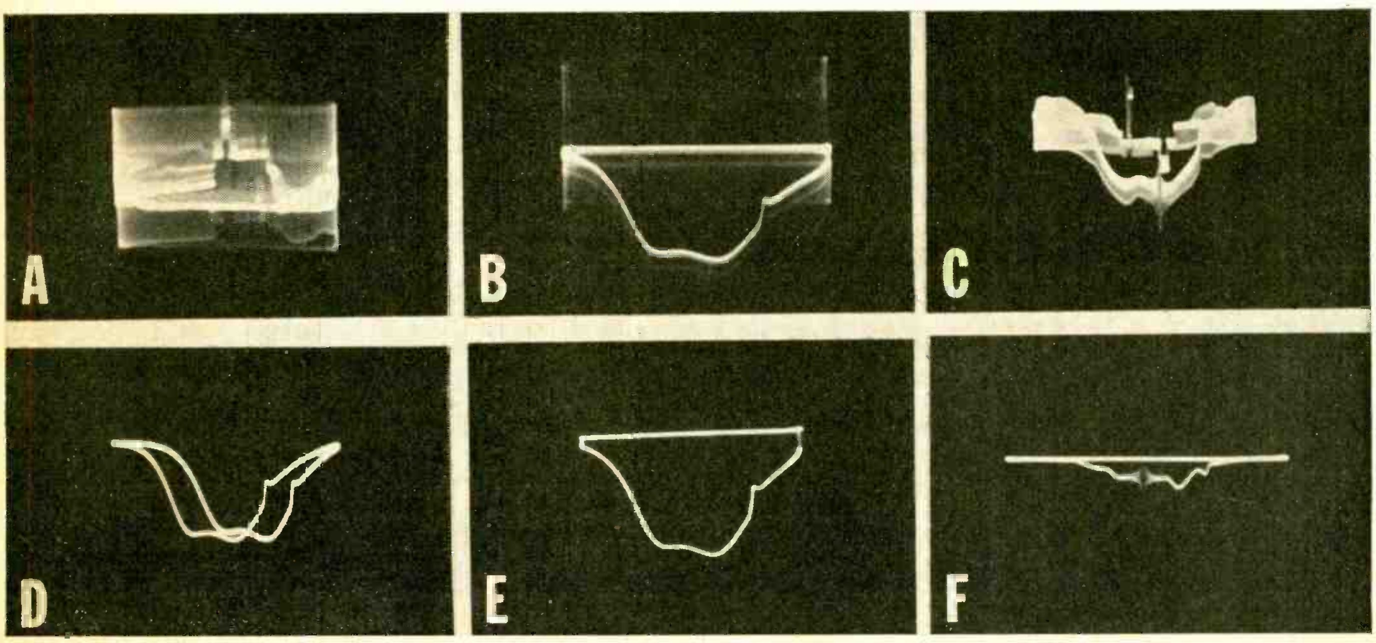
Handling the Tuner

With low-cost tuner repair service available, not too many technicians bother with tuner servicing. However, you can check alignment before you ship it off to the repair depot. Aligning a tuner isn't much trouble, once the i. f. strip is okay.

You'll line up the oscillator first. Use station signals, because no ordinary generator is accurate enough. Nor do you need a sweep generator. Chances are the tuner response curve, which you'll check later, is the same on all channels. If the tuner has preset fine tuning, use it to tune each station properly. If not, take the following steps.

Tune the highest v. h. f. channel that's active in your locality. Turn the fine-tuning control all the way to one end and then all the way to the other. At one end you should get good sound, and the picture *(Continued on page 60)*

Fig. 7. Faults you might encounter in your sweep alignment setup. Text describes cause of each and tells how to cure it.



These are the quality features to look for if you want a superb automatic turntable for your hi-fi system.

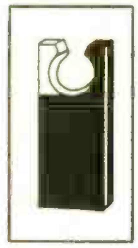
A vital determinant of the quality of an automatic turntable is the tone arm system. Here are some of the tone arm and related features that make the BSR McDonald automatic turntables the sophisticated units they are.

A resiliently mounted coarse and fine Vernier Adjustable Counterweight delicately counterbalances the tone arm assuring sensitive and accurate tracking.

Micrometer Stylus Pressure Adjustment permits ⅓ gram settings all the way from 0 to 6 grams. This important part of the tone arm assures perfect stylus pressure in accordance with cartridge specifications.

A much appreciated feature built into all BSR McDonald automatic turntables is the Cueing and Pause Control Lever. It permits pausing at any listening point and then gently permits the tone arm to be lowered into the very same groove. Positioning of the stylus anywhere on the record is accomplished without fear of damaging the record or the cartridge.

To achieve the ultimate in performance, BSR McDonald has brought to perfection the Anti-Skate Control. This adjustable dynamic control applies a continuously corrected degree of compensation as required for all groove diameters. It neutralizes inward skating force and eliminates distortion caused by unequal side wall pressure on the stylus. All of the BSR McDonald automatic turntables incorporate anti-skate.



After the last record has played on any of the three BSR McDonald automatic turntables, the tone arm automatically returns to the Locking Rest. In conjunction with this action, the On-Off-Reject lever automatically shifts into the Off position which securely locks the tone arm in its cradle to protect it from accidental drops and resulting stylus damage.

All BSR McDonald automatic turntables have a Clip-In Cartridge Head. This lightweight tone arm head, with finger lift and clip-in cartridge holder, provides universal mounting and quick change facility. It can accommodate practically every contemporary cartridge currently on the market.

Please send FREE detailed literature on all BSR McDonald automatic turntables.

Name __________

Address __________

City __________ State __________ Zip __________

Or just look for this name... BSR McDONALD

PRECISION CRAFTED IN GREAT BRITAIN
BSR (USA) LTD., BLAUVELT, N.Y. 10913

CIRCLE NO. 122 ON READER SERVICE CARD

Learn electronics at home faster, easier, almost automatically—with RCA AUTOTEXT

Are you just a beginner with an interest in the exciting field of electronics? Or, are you already earning a living in electronics and want to brush-up or expand your knowledge in a more rewarding field of electronics? In either case, AUTOTEXT, RCA Institutes' own method of Home Training will help you learn electronics more quickly and with less effort, even if you've had trouble with conventional learning methods in the past.

THOUSANDS OF WELL PAID JOBS ARE OPEN NOW TO MEN SKILLED IN ELECTRONICS!

Thousands of well paid jobs in electronics go unfilled every year because not enough men have taken the opportunity to train themselves for these openings. RCA Institutes has done something positive to help men with an aptitude and interest in electronics to qualify for these jobs.

HOME STUDY CAN TRAIN YOU FOR REWARDING CAREER OPPORTUNITIES

To help fill the "manpower gap" in the electronics field, RCA Institutes has developed a broad scope of Home Training courses, all designed to lead to a well paying career in electronics in the least possible time. You also have the opportunity to enroll in an RCA "Career Program" exclusively created to train you quickly for the job you want! Each "Career Program" starts with the amazing AUTOTEXT Programmed Instruction Method. And, all along the way, your program is supervised by RCA Institutes experts who become personally involved in your training and help you over any "rough spots" that may develop.

VARIETY OF KITS ARE YOURS TO KEEP

To give practical application to your studies, a variety of valuable RCA Institutes engineered kits are included in your program. Each kit is complete in itself, and yours to keep at no extra cost. You get the new Programmed Electronics Breadboard for limitless experiments, including building a working signal generator, multimeter, and a fully transistorized superheterodyne AM receiver.

ONLY FROM RCA INSTITUTES—TRANSISTORIZED TV KIT—VALUABLE OSCILLOSCOPE

All students receive a valuable oscilloscope. Those enrolled in the Television program receive the all-new transistorized TV Kit. Both at no extra cost and only from RCA Institutes.

CHOOSE THE "CAREER PROGRAM" THAT APPEALS MOST TO YOU

Start today on the electronics career of your choice. Pick the one that suits you best and mark it off on the attached card.

- Television Servicing
- Telecommunications
- FCC License Preparation
- Automation Electronics
- Automatic Controls
- Digital Techniques
- Industrial Electronics
- Nuclear Instrumentation
- Solid State Electronics
- Electronics Drafting

ADVANCED TRAINING

For those already working in electronics, RCA Institutes offers advanced courses. You can start on a higher level without wasting time on work you already know.

UNIQUE TUITION PLAN

With RCA Institutes Training, you progress at your own pace. You only pay for lessons as you order them. You don't sign a long-term contract. There's no large down-payment to lose if you decide not to continue. You're never badgered for monthly payments. Even if you decide to interrupt your training at any time, you don't pay a single cent more.

CLASSROOM TRAINING ALSO AVAILABLE

If you prefer, you can attend classes at RCA Institutes Resident School, one of the largest of its kind in New York City. Coeducational classroom and laboratory training, day and evening sessions, start four times a year. Simply check "Classroom Training" on the attached card for full information.

JOB PLACEMENT SERVICE, TOO!

Companies like IBM, Bell Telephone Labs, GE, RCA, Xerox, Honeywell, Grumman, Westinghouse, and major Radio and TV Networks have regularly employed graduates through RCA Institutes' own placement service.

SEND ATTACHED POSTAGE PAID CARD TODAY. FREE DESCRIPTIVE BOOK YOURS WITHOUT OBLIGATION. NO SALESMAN WILL CALL.

All RCA Institutes courses and programs are approved for veterans under the New G.I. Bill.

RCA INSTITUTES, DEPT. EW-98
320 West 31st Street,
New York, N.Y. 10001

Accredited Member National Home Study Council

RCA

JOHN FRYE

The vacuum tube, having survived many a premature obituary, seems finally on downhill road to oblivion.

TWILIGHT OF THE VACUUM TUBE

Mac was frowning at the tube order he had just prepared. "High prices on some of those tubes bugging you, boss?" Barney, the assistant technician, asked.

"I *don't* like the ridiculous prices on some of the older types, but what I was really thinking was how short this list seemed compared to the tube orders we used to send out. We're doing more business than ever before; yet this list is less than half as long as it would have been five or six years ago. The reason, of course, is we're doing more and more work on solid-state equipment, and we simply don't require the number of replacement tubes on our shelves that we used to need. I suppose we may as well face up to the fact that tubes are finally on the way out."

"You sound sort of sad about it."

"I probably am. After wrestling vacuum tubes for more than forty years, I've developed a kind of grudging respect and fondness for the ornery critters. Just remember my experience with them starts back with cold-filament 'BH' gas rectifiers and cranky WD-11's and goes on through the easily burned out 199's, the first really reliable general purpose 01A, the 226's and 45's that made the all-a.c. set possible, the indirectly heated cathode 227's and 224A's that came next, those temperamental and microphonic two-volt-filament '30 series tubes, that silly-looking squat 6H6 that introduced the all-metal octals, and finally the loktals—which in my opinion should never have happened—the baseless miniatures, the multi-element multi-purpose tubes, and the compactrons."

"Gee, you *are* old, aren't you?" Barney marvelled.

"I prefer the word 'experienced,'" Mac answered stiffly. "At any rate, in spite of all the intermittent filaments, the poor internal welds, the gassy tubes, and the output types with creeping plate current I've encountered, I feel very comfortable with tubes. It's a little like the feeling you have for an old clunker of a car you've had for a long time. It may be a little balky at times, but you're thoroughly familiar with all its tricks and shortcomings and know how to cope with them."

"I know exactly what you mean. Vacuum tube theory is easier to grasp than is solid-state theory. Imagining those electrons zipping across from the cathode to the plate is a lot easier for me to picture than is all that stuff about holes and carriers and barrier regions. And a semiconductor is more of a 'black box' device than is a tube. You can tell a lot about the performance of a glass tube simply by looking at it. The glow of gas amid the elements, the red-hot plates of a rectifier caused by a shorted filter capacitor, the white-hot screen of an output tube signalling an open output transformer primary—these need but a glance to make a diagnosis. Even a metal envelope tube conveys some useful information to the experienced hand of a technician by its temperature. But a transistor just sits there blandly refusing to give your senses the least little hint about its condition. Say, are you really sure tubes are on their way out?"

"I'm afraid so. I was just reading the result of a recent market study by Stanford Research Institute in which the value of receiving tubes in this country is expected to decrease from $288 million in 1965 to only $62 million in 1975. The peak was reached in 1966 at a little more than $300 million. During this same ten-year period, the number of tubes consumed is expected to sink from 403 million to 102 million.

"A major factor in the decline is the very rapid phase-out of tubes in the Government electronics sector. In 1965 this accounted for 21 million tubes, but this market is expected to be virtually non-existent by 1975. Vacuum tubes are being designed out of all types of military and space agency communications equipment used in aircraft, ships, ordnance, and infantry tactical units."

"How about tube prices? Will tube manufacturers lower these to try to hang on to what's left of their diminishing market?"

"Stanford thinks the average price of receiving tubes will remain pretty constant in the consumer market because the tubes used will be mostly the multifunction types used in both monochrome and color-TV applications, but prices in the industrial and Government markets are expected to fall sharply as development costs are written off and pressure from solid-state devices forces tube producers to compete.

"Another factor influencing tube prices is the importing of cheap foreign tubes into the U.S. market. Receiving tubes imported into the U.S. between 1964-66 increased 68%, according to the Parts Division of EIA. Not all of these imports, however, were really from foreign competitors. Many were being made for American companies who were seeking cheaper labor abroad in the same way semiconductor firms are doing."

"From what you say, the multifunction tubes seem to be the one type most likely to stick around for a while."

"That's right. Stanford sees increased use for this type for the next several years. They explain sets using these tubes, having up to four active elements, are extremely light in weight and can compete with transistorized versions which require additional transformers. It is also expected that tubes which now operate at 400 volts will be redesigned to operate at lower plate voltages, say around 270 volts, so they can be employed in color-TV sets using inexpensive voltage-doubler circuits."

"Don't you think tube producers brought some of this situation on themselves by hiking the prices of older tubes clear out of sight? Retubing a five-tube set using a 12SA7, 12SK7, 12SQ7, 50L6, and 35Z5 can make a twenty dollar bill look mighty sick. And since most people can't get it through their noggins that the technician does not set tube prices, it makes him look bad when he has to quote a price on a repair job that includes some of these tubes. I know I hesitate recommending that a radio using these tubes be repaired, even though it otherwise is in good shape, simply because the prices on the tubes it uses are so far out of line."

"I know what you mean, and I've never been able to free my mind completely from a sneaking suspicion there was a trace of 'planned obsolescence' behind the pricing policy of older tubes. Still and all, I doubt this has had much to do with the inevitable fate of tubes. Transistors and IC's simply

CIRCLE NO. 94 ON READER SERVICE CARD→

SUPER-TRACK
SHURE

have more to offer in the way of durability, reliability, compactness, light weight, cool operation, low operating potentials, modest power demands, and versatility. These are all advantages that appeal to modern design engineers.

"In fact, I'm sure tubes would have been eclipsed sooner than they were if it were not for the fact older engineers distrusted the new-fangled semiconductors they did not completely understand. They clung to the tubes with which they were familiar. But these engineers are gradually being replaced by a new breed who cut their teeth on germanium and silicon slabs, and things are going to be much different from here on in."

"I know you're right, and I strongly suspect there's going to be a new breed of service technicians around to welcome the change. These are the youngsters who got into servicing after transistors were going good, or the old gray beards like us who have burned a lot of midnight oil trying to update our knowledge of our field. Some of these modern kids savvy transistors better than they do tubes. It's like that brat of a nephew of mine who is always showing off his New Math. This stuff is really hard for me to grasp because I never had it in school and I have to sort of translate it into the math I know best. But it is as easy as pie for him because he has never known anything else."

"Adaptability is the sign of a truly intelligent man," Mac pontificated. "Everyone in electronics is either going to 'get with' transistors and IC's or get out. We've already seen what they can do for computers, and now they are on the verge of moving into two other mass markets: the automotive industry and the television industry. *Motorola* is already using an IC in the audio section of one of its color sets, and Richard Kraft, product manager for color-TV, says this is only a starter. Within the next three to five years he foresees small signal functional blocks housing IC's being used in i.f. amplifiers, in the sound section, in the color signal processing section, and in the synchronizing circuits.

" 'In color-TV we have a product so complex that only solid-state can hope to achieve the simplification needed for reliability,' says Mr. Kraft. 'In black and white sets, this was achieved with transistors; in color sets, it will be done with microcircuits.' "

"Other manufacturers, especially those involved in tube manufacturing, are somewhat more cautious in their predictions, but all foresee increasing use of IC's in color-TV. They point out, though, that the higher cost of the solid-state devices is a retarding factor. At the same time they admit the sophisticated modern customer has been so conditioned to expect and demand solid-state circuitry in other products that he may demand it in his color-TV set in spite of the additional cost."

"That may well be the deciding factor as to how fast IC's push tubes out of the color-TV sets," Barney said. "Since the picture tube decides the size of the cabinet, the miniaturization made possible by the use of IC's is not important in color-TV—at least not to the extent it is in hearing aids, lightweight military equipment, and in space electronics. On the other hand, if IC reliability turns out to be as good as promised, this may accelerate the changeover. During these days of spiraling labor costs, money spent to avoid service calls is a good investment. But what are the Japanese doing about IC's in their color sets? Considering the way they have used solid-state devices in their portable TV receivers and in CB equipment, I'd say they are the boys to watch."

"And you may well be right. Some experts think an all-IC color-TV set is only a year away in Japan. There, as here, the crux of the whole thing is a matter of cost. It is believed the Japanese are trying to get the price of a linear IC down to $1 before going all-out for IC color-TV. The *Kansai Electronic Development Center*, formed by 60 Japanese receiver and components manufacturers in the Osaka area, has recently begun a new project, with the aid of a government subsidy, aimed at producing an all-IC color-TV set by March 31, 1969."

"Well," Barney remarked, "you've convinced me the vacuum tube filaments are dimming down all over the world, and there is no use in feeling sorry or nostalgic about it. If transistors and IC's can do a better job—and we both know they can—I'm all for them."

"I can't argue with that," Mac admitted, "but it's still going to take a little while to train myself not to ask automatically: 'Do the tubes light?' when someone calls in and says their set is dead!" ▲

"What makes you think this place is bugged?"

TV Alignment

(Continued from page 50)

should have interference in it. At the other end, the sound may fade out just a little, and the picture get dull and smeary. This tells you that oscillator tuning for that station is normal. If fine tuning goes too far in either direction, turn the control all the way to the end nearest best sound; then turn it back about one-quarter turn. Reach into the front of the tuner, with a nonmetallic screwdriver, and tune the oscillator slug for just the slightest interference in the picture. Make sure the adjustment stays the same after you take the screwdriver away. Do the same for each active channel, working from highest to lowest.

Again, the manufacturer's own instructions are best for sweep alignment. You display the alignment curve the same way as you did for i. f. alignment, except that you feed the sweep and marker signals into the 300-ohm antenna terminal. The adjustment technique is the same, too. The manufacturer's instructions tell at what frequencies you should mark the curve. You then adjust the coils to make the curve conform to the markers.

The Sound Section

In modern TV receivers, this is the easiest section to align. With the quadrature sound detector, you can do it all by ear. Use the station signal, because the 4.5-MHz beat between the video and sound carriers is more accurate than your generator.

Tune the sound i. f. coil and the sound take-off coil—if it is adjustable—for maximum sound in the speaker. Then do the same thing with the quadrature coil, but listen carefully to the sound at low level; make sure there's no distortion. You may have to compromise volume every so slightly to get the cleanest sound, but it won't be enough to matter. Use women's speaking voices if you can, or a singing voice. Don't align the quadrature detector with music, because it's harder to hear the distortion. Distortion in voices will give them a raspy sound.

Now that you have had a chance to see how relatively simple alignment can be when done systematically, you should no longer shy away from handling sets whose performance can be drastically improved by making the requisite alignment. ▲

Editor's Note: We would also suggest at this point that it would be a good idea to go back to Part 1 of this article in order to review the material given there on the test equipment that is used for alignment. Once you understand both the equipment and the procedure, the alignment job should be a snap.

Bandwidth for FM

(*Continued from page 27*)

amplitude to make up the listing shown in Fig. 2B.

With these figures it is possible to find out something about the bandwidth requirements when low modulating frequencies are used, such as, for example, 750 Hz. In this case, $M = 75$ kHz/750 Hz $= 100$.

From Fig. 2B it can be seen that a modulation index of 100 produces 100 pairs of sidebands. Hence, *bandwidth* $= 100 \times 2 \times 750$ Hz $= 150$ kHz.

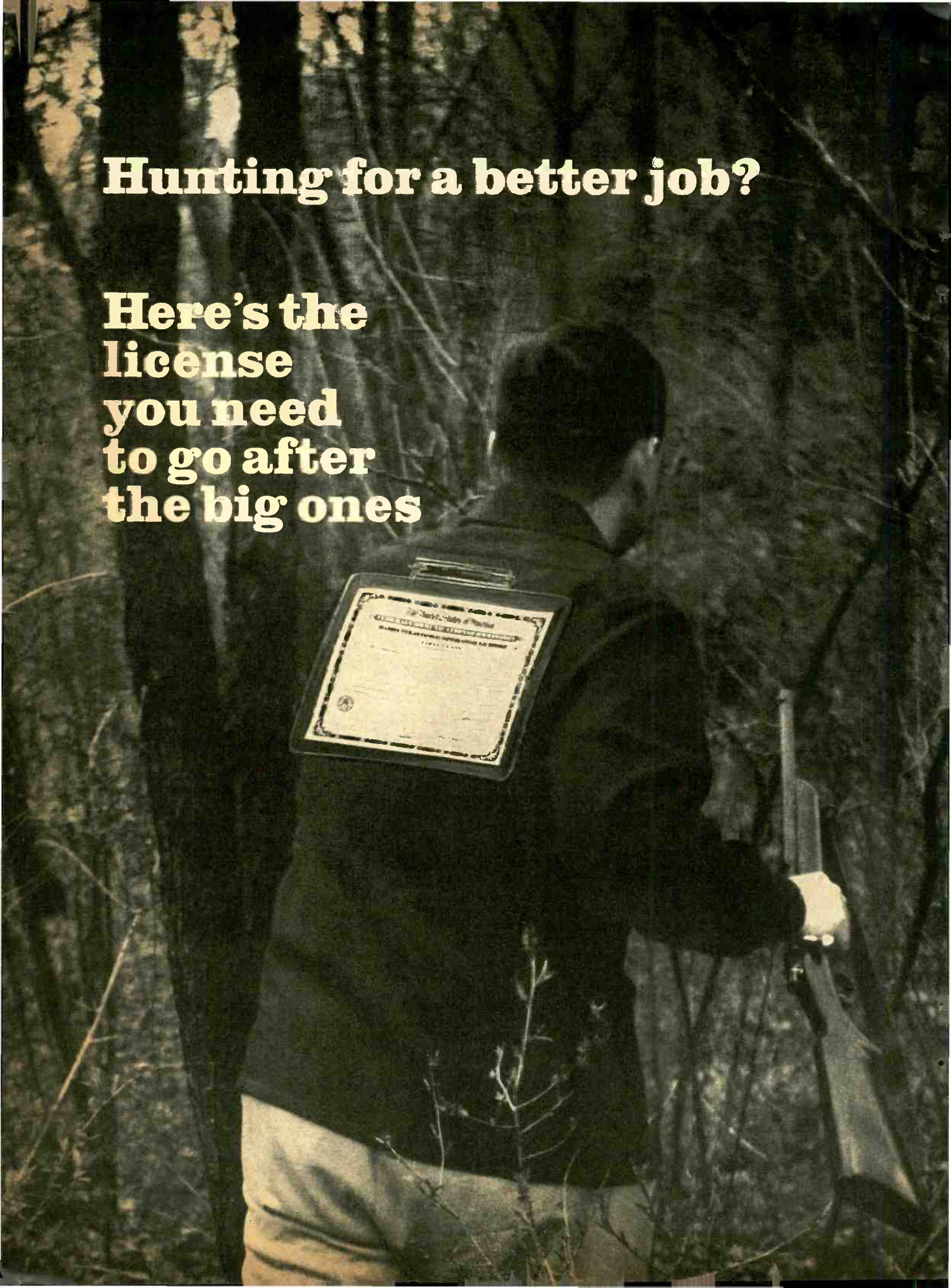
This is approximately the low-frequency turning point. With $M = 100$ or greater the required bandwidth is simply the deviation multiplied by 2. However since FM broadcast stations use 17-dB high-frequency pre-emphasis, the deviation would be 7 times down at 750 Hz and the modulation index would then be: $M = (75 \text{ kHz} \div 7)/750 \text{ Hz}) = 14$ which requires only 18 sideband pairs. Hence, *bandwidth* $= 18 \times 2 \times 750$ Hz $= 27$ kHz.

What About Stereo?

From the example just given, the reader will see that the low frequencies cause no trouble in the receiver, but what happens to the very high frequencies such as 53 kHz (38-kHz stereo subcarrier + 15 kHz) in a stereo transmission? Since 53 kHz is a conversion of the 15 kHz to the stereo subcarrier channel and since it is permitted to have a maximum of 90% deviation, the deviation figure used is 90% of 75 kHz or 67.5 kHz. Thus the equation becomes: $M = 67.5/53 = 1.2$ which requires 3 sideband pairs and the *bandwidth* $= 3 \times 2 \times 53$ kHz, or 318 kHz.

This bandwidth requirement seems rather strict. But looking at the amplitude of the sideband pair number 3 in Fig. 1, it will be seen that it is only about 0.03 at 1.2M, hence it would contribute only a small amount to the recovered audio. The loss of this sideband pair would not mean a complete loss of stereo separation at 15 kHz. This means that less expensive FM stereo receivers need not have this extended bandwidth. In the majority of such receivers there is much more loss in the multiplex unit at 15 kHz than would be caused by the loss of these sidebands. Also, since the response of the mono receiver discussed previously would not ordinarily be a perfectly rectangular 240-kHz bandpass, the skirt of the selectivity curve would probably allow the third sideband pair to pass quite readily.

From this last example, we can see that there is certainly nothing extravagant about using a 240-kHz bandwidth for stereo FM, but it is adequate. ▲


Hunting for a better job?
Here's the license you need to go after the big ones

A Government FCC License can help you bring home up to $10,000, $12,000, and more a year. Read how you can prepare for the license exam at home in your spare time — with a passing grade assured or your money back.

If you're out to bag a better job in Electronics, you'd better have a Government FCC License. For you'll need it to track down the choicest, best-paying jobs that this booming field has to offer.

Right now there are 80,000 new openings every year for electronics specialists—jobs paying up to $5, $6, even $7 an hour...$200, $225, $250 a week...$10,000, $12,000, and up a year! You don't need a college education to make this kind of money in Electronics. You don't even need a high school diploma.

But you *do* need knowledge, knowledge of electronics fundamentals. And there is only one nationally accepted method of measuring this knowledge...the licensing program of the FCC (Federal Communications Commission).

Why a license is important

An FCC License is a legal requirement if you want to become a Broadcast Engineer, or get into servicing any other kind of transmitting equipment—two-way mobile radios, microwave relay links, radar, etc. And even when it's not legally required, a license proves to the world that you understand the principles involved in *any* electronic device. Thus, an FCC "ticket" can open the doors to thousands of exciting, high-paying jobs in communications, radio and broadcasting, the aerospace program, industrial automation, and many other areas.

So why doesn't everybody who wants a good job in Electronics get an FCC License and start cleaning up? The answer: it's not that simple. The government's licensing exam is tough. In fact, an average of two out of every three men who take the FCC exam fail.

There is one way, however, of being pretty certain that you will pass the FCC exam. And that is to take one of the FCC home study courses offered by Cleveland Institute of Electronics.

CIE courses are so effective that better than 9 out of 10 CIE graduates who take the exam pass it. That's why we can afford to back our courses with this iron-clad Warranty: Upon completing one of our FCC courses, you must be able to pass the FCC exam and get your license—or you'll get your money back!

They got their licenses and went on to better jobs

The value of CIE training has been demonstrated time and again by the achievements of our thousands of successful students and graduates.

Ed Dulaney, Scottsbluff, Nebraska, for example, passed his 1st Class FCC License exam soon after completing his CIE training...and today is the proud owner of his own mobile radio sales and service business. "Now I manufacture my own two-way equipment," he writes, "with dealers who sell it in seven different states, and have seven full-time employees on my payroll."

Daniel J. Smithwick started his CIE training while in the service, and passed his 2nd Class exam soon after his discharge. Four months later, he reports, "I was promoted to manager of Bell Telephone at La Moure, N. D. This was a very fast promotion and a great deal of the credit goes to CIE."

Eugene Frost, Columbus, Ohio, was stuck in low-paying TV repair work before enrolling with CIE and earning his FCC License. Today, he's an inspector of major electronic systems for North American Aviation. "I'm working 8 hours a week less than before," says Mr. Frost, "and earning $228 a month more."

Send for FREE book

If you'd like to succeed like these men, send for our FREE 24-page book "How To Get A Commercial FCC License." It tells you all about the FCC License...requirements for getting one...types of licenses available...how the exams are organized and what kinds of questions are asked...where and when the exams are held, and more.

With it you will also receive a second FREE book, "How To Succeed In Electronics." To get both books without cost or obligation, just mail the attached postpaid card. Or, if the card is missing, send your name and address to CIE at the address below.

ENROLL UNDER NEW G.I. BILL. All CIE courses are available under the new G.I. Bill. If you served on active duty since Jan. 31, 1955, or are in service now, check box on reply card for complete details.

CIE
Cleveland Institute of Electronics
1776 E. 17th St., Dept. EW-49, Cleveland, Ohio 44114

Accredited Member National Home Study Council
A Leader in Electronics Training...Since 1934

CIRCLE NO. 118 ON READER SERVICE CARD

EW Lab Tested

(*Continued from page* 17)

ceived with equal quieting and freedom from distortion. The FM distortion at 100% modulation was 0.65%. The muting worked well with only a slight "thump" when tuning off a station.

The FM frequency response was ±2 dB from 30 to 15,000 Hz. The slight high-frequency drop-off shown on the graph was apparently due to a very effective ultrasonic filter in the tuner outputs, since we found little trace of 19- or 38-kHz signals in its audio outputs. This prevents the "birdies" which are sometimes heard when tape recording stereo broadcasts. FM-stereo channel separation was better than 30 dB in the mid-range and exceeded 20 dB from 100 to 10,000 Hz.

The AM section of the 530, incidentally, is quite good as such tuners go, although we would not call it "high fidelity."

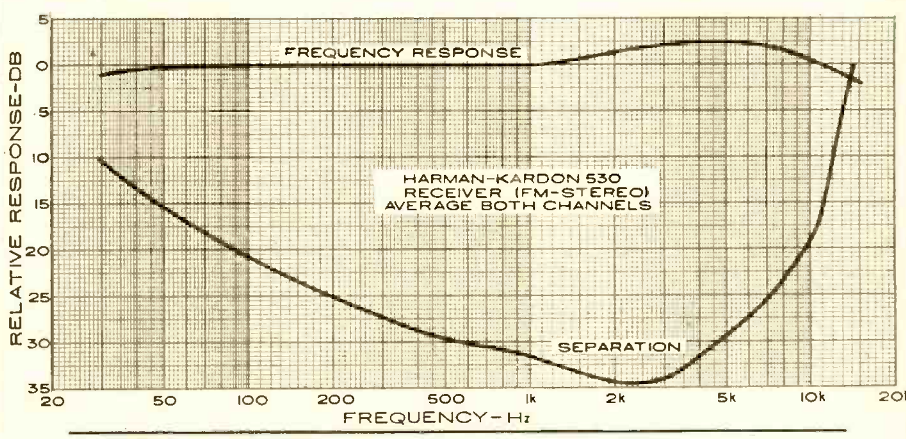
The high-cut filter had a 6-dB-per-octave slope above 2500 Hz which, while fairly effective in noise reduction, dulled the program sound noticeably. The loudness control had a shelved characteristic, with the response below 150 Hz boosted about 10 dB relative to the higher frequencies at normal volume control settings. The RIAA phono equalization was very accurate, within ±0.8 dB from 30 to 15,000 Hz.

The audio performance of the receiver was impressive. It is not powerful, by modern standards, delivering about 16 watts per channel into 8 ohms with less than 1% distortion between 20 and 15,000 Hz. At power outputs only slightly below the maximum, the distortion was extremely low (less than 0.1%) between 100 and 3000 Hz. At half-power or less, the distortion was under 0.2% from 20 to 9000 Hz, reaching a maximum of about 0.8% at 20,000 Hz.

At 1000 Hz, the harmonic distortion was under 0.25% from 0.1 to 18 watts, and under 0.1% from 1 watt to 17 watts. The IM distortion was under 0.25% for all powers below about 14 watts.

Despite its modest power, the audio system of the 530 ranks with the best in its distortion and frequency-response characteristics. It never seemed strained when driving speakers of moderate efficiency, even at a maximum volume-control setting. It is worth noting that the speaker systems manufactured by *Harman-Kardon* are 4-ohm types, into which the amplifier will deliver about 27 watts per channel continuous power. The manufacturer rates the receiver as a 70-watt unit or 35 watts per channel (4-ohm) by the IHF dynamic-power method, which appears to be quite consistent with our findings.

We commented earlier on the 530's airy, "live" sound. Repeated exposure to it, and comparison with other receivers, convinced us that this was not an illusion. The slight rise in the FM frequency response at upper-middle frequencies (although it amounts to only about 2 dB) might explain some of this sound. However, the receiver sounds much the same from tape and disc inputs. The sound quality does not appear to result from distortion, and the frequency response is as flat as one could desire. A few years ago, it might have been termed "transistor sound." Today, we would simply call it one of the cleanest, most open sounding receivers we have heard. The *Harman-Kardon* 530 sells for $349, and the 520 (without AM) is $315. ▲



Concord 510-D Tape Deck/Preamp

For copy of manufacturer's brochure, circle No. 31 on Reader Service Card.

THE *Concord* 510-D is a compact tape deck/preamp designed to be plugged into the tape output and input jacks of any stereo amplifier or receiver. The unit comes installed on a wooden base and it can be used either vertically or horizontally. The transport has three speeds (7½, 3¾, and 1⅞ in/s) and unlike some other low-priced decks that require changing a capstan bushing, the 510-D has a single lever that selects the operating speed. Tape reels

up to 7 inches in diameter can be accommodated.

The 510-D is a two-head machine with separately switchable record/playback solid-state preamplifiers. This gives it the capability of making sound-on-sound recordings, copying one channel onto the other while adding new program material from a microphone or from an external source. A three-position slide switch sets up the electronics for normal operation, copying channel #1 onto channel #2, or *vice versa*. No external cable jumpers are required in this case.

In the rear of the recorder are high-level input and output jacks. A pair of microphone jacks are located on the front panel. The microphone input signals are mixed with any signals coming in through the rear jacks. A pair of illuminated meters monitor both the recording and playback levels. A "0-dB" playback level on the meters corresponds to a 1.2-volt output signal per channel to the external stereo amplifier. Since the 510-D has no playback level controls, the volume must be controlled from the external amplifier with which the unit is used.

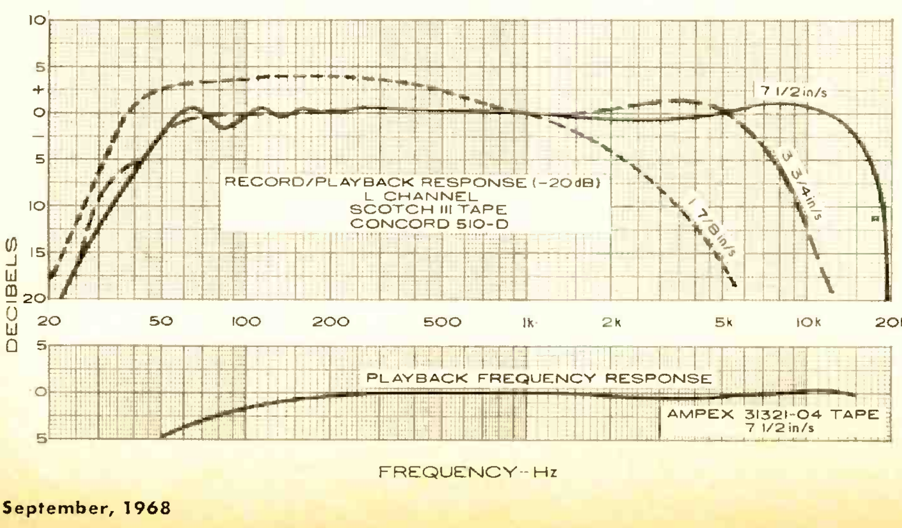
The tape is lifted from the heads when in wind or rewind modes, and the transport shuts off automatically if the tape breaks or runs out. There is a four-digit push-button reset type of index counter.

We measured the playback frequency response of the unit with the 7½ in/s *Ampex* 31321-04 quarter-track test tape as +0.3, −4.5 dB from 50 to 15,000 Hz, with the roll-off occurring at the lower frequencies. The over-all record/playback frequency response at 7½ in/s was very good, +1, −2.5 dB from 50 to 15,000 Hz. At 3¾ in/s the record/playback frequency response was +1.5, −3 dB from 45 to 7000 Hz. The 1⅞ in/s tape speed was suitable only for speech, with a frequency response of ±1.5 dB from 40 to 800 Hz, falling to 11 dB below the low-frequency plateau at 3000 Hz.

Wow and flutter were negligible. They measured, respectively, 0.06% and 0.07% at 7½ in/s and were both 0.08% at 3¾ in/s. The signal-to-noise ratio was 48 dB referred to 0-dB recording level, and the noise consisted essentially of hiss that was inaudible under conditions of normal use. The play and record speeds were slightly fast, with a timing error of approximately 45 seconds in 30-minutes playing time. In fast-forward, 1200 feet of tape was handled in 140 seconds; in the rewind mode 170 seconds was required to handle this amount of tape.

The unit was very easy to use. The controls were clearly identified and it was possible to operate them without reference to the instruction manual. The sound quality at 7½ in/s was essentially indistinguishable from the incoming program. At 3¾ in/s, a dulling of the highs could be heard, although the final sound was quite adequate for popular or background music. At the slowest speed, speech was quite muffled, and we found it necessary to use the tone controls on the external amplifier to restore a reasonable tonal balance. The sound-on-sound feature proved easy to use.

All in all, we found the *Concord* 510-D to be a versatile adjunct to a home-music system. Its quality, particularly at 7½ in/s, was compatible with the highest quality audio components. The tape deck/preamp sells for under $160. ▲



Free 1969 Heathkit® Catalog

New Lower Prices On Heathkit Color TV Make Them A Better Buy Than Ever!

Deluxe "295" Color TV...Model GR-295 — now only $449.95 (less cabinet)

New improved phosphors and low voltage supply with boosted B+ for maximum color fidelity and operation • automatic degaussing • exclusive Heath Magna-Shield • ACC and AGC assures color purity, flutter-free pictures under all conditions • preassembled IF with 3 stages instead of the usual 2 • deluxe VHF turret tuner with "memory" fine tuning • choice of installation—wall, custom or optional Heath factory assembled cabinets • Easy to assemble.

Big, Bold, Beautiful . . . With Advanced Features and Exclusive Heathkit Self-Servicing. Top quality, American brand color tube . . . 295 sq. inch viewing area. The built-in dot generator and full color photos and simple instructions let you set-up, converge and maintain the best color pictures at all times. Add to this the detailed trouble-shooting chart in the manual and you put an end to costly TV service calls for periodic picture convergence and minor repairs.

GRA-295-4, Mediterranean cabinet shown **$119.50**
Other cabinets from $62.95

Deluxe "227" Color TV...Model GR-227 — now only $399.95 (less cabinet)

Has same high performance features and built-in servicing facilities as the GR-295, except for 227 sq. inch viewing area. The vertical swing-out chassis makes for fast, easy servicing and installation. The dynamic convergence control board can be placed so that it is easily accessible anytime you wish to "touch-up" the picture.

GRA-227-1, Walnut cabinet shown **$59.95**
Mediterranean style also available at $99.50

Deluxe "180" Color TV...Model GR-180 — now only $349.95 (less cabinet)

Same high performance features and exclusive self-servicing facilities as the GR-295 except for 180 sq. inch viewing area. Feature for feature the Heathkit "180" is your best buy in deluxe color TV viewing . . . tubes alone list for over $245. For extra savings, extra beauty and convenience, add the table model cabinet and mobile cart.

GRA-180-5, table model cabinet and cart................. **$39.95**
Other cabinets from $24.95

Now, Wireless Remote Control For Heathkit Color TV's

Control your Heathkit Color TV from your easy chair, turn it on and off, change VHF channels, volume, color and tint, all by sonic remote control. No cables cluttering the room . . . the handheld transmitter is all electronic, powered by a small 9 v. battery, housed in a small, smartly styled beige plastic case . . . feather-light and contoured to fit comfortably in your hand for easy pushbutton operation. The receiver contains an integrated circuit (15 resistors, 10 transistors, 1 diode) and a meter for adjustment ease. Circuit board construction and plug-in wire harness make installation of receiver and control motors easy. For greater TV enjoyment, order yours now.

kit GRA-295-6, 9 lbs., for Heathkit GR-295 and GR-25 Color TV's.. **$69.95**
kit GRA-227-6, 9 lbs., for Heathkit GR-227 and GR-180 Color TV's.. **$69.95**

3 HEATHKIT® COLOR TV'S NOW! ALL WITH 2-YEAR WARRANTY ON PICTURE TUBE

kit GR-295

kit GR-227

kit GR-180

NEW Wireless TV Remote Control $69.95

FREE 1969 Heathkit Catalog

Shows these and over 300 other easy-to-build kits that save up to 50% . . . Electronic Organs, Stereo, Marine, CB, Ham Radio, Test, Photography, Educational for home & hobby. No skills or experience needed. Send for your free copy today. Mail coupon or write Heath Co., Benton Harbor, Michigan 49022.

HEATH COMPANY, Dept. 15-9
Benton Harbor, Michigan 49022
In Canada, Daystrom Ltd.

☐ Enclosed is $ ____________, plus shipping.
Please send model (s) ____________
☐ Please send FREE Heathkit Catalog.
☐ Please send Credit Application.

Name ____________
Address ____________
City ________ State ________ Zip ________

Prices & specifications subject to change without notice. CL-335

CIRCLE NO. 108 ON READER SERVICE CARD

Decimal Counting

(*Continued from page 43*)

or a "9" output. Three new gates can be used to derive the remaining 2 or 3, 4 or 5, and 6 or 7 outputs.

The outputs can be combined into a readout using transistor drivers and either a group of ten lamps or a special Nixie. If we use individual light bulbs, we group the "B+" side of the bulbs into even and odd groups. The 1, 3, 5, 7, and 9 bulbs go in one group, and the 0, 2, 4, 6, and 8 bulbs go into another group. The even-odd output determines which of the two groups receive "B+" power.

The rest of the decoder outputs ground the other end of the bulbs, two at a time. For instance, on count 3, the odd bulb group is powered, and bulbs 2 and 3 are grounded. Bulb 3 lights.

The *p-n-p* transistors in series with the bulbs serve to eliminate sneak paths caused by series combinations of bulbs.

This particular counter uses only 700 milliwatts of supply power and can be built for $10.90 per decade.

Add-Subtract Decimal Counters

An add-subtract or up-down counter is one which is capable of going in either direction. Such counters are often used in calculators, computers, and positional controls. They are always more complex than unidirectional counters. There are two approaches to the add-subtract counter, the true up-down counter and the 9's complement up-down counter.

The true up-down counter behaves exactly as an add-subtract, two-coil mechanical stepping relay. In the add mode, one count is added each time. In the subtract mode, one count is removed each time. A carry output is produced every time you go from 9 to 0, and a borrow output is produced every time you go from 0 to 9. This is usually a very complex circuit, requiring either five JK flip-flops and 15 gates, or four JK flip-flops and 24 gates, not including the decoding circuit. The reasons for the complexity are twofold. In switching from add to subtract, we cannot alter the toggle inputs on the flip-flops, for if we did, it would change the count and, obviously, the count must stay the same. Second, the decoding must remain the same for both addition and subtraction. Many simple counter coding schemes do not allow this.

The 9's complement up-down counter falls into the "sneaky trick" category and gives the same results as a true up-down counter at a fraction of the cost and complexity. An ordinary decimal up-only counter is used in the add mode, and we simply apply pulses and use the carrys. To subtract, we multiply the number of input pulses by nine, and add in nine times as many events as we really have. This is the long way around, but it gives the right answer.

To borrow, the number of input counts before multiplication is compared to the number of carry pulses the counter produces. If the input pulses exceed in number the carry pulses, a borrow is needed from the next stage. Two gates, connected as a set-reset flip-flop, are normally required for this comparison. The ×9 multiplier, borrow logic, and automatic add-subtract switching take four to five IC's and add about $5 to $7 to the cost of the basic up-only counter.

The 9's complement technique's major limitation is speed. Multiplying the input pulse rate by 9 means that the speed is proportionately reduced, often by a factor of 20 or more.

Predetermining Counters

A decimal counter that can be "trained" to stop at any desired number is called a predetermining counter. Predetermining counters are used in industrial process controls, for example to count out 54,239 bottle caps. Another important application is for photographic or other precision timers where the power-line or a crystal-reference frequency is counted down to obtain a precise time duration.

Predetermining counters vary in complexity but there are four major approaches to the design of a predetermining counter. You can enter in the counter the desired number using the preclear inputs, count down to zero. When the counter gets to zero, a gate closes. Or, an up-only counter can be used and the difference between the desired number and the total possible count precleared.

The count can also begin with the up-counter at zero and a gating circuit can be used to stop the counter at the right place. While this is the most obvious approach, it is usually the most expensive and often requires very complex switches and gating.

A very simple approach is to use a walking ring counter and an additional JK flip-flop. There are ten available outputs in a walking ring, and each has one and only one negative clock transition per ten counts. Since outputs are staggered, one per count, only six flip-flops and a single-pole, 10-position selector switch are needed. The chosen negative transition toggles the extra flip-flop when the desired count comes up. But this flip-flop is enabled after the ones on the more significant decades are satisfied. For example, if we are looking for an output at 397, we enable the extra hundreds flip-flop. On count 300, this flip-flop toggles, turns around, and enables the tens flip-flop. On count 390, this flip-flop toggles, and passes on an enabling signal to the units flip-flop, which now toggles on 397, and produces the desired output signal.

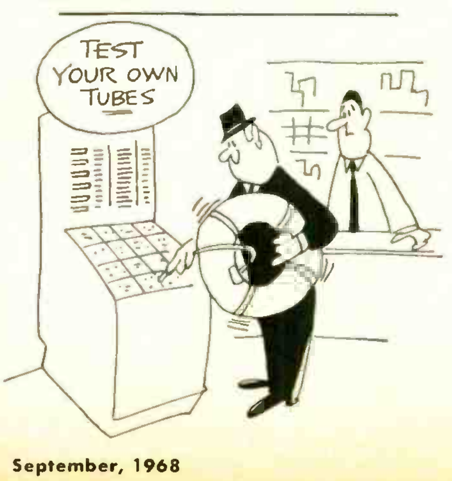
This particular counter requires six flip-flops and a buffer per decade. No decoding is needed if the individual counter states do not have to be indicated.

Fully Integrated Counters

IC divide-by-ten counters and shift registers are readily available, but are still too expensive for many applications. One technique is shown by the *Fairchild* CμL958, 959, and 960 series circuits. The CμL958 is a complete 1, 2, 4, 8 counter in a single package while the CμL959 provides a momory or a strobe action that remembers the present count while the CμL958 is working on a new count. This is handy in counters and digital voltmeters where the results from the last count remain visible while the instrument is working on a new count. The final IC in the series is the decimal decoder-driver that internally converts the 1, 2, 4, 8 code into a decimal output powerful enough to directly drive a Nixie or other gas-filled readout. Other manufactures offer competing systems. But, at present, these IC's run from $8 to $25 each, making the cost per decade of a fully integrated counter with readout about $30 to $50. Complete commercial modules are priced from $60 to $100 each, with imported versions slightly cheaper. Large-quantity prices usually are far lower than this.

Today, RTL integrated circuits and discrete components are significantly lower in cost. A $10.90-per-decade cost can be realized on an RTL biquinary counter, decoder, driver, and readout. We can soon expect the prices of fully integrated counters to drop drastically and the day of a practical $5.00, one-piece decimal-counting module is in the not too distant future. ▲

Editor's Note: A complete kit of the circuit in Fig. 8, including bracket, circuit boards, bulbs, resistors, and semiconductors, is available at $10.90 per decade from Southwest Technical Products, 219 West Rhapsody, San Antonio, Texas 78216.



"He's a good worker. I'd promote him right now if he had more education in electronics."

Could they be talking about you?

You'll miss a lot of opportunities if you try to get along in the electronics industry without an advanced education. Many doors will be closed to you, and no amount of hard work will open them.

But you can build a rewarding career if you supplement your experience with specialized knowledge of one of the key areas of electronics. As a specialist, you will enjoy security, excellent pay, and the kind of future you want for yourself and your family.

Going back to school isn't easy for a man with a full-time job and family obligations. But CREI Home Study Programs make it possible for you to get the additional education you need without attending classes. You study at home, at your own pace, on your own schedule. You study with the assurance that what you learn can be applied to the job immediately.

CREI Programs cover all important areas of electronics including communications, radar and sonar, even missile and spacecraft guidance. You're sure to find a program that fits your career objectives.

Photocells

(*Continued from page* 26)

color-temperature response: it would measure illumination accurately for light of any spectral distribution. The selenium photovoltaic cells used in better quality footcandle meters are fitted with corrective filters so that the resultant spectral response does not deviate appreciably from the response of the human eye.

Color temperatures of common light sources range from less than 2000° K for candle (or oil lamp) light to near 6000° K for sunlight. While the spectral response curves of cadmium sulfide cells do differ from those for the human eye, cells are available whose output is quite insensitive to color temperature over most of this color temperature range.

A measure of the sensitivity of cadmium sulfide and cadmium selenide cells may be gleaned from the fact that cell resistance specifications are based upon an illumination of 2 footcandles (fc). Average room light illumination is near 50 fc.

Stock cells are available in the small TO-18 transistor case with 2-fc resistances ranging from 1.4 megohms down to 2000 ohms. In the TO-8 case, 250 ohms is the specified 2-fc resistance for one cadmium selenide cell. Ultimate cell dark resistances are in the multi-megohm range and are not usually specified. A common specification is the minimum 2-fc to dark resistance ratio 5,10, or 30 seconds after the cell has been shuttered from 2-fc exposure. Ratios may be 100:1 for the slower, lower slope cadmium sulfide cells; 1000:1 for the faster, steeper sulfide units and low-resistance selenides; to 10,000:1 for cadmium selenide cells peaking at 7350 Å.

Selecting the Proper Photocell

The selection of the correct cell for any specific application appears to be a formidable task in light of the fact that one manufacturer, *Clairex*, for example, lists eighty stock cells.

The selection of the photosensitive material is the first step toward narrowing the field. As a general rule, measurement or analog control are most accurately performed with cadmium sulfide cells due to their lower temperature coefficients and lesser magnitude of light-history effect.

Measurement or control of illumination is best performed with the material least sensitive to variations in color temperature.

When measuring cells must follow rapid variations, use of the fastest sulfide material is indicated.

The spectral nature of the light source to be detected or measured may compel use of a specific material. The sensing of near infrared or control with an invisible-infrared beam calls for a selenide type of cell.

Color balancing in color-print enlarging may serve as an illustration of a more complex design problem. Here, the three primary colors must be measured. At first glance, one might attempt to measure each color with that material most spectrally favorable. However, measurement stability would suffer due to the different temperature and light-history effects of the three different materials. Moreover, we have not yet reckoned with such other factors as the light source, generally incandescent, or the color of color negative film, orange-brown. This combination of the incandescent lamp and the orange film results in a color distribution that is preponderantly red. The selection resolves itself into a search for the material which, with appropriate narrow-band filtering, will see the blue. The red skirt sensitivity of any material will be more than adequate for the red measurement required.

With the appropriate cell material chosen, the specific cell package may be selected depending on the following criteria:

1. The power which the cell must dissipate in the contemplated circuit.

2. The space that is available for the cell.

3. The optical geometry. Is the light to be presented to the cell diffuse or sharply collimated?

4. The relationship between the maximum voltage to be applied to the cell and the desired cell resistance: larger cell areas permit higher voltage operation (wider electrode gap) for equivalent cell resistance.

5. The cell resistance required at the available light level; lowest resistance is obtainable with the largest cell.

When the cell package has been selected, there may still be more than one cell listed. Where circuit considerations do not dictate a specific cell, the following criteria will assure maximum reliability:

1. If voltage transients are a possibility, the cell with the widest gap (highest resistance among cells of the same material in the same package) will provide highest voltage capability.

2. If cell feeds a voltage-driven input (tube grid, emitter-follower, FET), the highest resistance cell compatible with adequate circuit performance will insure the least amount of cell power dissipation.

3. If cell feeds a current-driven output (transistor emitter, relay), the lowest resistance cell compatible with circuit performance will minimize cell dissipation.

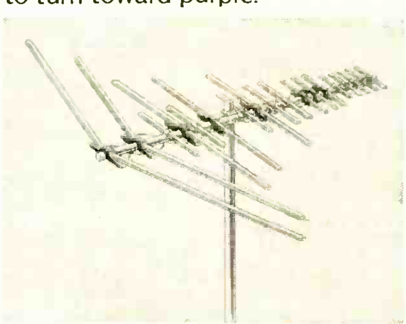
As is usual in engineering design, the final decision must be a weighted compromise. ▲

New antenna combines best performance features of Yagi and Log-Periodic

By G. A. VAN IDERSTINE

The Yagi design, developed by the Japanese inventor of that name, was for many years considered to be the best all round television antenna. However, with the advent of color TV, Yagis fell into some disfavor. While they provide excellent gain, most Yagis are not uniformly flat enough in frequency response to meet the needs of color TV.

TV engineers agree that response should be flat ±1 db per television channel to prevent color distortion. Yet some Yagis vary by more than 6 db within a single channel, causing yellows to turn greenish and reds to turn toward purple.



Gavin 82 channel V-Yagi.

The log-periodic design became popular recently because it solved the flatness problem. Log periodics do not provide as much gain as Yagis, but they produced better color pictures.

All of this set the stage for the new V-Yagi principle, developed by Gavin. The V-Yagi combines the high gain of a Yagi with the flatness of a Log-Periodic. This is done through judicious sizing and spacing of antenna elements. Like the Log-Periodic, the V-Yagi uses numerous driven elements, with each group of elements tuned for a specific channel or channels. However, the Log-Periodic's driven elements are logarithmically spaced, while the V-Yagi elements are evenly spaced. This gives the V-Yagi an advantage in size. In other words, using a given boom length and a given amount of aluminum, the V-Yagi will provide significantly more gain than the Log-Periodic.

In both the V-Yagi and the Log-Periodic design, elements serve double duty by resonating in two modes simultaneously. For example, an 85-inch element is a half wave length long at channel 4, and 3/2 wavelengths long at channel 12.

Unfortunately, an element operating in the 3/2 wavelengths mode produces side lobes. Side lobes are objectionable in many areas, since they can pick up reflected signals which appear on the screen as "ghosts." To eliminate the side lobes, the last two elements in the V-Yagi are Veed forward. You'll notice that many Log-Periodic antenna elements are also Veed forward, for exactly the same reason.

The long Veed rear elements in the V-Yagi serve other purposes as well. For one thing, they provide gain on some channels. For another, they improve the front-to-back ratio of the antenna.

The V-Yagi principle can be used not only in VHF-only antennas, but in 82 channel antennas as well. Indeed, while many all-channel antennas are nothing more than a U antenna stuck onto the front of a V antenna, the Gavin V-Yagi units are truly integrated.

Also, many all-channel antennas attenuate the FM band, but the fully integrated V-Yagi provides excellent FM gain. Thus, it is capable of serving all home reception needs.

In addition to providing better electronic performance, the new Gavin V-Yagi antennas offer a number of mechanical advantages, including the following:

1. They are made of light, rugged aircraft aluminum. Not only does this aluminum offer excellent fatigue life, it also lightens the load for rotators.

2. The booms are round. Some people prefer square booms esthetically, but round booms reduce wind and ice loading significantly. The booms are also pre-stressed for added rigidity.

3. The elements are supported by internal Cycolac braces. Virtually unbreakable, Cycolac is one of the toughest materials known to man. It's the same polymer used in golf clubs and timber splitting wedges.

4. Insulators too are made of Cycolac.

5. Spring loaded contacts made from heavy duty rivets and resilient Cycolac maintain peak antenna performance.

6. Heavy duty plated U-bolts and saddle bracket which locks into saddle clamp. Where competitive U-bolts often rust, all Gavin steel hardware is plated irridited, and gold chromated. Double U-bolts are provided on heavier models.

Splitter separates signals to UHF and VHF antenna terminals, plus extra FM output. Supplied free with each 82 channel V-Yagi.

7. Improved saddled boom braces damp the natural resonance of the boom, minimizing vibration.

The Gavin 82 channel V-Yagi line comprises six models ranging in list price from $16.45 to $67.95.

Gavin

GAVIN INSTRUMENTS, INC.
Subsidiary of ADVANCE ROSS CORP.
Somerville, N. J. 08876 U. S. A.

CIRCLE NO. 84 ON READER SERVICE CARD

How to Fly to the Moon

(Continued from page 37)

Fig. 8 shows the orientation of radar beams relative to the spacecraft's coordinate system. Beams 1, 2, and 3 sense spacecraft velocity along their axes while beam 4 senses range. If V_1, V_2, and V_3 are measured velocities along these beams then the velocity relative to the space craft *X*, *Y*, and *Z* axes may be defined by the following equations:

$$V_x = \frac{V_1 - V_2}{2A}$$

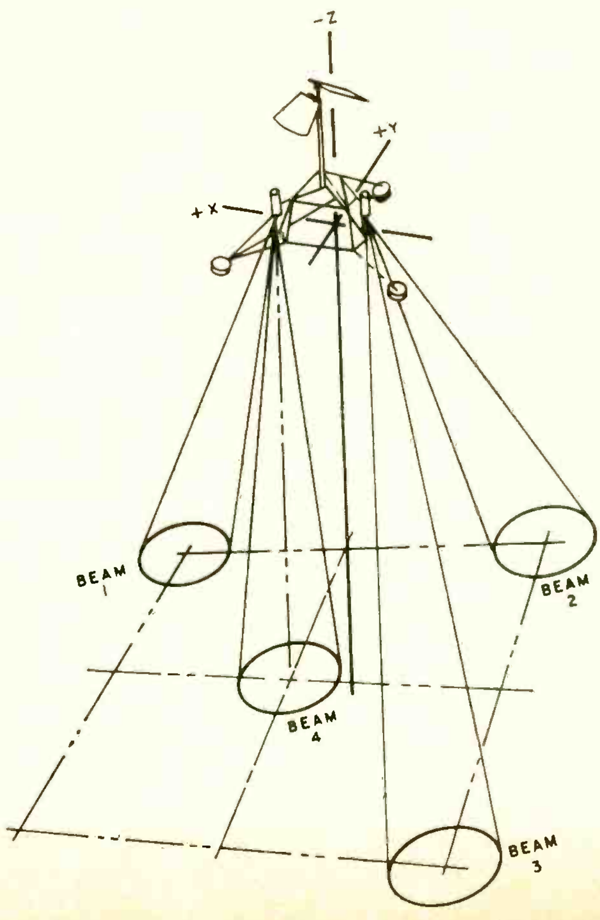
$$V_y = \frac{V_2 - V_3}{2A}$$

$$V_z = \frac{V_1 + V3}{2B}$$

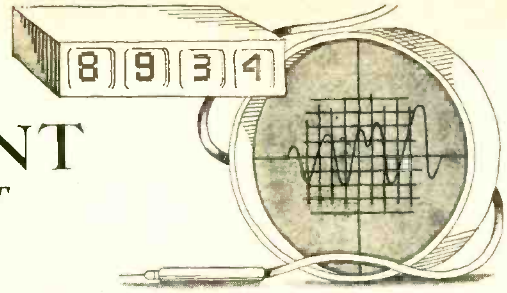
where *A* and *B* are constants defined by the beam geometry relative to the spacecraft. Thus, gravity turns can be accomplished by simply commanding rotations about the spacecraft *X* and *Y* axes until V_x and V_y become zero. The two major advantages of a gravity-turn descent are: first, a vertical descent is not necessary so sensor requirements are simplified, and second, as the total velocity approaches zero, the flight path tends toward the vertical.

At approximately 13 feet from the moon's surface the engines cut off and the spacecraft free falls. To insure that the spacecraft is stable at engine cutoff, attitude control is switched from the radar back to the inertial mode (fixed attitude) and a constant descent velocity of 3.5 mi/h is maintained from an altitude of 40 feet to engine cutoff. Normally this results in a touch-down velocity of 8 to 9 miles per hour. ▲

Fig. 8. A radar altimeter and Doppler velocity sensor guide the Surveyor during the final landing phase. Beams 1, 2, and 3 are the velocity sensors and beam 4 is the altimeter.

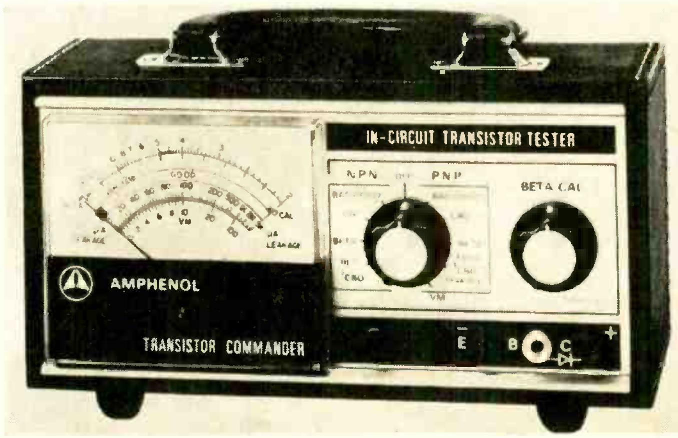


TEST EQUIPMENT
PRODUCT REPORT



Amphenol Model 830 Transistor Tester

For copy of manufacturer's brochure, circle No. 32 on Reader Service Card.



THE new *Amphenol* Model 830 "Transistor Commander" not only checks transistors both in and out of the circuit, but it also doubles as a sensitive d.c. voltmeter. The instrument can measure d.c. voltages on its 100-volt range at an input impedance of 100,000 ohms. An expanded voltage scale is used so that the range from 0 to 10 volts is spread out over more than half the scale. This makes it easy to read low transistor supply voltages. In addition, the tester functions as a diode analyzer that can measure both forward and reverse currents.

The "Transistor Commander" is able to: (1) check high- and low-power *n-p-n* and *p-n-p* transistors for in-circuit d.c. *beta*; (2) check such transistors out-of-circuit for d.c. *beta*, collector-to-base leakage current, and collector-to-emitter leakage current; (3) check diodes and rectifiers for in-circuit opens, shorts, and ability to rectify; and (4) check diodes out-of-circuit for forward and reverse currents. The *beta* range of the tester is from 1 to 1000 while leakage currents can be measured directly up to 5000 μA.

The new analyzer contains a current-limiting circuit for protection against accidental burn-out of transistors and diodes. It also has an automatic power protection circuit that prevents shorted transistors and diodes from damaging the instrument.

The tester is 9¼-in wide, 5¾-in high, and 6⅜-in deep. Like other products in this manufacturer's line of test equipment, a handsome black luggage-type case with carrying handle is used to house the instrument. The unit operates from the a.c. power line. It is priced at $79.95. ▲

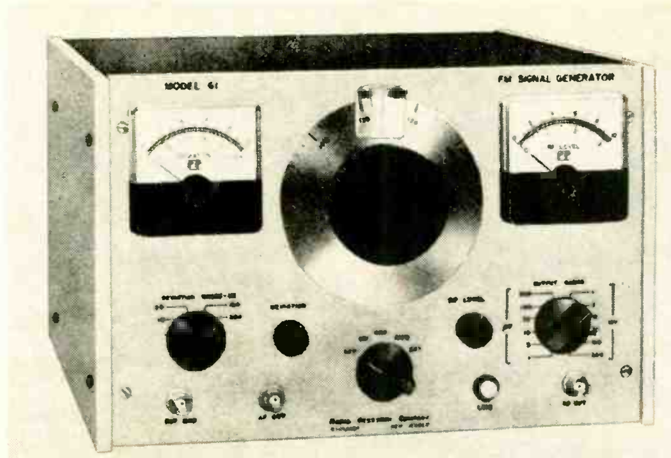
Radio Research Model 61 FM Signal Generator

For copy of manufacturer's brochure, circle No. 155 on Reader Service Card.

THE new Model 61 FM signal generator from *Radio Research Co.* is a laboratory-quality sweep generator intended for production-line or general lab use. Of particular interest to those manufacturing or designing entertainment receivers, the generator has a wide modulation bandwidth that permits accurate stereo separation measurements to be made when the generator is driven by a suitable stereo source.

The instrument is completely solid-state. It is electronically regulated against variations of both line and load.

The frequency covered is 83 to 135 MHz at an accuracy of 1 percent. The frequency range is such that there is complete coverage of the FM broadcast band along with coverage of the normal image frequencies of FM sets. The r.f. stability is 0.005 percent or better over a period of 10 minutes. There is complete control of the r.f. level all the way down to 0.1 microvolt. Maximum output is 0.3 volt (r.m.s.) into a 50-ohm load. The output is continuously variable and



metered in 12 ranges. Frequency deviation, which is also variable and metered, is 0 to 250 kHz.

An internally mounted adapter is available to heterodyne the high-frequency output of the signal generator down to 1 to 35 MHz for use in low frequency and i.f. sweep alignment applications.

Price of the Model 61 is $695, while the low-frequency adapter is available at $145. ▲

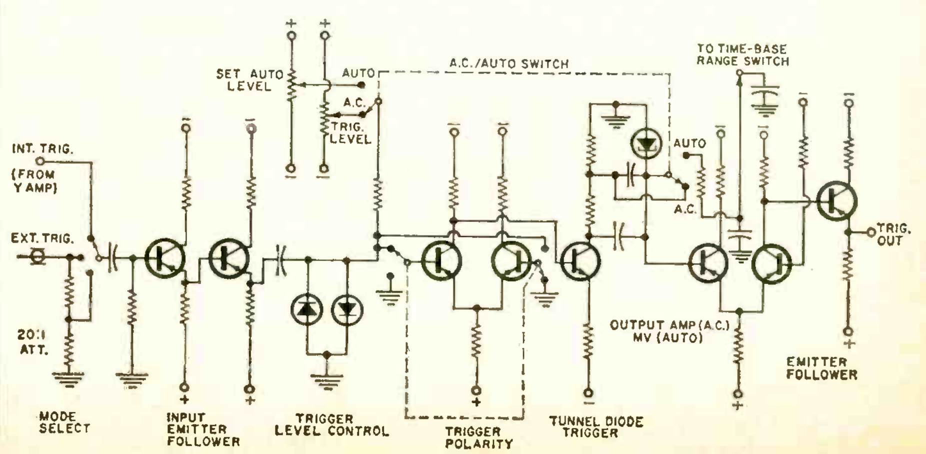
Motorola Model S1301A Oscilloscope

For copy of manufacturer's brochure, circle No. 33 on Reader Service Card.

ENGINEERS and technicians may soon have an oscilloscope issued to them, along with their tools and meter, instead of having to share a few scopes with many co-workers. The reason is the availability of new, lower-cost, laboratory-quality oscilloscopes such as the *Motorola* Model S1301A. This scope is quite reasonably priced ($665) for a unit that features a bandwidth conservatively spec'd at 20 MHz (usable to 35 MHz), a rise time of 17 nanoseconds, 18 calibrated sweep ranges, an internal square-wave voltage calibrator, and triggering stability in excess of 30 MHz.

In addition, the scope is ideal for field use. An internal battery and a built-in charger allows the unit to be used anywhere. The scope weighs only 17 pounds and measures 8½ inches x 9 inches x 15 inches. In addition to the internal battery, it may also be operated from an external 12-volt d.c. source or from an a.c. line, 95-130 V or 190-260 V at 40 to 500 Hz. Power consumption is only 20 watts d.c. (or 25 watts a.c.).

The small size, low power requirements and moderate cost can be attributed to the solid-state design and to the use of a mesh-type post-acceleration CRT. (*Editor's Note: This tube uses a mesh screen between the deflection plates and the fluorescent screen. A voltage is applied to the mesh which is used to accelerate the beam. The purpose is to reduce the length of the tube.*) The increased spot size and re-



duced writing rate usually associated with this type of tube are overcome by careful design, including optimizing the gun voltage, increasing the effective transconductance of the CRT, and a good mesh configuration.

A distinctive circuit feature of the Model S1301A lies in the use of a tunnel diode as the bistable element in the trigger circuit. It is this feature that provides the outstanding triggering stability.

Referring to the simplified schematic diagram shown, trigger pulses may be derived either from the Y amplifier output or applied to an external trigger input socket. The selected trigger signal is passed *via* two cascaded emitter followers to a level-selecting circuit consisting of two diodes. The current fed to the diodes is adjusted by means of the Trigger Level (or Set Auto-Level pre-set) control such that one or the other of the diodes conducts, depending upon the polarity of the applied signal. The signal is thus clamped to ground until its amplitude is sufficient to back-bias the conducting diode and to forward-bias the second diode.

When this changeover occurs, a voltage step is produced which is then applied to a two-stage transistor amplifier which either acts as a simple inverter or as a long-tailed pair, depending upon the setting of the trigger signal polarity switch. The output is taken from the same collector in either event, thus always providing a positive-going output which causes a following *n-p-n* transistor to conduct.

The final output trigger pulse is derived from a tunnel diode which is reverse-biased when the *n-p-n* stage is cut off and forward-biased when the transistor conducts. As the forward current through the tunnel diode increases, a discontinuity occurs, producing a sharp negative-going voltage transition. This voltage step is fed through an amplifier stage and an emitter follower to the time-base circuitry which produces the required sawtooth sweep waveform.

When the Trigger Mode switch is set to "Auto", the first transistor of the amplifier and the tunnel diode combine to operate as a free-running multivibrator. The frequency is controlled by means of capacitors associated with the Time Base range switch so that time base sweeps occur at a repetition rate of approximately 10 kHz on the six fastest ranges, at 200 Hz on the next six, and about 5 Hz on the six slowest ranges. This facility assists in maintaining constant display brightness in the absence of a signal.

The simplicity of the front-panel layout and control functions—in particular the trigger performance—of the Model S1301A makes the instrument highly suitable for educational, laboratory, and general service use. ▲

Double the TV Signal on Coax Installations

By VIC BELL

Eliminating matching transformer used at the TV set gives better performance for weak-signal coax systems.

WHEN a coaxial cable antenna system is installed, most TV sets require a matching transformer. The transformer is used to match the impedance of the coax (75 ohms) to the impedance of the set's antenna input (300 ohms).

Many matching transformers available for this job are inexpensive, high-loss units which often match poorly. But even with a good match, the transformer's losses are usually 3 dB or more. In other words, half the signal power gets lost. By modifying the tuner's input circuit, most sets can be adapted to match the coax input directly, thus eliminating the additional transformer.

Besides increasing the signal level to the tuner, eliminating the possibility of mismatch, and reducing system cost, there is another advantage to making this modification. Snivets, herringbone interference, Barkhausen oscillations, and a host of other picture troubles are often generated within the TV set and picked up by the receiver's internal antenna lead. Some color sets have such a high level of 3.58-MHz radiation that harmonics interfere with TV viewing on low-band stations.

The modification was tried on several interference-ridden color sets and, in all cases, the improvement was noticeable, and even in some severe cases the interference was eliminated.

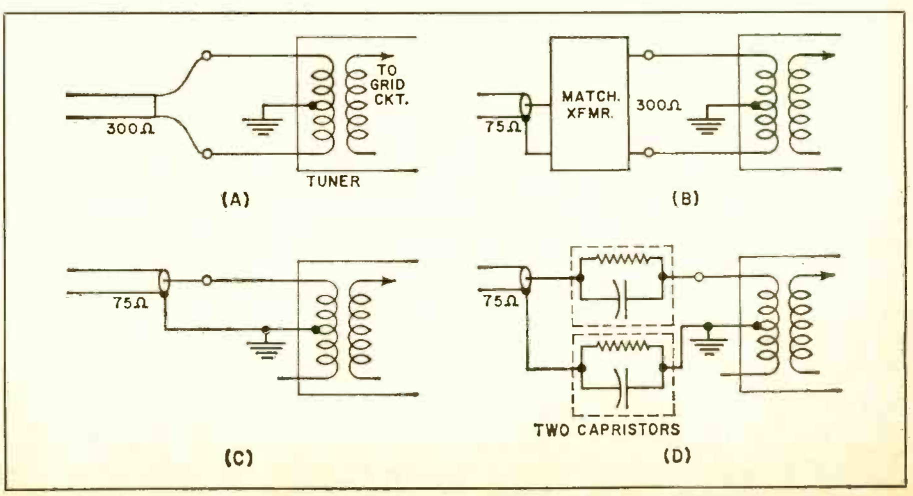
Fig. 1A shows the normal connections for a 300-ohm hookup and of the same set for a normal coax installation (Fig. 1B). Notice that the 300-ohm balun input to the tuner is center-tapped. Actually, each half of the input balun on the tuner has an input impedance of 75 ohms to ground. Consequently, we can use the balun as a matching transformer. See Fig. 1C.

If the set you're concerned with does not have a center-tapped balun input, you are out of luck. Further, if the set is a hot-chassis type, you'll need to make some additions to protect against blown fuses and shock hazard. The connections for using this circuit on a hot-chassis set are shown in Fig. 1D.

When making the 75-ohm input modification, keep the coax leads short. Clamp the coax to the tuner to keep it from shorting or being pulled from the tuner and damaging the tuner balun. To make the set easier to service, use a coax connector near the rear of the set.

Don't try to make the set usable on both 75- and 300-ohm inputs if you have an interference problem. The additional wire lengths on the tuner balun form a good antenna which can pick up interference. ▲

Fig. 1. (A) Normal tuner inputs have center-tapped balun inputs. (B) To connect 75-ohm coax cable to most sets, a matching transformer is used. (C) On transformer-powered sets, a 75-ohm antenna system can be connected directly to the tuner with one leg of the balun left open. (D) Hot-chassis sets require capacitor-resistor combination in both legs of the tuner input. Typical values are 3 megohms for each resistor and 220 picofarads for each capacitor.



BOOK REVIEWS

"LINEAR INTEGRATED CIRCUITS" edited by Jerry Eimbinder. Published by *John Wiley & Sons, Inc.*, New York. 316 pages. Price $9.95.

The bulk of this book is made up of papers presented at a 1967 linear IC clinic, with four chapters of new material especially prepared to round out the subject.

The first chapter covers the use of off-the-shelf linear circuits in various applications while the balance of the book is devoted to specifics. Using IC's at high frequencies; in communications; operational-amplifier noise measurements; automatic parameter testing; how to select, specify, and use audio-amplifier IC's; single-ended linear IC's; broadband amplifiers; i.f. applications; wideband amplifiers, etc., etc. Three appendices cover the operation of integrated circuits, bonds, and thin-film deposition methods.

* * *

"TRANSISTOR CIRCUITS AND APPLICATIONS" by Laurence G. Cowles. Published by *Prentice-Hall, Inc.*, Englewood Cliffs, N. J. 07632. 318 pages. Price $10.95.

This is a practical handbook for technicians, junior engineers, and practicing electronics engineers. It can be used as a classroom text, as a reference source, or as a lab manual for performing experiments and building the circuits discussed.

The text is divided into 15 main sections with the 15th devoted to laboratory instruments and techniques. The laboratory experiments are covered in a special section at the back of the text and includes 16 practical and worthwhile projects.

A summary at the end of each chapter, a series of review problems, and the easy, informal style of the author all combine to make this a book that the student working on his own will find as useful as the formally enrolled member of a class.

* * *

"PINPOINT TV TROUBLES IN 10 MINUTES" by Harold P. Manly. Published by *Tab Books*, Blue Ridge Summit, Pa. 17214. 342 pages. Price $4.95. Soft cover.

This handy little book is for practicing technicians and is intended to help cut troubleshooting time by showing in 70 pictures approximately 700 circuit faults responsible for the faulty pictures.

The picture section consists of 11 pages in the front of the book. Beneath each of the faulty pictures is a listing of possible service troubles and cross-references to the page on which the trouble is discussed.

The author's style is almost telegraphic which is exactly the right approach for the busy service technician. With practice, the technician troubleshooting by this method should be able to turn out appreciably more sets each working day and increase his income substantially.

* * *

"ALL ABOUT FM ANTENNAE AND THEIR INSTALLATION" by L. F. B. Carini. Published by *Apparatus Development Co., Inc.*, Box 153, Wethersfield, Conn. 06109. 38 pages. Price $0.50. Soft cover.

This little book is addressed to the layman and is designed to impress on him the relationship between a good FM antenna installation and his enjoyment of FM programs.

The author describes the criteria for selecting an FM antenna, transmission lines, mounting locations, rotators, antenna boosters or preamps, accessories and finally gives a directory of FM stations in all 50 states, the District of Columbia, and in Canada.

* * *

"SEMICONDUCTOR AND TUBE ELECTRONICS" by James G. Brazee. Published by *Holt, Rinehart and Winston, Inc.*, New York. 640 pages. Price $10.95.

Subtitled "An Introduction", this volume has been addressed to students in technical institutes, junior colleges, and to those in industrial in-service training programs. Like most textbooks, each chapter carries review questions and problems, references, and in some cases laboratory exercises.

Prerequisite is an understanding of basic a.c. and d.c. theory and a working knowledge of algebra. Higher math and more sophisticated electronics courses are not required.

The sixteen chapters cover device physics; *p-n* junction devices; common-base, common-emitter, and common-collector configurations; vacuum tubes; FET's; cascaded amplifier and amplifier pairs; power amplifiers; negative feedback; sinusoidal feedback oscillators; nonlinear application of devices; rectifier power supplies; and microelectronics.

* * *

"RCA RECEIVING TUBE MANUAL" compiled and published by *RCA Electronic Components*, Harrison, N. J. 640 pages. Price $1.75. Soft cover.

The latest edition of this manual, designated Technical Series RC-26, is a revised and updated version of the company's familiar tube manual. It contains comprehensive information on tube types and technology, detailed descriptive data and application information on an extensive line of home-entertainment receiving tube types, picture tubes for black-and-white and color-TV receivers, and voltage-regulator and voltage-reference tubes.

Basic tube technology, operating characteristics, applications, ratings, and testing are discussed in six easy-to-read text chapters. The Circuits section has been expanded in terms of both the number of circuits and the types of applications covered.

* * *

"INTRODUCTION TO ELECTRONICS" by H. A. Romanowitz & R. E. Puckett. Published by *John Wiley & Sons, Inc.*, New York. 753 pages. Price $10.95.

This is a classroom text suitable for technical institute and junior college students starting work in electronics. The first chapter is a review of electrical circuit analysis and is sufficiently complete to fill in for students without the requisite background training. The balance of the text covers the behavior of semiconductors; crystal diodes; tube diodes; rectifiers; power supplies; and filters; triodes, tetrodes, and pentodes; transistors; voltage amplification; amplifier performance; power amplifiers; special-purpose amplifiers; feedback amplifiers and oscillators; modulation, detection, frequency translation; glow tubes; power conversion; photoelectric devices; IC's; and the application of electronics principles to practical circuits.

* * *

"DICTIONARY OF ELECTRONIC TERMS" edited by Robert E. Beam. Compiled and published by Technical Staff, *Allied Radio*, Chicago, Ill. 60680. 111 pages. Price $1.00.

This is the Eighth Edition of a compact and useful dictionary and contains up-to-date definitions for over 4800 terms and carries hundreds of illustrations.

Terms used in monochrome and color-TV, radio, high-fidelity, recording, ham radio and CB communications, p.a., solid-state and IC technology, computer work, aerospace, math, and physics are included.

The appendix carries a list of abbreviations and letter symbols, standard schematic symbols, letter symbols for vacuum tubes, transistor symbols, Greek alphabet designations, resistor color code, Ohm's Law, and a table of measures. ▲

Electronic Intrusion Alarms

(*Continued from page 46*)

plifies the frequencies that would be caused by an intruder. The 5-Hz channel is sensitive to the very low frequencies which are caused by thermal turbulences.

Obviously, you do not want thermal turbulence to cause a false alarm. Turbulence compensation is accomplished by comparing the output of the 5-Hz amplifier with the output of the 35-Hz amplifier in such a way that the remaining amount of response to turbulence in the 35-Hz band is mostly balanced out.

The ratio for the correct balance condition necessary for turbulence compensation is determined roughly by the values of the output resistors shown. It can be adjusted by changing the setting of the potentiometer which controls the output of the 5-Hz amplifier.

The combined signal, which is the compensated 35-Hz intruder signal, goes through a four-stage d.c. amplifier and is then used to close an alarm relay.

One of the problems with this unit is that turbulence compensation may overcompensate the 35-Hz response. In other words, the unit will be insensitive to an intruder who moves slowly. Therefore, the unit uses an override circuit. This causes the alarm relay to close if a low-frequency doppler signal exceeds a predetermined level. A large, low-frequency input triggers the alarm directly without passing through the compensating stages.

A somewhat different technique is used in the *Honeywell* "Sono-Sentry." This uses an audible signal (460 Hz) transmitted and received by a single unit which looks like a conventional p.a. loudspeaker. Since the protecting signal can be heard by any would-be intruder, it has a deterrent effect. The manufacturer also feels that audible sound waves are less likely to be triggered by false alarms that might be produced by heating units, air conditioning, gusts of wind, or even rustling curtains.

Remote-Alarm Systems

So far, we have discussed burglar sensing units. But once the intruder is detected, this information must be sent to the proper place. Some units are self-contained, with built-in bells.

However, many systems are made more effective by remote alarms. To provide this capability, wireless transmitters are quite useful. (*These are wireless in the sense that no interconnecting wiring is needed between the transmitting and receiving/alarm units. By plugging each unit into the a.c. line, the power wiring can be made to carry the signals and interconnect the units.—Editor*)

For example, the *Heath* transmitter and receiver shown in Fig. 7 can be used with a very wide variety of sensors including: fire alarms, freeze warnings, cooling-heating alarms, and flood alarms, as well as intrusion alarms.

The transmitter works on a frequency of 50 kHz which is applied to the 60-Hz power line. The transmitter can be activated by any sensor connected across normally closed or normally opened terminals. Any interruption of power also sends a warning signal to the receiver/alarm unit.

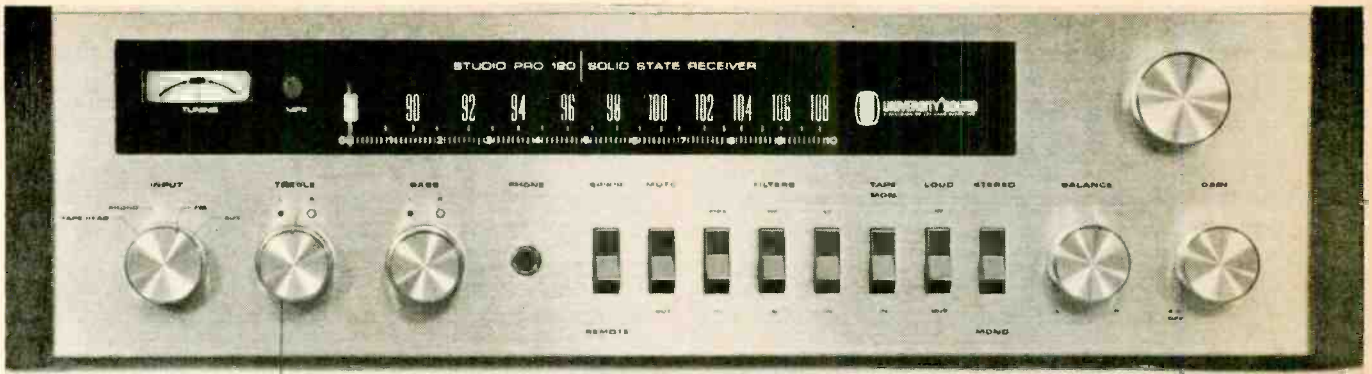
The 50-kHz carrier frequency is generated by a two-transistor stable multivibrator. It is coupled to the receiver through the a.c. power line. The receiver amplifies the signal, detects it, filters it, and uses it to close the proper relay.

The *Heath* units are available in kit form. Wireless transmitters and receivers for security use are also made by a number of other manufacturers, including *Honeywell*.

Next month's article will cover a system which uses 400-MHz r.f. energy to stop burglars. It will also discuss telephone alarms, fail-safe accessories, fire sensors, prowler and hold-up alarms.

(*Concluded Next Month*)

Fig. 7. This home-protection system uses the power line to interconnect transmitter and receiver/alarm units.



If you don't mind paying a lot less for a lot more, try the new University deceiver

If we had priced our new Studio Pro-120 Solid-State FM/Stereo Receiver at half again more than its $379.50, the whole thing would have been deceptively simple. Then no one, not even the most spend-thrifty status seeker, could question its modest price versus its immodest quality.

If the thought of paying a lot less to get a lot more bothers you, we'll tell you why the Studio Pro-120 is such a value. For over 35 years, we've built some of the world's finest speakers and sold them at prices lower than anything comparable. We're famous for that. But who ever heard of a University receiver?

The Studio Pro-120 is our first, so we put everything we could into it, including our many years of experience in designing sophisticated audio electronics for the military.

The results turned out to be so fantastic, we had every spec certified by a leading independent testing lab. That way, when you compare our middle-of-the-line price with quality that's quite comparable to the top-of-the-line of the Big 5, you'll know both are for real. And if that isn't enough, how about asking your dealer for a re-print of the three-page article on the Studio Pro-120 from the January, 1968, issue of *Audio* Magazine.

Better yet, play with the Pro-120. Listen to it. And by all means compare it to any much higher-priced receiver in the store. We'll bet you'll wind up with our magnificent deceiver, as long as you don't mind paying a lot less while getting a lot more.

UNIVERSITY® SOUND
A DIVISION OF LTV LING ALTEC, INC
9500 West Reno · Oklahoma City, Oklahoma 73126

AMPLIFIER SECTION: IHF Power Output: 120 watts total, IHF Standard at 0.8% THD, 4 ohms (60 watts per channel). RMS Power Output: 8 ohms: 30 watts per channel at 0.3% THD. Frequency Response: +0, -3 dB from 10 Hz to 100 kHz. Power Bandwidth: 10 Hz to 40 kHz, IHF Standard. Intermodulation Distortion: Less than 0.5% at any combination of frequencies up to rated output. Tone Control Range: ±18 dB at 20 Hz and 20 kHz. Damping Factor: 50 to 1. Noise Level: (Below rated output) Tape monitor: -83 dB—Auxiliary: -80 dB—Phono: -60 dB—Tape Head: -63 dB. Input Sensitivity: (For rated output) Tape Monitor: 0.4 Volts—Auxiliary: 0.4 Volts—Tape Head: 1 mV at 500 Hz—Phono: 4 mV at 1 kHz. Input Impedance: Phono and Tape Head: 47,000 ohms—Tape Monitor: 250,000 ohms—Auxiliary: 10,000 ohms. Load Impedance: 4 to 16 ohms. FM TUNER SECTION: Sensitivity: 1.6 μV for 20 dB of quieting, 2.3 μV for 30 dB of quieting, IHF. Frequency Response: ±½ dB from 20 to 20,000 Hz. Capture Ratio: Less than 1 dB. Image Rejection: Greater than 90 dB. IF Rejection: Greater than 90 dB. Separation: 40 dB at 1 kHz. Selectivity, Alternate Channel: 55 dB. Drift: .01%. Distortion: Less than 0.5% at 100% modulation ±75 kHz deviation. Multiplex Switching: Fully automatic logic circuit. GENERAL: Dimensions: 4⅝" H x 16⅜" W x 12" D (including knobs). Weight: 17 lbs. Amplifier Protection: Three 1-ampere circuit breakers. Complement: 31 Silicon & MOSFET transistors, 21 Diodes, 2 Integrated circuits (each containing 10 transistors, 7 diodes, 11 resistors).

UNIVERSITY saving money never sounded better

CIRCLE NO. 85 ON READER SERVICE CARD

"Q"-PREDICTION NOMOGRAM

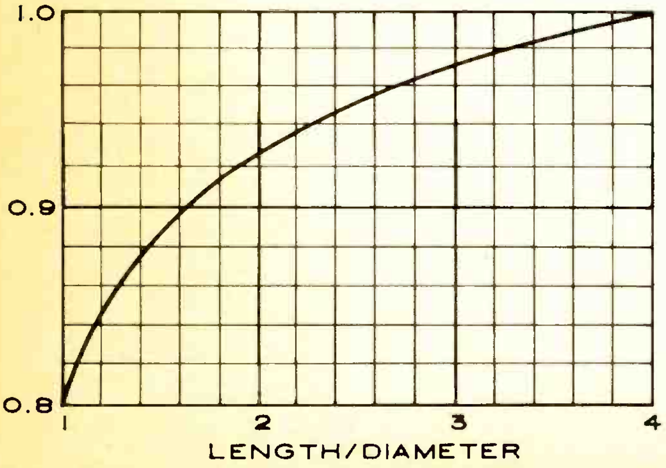
IT IS NOT necessary to accept the usual practice of finishing a coil and measuring it before knowing its "Q", nor is it necessary to wind a second coil to determine if proposed changes will have the desired effect on "Q". This nomogram quickly predicts "Q" when design dimensions such as wire size, spacing of windings, and coil diameter are known. Another application for this nomogram is to help determine what physical changes in a coil will be most effective in obtaining a specified "Q".

Although the investigators who have worked on this problem have all arrived at different empirical formulas, the divergence is actually quite small and there is a clear agreement on the trends. This nomogram is based on a compromise with those results plus some adjustments based on many measurements recorded in the author's notebooks. Reliability of the predictions is especially noted for air-core coils with length equal to at least six diameters; between four and six diameters long there is an amount of uncertainty that sometimes causes a small unexplainable deviation from predicted results. The nomogram can also apply, with a correction factor, to coils as small as one diameter long, if the windings are spaced by about a wire diameter or more. In short, use the nomogram for all coils except short coils with little or no spacing between windings. It is, of course, assumed that "Q" is to be predicted at frequencies well below the coil's self-resonance.

Using the Nomogram

The quantities which must be known are wire gauge (or diameter), spacing between turns, frequency, and coil diameter. Starting at lower left (turn page sideways), locate wire size on the first scale and the center-to-center spacing between turns on the second. If wire size is known in gauge, use the top of the first scale and if it is known in decimal parts of an inch, use the lower side. Draw a straight line between these two locations and note the point at which that line crosses the horizontal axis of the curve in the upper left. From that point proceed straight up to the curve, using the dashed lines as guides. Move straight out from the curve to the vertical axis on the right of the curve, using the horizontal dashed lines as guides. Draw a straight line from that point on the vertical axis, through the correct value on the "Frequency" scale, to the "Turning Scale". Draw a final line from that intersection on the "Turning Scale," through the correct point on the "Coil Diameter" scale, and read the "Q" where that line crosses the last scale. For coils between one and four diameters long, multiply this value of "Q" by the correction factor as indicated below in Fig. 1.

Fig. 1. Correction factors to be used with the nomogram.



If the coil is wound with no spacing between turns, this procedure can be shortened by omitting all steps prior to arriving at the vertical axis to the right of the curve. Simply use the top of the vertical axis as the starting point and draw the first line from there, through the selected point on the "Frequency" scale, to the "Turning Scale" and continue as before. This shortcut can be justified by noting that whenever the center-to-center turns spacing equals the wire diameter the line drawn between these two scales will intersect the curve's horizontal axis at the left end and then sliding to the curve and out again leads to the top of the vertical axis.

Coil diameter is defined here as the dimension from the center of one wire to the center of a wire on the opposite side of the coil form. In other words, coil diameter is equal to o.d. of the coil form plus one wire diameter.

Example of Using Nomogram

Predict the "Q" at 5 megahertz of a coil ¼" in diameter and ½" long, wound with #28 wire so that there is a space equal to two wire diameters between turns.

Opposite 28 on the first scale it can be seen that the diameter of this size wire is about 0.0127 in, therefore the turns spacing will be three times that, or 0.0381 in. The first line is then drawn from 28 on the "Wire Gauge" scale, through 0.038 on the "Turn Spacing " scale, to the horizontal axis of the curve. Slide straight up from that intersection to the curve, turn and proceed straight out to the vertical axis. From that point draw a straight line to the "Turning Scale," going through 5 on the "Frequency" scale. Draw the last line from that crossing on the "Turning Scale" to the "Q" scale, going through 0.25 (¼") on the "Coil Diameter" scale. At the last scale, read a "Q" of 74 for this coil. Since this coil is only 2 diameters long, reduce the predicted "Q" by a correction factor of about 0.93, from Fig. 1, for a final predicted "Q" of 69.

Other Applications of Nomogram

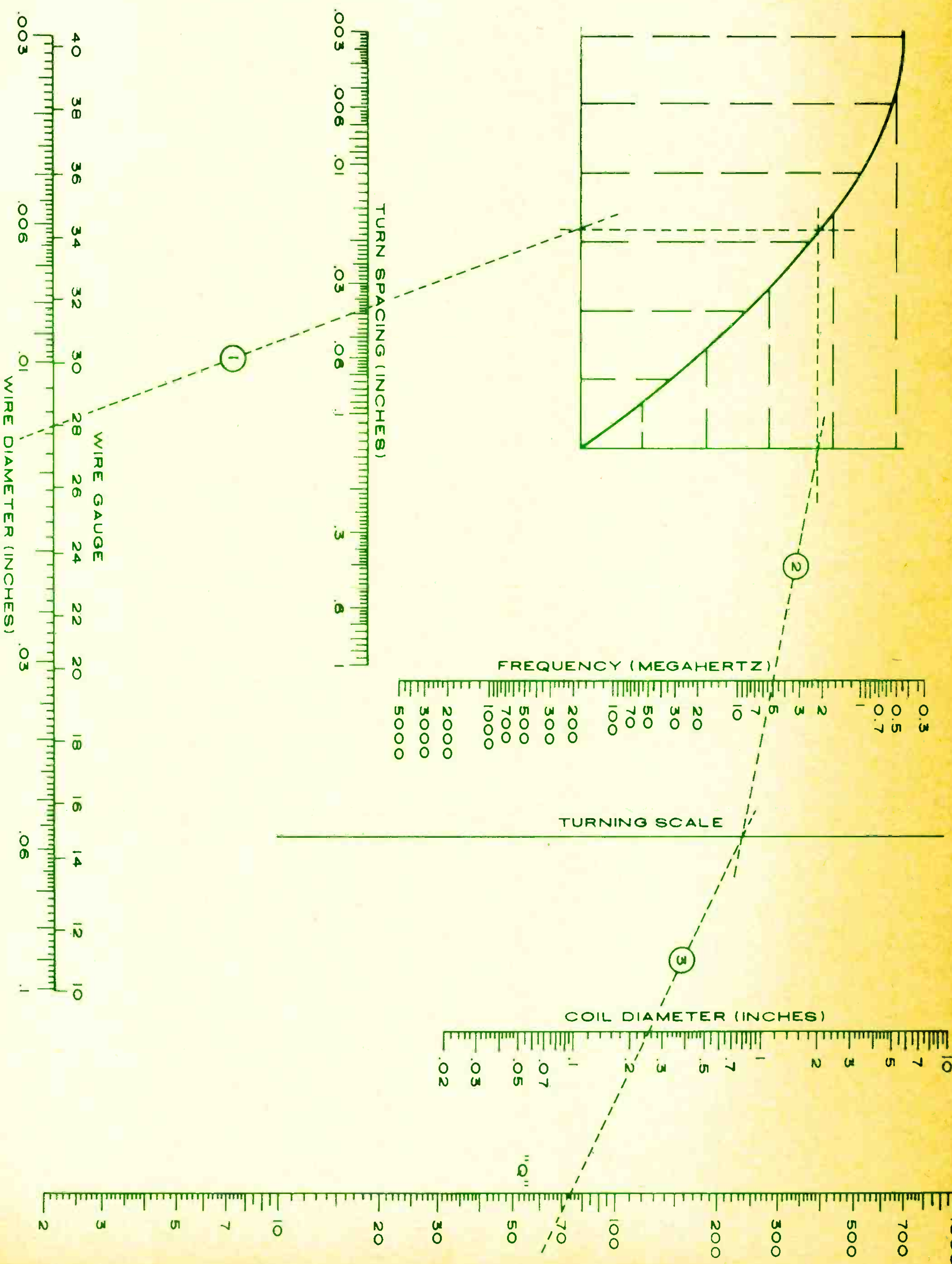
Several relationships can be noted between "Q" and other parameters by casual examination of the nomogram. For instance, it can be seen that "Q" will increase if the coil diameter is increased, the frequency is increased, or the turn spacing is decreased. If one parameter is changed so as to increase "Q" and another changed so as to decrease "Q", the nomogram can be worked through completely to determine the net effect.

Note that beyond 4 or 6 diameters of length, "Q" is independent of coil length. This independence is to be expected because "Q" is a ratio of reactance to resistance and these two quantities are increased at about the same rate as the coil is made longer. It has already been shown that "Q" is independent of wire size if there is no spacing between turns.

The uncertainty mentioned earlier for short coils with close windings lies in the curve at the upper left of the nomogram. Therefore, if such a coil is being used, and its "Q" has been measured at a certain frequency, the nomogram can still be used to reliably predict the effect of changes in coil diameter and/or frequency. To use the nomogram in this manner, work it backwards by drawing a straight line from the known value on the "Q" scale, through "Coil Diameter", to the "Turning Scale"; another line from there through "Frequency" and to the vertical axis of the curve. Now that point on the vertical axis can be used as a starting point to work forward again, through new values of frequency and/or coil diameter, to see the effect of the changes on coil "Q". ▲

By knowing the dimensions of an air-core coil, it is possible to estimate its "Q" closely without having to actually construct and measure the coil.

By DONALD W. MOFFAT



NEW PRODUCTS & LITERATURE

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

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

SOLID-STATE BATTERY CHARGERS

A new line of solid-state battery chargers that will enable users of silver-zinc, silver-cadmium, and nickel-cadmium batteries to increase the life of their batteries has been announced.

Typical of the new line is the Model 10, a precision solid-state power supply with end-of-

charge voltage precisely held. A charging lamp is used to indicate when the battery is being charged. It is possible to leave a battery connected indefinitely to the charger without damage to the battery or the charger. End-of-charge voltage is factory set at up to 20 volts cut-off for the battery or batteries to be charged. This setting remains within 1% of the nominal setting for normal line and ambient changes. Yardney

Circle No. 1 on Reader Service Card

TUNER CLEANER

A new tuner product for the professional technician is on the market as "Blue Stuff for Tuners." It is a thick concentrate that has been packed into a pressurized container. Non-evaporative, the new cleaner contains no liquid cleaning agents.

It is guaranteed to be safe on all tuners and cannot harm plastics. Tech Spray

Circle No. 2 on Reader Service Card

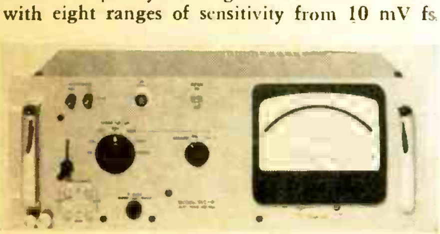
MICROMINIATURE VARIABLES

A new line of microminiature variable ceramic capacitors designed to fit 0.100" grid-spaced PC boards has been introduced as the MT500 series. There are nine capacitors in the line covering the range 4.0 to 60.0 pF. Unusual stability is provided by a proprietary ceramic material and a unique monolithic rotor. The series meets or exceeds the applicable requirements of the latest revision of MIL-C-81 over an operating temperature range from −55 to +85 degrees C. JFD

Circle No. 126 on Reader Service Card

R.F. MILLIVOLTMETER

The Model 91K high-impedance r.f. millivoltmeter has been designed to provide an input impedance of greater than 4 megohms shunted by 2.5 pF at frequencies up to 25 MHz, falling to about 1 megohm shunted by 2.5 pF at 100 MHz. Frequency coverage is 0.5 to 600 MHz with eight ranges of sensitivity from 10 mV fs



to 30 V fs in a 1-3-10 sequence. Subcalibrations of 1 and 2 mV are provided on the 10 mV fs range.

Standard equipment includes an r.f. probe with low-noise cable and connector assembly, probe tip with grounding clip, and 50-ohm terminated BNC adapter. Boonton

Circle No. 127 on Reader Service Card

INTEGRATED CIRCUIT KIT

An integrated circuit experimenter kit containing five popular RTL integrated circuits is now available as the HEK-1. The devices in the kit include two dual two-input gates and one each J-K flip-flop, dual buffer, and four-input gate. In addition, the kit includes a booklet on the theory and use of IC's, eight IC projects, and an IC cross-reference guide. Motorola Semiconductor

Circle No. 3 on Reader Service Card

TV ANTENNA ROTATOR

A new type of rotator for home television antennas has been introduced as the "Dyna-Rotor". It comes as an all-solid-state control unit with a light, fast, accurate home TV antenna rotor. Powered by a unique dynamic spline drive, the new unit develops high starting torque to overcome inertia, wind, and ice loading.

The mast-mounted unit is permanently synchronized with the control unit at the TV set and automatically locks into any selected position without regard to wind loading. Housed in a cast aluminum case, the rotor assembly weighs only five pounds.

The solid-state control is totally silent in operation. A pilot light inside the unit lights when the antenna is in motion. When the light goes out, the antenna has reached its aimed position. Jerrold

Circle No. 4 on Reader Service Card

BENCH SUPPLY

The Model BP-118 universal bench supply is a rugged unit which has an output of 0-34 volts at 1.5 amps. Regulation is 1 mV or 0.01% with ripple as low as 250 µV. Voltage and current output are continuously monitored by two taut-band meters.

The front panel features an a.c. on/off switch, neon pilot light, five-way binding posts, and coarse and fine voltage adjustments. The circuit meets MIL-Specs and is completely short-circuit-proof. Power/Mate

Circle No. 128 on Reader Service Card

LOW-NOISE POTENTIOMETER

A low-cost, low-noise-level potentiometer with typical noise level of 0.25% and 5% linearity is now on the market as the Model 380.

The company guarantees that the pot will operate at noise levels of no more than 1% and a resistance change of no more than 5% after 100,000 cycles. A special multi-finger contact is also incorporated to insure greater reliability.

The pot measures 1 1/16" in diameter, is rated at 2 watts, and has a resistance range of 100 ohms to 5 megohms. Clarostat

Circle No. 129 on Reader Service Card

IC EXPERIMENT KIT

The Model IC-100 integrated-circuit experimenter's kit has been especially designed to help the electronics student, technician, designer, and experimenter gain valuable knowledge, experience, and insight into the operation and applications of IC's.

Included in the kit is a manual which offers a discussion of the applications for IC's. Five easy-to-follow experiments and many diagrams and schematics help the user gain valuable practical experience in working with these devices.

Two Fairchild µ1914 IC's, several other components, and two pre-etched PC boards are included in each kit. Kaye Engineering

Circle No. 5 on Reader Service Card

NARROW-TOLERANCE PHOTOCELLS

A series of three photoconductive cells with narrow resistance tolerance guaranteed over a 100:1 light level range is available from stock

as the T-Series. The T-Series comprises one cell in a TO-5 case and two in TO-18 cases.

The resistance tolerance of the T-Series is ±15%, less than half that of conventional stock photocells, and applies over the range from 1 to 100 footcandles. Clairex

Circle No. 130 on Reader Service Card

FIELD-EFFECT METER

The Model FE16 field-effect meter has just been put on the market, combining the features and advantages of the v.t.v.m. and v.o.m. for various applications in the electronics industry.

The FE16 features a 1.5% accuracy on seven d.c. ranges from 0 to 1 volt to 1000 volts and 3% on seven a.c. ranges from 0 to 1 volt to 1000 volts. The new multimeter measures peak-to-peak on its a.c. ranges, and has a zero-center d.c. range of ±0.5 volt that is ideal for solid-state servicing.

The meter, which measures 7 1/2" x 5 1/4" x 3 1/16", is battery operated from a standard 9-volt transistor radio battery. The 4 1/2" meter has a mirrored scale for antiparallax readings. Sencore

Circle No. 6 on Reader Service Card

MICA CAPACITORS

A new series of extremely stable, close tolerance mica capacitors have been introduced as Type 424M, 425M, 426M, and 428M. Ratings between 47 and 91,000 pF are available in these dipped mica capacitors with a capacitance tolerance as close as ±0.5%. They are especially suited for use in precision amplifiers, audio and r.f. oscillators, and other ultra-stable equipment. The capacitors are rated for continuous operation at temperatures as high as +125°C. Voltage ratings of 100, 300, and 500 volts d.c. are available.

Engineering Bulletin No. 1015 contains complete information on this new line. Sprague

Circle No. 131 on Reader Service Card

MINIATURE INDUCTORS

A new line of low-cost inductors designed to replace toroids has been introduced as the Hi-Q Series. These inductors have exceptionally high "Q" values and are completely electromagnetically shielded. They are epoxy encapsulated for stringent environmental conditions and are available in 0.260" square x 0.125" maximum height. They are available with radial leads on 0.200-inch grid spacing and in inductance values from 0.1 μH to 10,000 μH. Delevan Electronics

Circle No. 132 on Reader Service Card

LOW-COST DISC CAPACITORS

A complete new line of economical disc capacitors for general-purpose applications is now available as the D-B series.

Rated at 100 volts, these units are available in temperature characteristics Z5U nd Z5V. Capacitance for Z5U ranges from 600 to 35,000 pF; for Z5V from 1000 to 100,000 pF. Insulation resistance is 10,000 megohms minimum at 100 V d.c. and 25°C. Centralab

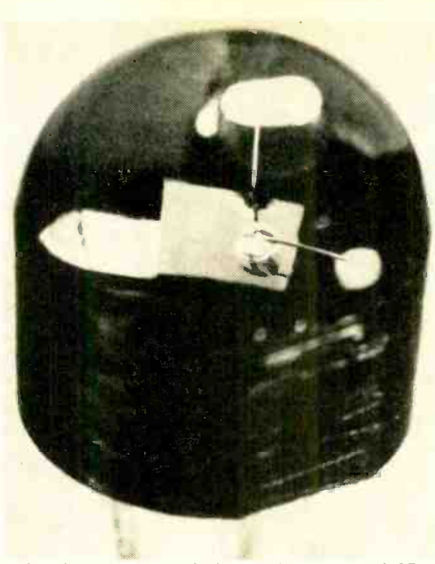
Circle No. 133 on Reader Service Card

PLASTIC PHOTOTRANSISTOR

A plastic "n-p-n" phototransistor which features three terminals for greater flexibility and control in circuit design is now available as the FPT100.

The unit has a special transparent resin encapsulation that gives it an extremely stable characteristic under high humidity conditions. No degradation occurs after extended moisture resistance tests at 65°C and 95% relative humidity. The device is guaranteed against degradation after 1000 hours of high-temperature reverse bias tests in which V_{CEO} equals 25V and ambient temperature equals 85°C.

The FPT100 offers high illumination sensi-



tivity, based upon a light sensitive area of 35 x 35 mils. The chip itself is 40 mils square. Fairchild Semiconductor

Circle No. 134 on Reader Service Card

DIGITAL MODULE

A high-speed-forward decimal counter with display which features integrated circuitry, 8-4-2-1 bipolar BCD outputs, and a bright readout is now on the market as the IDC 44 digital module. According to the company, maintenance is minimal and both power consumption and failure rate are low.

The counting frequency is 1 MHz minimum. The unit responds to the trailing edge of clock pulse transitions as short as 1 nanosecond or as long as 100 nanoseconds. The clock pulse amplitude may be between +1 and +4 volts. Wagner

Circle No. 135 on Reader Service Card

HI-FI—AUDIO PRODUCTS

STEREO CARTRIDGE

The Model 550/E magnetic stereo cartridge will track any 33⅓ r/min record, stereo or mono, at the optimum tracking force of 1½ grams. The new cartridge uses the induced magnet principle developed by the firm. The unit has an elliptical stylus controlled to a dimension of 0.0007" lateral radius and 0.0003" contact radius.

Sensitivity is 5 mV at 5.5 cm/s recorded velocity, tracking force range is from ¾ to 2½ grams, frequency response is 10 to 20,000 Hz ±3 dB, channel separation is 20 dB from 50 to 8000 Hz, and compliance is 28 x 10^{-6} cm/dyne. Recommended load impedance is 47,000 ohms. Audio Dynamics

Circle No. 7 on Reader Service Card

SOLID-STATE TAPE DECK

The Sony 355 solid-state stereo tape deck incorporates several exclusive features rarely found in a machine designed for home recording. It is of professional three-head design for sound-on-sound and special effects recording. It is equipped with a noise suppressor switch; a special filter that will eliminate undesirable hiss that may exist on older recorded tapes while not affecting the quality of sound reproduction; and tape source monitoring for audible comparison of original sound source and the tape being recorded.

The deck will operate either vertically or horizontally and at three speeds, 7½, 3¾, and 1⅞ in/s. It will accommodate reels up to 7 inches. The deck comes complete with oiled-walnut finished base and protective dust cover. Superscope

Circle No. 8 on Reader Service Card

TAPE DECK FOR CHURCHES

The Model TD-101 tape deck is being offered as an economical source of church music for regular services or special events. The tape deck comes with three tapes of chimes, bell, and organ selections. Tapes can be played over any church p.a. system by simply plugging in the unit.

The unit is portable, compact, and easy to operate. A two-hour, no rewind continuous-play cartridge slips in and out from the front. All controls, power switch, cartridge, lock, and fuse are equally accessible. The unit is fully transistorized. Frequency response is 50-7500 Hz. Bell P/A

Circle No. 9 on Reader Service Card

RECHARGEABLE PACK FOR CASSETTES

A new rechargeable power source for the *"Carry-Corder"* cassette tape recorder is now available. Known as the "Powerpak," the battery pack comes with an a.c. charger to provide 9 hours of continuous operation and make the recorder completely self-sufficient.

The unit is fully charged by plugging the charger attachment into an electrical outlet overnight. The charger also permits the recorder to be operated from household current, thus saving the battery supply for portable applications. Norelco

Circle No. 10 on Reader Service Card

COMPACT MUSIC CENTERS

Two moderately priced compact home music systems have been introduced as the Models 120 and 125. Each system consists of a receiver-

phonograph module and two acoustically matched speaker systems. The Model 120 features an FM-stereo/phono system while the Model 125 includes AM as well.

Microminiature circuits, including FET's and IC's, are used in the newly designed FM front-end and i.f. amplifier section. Baxandall feedback circuits are used in the bass and treble controls. A main/remote speaker switch, loudness contour, and full tape and phono facilities are included in the receiver. The four-speed automatic turntable with cue control, anti-skating, balanced tonearm and magnetic cartridge, is mounted atop the receiver. Fisher

Circle No. 11 on Reader Service Card

ULTRASONIC ANNUNCIATOR

The Model AN-1 ultrasonic annunciator is designed for use in offices, homes, and stores. According to the manufacturer, the new unit will cover an area, rather than a specific entrance, and can double as a short-range intrusion alarm at times when the premises are not occupied and the annunciator function is not needed.

By using ultrasonics, it has been possible to eliminate the need for photocells, light sources, and installation wiring. The AN-1 plugs into any standard 117-volt outlet and is aimed at the general area to be covered. A standard a.c. receptacle at the rear accepts a line cord from a chime, a bell, buzzer, or lamp—or any combination that does not exceed 5 amperes. Small motors may also be connected to this outlet. Euphonics

Circle No. 12 on Reader Service Card

PORTABLE TAPE RECORDERS

Two portable stereo tape recorder systems have just been introduced as the Models 761 and 1461. Featuring new cube-shaped speakers that nest in the recorder cabinet for carrying or playing, the speakers may also be removed from their compartments and placed up to 20 feet apart for full stereo separation.

The Model 761 has three heads to allow tape monitoring, sound-on-sound facilities, sound-with-sound, and echo effect. The Model 1461 has four heads and is capable of sound-with-sound and tape monitoring. An automatic replay feature allows a tape to be programmed to repeat indefinitely.

Both recorder systems feature stereo headphone outputs, automatic shut-off, safety record lock, individual-channel volume controls, separate bass and treble controls, and illuminated vu meter. Ampex

Circle No. 13 on Reader Service Card

PORTABLE STEREO PHONO

Weighing only 30 pounds, the new Model 1020 portable stereo phonograph is housed in a luggage-type carrying case which measures only 15" x 26" x 7 3/8" deep. Easily set up for playing, the unit features a Miracord auto/manual turntable equipped with push-button controls, and Elac STS-244 magnetic cartridge, matched two-way EMI speaker systems, a special jack for headphones, and an auxiliary input jack. Benjamin

Circle No. 14 on Reader Service Card

POWER COLUMNS FOR INSTRUMENTS

A complete line of power columns for electronic musical instruments is now available. Each column contains two lifetime-guaranteed loudspeakers rated at 100 watts and the columns are stackable to make a 400-watt system. A high-frequency power multi-horn provides brilliant highs for the system.

Available with 12" or 15" loudspeakers, the columns are designed for lead guitar, rhythm guitar, combo organ, string bass, or bass guitar. Jensen

Circle No. 15 on Reader Service Card

TWO-HOUR CASSETTE

A 120-minute magnetic tape cassette has been added to the Scotch-brand line of unrecorded cassettes. Known as the C-120, the unit utilizes the firm's Dynarange tape which provides improved high-frequency response while offering complete compatibility with slow-speed recording applications.

The cassette also features a new and improved shim material which offers reliability while eliminating tape binding and jamming. It also reduces friction drag and therefore increases recorder battery life by as much as 25%. 3M

Circle No. 16 on Reader Service Card

DYNAMIC MICROPHONES

Twelve new dynamic microphones have been introduced in three series: the 810 ultra-cardioid, the 820 omnidirectional probe, and the 840 lavalier.

Designed especially for public-address use, the response characteristics of the new microphones make them suitable for use in broadcast, recording, and other sound applications as well. According to the company, the new units are pop- and blast-proof and have built-in wind filters. Each of the microphone series is available in two types, with or without switches; and two finishes, brushed chrome or brushed satin gold. Astatic.

Circle No. 17 on Reader Service Card

PORTABLE STEREO RECORDER

The Uher Model 4400 Report stereo is a portable stereo recorder of professional quality that weighs just 8 pounds and measures 11" x 9" x 3 1/2".

The recorder operates on a.c. where power

lines are available but instantly converts to battery operation to make stereo or mono field recordings. Where extended record and playback time is required, all four tracks can be used monophonically at 15/16 in/s, with long-play tape, to give the user 25 1/2 hours to a single reel.

The machine offers four tape speeds, 15/16, 1 7/8, 3 3/4 and 7 1/2 in/s. Frequency response is ±2 dB from 40-20,000 Hz at 7 1/2 in/s. Input facilities are also provided for microphone, radio, and phonograph. Power output is 1 watt at 4 ohms. Martel

Circle No. 18 on Reader Service Card

SOLID-STATE STEREO AMP

The Model AU-777 solid-state integrated stereo amplifier provides an output of 70 watts dynamic power (IHF), or 25 W/ch r.m.s. power at 8 ohms. Frequency response is 20-50,000 Hz with less than 0.5% distortion over the entire frequency range, according to the company.

Negative feedback is used in all stages for improved frequency response, signal-to-noise, and

distortion. The main amplifier has a response of 20-100,000 Hz. The preamp output has less than 0.1% distortion at the rated output of 1 volt.

The amplifier features dual-concentric, two-stage, negative-feedback tone controls, stepped in 3-dB increments, providing for independent adjustment of each channel for boost and attenuation of 15 dB at both the bass and treble ends.

Complete specifications on the AU-777 will be forwarded on request. Sansui

Circle No. 19 on Reader Service Card

BOOKSHELF SPEAKER SYSTEM

A high-compliance, infinite-baffle bookshelf system has just been introduced as the 892A "Madera."

Finished in hand-rubbed walnut, the system measures 13" high x 11 3/4" deep x 23 3/4" wide. Featuring a 406A 10-inch low-frequency speaker and a high-frequency die-cast aluminum compression-driven exponential horn, the system has a frequency range of 45-18,000 Hz, a nominal impedence of 8 ohms, and a crossover frequency of 2500 Hz. The system includes high-frequency shelving in three steps of 3 dB attenuation above 2000 Hz. It is designed to work with amplifiers rated up to 50 watts continuous power. Altec Lansing

Circle No. 20 on Reader Service Card

RECEIVER/SPEAKER SYSTEM

The KS-33 stereo receiver/speaker system consists of an FET 30-watt AM-FM solid-state receiver, two compact two-way speaker systems, and all accessories required for operation, including FM antenna and speaker cables. The system comes complete with a receiver cabinet.

Input terminals are provided for phono, auxiliary, tape record, and tape playback. The receiver incorporates automatic silent switching from stereo to mono modes as well as an automatic stereo light and illuminated tuning meter. The bookshelf-size speakers included a 6 1/2" air-suspension woofer and a 2 3/4" cone-type tweeter in each enclosure. Kenwood

Circle No. 21 on Reader Service Card

AM-FM-STEREO RECEIVER

A 50-watt AM-FM-stereo receiver at moderate price is now available as the 175-T. The tuner section incorporates IC's and FET's, Stereo Beacon automatic mono/stereo switching, usable sensitivity of 2 μV, alternate-channel selectivity of 45 dB, a wide-band AM tuner with a.g.c., and a built-in ferrite antenna.

The amplifier provides 50 watts of dynamic

power (IHF), all-silicon transistors, an overload protection circuit, 4-way main/remote speaker switch, 5-position program selector, tape and phono facilities, loudness contour control, and bass, treble, and balance controls.

The receiver measures 15½" wide x 5¼" high x 12¾" deep and weighs 18 pounds. An optional walnut cabinet is available at additional cost. Fisher

Circle No. 22 on Reader Service Card

CB-HAM-COMMUNICATIONS

POWER ADAPTER FOR MOBILE UNITS

A well-regulated a.c. adapter for 12-14 volt mobile transceivers is now available as the Model 790. Suitable for use with nearly all 5-watt CB and low-power amateur and Business Radio Service vehicular communications equipment, the

new "Power Pedestal" requires no special connectors, mounting straps, terminal lugs, or alignment pins. The transceiver is simply placed atop the unit and turned on. Electrical connections are made to two binding posts, clearly marked for polarity, at the rear of the power-supply chassis.

The adapter measures 6" w. x 8" l. x 3" h. and weighs 4 pounds. Amphenol Distributor Div.

Circle No. 23 on Reader Service Card

BASE STATION ANTENNA FOR CB

A new, improved Delta-5, five-element base station antenna has just been introduced as the Model SA-511-S. Designed and engineered for greater boom end support while maintaining a good unidirectional pattern, boom sag or droop has been eliminated. Mounted vertically or horizontally, the new antenna provides dependable all-weather performance. With an s.w.r. of 1.5/1 or better, a feedpoint impedance of 52 ohms, and incorporating gamma matching, the antenna has a 20-dB front-to-back ratio and a forward gain of 9.5 dB compared to a reference dipole.

Complete mechanical and electrical specifications are available on request. Mosley

Circle No. 24 on Reader Service Card

23-CHANNEL BASE STATION

The "Messenger 223" is a 23-channel, CB base station which combines tubes with a solid-state frequency synthesizer to transmit a clear, penetrating signal, as well as receive distant stations with clarity, according to its maker. An improved circuit offers at least 15 dB more audio gain than the firm's "Messengers I and Two" as well as maximum legal power output at the antenna terminals.

Weighing 12 pounds, the new unit measures 5$\frac{9}{16}$" high x 11" wide x 9$\frac{1}{16}$" deep. A built-in "S" meter/power meter measures input strength of r.f. signals and relative power output of the transmitter. The unit comes ready to operate on all 23 channels. E.F. Johnson

Circle No. 25 on Reader Service Card

TRANSISTORIZED CB UNIT

A new solid-state, 23-channel, two-way radio, which the company claims is the smallest all-channel CB unit on the market, has been introduced as the "Traveller".

The fully transistorized unit measures 5¾" w. x 6¼" d. x 1⅞" h. It will fit in the glove compartment of many cars. Silicon transistors are used throughout. An incoming signal indicator lights up automatically when receiving S-6 or better signals. The unit also features an illuminated channel selector, auxiliary speaker jack, modulation indicator, and single-knob tuning. There is a wired-in noise-cancelling microphone. Courier

Circle No. 26 on Reader Service Card

MANUFACTURERS' LITERATURE

SEQUENCE TIMER DATA

A one-page, two-color data sheet on its repeat or interval timer has just been issued. In addition to listing special features of the new timer and application data, the publication provides complete electrical specifications, available time cycles, and mechanical specifications. Mallory Timers

Circle No. 136 on Reader Service Card

PC CONNECTOR CATALOGUE

A new 24-page printed-circuit connector catalogue has just been issued as PC-4. The new publication features photographs, line drawings, electrical characteristics, and mechanical specifications on over 3000 different printed-circuit connectors.

A selection guide provides information necessary for finding the right connector for any PC board application. Amphenol Industrial Div.

Circle No. 137 on Reader Service Card

CROSS-REFERENCE SLIDE RULE

A handy slide rule which gives a quick cross-reference between the firm's precision pots and those of other major manufacturers is now being offered to engineers without charge.

Data used in the guide was taken from the company's nine-model line of continuous rotation servo and bushing mount precision pots as well as data and specifications common to the entire line of pots. Models covered range from ¾" to 3" diameter in single or multi-cup models which meet or exceed the requirements of MIL-R-12934 and NAS-710. Dale Electronics

Circle No. 138 on Reader Service Card

MODULAR STEREO COMPONENTS

A new line of modular-circuit, solid-state stereo components is described and illustrated in a 14-page catalogue (No. 268) just issued. Covered in the new line are amplifiers, receivers, and tuners, with appropriate loudspeakers, speaker systems, crossovers, mixer transformers, etc. to be used with the new components included. Electro-Voice

Circle No. 27 on Reader Service Card

LIGHTED HARDWARE DEVICES

Catalogue CML-1 describes lighted hardware devices to meet the needs of all industries. Designed for easy readability and reference, the opening pages discuss technical aspects of sub-miniature and miniature lighted devices. The product pages that follow begin with smaller assemblies and wind up with lens end-light assemblies and beam emitters. An index is provided for locating specific types quickly and easily. Chicago Miniature Lamp

Circle No. 139 on Reader Service Card

INFRARED SPECTROSCOPY

A 36-page handbook covering an expanded line of infrared spectrophotometer accessories has just been issued as Catalogue BE-68.

Hundreds of items pictured and described include advanced design in ATR and specular reflectance spectroscopy; liquid, gas and solid sample cells; crystals of every size, shape, and transmission materials; GC fraction collector, pyrolyzer, beam condenser, attenuator, and variable temperature chamber. Performance characteristics and how-to data useful to spectroscopists are included in this full-color catalogue. Barnes Engineering

Circle No. 140 on Reader Service Card

MINIATURE LAMPS

Twenty-one stock types of miniature incandescent lamps are shown in actual size and completely described as to physical and electrical characteristics in a two-page bulletin #1-98. Welch Allyn

Circle No. 141 on Reader Service Card

PRODUCT LINE BOOKLET

A handy, 34-page booklet which not only provides information about the company and its capabilities but data on an extensive line of stock and custom products, is now available.

Included in the company's line are crystals, crystal ovens, general-purpose and CB crystals, microphone amplifier/speech clipper, converter, coaxial switches, PC's, and transistor oscillators. The publication is lavishly illustrated with charts, circuit data, tables, and graphs. Sentry

Circle No. 142 on Reader Service Card

NICKEL-CADMIUM BATTERIES

A technical paper entitled "The Sealed Rechargeable Nickel-Cadmium Battery" is now available as a reprint. The paper offers a brief introduction to nickel-cadmium battery systems, battery sizes, packaging, battery features, and physical and electrical characteristics. Details on new methods of controlling battery reversal by using anti-reversal devices are also covered. Sonotone

Circle No. 28 on Reader Service Card

PHOTOELECTRIC TAPE READERS

A descriptive, eight-page brochure (GEA-8492) on the firm's line of photoelectric tape readers, reelers, and reader/reeler combinations is now available.

The brochure illustrates the complete reader line including through-the-tape and reflected light readers and associated tape handling equipment. These products are designed for use in digital data handling, communications, numerical control, photo-typesetting, ground support, and other tape-programmed systems. General Electric

Circle No. 143 on Reader Service Card

VOLTAGE-VARIABLE CAPACITORS

A four-page technical bulletin on voltage-variable capacitors, which also catalogues over 400 of the most frequently used types, is now available as bulletin No. 371.

Technical information includes a description of voltage-variable capacitor requirements in terms of function generators, giving the equation which describes their performance. A discussion of capacitance versus voltage and "Q" values is also included. Computer Diode

Circle No. 144 on Reader Service Card

HALF-RACK POWER SUPPLIES

A new line of high-performance, metered power supplies for rack or bench use is described in a new 4-page illustrated bulletin just published.

Bulletin LR gives complete specifications, capabilities, and prices for four different models in this new LR series. Voltage ranges are up to 0-250 volts d. c. with current ranges up to 1.8 amps. Lambda

Circle No. 145 on Reader Service Card

VACUUM CAPACITORS

A new 52-page catalogue (No. 101) has been issued covering an extensive line of vacuum capacitors. The publication also contains much useful information which describes the characteristics

BIG CATALOG
World's "BEST BUYS" in GOV'T. SURPLUS Electronic Equipment

RECEIVERS:

RCAF GR-10—195-410 KC and 1.4-31 MC .... Used. Checked: $99.95
BC-603—20-27.9 MC FM Receiver with sensitivity and squelch: ..Used. Not Checked 22.95
Used. Checked for operation 32.95
BC-348 Receiver—200-500 KC and 1.5-18 MC w/Crystal Phasing BFO. and Vernier Tuning. AVC. MVC. Prices: Used. less Dynamotor:... 69.50
Used. less Dynamotor. operation checked: 79.50
Power Supply for BC-348—115 VAC......New: 18.95

COMMAND RECEIVERS — TRANSMITTERS:

BC-453—190-550 KC ....Used: $16.95
BC-454—3.0-6.0 MC. with Dynamotor..Re-New: 19.95
BC-455—6.0-9.1 MC. with Dynamotor..Re-New: 14.95
R-25/ARC-5—1.5-3.0 MC. less Dynamotor..New: 19.95
R-28/ARC-5—100-156 MC. less Dynamotor Used: 22.95
T-18/ARC—2.1-3.0 MC...Used: $9.95...New: 12.95
T-20/ARC—4.0-5.3 MC...Used: $6.95...New: 9.95
T-21/ARC—5.3-7.1 MC...Used: $6.95...New: 9.95
T-22/ARC-5—7.0-9.1 MC ....Unused: 18.95
T-23/ARC—100-156 MC ....New: 24.95
BC-696—3.0-4.0 MC .....Gov't. Reconditioned: 12.95
BC-456 Modulator—Use with Command Transmitters 3.95
MD-7/ARC-5 Modulator—ARC-5 and Comm. Trans. 9.95

RECEIVER — TRANSMITTERS:

BC-620 FM TRANSCEIVER—20-27.9 MC Crystal Control. and PE-97 Power Supply—6/12 VDC ....Re-New: $19.95
BC-659 FM TRANSCEIVER—27-38.9 MC Crystal Control. and PE-117 Power Supply—6/12 VDC ....Re-New: 19.95
SCR-522 RECEIVER-TRANSMITTER—AM Four Channel Crystal Control—100-156 MC...Used: 29.95
ARC-3—100-156 MC 8 Channel Crystal Control AM—Aircraft Equip. Electric Band Change.
R-77/ARC-3 Receiver ....Used: 24.95
T-67 ARC-3 Transmitter ....Re-New: 29.50
W/S CDN No. 29 "B" Set-UHF Receiver-Trans.—Approx. 230-245 MC. 12/24 VDC—Two Preset Channels ....Used: 18.95
TRANSCEIVER AF/UTA-68 AM—115-152 MC Crystal Control. Power output approx. 5 Watts. Less Crystals ....Used: 24.95
LM FREQUENCY METER—125-20,000 KC Crystal Calibrated Heterodyne type. With Modulation. Minor parts missing. w/Cal. Book: 24.95
W/All Parts & Cal. Book ....Not Checked: 29.50

BIG FREE CATALOG—Send for your copy today!
Address Dept. EW • Prices F.O.B. Lima, O. • 25% Deposit on C.O.D.'s

FAIR RADIO SALES
1016 E. EUREKA • Box 1105 • LIMA, OHIO • 45802

STEREO Tape Club: Average cost $3.78–$4.20. Cartridges, Cassettes, Reels. No minimum monthly purchases. Free brochure—catalog. Star Recordings, Box 1055, El Paso, Texas 79946.

DO-IT-YOURSELF

PROFESSIONAL ELECTRONICS PROJECTS—$1.00 up. Catalog 25¢. **PARKS,** Box 25665A, Seattle. Wash. 98125.

RECORDS

SPECIAL INTEREST RECORDS AVAILABLE, PRODUCED BY THE EDITORS OF THE WORLD'S LEADING SPECIAL INTEREST MAGAZINES. SEND FOR FREE CATALOG. RECORD CATALOG-EW, ZIFF-DAVIS PUBLISHING COMPANY, ONE PARK AVENUE, NEW YORK, N.Y. 10016.

RECORDS!!! 45 rpm—15¢ LP's $1.00. Details $2.00. Records, 129 Carol Avenue, Aberdeen, Maryland 21001.

HIGH FIDELITY

FREE! Send for money saving stereo catalog #E9W and lowest quotations on your individual component, tape recorder or system requirements. Electronic Values Inc., 200 West 20th Street, N.Y., N.Y. 10011.

HI-FI Components. Tape Recorders at guaranteed "We Will Not Be Undersold" prices. 15-day money-back guarantee. Two-year warranty. No Catalog. Quotations Free. Hi-Fidelity Center, 239 (L) East 149th Street, New York 10451.

HIFI EQUIPMENT—Get Our "ROCK BOTTOM" prices on **NAME BRAND** amplifiers—tuners—tape-recorders — speakers **FRANCHISED — 59 YEARS IN BUSINESS.** Write for this month's specials—**NOW!** Rabson's 57th St., Inc., Dept. 569, 119 W. 57th St., New York. New York 10019.

LOW, LOW quotes: all components and recorders. Hi-Fi, Roslyn, Penn. 19001.

HI-FI components, tape recorders, sleep learn equipment, tapes. Unusual Values. Free catalog. Dressner, 1523 R Jericho Turnpike, New Hyde Park, N.Y. 11040.

ACOUSTIC RESEARCH, Dyna, Koss, Shure discount specialists. Write for free catalog. Stereo Component Systems Corp., 95 Vassar Street, Cambridge, Mass. 02139.

ACOUSTIC RESEARCH products now available to citizens of foreign countries, overseas personnel, diplomats, government employees, etc. Write for full product and dealer information, **AR INTERNational,** Dept. EW, 24 Thorndike St., Cambridge, Mass. 02141.

PHOTOGRAPHY—FILM, EQUIPMENT, SERVICES

MEDICAL FILM—Adults only—"Childbirth" one reel, 8mm $7.50; 16mm $14.95. International W. Greenvale, Long Island, New York 11548.

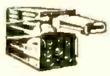
SCIENCE Bargains—Request Free Giant Catalog "CJ"—148 pages—Astronomical Telescopes, Microscopes, Lenses, Binoculars, Kits, Parts. War Surplus bargains. Edmund Scientific Co., Barrington, New Jersey 08007.

G & G SURPLUS SPECIALS!

AN/APR-4Y FM & AM RECEIVER "FB" FOR SATELLITE TRACKING!

High precision lab instrument, for monitoring and measuring frequency and relative signal strength, 38 to 4000 Mc. in 5 tuning ranges. For 110 V 60 cycle AC. Built-in power supply. Original circuit diagram included. Checked out, perfect, **LIKE NEW** $88.50
All Tuning Units Available for Above

LORAN R-65/APN-9 RECEIVER & INDICATOR

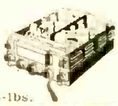


4-Channel single unit system, used in ships and aircraft. Determines position by radio signals from known xmitters. Accurate to within 1% of distance. Complete with tubes and crystal. IN LIKE NEW Condition. $88.50
All accessories for Loran Equipment in stock.

BC-929 3-Inch Scope. with all tubes, **EXC. USED** $16.95
Conversion instructions. with diagram, for 110 V AC operation .... $ .65

FAMOUS BC-645 TRANSCEIVER

15 Tubes 435 to 500 MC



Can be modified for 2-way communication. voice or code, on ham band 420-450 mc. citizens radio 460-470 mc. fixed and mobile 450-460 mc. television experimental 470-500 mc. Now covers 460 to 490 mc. Brand new with tubes. less power supply in factory carton. Shipping weight 25-lbs.

SPECIAL! **$16.95**

PE-101C Dynamotor 12/24v input $7.95
UHF Antenna Assembly 2.95
Complete Set of 10 Plugs 5.50
Control Box 2.95

SPECIAL "PACKAGE" OFFER:
BC-645 Transceiver, Dynamotor and all accessories above. COMPLETE, BRAND NEW. While Stocks Last **$26.95**

VISIT OUR NEW SHOWROOM AT 45 WARREN STREET, N.Y.C.

ARR-15 COLLINS RADIO RECEIVER, 1.5 to 18 Mc tunable in 6 bands. AM & CW. Complete with 14 tubes and dynamotor power supply. Exc. Used **$79.50**

ARC-3 RECEIVER & TRANSMITTER 100 to 156 Mc. easily adapted for Ham 2-meter band! Receiver, exc. Used, with all tubes **$21.50**
Transmitter, exc. used with all tubes. Including two 832s **$18.50**

R-4/ARR-2 RECEIVER, 234-258 Mc, Tunable. Complete with 11 tubes, NEW $11.95
Dynamotor (24VDC) for ARR2 .... $ 2.45

SCR-274-N, ARC-5 COMMAND SET HQ!

Freq. Range	Type	Exc. Used	BRAND NEW
RECEIVERS, Complete with Tubes			
190-550 Kc.	BC-453	$18.95	$23.50
3-6 Mc.	BC-454	$16.50	$21.50
6-9.1 Mc.	BC-455	$14.95	$19.95
1.5-3 Mc.	R-25	—	$21.50
TRANSMITTERS, Complete with Tubes			
4-5.3 Mc.	BC-457	$ 6.95	$11.95
5.3.7 Mc.	BC-458	$ 6.95	$12.95
7-9.1 Mc.	BC-459	$17.95	$22.50
2.1-3 Mc.	T-18	—	$10.95
3-4 Mc.	T-19	$10.50	$14.95
MODULATOR, Complete with 3 Tubes			
Voice	BC-456	$ 2.75	$ 4.95

All Command Set Accessories In Stock

SCR-625 MINE DETECTOR $32.50
BC-1206-C Beacon Recvr. 200-400 Kc, Brand new, with tubes $12.95
BC-1206-C as above, Brand new, less tubes .... $ 8.50
SCR-522 Transmitter-Receiver, Like New $39.50

NEW G&G CATALOG 24 Pages Terrific Buys in Military Electronic Gear. **SEND 25c—Refunded with First Order.**

TERMS: Either 25% Deposit with order, balance C.O.D. —OR—Remittance in Full. Minimum Order $5.00. All shipments F.O.B. our warehouse. NYC. All merchandise subject to prior sale and price change.

G & G RADIO SUPPLY COMPANY
Telephone: (212) CO 7-4605
75-77 Leonard St., New York, N.Y. 10013

TRIACS

TO-66
5 AMP

PRV	
100	.90
200	1.40
300	1.75
400	2.25
500	2.60

Silicon Control Rectifiers

PRV	3A	7A	20A	70A
50	.35	.45	.70	
100	.50	.65	1.00	4.00
200	.70	.95	1.30	8.00
300	.90	1.25	1.70	
400	1.20	1.60	2.10	12.00
500	1.50	2.00	2.50	
600	1.80	2.40	3.00	16.00
700	2.20	2.80		
1000			5.00	24.00

Silicon Power Rectifiers

PRV	3A	12A	20A	40A
100	.09	.30	.40	.75
200	.16	.50	.60	1.25
400	.20	.70	.80	1.50
600	.30	1.00	1.20	1.80
800	.40	1.25	1.50	
1000	.55	1.50	1.80	

ZENERS 1 Watt 7-33V $ .50
10 Watt 7-200V $ .75
50 Watt 7-200V $1.75

☐ **N-CHANNEL FET'S TO-18** plastic units, low noise, low leakage, 25 volts source to gate, 50 ma gate current Gain to 9000 μmho's. $1.00

☐ **SIM** to 2N3429 (NPN). SI 7/8" stud, min HFE of 30, 7.5 Amps. 175 watts, VCe of 75 .... $1.75

☐ **SILICON BILATERAL SWITCH.** Replaces two SCR's by firing in either direction when breakdown voltage is exceeded. Used in light dimmers, etc. .... 2/$1.00

☐ **NEON LIGHT OR NIXIE TUBE DRIVERS.** An NPN, TO-18, SI Transistor. With a VCBO of 120 .... 3/$1.00

☐ **SIM. to 2N2875 (PNP).** Silicon 20 watts with 30 MHz cut off .... $.75

☐ 500 HFe plastic transistors. NPN, TO-18, SI unit similar to 2N3565 .... 4/$1.00

AVALANCHE MODE TRANSISTORS, used for TRIGGERING SCR's & TRIACS, with diagrams .. 3/$1.00

INTEGRATED CIRCUITS

LINEAR CIRCUITS

FM IF AMPLIFIERS $2.00
702C WIDE BAND DC AMPL. $4.50
709C OPERATIONAL AMPL. $4.50
710C HI SPEED DIFF. AMP. $5.00
711C DUAL COMPARATOR $5.50

DIGITAL CIRCUITS

SR FLIP FLOP .... $ .90
SR CLOCKED FLIP FLOPS $1.15
944 POWER GATES $1.50
DUAL NAND NOR GATES $1.00

UNIJUNCTIONS!

Similar to 2N2419. RBB of 5-7 stand off ratio of .6 and Ip of 12, with data sheet $1.50

We promise to supply you with the highest quality products at the most attractive prices with the fastest service in the industry.

Terms: FOB Cambridge, Mass.

Send check or Money Order. Include Postage, Average Wt. per package ½ lb. No C.O.D.'s. Minimum Order $3.00

Rated companies 30 days net
TELEPHONE (617) 547-4005

SOLID STATE SALES

POST OFFICE BOX 74B
SOMERVILLE, MASS. 02143
featuring transistors, rectifiers and components
SEND FOR OUR LATEST CATALOG
Business Address: 325 Elm St., Cambridge, Mass.

CIRCLE NO. 93 ON READER SERVICE CARD

EDUCATIONAL OPPORTUNITIES

LEARN While Asleep, hypnotize with your recorder, phonograph. Astonishing details, sensational catalog free! Sleep-Learning Association, Box 24-ZD, Olympia, Washington 98501.

LEARN WHILE ASLEEP. Miraculously build Mind Power, achieve Self Confidence, improve Health, gain Success. Method 92% effective. Details free. ASR Foundation, Box 7021EG Henry Clay Station, Lexington, Kentucky 40502.

USED Correspondence Courses and Books sold and rented. Money back guarantee. Catalog free (Courses Bought). Lee Mountain, Pisgah, Alabama 35765.

BOOKS

FREE CATALOG. BOOKS FOR ADULTS. CATALOG. 2217 LACKLAND, ST. LOUIS, MISSOURI 63114.

GOVERNMENT SURPLUS

GOVERNMENT Surplus How and Where to Buy in Your Area. Send $1.00 to: Surplus Information EW, Headquarters building, Washington, D.C. 20036.

JEEPS Typically From $53.90 . . . Trucks From $78.40 . . . Boats, Typewriters, Airplanes, Multimeters, Oscilloscopes, Transceivers, Electronics Equipment, Used. 100,000 Big Bargains Direct From Government Nationwide. Complete Sales Directory and Surplus Catalog $1.00 (Deductible First $10.00 Order). Surplus Service, Box 820-K, Holland, Michigan 49423.

AUTHORS' SERVICES

AUTHORS! Learn how to have your book published, promoted, distributed. FREE booklet "ZD," Vantage, 120 West 31 St., New York 10001.

PERSONALS

MAKE FRIENDS WORLDWIDE through international correspondence. Illustrated brochure free. Hermes, Berlin 11, Germany.

FREE Catalog low priced, high performance subminiature listen-in devices direct from manufacturer. Dealers welcome. Audiotronix-W, 156 Fifth Avenue, New York, N.Y. 10010.

HYPNOTISM

FREE Hypnotism, Self-Hypnosis, Sleep Learning Catalog! Drawer H400, Ruidoso, N.M. 88345.

FEMALE, MALE HYPNOTISM!! Easily! Instantly! Secret Nerve Centers! $2.20. Brugenheimer, Box 158-E30, Lexington, Mass. 02173.

HYPNOTIZE MALES, FEMALES! – Unnoticed! Quickly! Nerves! Exciting! $2.25. Research Enterprises, 29-SN21 Samoset, Woburn, Mass. 01801.

HYPNOTIZE SUCCESSFULLY! "Instantaneous—One Word—Against Will". Methods Exposed! Complete illustrated course including "Secret Nerve Pressure Technique—Self-Hypnosis"—10" Hypno-Disk. $2.00. **RESULTS ABSOLUTELY GUARANTEED.** Fowler, Box 4396, Woodbury, N.J. 08096.

RUBBER STAMPS

RUBBER ADDRESS STAMP $1.50. SIGNATURE $3.50. FREE CATALOG. JACKSON, BOX 443-G, FRANKLIN PARK, ILL. 60131.

MAGNETS

MAGNETS. All types. Specials—20 disc magnets, or 2 stick magnets, or 10 small bar magnets, or 8 assorted magnets, $1.00. Maryland Magnet Company, 5412-E Gist, Baltimore, Maryland 21215.

INVENTIONS WANTED

INVENTORS We will develop, help sell your idea or invention, patented or unpatented. Our national manufacturer clients are urgently seeking new items for outright cash sale or royalties. Financial assistance available. 10 years proven performance. For free information, write Dept. 42, Wall Street Invention Brokerage, 79 Wall Street, New York, N.Y. 10005.

INVENTORS! Receive free invention analysis at no risk to you. Send for **FREE** disclosure form today. New York Invention Service, Dept. 19, 160 Broadway, New York, N.Y. 10038.

PATENT Searches including maximum speed, full airmail report and closest patent copies, $6.00. Quality searches expertly administered. Complete secrecy guaranteed. Free Invention Protection forms and "Patent Information." Write Dept 23, Washington Patent Office Search Bureau, 711 14th Street, N. W., Washington, D.C. 20005.

BUSINESS OPPORTUNITIES

$200.00 DAILY In Your Mailbox! Your Opportunity To Do What Mailorder Experts Do. Free Details. Associates, Box 136-K, Holland, Michigan 49423.

FREE CATALOGS. Repair air conditioning, refrigeration. Tools, supplies, full instructions. Doolin, 2016 Canton, Dallas, Texas 75201.

I MADE $40,000.00 YEAR by mailorder! Helped others make money! Start with $10.00—Free proof. Torrey, Box 318-N, Ypsilanti, Mich. 48197.

"FLAT PAK" INTEGRATED CIRCUITS!!

Solid State KING

BRAND NEW! $1.49 ☐

DUAL 914★

We include 30 Basic IC Projects RADIO-ELECTRONICS January & JULY 68

RTL Logic −55° C to +125° C Electronics World:

★ First time anywhere two identical IC's in one package.

☐ POLY BEST BUY **$10 ORDERS CHOOSE ANY $1 ITEM Free**

1 AMP TOP HAT AND EPOXIES

PIV	SALE	PIV	SALE	PIV	SALE
50 ☐	.05	800 ☐	.19	1800 ☐	.87
100 ☐	.07	1000 ☐	.31	2000 ☐	1.05
200 ☐	.08	1200 ☐	.44	3000 ☐	1.60
400 ☐	.11	1400 ☐	.62	4000 ☐	1.90
600 ☐	.16	1600 ☐	.72	10000 ☐	4.80

IT'S NEW! ONE WATT INTEGRATED CIRCUIT AUDIO AMPLIFIER!

★ 8 Transistors ★ 6 Diodes ★ Dime Size **4.95**

Never before offered! Self-contained, integrated circuit—size of a DIME! TO-5 case, 8 leads. Use for phono, tape, intercom & 100's of microminiature audio circuits, mike, phono, tape. Output: 3 to 16 ohm speaker. Complete with data.

LINEAR AMPLIFIERS *with circuits & data*

- ☐ 702C WIDE BAND DC $3.98
- ☐ 703H RF-IF-FM $1.49
- ☐ 709C HI-GAIN OPERATIONAL $3.98
- ☐ 710C HI-SPEED DIFF. COMP. $3.98
- ☐ 711C DUAL COMPARATOR $4.98

10c for bargain catalog on ☐ 100's of $1 Poly Pak assortments, ☐ transistors, rectifiers, zeners, ICs, Triacs, SCRs, etc., ☐ parts & equipment. "It's the hottest bargain parts catalog in the industry."

FAIRCHILD INTEGRATED IN-LINE CIRCUITS

Tested, with data sheets

- ☐ 930 DUAL 4 INPUT GATE & EXPANDER $1.00
- ☐ 933 DUAL INPUT EXPANDER $1.00
- ☐ 944 DUAL POWER GATE $1.00
- ☐ 946 QUAD 2 INPUT NAND/NOR GATE $1.00
- ☐ 952 DUAL 2 INPUT INVERTER GATE $1.00
- ☐ 953 2-2-3 INPUT AND GATE $1.00
- ☐ 954 DUAL 4 INPUT AND GATE $1.00
- ☐ 955 8 INPUT AND GATE W/2 INPUTS $1.00
- ☐ 956 DUAL INPUT BUFFER $1.00

100's of other IC's including: Flip-Flops, Registers, Adders, etc. Write for listing.

SOLID STATE BARGAINS

- ☐ 1—TUNNEL DIODE, 1N3716 for amps-osc $1.47
- ☐ 1—UNIJUNCTION TRANSISTOR, 2N489 .. $1.47
- ☐ 1—SOLID STATE 8 TRANSISTOR PREAMP $4.88
- ☐ 1—COLOR TV RECTIFIER 14,500 PIV $1.45
- ☐ 12 INTEGRATED CIRCUITS gates etc, notest $2.59
- ☐ 1—CM-600 10,000 mmhos, FET, n channel $1.00
- ☐ 1—FET CM-600, 10K mmhos, n channel .. $1.00

FAIRCHILD ** **BRAND NEW!** **"FLAT PAK" RTL INTEGRATED CIRCUITS**

			Sale
☐	900	Buffer	$1.49
☐	903-903*	3 Input Gate	$1.69
☐	904-904*	Half Adder	$1.69
☐	914-914*	Dual 2 Input Gate	$1.49
☐	923	JK Flip Flop	$1.69
☐	923-923*	JK Flip Flop	$1.98
☐	927-927*	Quad Inverter	$1.69

*First time anywhere two identical IC's in one package, example 923-923 contains two separate JK flip-flops in one package. 914's and 923. We include 50 uses. ** Licensed. ¼" x ¼"

WORLD'S MOST POPULAR **$1 PARTS PAKS**

- ☐ $25 SURPRISE PAK: transistors, rect, diodes, etc. .$1
- ☐ 5 ONE AMP 800 PIV RECTIFIERS, silicon top hat $1
- ☐ 10 KODAK LENSES, convex, piano, etc. Hobby mus $1
- ☐ 50 GERMANIUM GLASS DIODES, 1N34, 1N48 no tes $1
- ☐ 40 TOP HAT SILICON RECTIFIERS, no testasst value $1
- ☐ 25 EPOXY RECTIFIERS, silicon asst. no test $1
- ☐ 40 PRECISION RESISTORS, ½-2W. 1% asst values .$1
- ☐ 30 TRANSISTORS, rf, if, audio, osc. no test $1
- ☐ 60 TUBULAR CONDENSERS, to .5mf to 1KV, asst ...$1
- ☐ 50 DISC CONDENSERS, to .05mf npo, temp coef, ass $1
- ☐ 60 TUBE SOCKETS, receptacles. plugs, audio, etc. .$1
- ☐ 30 POWER RESISTORS, to 25 watts, to 24K ohms ...$1
- ☐ 3 2N3568 NPN TRANSISTORS, 200mc, 200V, 200hfe $1
- ☐ 3 2N3563 TRANSISTORS, npn, 600mc, 100hfe, epoxy $1
- ☐ 10 VOLUME CONTROLS, to 1 meg, switch too! $1
- ☐ 10 ELECTROLYTICS, to 100mf, tubulars too, asst ...$1
- ☐ 50 RADIO & TV KNOBS, asstd colors & styles $1
- ☐ 10 TRANS'TOR ELECTROLYTICS to 100mf, asst value $1
- ☐ 50 COILS AND CHOKES, if, rf, ant, osc, peaking, etc $1
- ☐ 65 HALF WATTERS, to 1 meg, 5% popular values to $1
- ☐ 60 HI-QUALITY RESISTORS, ½, 1, 2W asst values ...$1
- ☐ 10 RCA PHONO PLUGS & JACK SETS, tuners, etc. ...$1
- ☐ 4 INTEGRATED CIRCUITS, gates, etc. no test $1
- ☐ 2-PC INFRA-RED DETECTOR & FILTER SET science pro $1
- ☐ 2 FIELD EFFECT TRANSISTORS, n channel, hobby ...$1
- ☐ 50 TERMINAL STRIPS, 1 to 8 lug types $1
- ☐ 3 PHOTO ELECTRIC CELLS, hi. imp., schematic $1
- ☐ 3 TRANS'TOR AMPLIFIER, WIRED, 3x2x¾" schematic $1
- ☐ 10 PRINTED CIRCUIT BOARDS, copper clad, 100 uses $1
- ☐ 10 TRANSISTOR SOCKETS, for pnp & npn types.....$1
- ☐ 10 PANEL SWITCHES, toggle, slide, micro, rotary .$1
- ☐ 5 "SUN" BATTERIES, for 100's of lite sens projs ...$1
- ☐ 5 RAYTHEON CK-722 TRANSISTORS, pnp, most pol $1
- ☐ 5 G.E. 2N107 TRANSISTORS, pnp, audio ckts $1
- ☐ 6 "IBM" COMPUTER BOARDS, many trans, diodes $1
- ☐ 40 "MICRO" CONDENSERS, for transistor circuitry $1
- ☐ 3 14W. EPOXY TRANSISTORS, npn, silicon, B-5000 $1
- ☐ 15 3 to 12 AMP STUD RECTIFIERS, up to 600 PIV ...$1

Terms: add postage. **Rated:** net 30, cod's 25%
Phone Orders: Wakefield, Mass. (617) 245-3829
Retail: 211 Albion, St., Wakefield, Mass.

POLY PAKS P.O. BOX 942W 01940 SO. LYNNFIELD, MASS.

CIRCLE NO. 98 ON READER SERVICE CARD

INVESTIGATE ACCIDENTS: Earn to $1000 monthly. Men urgently needed. Car furnished. Business expenses paid. No selling. No college education necessary. Pick own job location. Investigate full time or earn to $8 hour spare time. Write for **FREE** information. No obligation. Universal Schools, CZ-9, 6801 Hillcrest, Dallas, Texas 75205.

JAPANESE Electronics New Products Monthly! Specimen copy $1, deductible. Dee, 10639-W Riverside, North Hollywood, Calif. 91602.

FREE BOOK "990 Successful, Little-Known Businesses." Work home! Plymouth 245J, Brooklyn, New York 11218.

REPAIRS AND SERVICES

SPEAKER REPAIR. Hi-Fi, guitar, organ speakers reconed good as new at fraction of new speaker price. For details and Reconing Center in your area write: Waldom Electronics, Inc., Dept. EW, 4625 W. 53rd St., Chicago, Ill. 60632.

MISCELLANEOUS

WINEMAKERS: Free illustrated catalog of yeasts, equipment. Semplex, Box 7208, Minneapolis, Minn. 55412.

WATCHES AND CHRONOGRAPHS—Import from Switzerland, save 50%. Color catalog. DFI, West Dennis, Massachusetts 02670.

EMPLOYMENT Resumes. Get a better job & earn more! Send only $2.00 for expert, complete Resume Writing Instructions. J. Ross, 80-34 Kent St., Jamaica, N.Y. 11432 Dept. EW.

TEN Winemaking Recipes and Winemaking Supplies catalog 10¢. Country Winemaker, Box 191E, RFD 1, Mattapoisett, Mass. 02739.

STOP BURGLARS THE EASY WAY!! Affix authentic "Protected by Electronic Sentry Alarm" Decals to auto windows, doors & windows of home, retail stores; vending machines, etc. Whether you have an alarm or not—thieves stay away! Only $1.00 for each set of two. J. Ross, 80-34 Kent St., Jamaica, N.Y. 11432. Dept. EW.

ELECTRONICS WORLD SEPTEMBER 1968

ADVERTISERS INDEX

Printed in U.S.A.