Electronics World

MARCH, 1965
50 CENTS

UNUSUAL 200-WATT SOLID-STATE HI-FI AMPLIFIER DESIGN

THE EVOLVING TRANSISTOR—State-of-the-Art Roundup

ELECTRONIC TIMERS FOR AUTOMATIC CONTROL

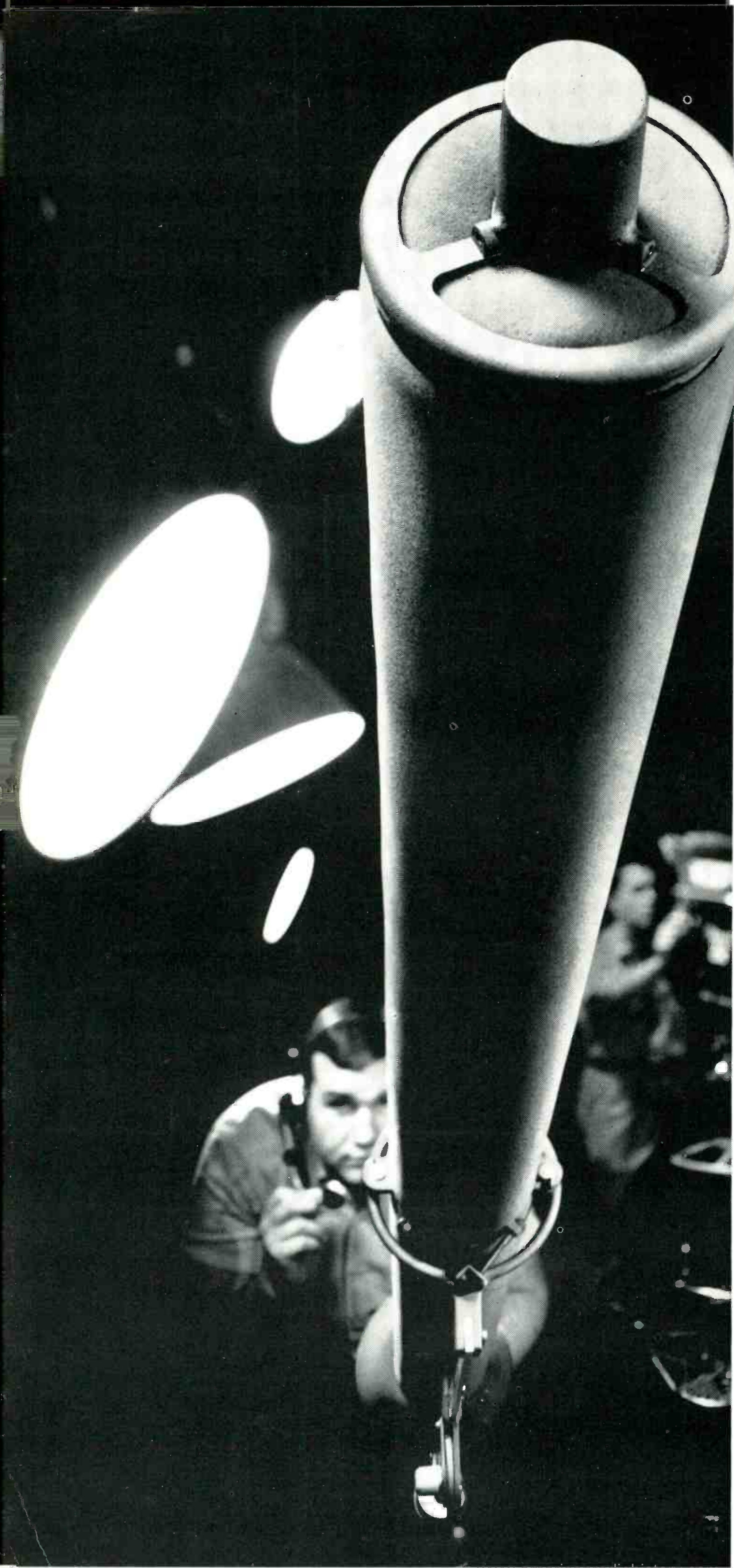
CLOSED-CIRCUIT TV CAMERAS

special feature on:

MAGNETIC TAPE for

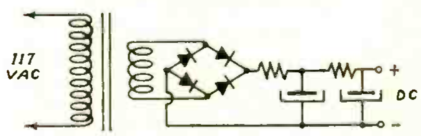
VIDEO • INSTRUMENTATION •

A ZIFF-DAVIS PUBLICATION



How to reduce ripple in solid state circuits

Full wave bridge rectifier



Rectifiers:

FW: 1.5 amp

Type S
3 amps

Type VS
15 amps

Type V
25 amps

Capacitors:

CG

FP

TC

Many of the new solid state circuits you'll be working with are line operated. This means that the power supply has to produce just about as pure DC as possible, at anywhere from 3 to 25 volts. How do you get ripple down to the rock bottom minimum, so there's no trace of 60 cycle hum in the output?

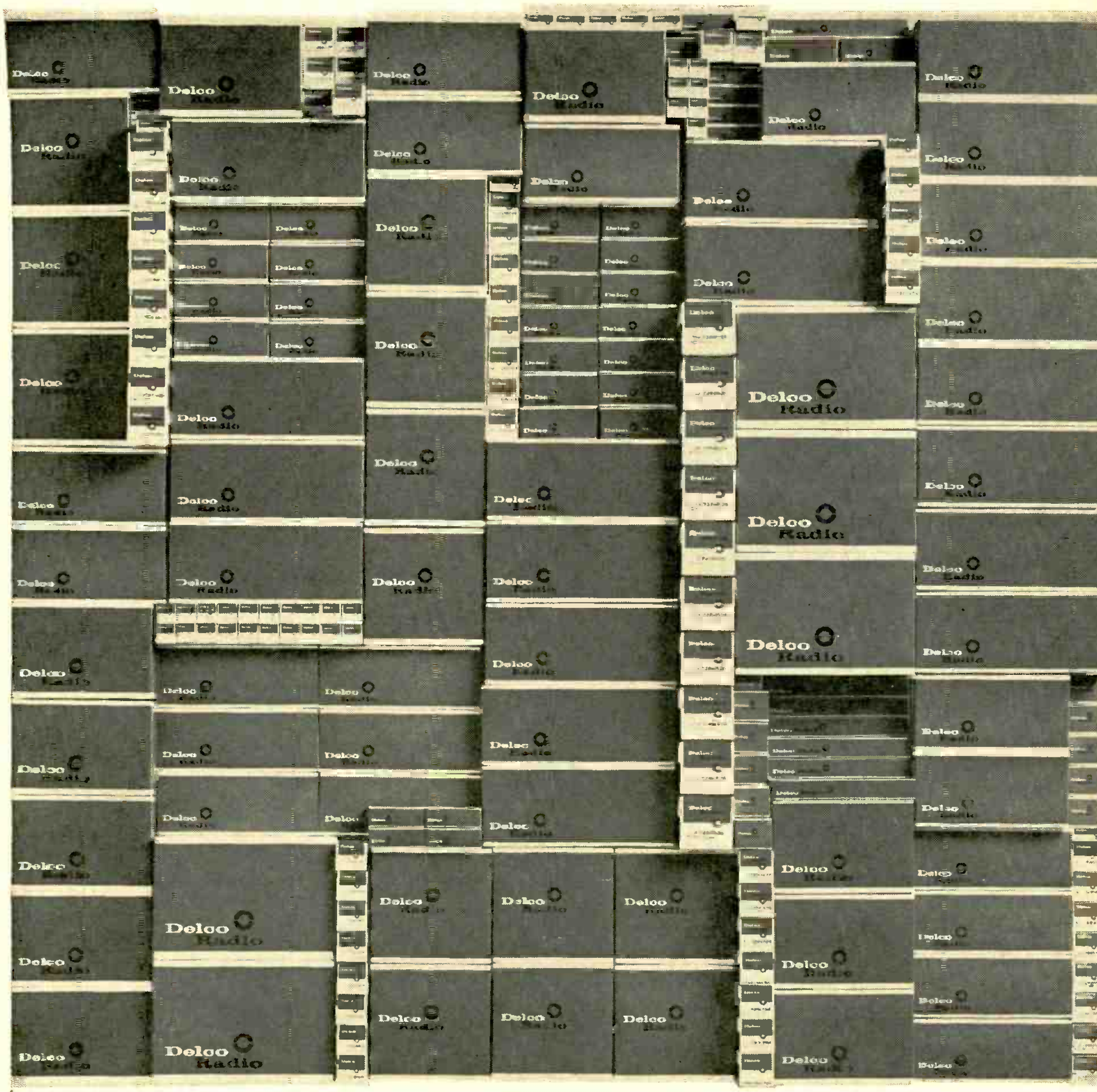
First tip: start out with a full wave rectifier. This inherently gives you far less filtering to do than a half-wave rectifier. If you need up to 1.5 amperes DC, the simplest way to do the job is to use a Mallory Type FW full wave bridge circuit package. All four rectifiers are factory-connected in this compact, encapsulated unit. All you need to do is connect the four leadwires—AC input and DC output—in your circuit, and you're ready to go. You'll save yourself some money, because the package costs appreciably less than four separate rectifiers. Or you can use a full wave center tap . . . we have packaged circuits with either positive or negative center, also rated 1.5 amperes. And if you need higher currents, take a look at our stud-mount and press-fit types which go up to 25 amperes.

Next tip: use a lot of capacitance. Brute force filtering is the sure way to kill ripple. And when it comes to packaging maximum capacity into a filter, the Mallory line gives you a broad choice. The "mostest microfarads" comes in the CG computer grade series, where you can get up to 115,000 mfd. at 3 volts in standard, off-the-shelf parts . . . dollar for dollar, the most filter for your money. But you don't always need this much capacitance, or perhaps you have limitations on physical size. Then take a look at what you can get in Mallory TC capacitors (the horizontal mounting type): up to 1000 mfd., at 50 volts.

Or maybe you'd prefer a vertical twist-mount type. That's our famous FP series. Up to 10,000 mfd. at 6 volts, or 7,500 mfd. at 25 volts in single units, and slightly less in multiple-section types.

Your Mallory distributor carries a wide selection ready for immediate delivery. See him soon. He's your best source for everything that's best in electronic components.

CIRCLE NO. 129 ON READER SERVICE PAGE



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How can we be so sure we've got the auto radio parts you need? There are two reasons. One, nearly *half* the cars on the road have Delco radios. And we make Delco radio parts. Two, you can service *most* other kinds of radios with Delco parts.

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CIRCLE NO. 123 ON READER SERVICE PAGE

CONTENTS

MARCH 1965
VOL. 73, No. 3

OUR COVER shows three standard-sized reels of magnetic recording tape. The upper reel is 2-in.-wide video tape used to record TV programs. The center reel is ½-in.-wide tape for computers. The lower reel is ¼-in.-wide audio tape such as would be used on a home recorder. Small portions of these tapes have been specially treated to make their recordings visible. The vertical-sync pulses (light vertical lines) and horizontal sync pulses (light regularly spaced dots) are clearly visible on the video tape. On the computer tape, 8 tracks of digital information can be seen, and on the audio tape, 2 tracks are visible. (Tape: Reeves Soundcraft. Photograph .... Jay Seymour, Burns Brothers, New York.)

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COMING NEXT MONTH

SPECIAL ISSUE

Review of the Electronics Industry—A complete report on how the industry grew in the past, its status today, and its future potential. Products, people, and prospects are covered with emphasis on the employment situation for scientists, engineers, and technicians on the East Coast. A comparison of industry activity on the East Coast, Midwest, and West Coast is included as a service to our readers.

Fixed Resistors—Technical facts and figures on the many different types of fixed resistors being used today are included in this special section. The various articles include information of vital importance to those responsible for specifying and purchasing resistors at all industry levels.

NEW LINE-CORD OPERATED TRANSISTORS
The development of a new family of high-voltage power transistors by RCA and Delco makes possible line-cord "instant play" all-transistor a.c.-d.c. receivers, without step-down transformers or dropping resistors. These components can also be used in TV deflection circuits and high-voltage regulators.

MARINE RADIOTELEPHONE ANTENNA
Details on a simple, grounded shunt-fed antenna for runabouts that is both electrically safe and highly efficient for the 2- to 3-mc. band. The antenna is not affected by rain or salt-spray and is so designed that it can be touched while the transmitter is in operation.

NEW INDUSTRIAL RADIO BAND
In an effort to relieve the overcrowded CB bands which are widely used for remote-control applications, the FCC has assigned a block of 30 channels in the 72-76 mc. band under the Manufacturers Radio Service. These low-power transmitters can be used for remote-control of a wide variety of equipment.

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

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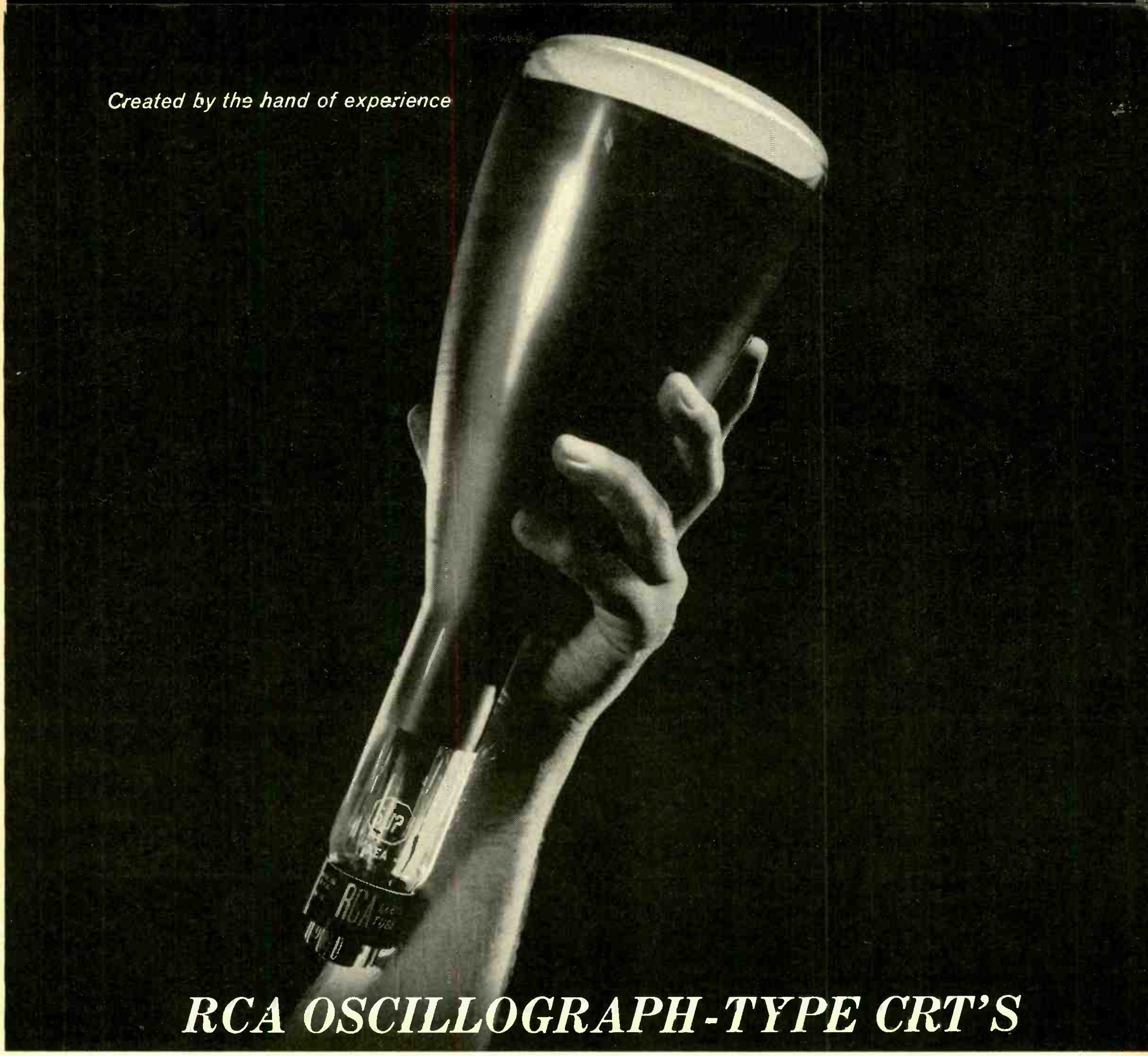

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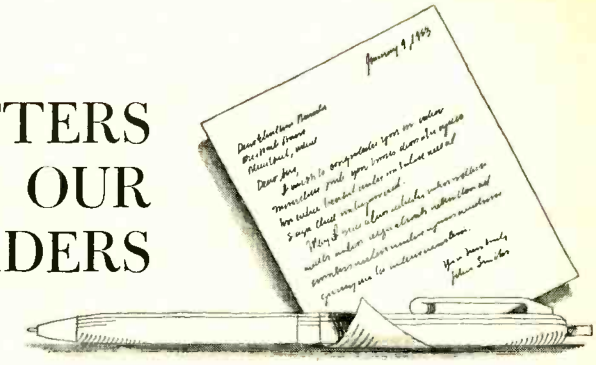
LETTERS FROM OUR READERS



CATV EDITORIAL

To the Editors:

Your recent editorial on CATV was an excellent condensation of a very complex situation. However, I would like to take issue with the following statement:

"Since a new u.h.f. station would find it hard to compete with a CATV system, the public would thereafter be deprived of free TV through u.h.f."

This statement sounds so logical that people seldom question it. But it just isn't so. I'd like to cite some facts to prove my point:

1. CATV has not hurt existing u.h.f. stations. In 1959 a Senate committee heard testimony from 12 small-market TV stations on how CATV affected their operations. Only one of these stations, KIMA-TV in Yakima, Washington, was u.h.f. KIMA-TV did testify that the local CATV system posed a serious threat to their existence. That was almost six years ago. Since then, KIMA-TV has not only survived, but has raised its rates by 16⅔%.

2. Of the 107 u.h.f. stations that have gone off the air, only ten were in CATV communities. Of these ten, one cited CATV as a factor in its demise, while two others wrote letters commending CATV for helping them stay on the air as long as they did.

An excellent example of a u.h.f. channel that has thrived in a CATV area is WBOC-TV, channel 16 in Salisbury, Maryland. Channel 16 cooperates wholeheartedly with the local cable system. Since 1960, when cable operations began, WBOC-TV has almost doubled its rates.

3. U.h.f. channels have already gone on the air in 14 communities where CATV service had begun prior operations and built set saturation.

4. A CATV system actually helps a new u.h.f. channel to compete with the existing v.h.f. stations. The big problem any new u.h.f. channel has to face is that very few TV sets are equipped to receive u.h.f. The recently passed all-channel law will help this situation, but not for years to come. The prospective viewer must invest in a converter or a new TV set before he can watch u.h.f.

5. A number of CATV operators have applied for u.h.f. TV stations themselves, and more will undoubtedly follow. Because the CATV system operator already has a tower, land, a building, office space, and an engineering staff, he can operate a u.h.f. station more economically in his area than most other applicants.

Milton J. Shapp
Chairman of the Board
The Jerrold Corp.
Philadelphia, Penna.

* * *

AUDIO SWEEP GENERATOR

To the Editors:

Regarding the article by Robert H. Douglas in the August issue of Electronics World on an audio sweep generator (p. 71), I am in doubt about your marker circuit. I do not believe this will ever work and have tried it and found it inaccurate.

Mixing of the two signals as shown produces a lot of garbage all over the scope rather than a pip. I am very interested in knowing if you have successfully used this circuit.

Playing around with audio sweep generators, I have tried many ways to produce a marker pip simply. Unfortunately, this cannot be done.

Edward Jacobson
Morton Grove, Illinois

Following is a copy of Author Douglas' reply to the above, as well as his comments on some additional notes by Frank J. Manus in our November issue (p. 112) concerning this sweep generator.—Editors.

To the Editors:

After using an r.f. sweep generator, one becomes used to small distinct marker pips. With the circuit described in my article, the display generated might be said to contain a disturbance rather than a pip.

The marker generator operates by heterodyning the outputs of the audio sweep generator with a fixed-frequency oscillator. The mixed signal, consisting of the two original frequencies plus their sum and difference, is passed through a low-pass filter. When the frequency of the sweep generator is very near that of the fixed-frequency oscillator, the difference signal will be low enough to pass the filter and will appear on the scope. This causes a pip or disturbance on the scope at the point on the trace where the generator is sweeping through the

Some plain talk from Kodak about tape:

Sensitivity and frequency response

Controlling every electrical factor involved in the making and using of sound tape is a bit like trying to watch a three-ring circus . . . it can be done, but you need fast eyeballs. Let's discuss two critically important parameters: sensitivity and frequency response.

Sensitivity means the degree of output for a given input.

We put in a 400-cycle signal and measure the output. The result: low-frequency sensitivity. We choose 400 cycles for a number of good reasons. A 400-cycle note recorded at 15 inches-per-second gives us a wave length that the tape "sees" of roughly .0375 inches, and by a happy coincidence this wave length penetrates the entire depth of the oxide coating, but not the support material. Everything else being equal, low-frequency response is a function of the thickness of the coating. The thicker the coating, the better the bass response. We test at a frequency that penetrates the entire coating. We choose 400 cycles instead of, let's say, 20 cycles because the 400-cycle note tells us just as much—and has an added advantage. An engineer can *hear* 400 cycles, so we have audio monitoring as well as instrumented observation on a scope face.

Just as the low-frequency sensitivity test gives us an idea about oxide thickness, the high-frequency test gives us a fairly accurate picture as to just how smooth the surface of the tape is. Good high-frequency response is impossible on a tape having a rough surface. Here's why: The low points will represent gaps in the oxide and cause a loss of H.F. response. We test our high-frequency sensitivity at 15,000 cycles. (Inches-per-second divided by cycles-per-second gives us recorded wave length.) So at 15 ips the arithmetic looks like this:

$$\frac{\frac{\text{inches}}{\text{second}}}{\frac{\text{cycles}}{\text{second}}} = \frac{\text{inches}}{\text{second}} \times \frac{\text{second}}{\text{cycles}} = \frac{\text{inches}}{\text{cycles}} \quad \text{which is wave length } (\lambda)$$

THUS:

$$\frac{\frac{15\text{ inches}}{\text{second}}}{\frac{15{,}000\text{ cycles}}{\text{second}}} = \frac{15\text{ inches}}{\text{second}} \times \frac{\text{second}}{15{,}000\text{ cycles}} = \frac{1\text{ inch}}{1000\text{ cycles}} = 1\text{ mil wave length}$$

At this high frequency (short wave length) we are recording only on the surface of the tape. If any roughness is present, big troubles result. If you have a surface condition where the amplitude of the roughness is just .0001 inches and your recorded signal has a 1-mil wave length, you will lose 5.5 db in high-frequency response! Let's rephrase the catastrophe. It takes a surface variation of just one tenth the wave length to knock down response by about 6 db. And this can happen at any frequency!

We are working toward making a point: KODAK Sound Recording Tape has a surface that is unsurpassed in smoothness, a surface that varies no more than 25-50 millionths of an inch from a theoretically perfect plane.

Frequency response is merely the arithmetic subtraction of high-frequency sensitivity from low-frequency sensitivity. Ideally the response is zero. It's quite an easy matter to juggle the characteristics of an oxide around so that frequency response is nice and flat. For instance, if your oxide has poor high-frequency sensitivity, you can reduce the thickness of the oxide layer. This will degrade L.F. sensitivity, and thus effect a flat response. But is the resulting L.F. loss worth it? We don't think so. That's why we designed our coating to give us superior low- and high-frequency sensitivities, as well as a nice flat response.

Next time we'll chat about a few other basic considerations.

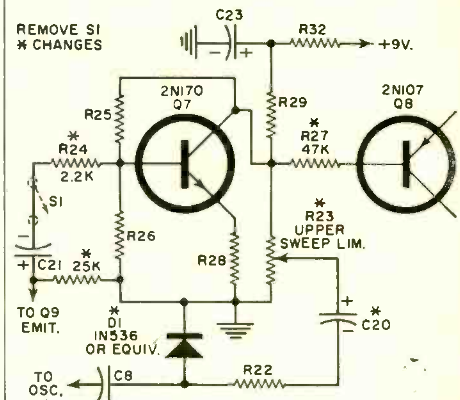
Choose KODAK Sound Recording Tape, Type 31A, for all general-purpose and low-print applications. Or Type 34A whenever you need high-output or low-noise characteristics. For extended playing times try our extra- or double-play tapes . . . or try the new triple-play tape—so thin you get 3600 feet on a 7-inch reel. KODAK Sound Recording Tapes are available at electronic supply stores, camera shops, specialty shops, department stores . . . everywhere.

EASTMAN KODAK COMPANY, Rochester, N. Y.

frequency of the fixed oscillator. This signal is of a very low level and the oscilloscope gain must be turned up to see it. I am sure that this disturbance can be observed in the "garbage," however.

In an article by Frank J. Manus in the November issue, Mr. Manus points out that the 1N950 diode may be hard to obtain. He suggests using a 1N536 series (1N536 to 1N540) diode, which is a readily obtainable, inexpensive power rectifier. As he mentions, substituting this diode in the original circuit reduces the maximum sweep to about 10 kc.

If one cannot obtain the diode or any substitute mentioned in the original article (two of which are listed in my old *Lafayette* catalogue), the following circuit will use almost any diode and



gives sweeps up to about 30 kc. I should point out that modifying the circuit in this manner eliminates one of the features of the device. In the original circuit, as the upper sweep-limit control was adjusted, the zero point on the trace tended to remain stationary. With the modified circuit, since the diode's polarity is reversed, the upper sweep limit will tend to remain constant, and the zero-beat control must be adjusted every time the upper sweep limit is adjusted. Mr. Manus suggests removing the upper sweep-limit control entirely. This all depends on whether you will ever want to sweep a range of less than 30 kc. or not. I often use the sweep generator as a fixed-frequency oscillator by turning down the upper sweep-limit control.

ROBERT H. DOUGLAS
San Francisco, Calif.

* * *

LOW-RIPPLE D.C. SUPPLY

To the Editors:

As several readers of my brief item "Low-Ripple D.C. Supply" (p. 64, November issue) have pointed out, the positions of resistors $R1$ and $R2$ in the voltage divider should be reversed. Also, the effective capacitance of the circuit equals the base capacitance times the h_{FE} of the transistor used. In this case, using a value of 100 for h_{FE}, the effective capacitance produced by the circuit would be 5000 μf. and not 50,000 μf.

PAUL H. FUGE
New Haven, Conn. ▲

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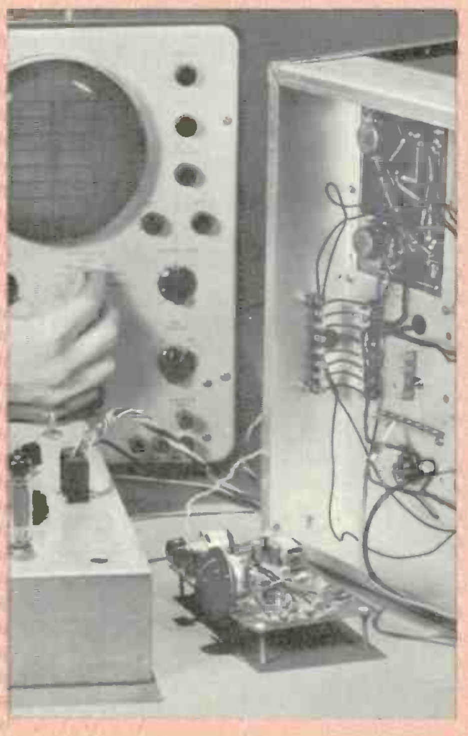

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"I want to thank NRI for making it all possible," says Robert L. L'Heureux of Needham, Mass., who sought our job consultant's advice in making job applications and is now an Assistant Field Engineer in the DATAmatic Div. of Minneapolis-Honeywell, working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

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

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

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

◀ SEE OTHER SIDE

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9. **MARINE COMMUNICATIONS** Much Electronic equipment is used on commercial ships and pleasure craft. Learn operation, maintenance of transmitters, direction finders, depth indicators, radar, etc. Prepares for FCC License.
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For the record

WM. A. STOCKLIN, EDITOR

1964: BANNER YEAR FOR INDUSTRY

THE electronics industry has just concluded one of the most prosperous years in its history. Dr. Harper Q. North, president of EIA, has just reported that the industry total sales for 1964 amounted to $16.3 billion compared with $15.2 billion in 1963. A 7.2% gain is an impressive figure and estimates are that our total sales will reach $17 billion by the end of 1965.

Each one of the four major divisions of our industry showed improvement. The consumer products area increased 10.8% to a total figure of $2.86 billion for 1964. The industrial products area increased 10.7% to $3.43 billion; government products increased 4.8% to $9.37 billion; and the replacement component area increased 5% to $.62 billion. Considering only the consumer, industrial, and replacement areas, that is, excluding the government market—the electronics industry would have shown a growth of 10.4%.

Although the Federal government remains by far the largest consumer of electronic products, there will probably be little or no further growth in this area in the near future. It has been in this area that the industry has had its greatest problems in the past, and expectations are that the coming years will show a leveling off. It is in this area where diversification and change-over from military to industrial and consumer products is prevalent and where unemployment among engineers, scientists, and technicians is greatest.

The bright spot in the industry has been consumer product sales. To be specific, it has been the sale of color-TV sets that has sparked the growth of the industry. Sales of color sets for 1964 should be about 1.4 million units with a factory sales value of $500 million. Ross D. Siragusa, Chairman of the Board of the *Admiral Corp.*, predicts that color-TV sales will reach 2 million units in 1965, approximately a 43% increase.

Sales of electron tubes, which have been on the decline for the past five years because of imports and the development of the transistor, dropped off again—from $274 million in 1963 to $260 million in 1964. Estimates are that 1965 sales will continue to drop to $210 million. Similarly, sales of power and special-purpose tubes will show a downward trend in sale volume.

Despite serious import competition, 1964 factory sales of electronic components were about $100 million higher than 1963's $3.7 billion.

The industrial electronics area is expected to show a continuing growth in the years ahead. As in the past, the most vigorous gain is expected in the sales of computing and data-processing equipment. Areas such as industrial control; processing equipment; test and measuring devices; communications; broadcast; commercial sound; navigational aids; nuclear electronic equipment; medical, scientific, educational, video tape recorders; closed-circuit television; electronic machine tools; and many other miscellaneous areas will add substantially to the 1965 growth of the industrial segment of our industry.

A noteworthy trend is the increasingly heavy demand for silicon transistors. A decade ago, silicon transistors were being outsold by germanium types 65 to 1. By 1963, the ratio was 5 to 1 and, although 1964 figures are not available, it is expected the gap has closed still further. The total sales of transistors reached a record of $303 million compared with $296 million in 1963. The sales of integrated circuits, including microelectronic devices, continued to increase in 1964, with sales climbing to $225 million from $155 million in 1963.

Although many would consider the CB market, including transceivers and accessories, to be fairly limited—it is noteworthy that 1964 showed an impressive rise of 18% to $39 million. This is nearly double that of 1960 sales.

Will 1965 be as good? Certainly not in terms of growth rate if EIA's estimate of $17 billion is correct, and there is no reason to doubt it. This would represent only a 4.3% gain compared with last year's 7.2%. But whether or not to be optimistic depends on the specific area of interest. Government expenditures will show little if any gain. It is obvious that in this segment of the industry there will be continued unemployment problems for scientists, engineers, and technicians. The growth must then come in the consumer, industrial, and replacement parts areas. There is no reason to doubt that this growth will be at least equal to that of 1964. Since our own interests and those of this publication are predominantly in these areas, we look forward to another record-breaking year. ▲


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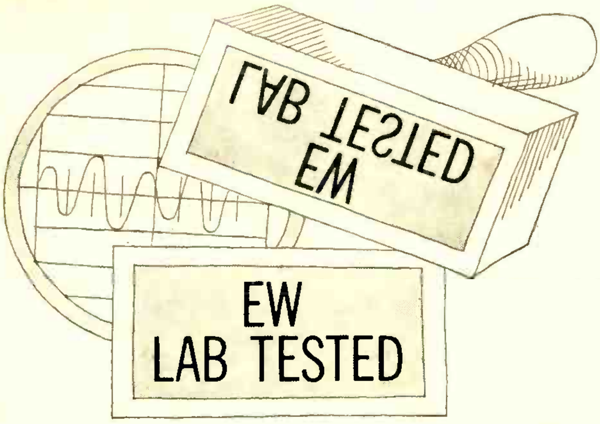
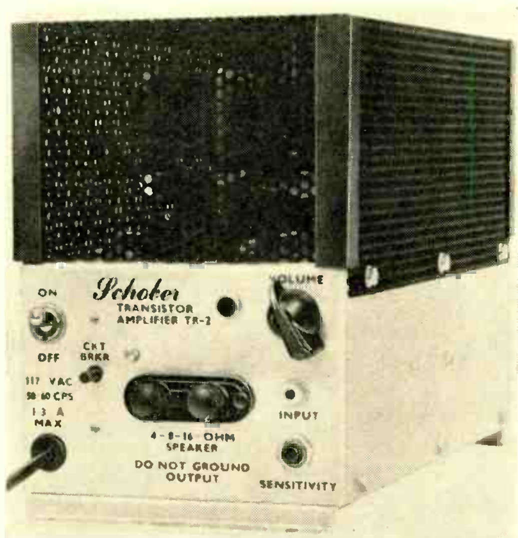


HI-FI PRODUCT REPORT

Schober TR-2 Amplifier
Sonotone RM-1 Speaker System

Schober TR-2 Amplifier

For copy of manufacturer's brochure, circle No. 60 on coupon (page 17).



THE requirements for a good electronic organ amplifier are, in many ways, more stringent than those for ordinary high-fidelity applications. In addition to the usual distortion, power, and frequency-response specifications, an organ amplifier must be able to deliver large amounts of continuous power, even at the lowest frequencies. The so-called "music-power" rating is certainly not applicable to amplifiers intended for organ service.

The *Schober* TR-2 is a fully transistorized basic power amplifier (single channel), designed specifically for use with electronic organs. It is equally well suited to home high-fidelity installations, public-address work, and other types of service. The TR-2 is rated at 40 watts output under continuous duty, into an 8-ohm speaker load, over the full 20- to 20,000-cps range at 0.75% distortion. It has a low source impedance, and will drive speakers with impedances from 4 to 16 ohms. It is a compact unit, measuring 11¼" long, 5¼" wide, and 7⅞" high, and weighing 13 pounds.

The amplifier is constructed on a heavy aluminum chassis which serves as a heat sink for the output transistors. A fan, mounted inside the perforated cover, forces a flow of air around and through the chassis. The cooling system is so effective that the amplifier can be operated at the highest power levels without becoming perceptibly warm. Although it is capable of absorbing considerable overload without damage to its transistors, the TR-2 is protected by a push-button resettable circuit breaker which will trip if its output is shorted under full-drive conditions.

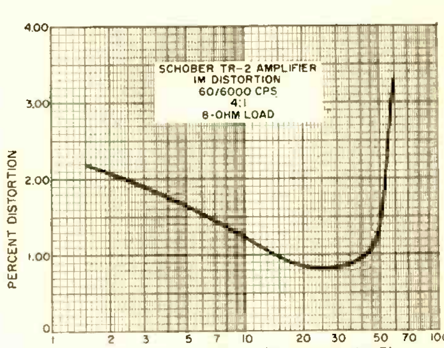
The output stage uses four 2N2147 germanium power transistors, in the well-known *RCA* single-ended push-pull configuration. The output is directly coupled to the speaker. A transformer-coupled driver stage is preceded by three low-level amplifier stages. A sensitivity control and a volume control provide a range of input sensitivity from approximately 0.05 to 0.8 volt to drive the amplifier to full output. The input impedance is 100,000 ohms.

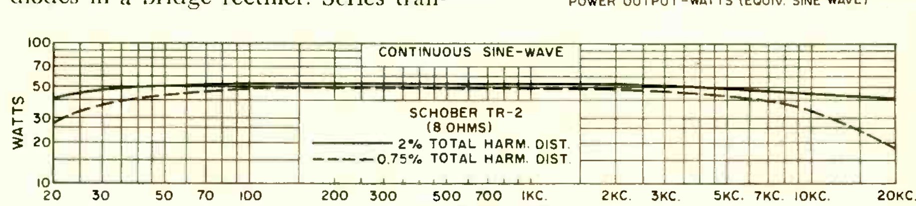
The power supply uses four silicon diodes in a bridge rectifier. Series transistor filtering is used for the low-level stages. Six-thousand microfarads of filter capacitance assures good filtering and regulation for the output stage.

The power rating of the unit proved to be very conservative. We measured over 50 watts output at 2% harmonic distortion and almost 50 watts at 0.75% distortion, over much of the audio range. At 0.75% distortion, it delivered over 40 watts from 35 to 7000 cps, dropping to 28 watts at 20 cps and 19 watts at 20,000 cps. At 2% distortion, it delivered over 40 watts from 20 to 20,000 cps. The frequency response at low levels was within ± 1 db from 20 to 20,000 cps. Like most transistor amplifiers, the TR-2 had relatively high IM distortion at very low power levels (about 2%), falling to less than 1% between 15 and 40 watts and rising again to 2% at 54 watts.

The amplifier was completely stable under capacitive loads. Its square-wave rise time was about 10 microseconds and was not affected by capacitances as great as 0.22 μf. shunting the 8-ohm load resistor. The measured sensitivity was adjustable from 45 mv. to 0.72 volt for 10 watts output, and hum was 66 db below 10 watts or 72 db below 40 watts. The maximum power output (at the

(*Continued on page* 86)





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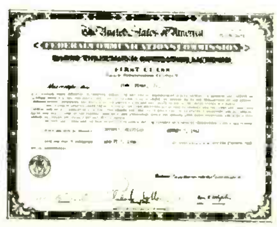

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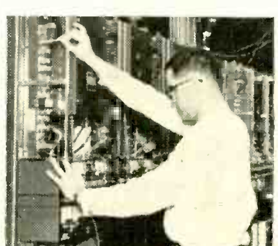

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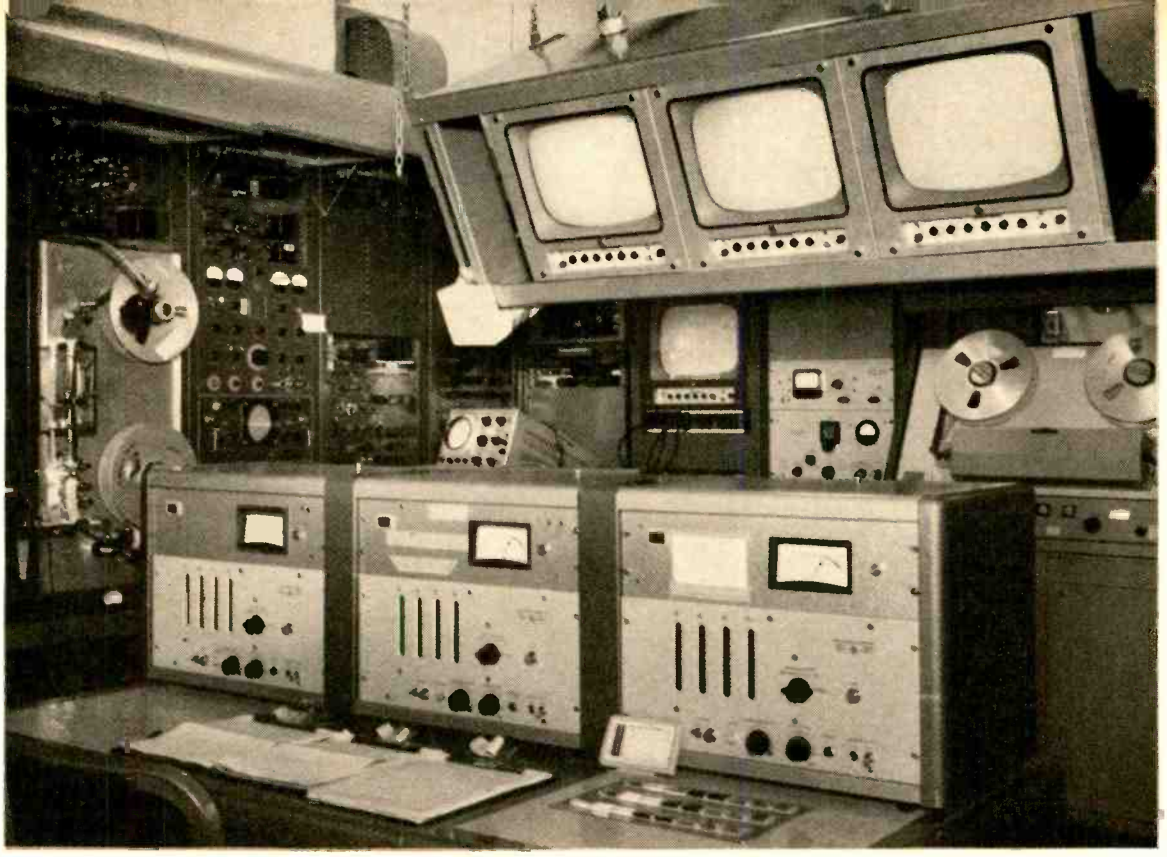


Video tape certification setup for tape that is to be used on professional, broadcast, quadruplex (4 rotating heads) recorders. The three counters in foreground automatically count number of dropouts that occur. A count is registered every time video signal from an accurately calibrated playback system drops below a certain preset value. Such a value represents an interruption in the video that lasts over 2 μsec. and is visible as brightness change on a TV monitor showing test pattern at a distance of 8 feet. Dropouts show up on a TV picture tube as dots, streaks, or flashes of white, grey, or black. No more than 20 dropouts per minute (@ 15 ips) are allowable.

MAGNETIC RECORDING TAPE

By EDWARD SCHMIDT
Vice-President, Research & Engineering
Reeves Soundcraft

Our most versatile and widely used memory medium, magnetic tape is used for sound and picture recording and for computers and instrumentation. The manufacturing techniques, testing, characteristics of different tapes, and problems are covered.

MAGNETIC recording tape is employed in just about every possible application where there is need for low-cost, accurate storage of memorizable information. It has been referred to as mankind's most versatile synthetic memory device.

What is behind this medium? What makes it work? To many technical people, tape is accepted as a useful component and, like a transistor or resistor, is expected to perform properly. Precious little information as to its hows and whys exists, even in technical literature.

Its basic construction concept is simple: magnetizable particles are spread thinly and uniformly on a ribbon of plastic and wound into a suitable length on a reel. The companies engaged in manufacturing tape spend millions of dollars annually on research, learning how to improve the product and extend its versatility. The complexities which develop in the manufacture and successful use of such a simple and basic raw material are manifold. These complexities are vividly illustrated by the requirements of the various recording systems employed in any space shot.

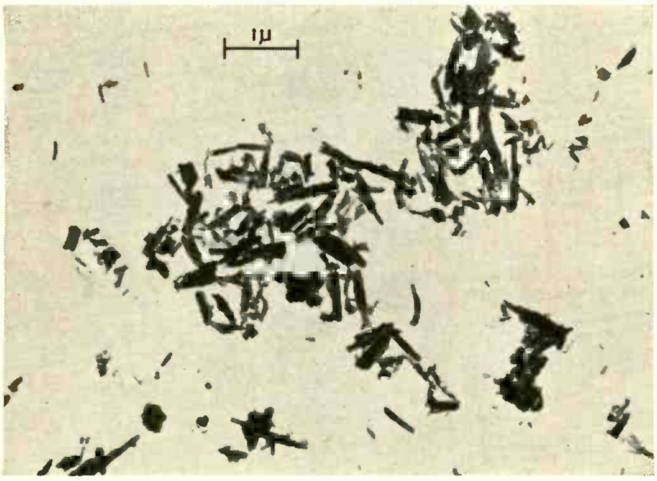


Fig. 1. Electron photomicrograph of typical gamma ferric oxide particles used in making sound recording tape.

The television video tape recorders employed use a two-inch-wide tape which moves at 15 ips. On one edge of the tape the voice of the announcer is recorded. The television picture information is recorded by high-speed rotating heads which scan across the width of the tape at a speed of 1400 ips. Thus, on this type of tape, we have a 100-to-1 speed of recording variation and a requirement for transverse orientation needed to obtain optimum video performance.

Seismic recorders may move the tape at speeds as slow as 0.2 inch per second. Computers write and read their numbers and letters using a binary code in which pulses are discrete magnetized spots on the tape. (A single roll of tape can store 155,000,000 discrete data points.) Telemetering recorders make a record of analog data, recorded as a voltage change on tape moving at 60 or 120 ips.

In the newer types of instrumentation recorders, wavelengths as short as 80 μin. may be employed, and these machines can record a total bandwidth of 1.5 mc. Geophysical recorders can and do respond to d.c. information.

In the space capsule, there is an endless loop of tape in a special magazine. Not only does this tape have to withstand difficult environmental temperatures and pressures, but each lap of the pile of tape must slide freely with very low friction.

While tape was simple in its beginnings, today's varied uses require product variations of considerable complexity and with many important but subtle differences.

Manufacturing Techniques

Fig. 1 is an electron photomicrograph of typical *gamma* ferric oxide particles used in modern tape. The particles are considerably less than one micron (39 μin.) long, are cigar-shaped, and have a length-to-breadth ratio of at least 10-to-1. These oxide particles are manufactured by first dissolving iron in an appropriate acid. Crystals in the *alpha* monohydrate form are then grown by a seeding process under carefully controlled conditions of temperature, pH, concentration, and agitation. This has been the historical first step in the manufacture of yellow iron pigments used for many years in paints, rouges, and fillers. These *alpha* particles are of the proper size and have the elongated shape of the finished magnetic oxide but are non-magnetic.

To render them magnetic, they are placed in sealed, rotary kilns with control of pressure and temperature. The particles are heated, the water of crystalization is driven off, and the oxide reduced to the Fe_3O_4 form, in a reducing atmosphere of hydrogen or natural gas. Then, under constant control of temperature, the particles are re-oxidized to Fe_2O_3 form while still maintaining the Fe_3O_4 crystallography. Thus, our particles are an anomaly to the extent that they are chemically Fe_2O_3, but physically Fe_3O_4.

The magnetic properties are influenced by each step of the process, particle size, shape, particle size distribution, rates of reduction, rates of oxidation, etc. Not only do the bulk magnetic particle properties influence the electromagnetic properties of the finished tape, but the actual particle physical properties of surface, area, degree of sintering, presence of chemical surface contaminants and the like, modify final tape performance by influencing the dispersion process.

The next step is the dispersion of these particles, and, ideally, to coat each individual particle with a continuous skin of organic binder in a suitable solvent system. This process of dispersion is normally done in ball mills and is the same as had been used in the manufacture of paints and inks for many years. But there are important differences.

Typical paints and inks are made from much larger particle pigments with a maximum 40-50% pigment-to-binder loading ratio, whereas some magnetic tapes will have pigment loadings of 85% total solids in the coating. Magnetic tapes usually need not be weather-fast, but must exceed paint films in their strength, durability, toughness, flexibility, low friction, wearability, thermal softening, abrasiveness, layer-to-layer adhesion, electrical conductivity, fungicidal properties and adhesion to thin, highly flexible base supports.

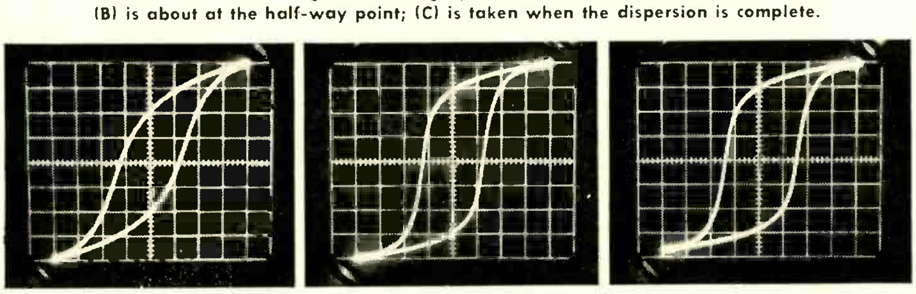
The instrumentation used to control the process of dispersion or milling is usually a BH meter. Here, with a 60-cps a.c. field, quick, accurate, and reproducible measurements of the bulk magnetic properties of the dispersion are made. It will be seen from the three BH curves (Fig. 2) made from tape coated with the dispersion taken at three stages of the milling cycle, that the coercive force, squareness, and remanence all change as the process continues.

The filtering of a magnetic dispersion has become a highly developed art. It is now common practice to filter these dispersions down to and below a one-micron classification. Filtering is required not only to remove trash and contaminants from the dispersion, but also to produce the proper magnetic properties. After filtering, laboratory coating tests are often run in order to obtain accurate electromagnetic property values on individual mill batches.

All major tape manufacturers are instrumented for quality-control measurements in accordance with Military Specifications WT-0070-1 through -5. The level and accuracy of this testing method is dependent upon the stability and calibration of a secondary reference tape. While this tape has been inspected and tested in a carefully controlled and supervised government laboratory, there are questions as to the accuracy of industry-wide standards, based on secondary reference tapes. These questions are especially valid in the area of short wavelengths as used in wide-band and video recording.

Nevertheless, the only practical standard today is the secondary reference tape, and all electromagnetic measurements

Fig. 2. BH curves of sound recording tape, made from coated samples of dispersion taken at three stages of milling cycle. (A) is taken early in the milling; (B) is about at the half-way point; (C) is taken when the dispersion is complete.



(A) (B) (C)

are based on this. Sensitivity, distortion, a.c. signal-to-noise, d.c. noise, short and long wavelengths, print-through, dropouts, resolution, noise spectra distribution, inter- and cross-modulation of adjacent signals are all measurable factors. The electromagnetic properties of tape for each use have become very specific, and no longer does a product designed for sound recording suffice for use either in an instrumentation or in a computer tape recorder.

Tape Characteristics

Most sound recording tapes have coercive force values in the area of 235-240 oersteds. The newer instrumentation tapes have coercive force values of 250-260 oersteds. Computer tapes have higher saturation output and magnetic squareness, and the newest high-resolution, wide-band tapes will demonstrate coercive force values of 280-290 oersteds with squareness values of 85%.

Over the years, tape coating densities have risen rapidly. Thus the coatings used in high-resolution systems have more useful pigment per unit area in much thinner coatings.

A remanence value of 900 gauss is typical for sound tapes with coating thickness of 0.45 mil. Equal or higher remanence values are obtained in high-resolution coatings only 0.2 mil thick. Hence, the net magnetic efficiency of the newer high-resolution coatings used for video and special tapes is greater than that of standard sound recording tapes.

As the effective gap length of the heads has decreased, it has been necessary to develop smoother and smoother surfaces for the oxide layer in order to obtain intimate contact with these high-resolution heads. Simultaneously, head-to-tape tensions have had to be increased in order to break down the air film which develops at recording speeds of 60 and 120 ips and interferes with good mechanical contact.

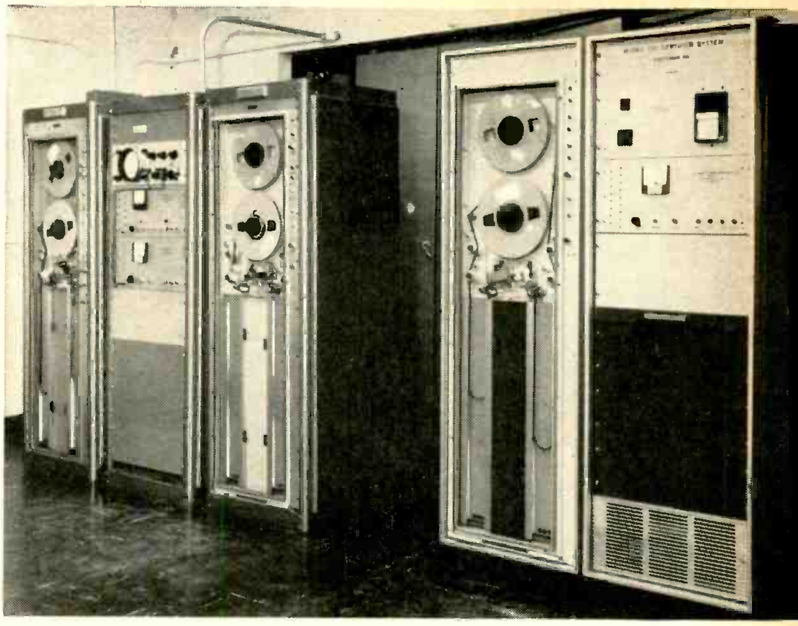
Tape tensions in high-resolution recording systems have values that are 4 to 8 times higher than tensions normally employed on sound recorders. The combination of high speed and high tension naturally produces higher friction at the head. This high friction can produce rapid head wear, rapid breakdown of the oxide surface, excessive dropout rates with tape wear, and increased severity of oxide shedding.

Smooth-surfaced oxides are not low-friction coatings. Excessive stiction (or uneven jerky motion) develops at the highly polished heads and guides, and the smooth oxide layer. As a result, the tape moves in waves across the heads. This motion irregularity, since it introduces an undesirable frequency change, obviously limits FM signal-to-noise capabilities, creates undesirable picture distortion in helical-scan video systems, introduces audible high-frequency distortion in slow-speed sound-recording applications and is, in general, a highly undesirable factor.

Fortunately, it now appears that the motion irregularities of smooth-surface tapes can be controlled and minimized by specialized treatments. All of these efforts are highly proprietary. The tape manufacturers have developed a list of descriptive tradenames which describe the products but do not disclose the methods used to develop smooth tapes with minimized stiction behavior.

Base Materials

The industry first followed the German lead, coating the oxide on calendered kraft paper. This was quickly supplanted in this country by the use of cast cellulose acetate base. In 1953 Mylar or polyethylene terephthalate, was introduced by *duPont*. This polyester type of base is now used on all computer, video, and instrumentation tapes and has almost supplanted the cellulose acetate base in the sound recording tape field. The reason for this is that Mylar contains no plasticizer; it is a complete chemical entity. Further, it has higher tensile strength and yield properties and is almost completely unaffected by temperature and humidity cycling within the range of interest. Common thicknesses of the base material used for magnetic tape are 1.5 mils, 1.0 mil, and 0.5 mil.



Computer tape test certifiers equipped for standard 7- or 9-track formats. No dropouts are permitted for entire length of the tape.

Most recently, a new type of higher strength Mylar has been introduced for certain recording applications in the field of video and instrumentation tape products. This new type of base has much lower ultimate elongation and about 40% higher tensile strength than the older "A" Mylar film. The new film is also characterized by a smoother surface structure which results in higher signal resolution and reduced noise.

Several new films are on the horizon which will extend the temperature capability of magnetic recording tape upward from its present practical limit of approximately 125°F.

Sound Recording Tapes

Many significant improvements have occurred in the manufacture of sound recording tape in recent years. These improvements have, in a way, been forced on the tape manufacturers through the development of slow-speed, multi-track stereophonic systems. With these, the record track has been reduced from the original full-track standard width to 40-mil wide tracks.

Similarly, recording speeds have dropped from 15 ips down to 7½, 3¾, and even slower operating speeds. For voice recording, speeds of 1⅞ and ¹⁵⁄₁₆ ips are not uncommon. The narrow tracks, close to the edges of the tape, are sensitive to dropouts which can be caused by improper tape slitting. Since the slow speeds do not "sweep clean" the heads as well as 15-ips operation, there is a greater tendency toward head fouling and the presence of oxide "dirt" on the tape, causing dropouts.

A most critical problem of sound recording is the hiss associated with narrow-track, slow-speed machines. This can also be a problem in the manufacture of the master or original recording. New "low-noise" tapes are now available which have been manufactured from very small, but still acicular iron-oxide pigments. These pigment particles are approximately one fifth that of the conventional *gamma* ferric oxides. Noise measurements using such tapes do not reflect the aural improvement that occurs, especially at slow speeds.

Computer Tapes

In the field of computer tape, the electromagnetic properties of the tape have to defer to mechanical and physical properties which make or break the performance capabilities of the product. Here a series of pulses written on multiple channels along the length of the tape must all be read back without error, after thousands of passes. The computer data is written in block form, and between each block of data is a blank space of ½ inch or so. This blank space is there to permit the tape to start and stop on command. Thus the tape

Quarter-inch recorder instrumented for secondary electromagnetic measurements in accordance with Navy specification WT-0070.

must accelerate from zero to a speed of 120 ips or more very quickly or it must decelerate from this high speed to zero equally fast. High mechanical stresses occur and these stresses rapidly deteriorate older high-friction binders used in tapes. Virtually all computer tape users have now switched to the new heavy-duty long-wear computer tapes, which will withstand more than 20,000 passes on a properly maintained transport before any deterioration sets in to cause loss of recorded information.

Before delivery, each roll of computer tape is certified on high-speed testers. All "ones" are written at the proper packing densities (556 bits per in., etc.) and then read back. Some of the newer testers have the capability of testing 16 channels in order to accommodate the present 7-channel standard and the new *IBM*-360 9-track format in one pass. If a single bit drops below 50% of the normal output level, the transport stops and exposes the tape on an operator's table. If the defect is a protrusion, small pieces of lint, or an oxide lump, it can sometimes be removed. Then the tester is automatically reversed: it writes and reads a new series of "ones" over the repaired area and the testing continues. This painstaking certification process is done in a clean environment, and the tape, after the testing and certification procedure, is placed immediately in a dirt-free container.

Instrumentation Tape

Instrumentation tape is a product which is used to record and store voluminous data, usually in an analog form. The source can be many miles away, as in the case of a satellite where data is to be telemetered to the ground, or the instrumentation recorder can be on site, such as in an experimental airplane or on a rocket sled. The outputs of all types of sensors, such as strain gages, thermometers, pressure-sensing transducers, and accelerometers, are continuously recorded. The data can then be analyzed and studied repeatedly, after the event.

The tape used on these instrumentation recorders started out as sound recording tape, slit wider and wound in longer lengths on a reel. As recording speeds and densities increased, requirements developed for special long-wearing oxide formulations.

Most recently, the field of predetection recording has resulted from the development of micro-gap heads. Here, on one pass at 120 ips, telemetered data over a 1.5-mc. bandwidth can be recorded directly on the tape. This method of recording has improved the reliability of telemetered data as well as extended bandwidths; it is now rapidly obsoleting the older types of instrumentation systems that had been used formerly.

In order for the tape to perform well on wide-band predetection equipment, we require very smooth, long-wearing surfaces and low head wear types of coatings. Unspliced lengths of 1-mil base tape, 9600 feet long on a reel, are common.

The instrumentation tape market is growing tremendously. The bulk of these systems are used by the military or for government research. Therefore, the industry has been seeing a proliferation of specifications in this field since each application demands a tape which differs in some important characteristics. Thus, in the instrumentation tape field, there are more different product types that are manufactured today than there are in any of the other fields.

Video Tape

Video tape represents the highest engineering development of the art. The problems of formulation, manufacture, quality control, and testing are severe. Only two American manufacturers are in routine production of video tape for commercial quadruplex applications.

The newer helical-scan or slant-scan video tape recorders add new problems. Here the tape is pulled at slow speed around a large diameter non-rotating drum. Thus, we combine two difficult frictional problems, one resulting from high speed (625 ips or more) and high pressure at the rotating heads, and the other from the slow speed as the tape is dragged under high tension over the drum.

Dropouts in video tape are perhaps the most difficult manufacturing and operational problem to overcome. The very narrow tracks (down to 5 mils on some equipment), the complication of high frequency (4.5-mc. and higher), the use of an SSB FM record-reproduce technique, and the fact that the video tracks are transverse to the coating direction, are only a few of the complications.

In spite of the complexity of magnetic video tape recording, the economic and quality characteristics of commercial program material on video tape favor its use. As color TV becomes more widespread, the advantages of tape become even greater.

Schools, factories, hospitals, airports, and government are using portable video tape systems for recording and reproduction of important picture information because of its immediacy, re-usability, and lower cost. New video-tape systems for document storage and retrieval are competing with microfilm processes. Several companies are working on low-cost video cameras and tape recorders for home use to compete with film cameras and projectors.

Industry Problems

Our industry and its versatile medium does have some problems. Perhaps most serious and fundamental is the fact that to date no satisfactory method has been developed to measure the surface magnetic induction at typical useful wavelengths on an absolute basis. As noted earlier, we have to depend on secondary reference tapes whose accuracy and stability may be questioned. Further, as we move to shorter wavelengths, the measurement accuracy requirements eclipse the capabilities of any known reference tape system.

The industry has recognized this and other limitations of present standards. A joint industry and government committee is being organized under the auspices of the Electronic Industries Association. The member manufacturers, who produce more than 95% of the volume of magnetic tape, have pledged engineering time, talent, and support to a working group committee on magnetic tape. This group is dedicated to developing standard definitions, tests, methods, and tolerances for both electromagnetic and mechanical properties of magnetic tape.

The committee will welcome any suggestions on methods of developing absolute measurement of tape surface induction from any source. Should any reader have any such suggestions, address them to this publication. They will be forwarded to the Chairman, P-8.6 Engineering Work Group on Magnetic Tape of the EIA. ▲

LINE-OF-SIGHT NOMOGRAM

By DAVID L. PIPPEN

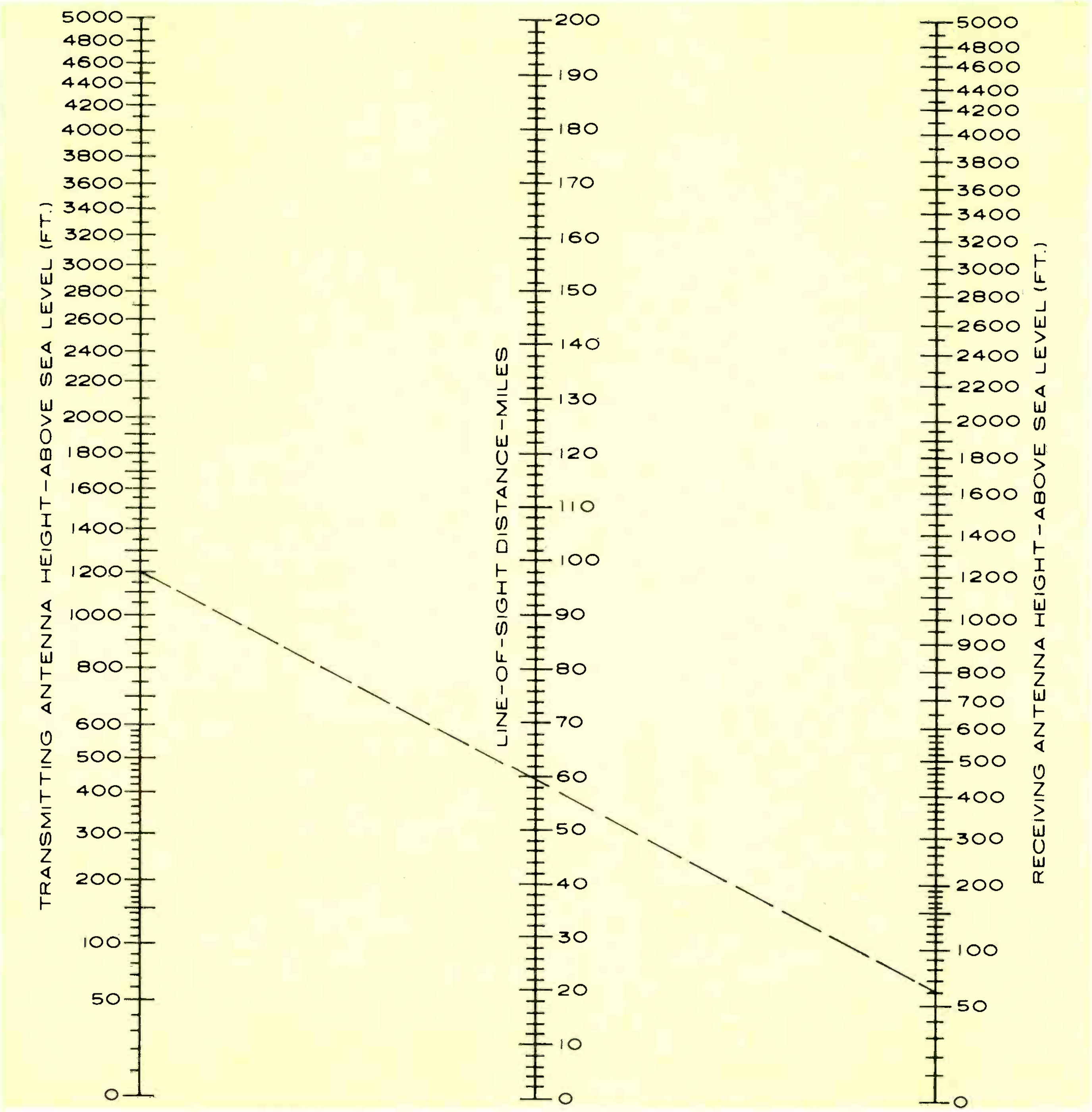
Required antenna heights for various reception ranges are readily determined by the use of a straightedge.

HOW high must a TV antenna be placed in order to receive direct line-of-sight communication from the TV transmitter located 60 miles away? This is a question frequently asked by TV set owners who realize that upper v.h.f. and all u.h.f. TV channels are, basically, line-of-sight.

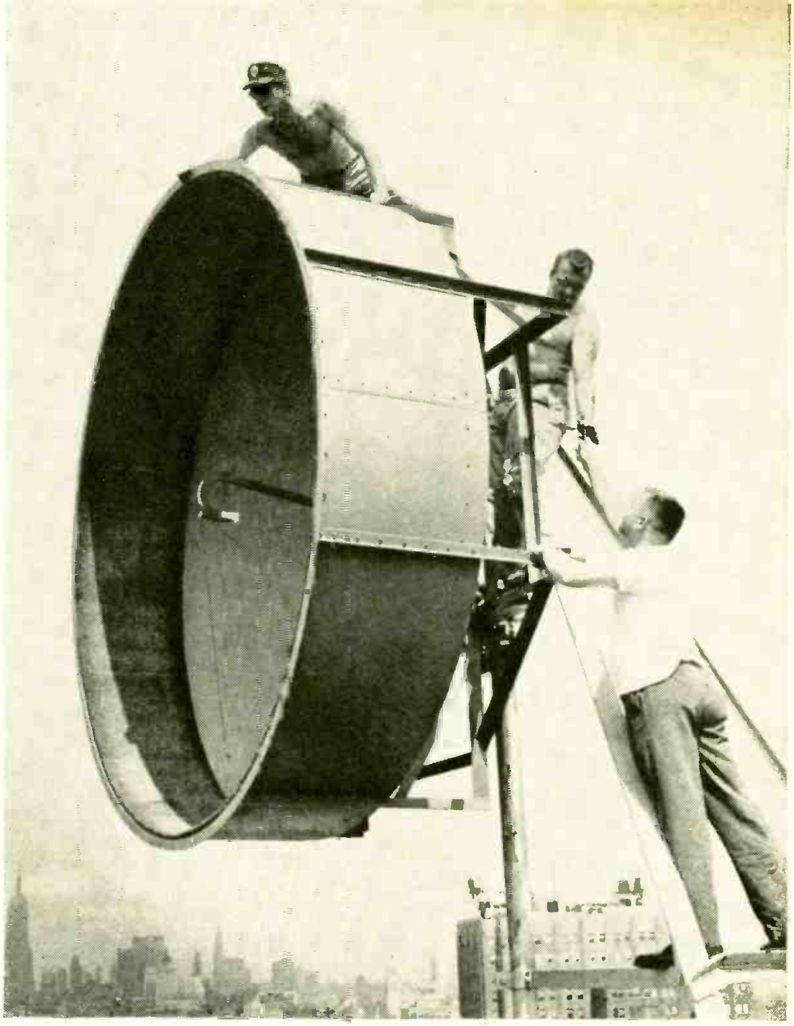
The nomogram below will provide a quick answer. Assume that the transmitting antenna is at an elevation of 1200 feet above sea level. Your receiver is located in a building whose roof is at an elevation of 50 feet, 60 miles from the transmitter. How high should you place your receiving antenna?

Place one end of a straightedge on 1200 on the Transmitting Antenna column and intersect 60 miles on the Line-of-Sight Distance column. The intersection of the straightedge at the Receiving Antenna Height column gives the answer of approximately 10 feet above 50 feet (total elev., 60 feet).

Thus, if there are no mountains or other interfering structures between your receiver and the transmitter, a 10-foot mast would be enough for line-of-sight communications. ▲

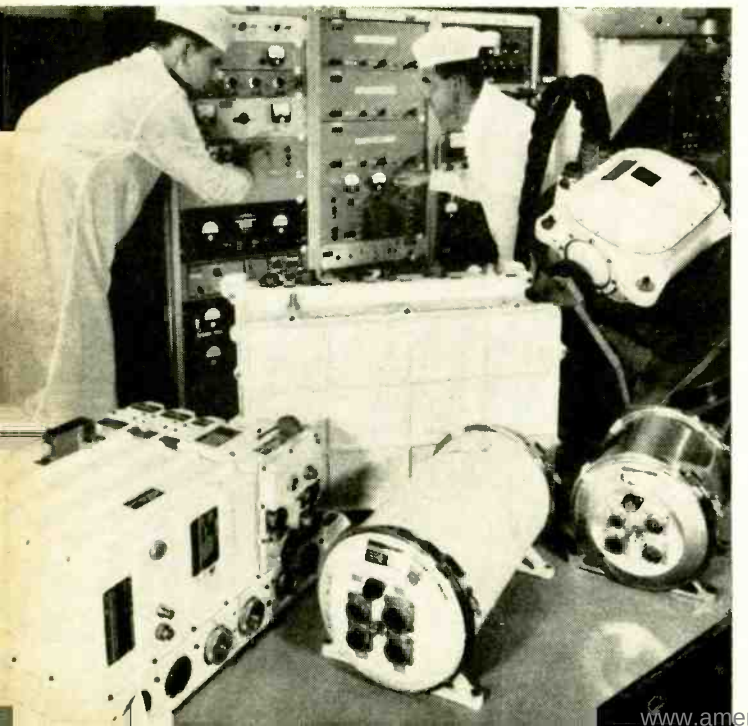


RECENT DEVELOPMENTS in ELECTRONICS



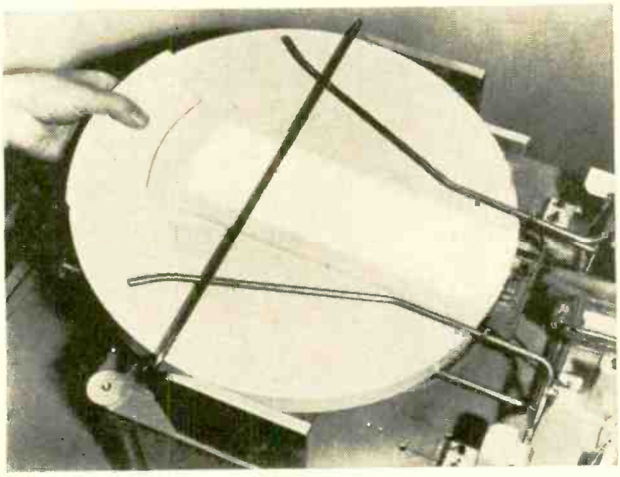
Transcontinental Microwave System. (Right) This microwave antenna, on top of Western Union's 24-story headquarters building in New York City, is one of 267 stations on the telegraph company's new 7500-mile transcontinental microwave system recently placed in service. The new system is capable of handling voice, facsimile, and video information as well as signals from punched tape, punched cards, and magnetic tape. The system was inaugurated for the press by a live coast-to-coast transmission of the heartbeats of a mother and her unborn child from a Los Angeles hospital to New York, where signals were viewed on a large display oscilloscope. The $80 million system is routed to avoid possible target areas and provides the nation with a second, separate transcontinental network of broadband facilities suitable for emergency defense use.

Full-Command Inertial Guidance. (Below) The complete guidance system for our Centaur rocket is displayed here. Centaur will be used to carry spacecraft to the moon for lunar studies before men land there. This guidance system makes the rocket the first U.S. space vehicle capable of complex stop and start maneuvers in space. The inertial platform of the Honeywell-designed system is at top right. The waffle-patterned container (center) contains accelerometer rebalance electronics and power supplies and is called the coupler. The digital computer is front left and the two cylinders in the foreground are the platform electronics (left) and the signal conditioner (at right).



Light Amplifier. (Above) Mounted on the gun being used by the soldier is an assembly containing a light amplifying image intensifier tube. Such tubes make it possible for soldiers to see in the dark without revealing their presence. Objects hidden in light levels far below the threshold of normal human vision show up as bright images. This provides the soldier with fire power and mobility at night comparable to daylight activities. The tubes are being produced by Machlett Laboratories under a $5 million Army contract. Although operating details on see-in-the-dark sighting systems are secret, it is known that some image intensifier tubes employ several stages of light amplification in which fiber-optic elements and photocathodes are used. The fiber-optic elements are in the form of faceplates that are made up of a large number of extremely fine glass fibers fused together. Such elements are far more efficient in transmitting light than a lens system. The photocathodes amplify the light focused on them as a result of their large amount of secondary emission.

Replaceable Computer Storage Disk. (Below) A single magnetic disk encased in a plastic cartridge forms a part of the random-access storage system used with the IBM data acquisition and control computer. The disk can hold 512,000 words, 16 data bits in length. Up to three drives, each making use of such a cartridge, can be employed with a single unit. The cartridge is inserted into the random-access assembly (shown uncovered in the photo), where it makes contact with the mechanism that will rotate the disk. The cartridge is then opened so that the read-write heads can be placed over and under the disk. The storage disk can be removed and replaced by another containing a different set of facts. The associated computer can monitor an assembly line, control a steel-making process, or analyze the precise status of a missile while it is test fired.



Railroad Television. (Above) For the first time, railroad passengers will be able to watch television on the way to their destinations. Twenty-three-inch black and white Olympic TV sets will be placed in all coaches, lounge, and recreation cars aboard the Atlantic Coast Line's "Florida Special." The train runs between New York and Florida. The sets are mounted on overhead shelves at ceiling height in the cars. They are connected to the railroad's TV antenna system. Reception has been good over the route.

Radio-Controlled Steering Boat. (Below) A radio-controlled bow steering boat for long, hard-to-maneuver barge tows has gone into service on the Mississippi River. The rudderless craft is completely controlled by a push-button radio system operated from the pilot house of the towboat at the rear of the string of barges. The steering boat, developed by Cargo Carriers, cuts round-trip travel time between Cairo, Ill. and New Orleans by a full day or more.

Anti-Missile Missile Radar. (Below) An advanced experimental radar system which detects, tracks, and identifies missile warheads and assigns targets to nearby anti-missile sites is being tested at White Sands, N. M. Called a multi-function array radar, the system was designed by Sylvania as part of the Nike-X program, our only anti-missile missile system in advanced development. Because it employs neither a mechanical drive mechanism nor rotating antenna, the equipment is housed in low-silhouette nuclear-blastproof structures.

Grown-junction, mesa, epitaxial-planar, field-effect—are some of the terms used today to describe transistors. What do these terms mean? Is there any advantage in the use of one type of transistor over another? What are the guides and characteristics in making a selection?

By ARTHUR H. SEIDMAN
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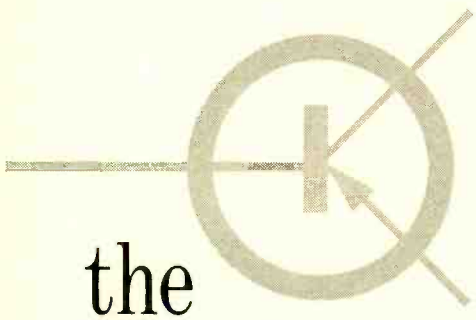


the Evolving Transistor

SINCE its appearance in 1948, the transistor has had a remarkable impact on the electronics industry. To cite a familiar example, the development of digital computer technology was quickly accelerated by the use of transistors. In the past decade, the computer was transformed from a huge structure containing innumerable vacuum tubes with its attendant heat to a small, cool, solid-state package. Analog systems were similarly affected. And now the general public has access to transistorized receivers, tape recorders, and numerous other devices.

What about the transistor itself? Has it undergone any changes? To meet the new requirements which arose in the transistorization of vacuum-tube circuits, different structures and types of devices evolved. In this article, various transistor types will be examined. These include a host of junction units and the field-effect transistor. Their relative advantages and limitations will also be considered.

Some Fundamentals

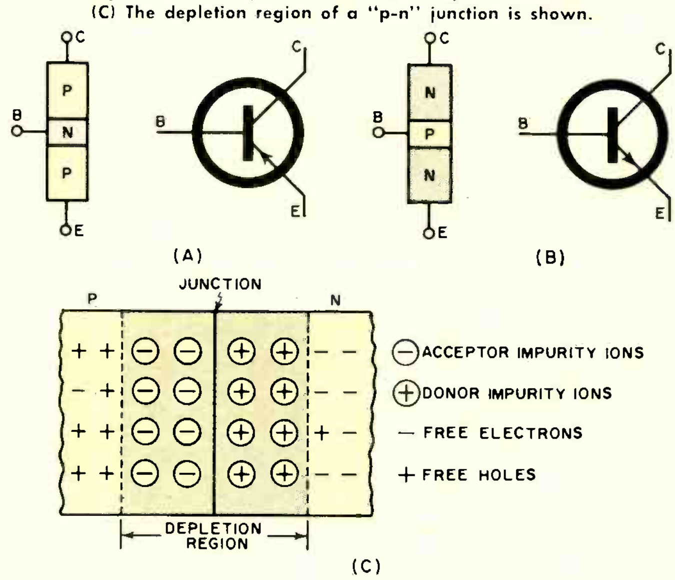
The transistor is generally made of semiconductor germanium (*Ge*) or silicon (*Si*) to which certain impurities have been added. Germanium and silicon each has four valence electrons. When an impurity atom which has three valence electrons, called an acceptor, is added to *Ge* or *Si*, holes are produced and the material is said to be *p*-type. Electrons are made available if an element having five valence electrons, called a donor, is the added impurity. The resultant material is then called *n*-type. Examples of acceptor impurities are boron and indium; antimony and arsenic are typical donor impurities.

Two commonly used methods for introducing the impurities (called "doping") into *Ge* or *Si* are *segregation* and *diffusion*. The segregation method takes advantage of the fact that impurities are more soluble in the molten semiconductor than in the solid form. In the diffusion process, the impurity may be either in a gaseous state or coated on the surface of a semiconductor. The combination is heated to a temperature of 800°C to 1300°C and after a predetermined time, the impurity diffuses into the material. Most transistors today are made by the diffusion process.

When a single crystal of *Ge* or *Si* is doped so that an *n*-type region is "sandwiched" between two *p*-regions, a *p-n-p* transistor is obtained (Fig. 1A). If the sandwiched material is *p*-type, the structure is an *n-p-n* transistor (Fig. 1B). In each case, two *p-n* junctions are formed: the emitter-base and collector-base junctions. For most applications, the emitter-base junction is forward biased and the collector-base junction reversed biased.

Because *Si* has a greater energy gap than *Ge*, silicon devices operate at higher temperatures (125-150°C) than their germanium cousins (85-100°C). The energy gap refers to the minimum energy, such as thermal energy, needed to produce an electron-hole pair. The generation of electron-hole pairs is a continuous process which increases rapidly with temperature. If a transistor is used above its maximum rated operating temperature, the number of electrons and holes generated may become comparable to the number of electrons and holes introduced by impurity atoms. The device will now have characteristics similar to that of a conductor.

Fig. 1. (A) "P-n-p" transistor. (B) "N-p-n" transistor. (C) The depletion region of a "p-n" junction is shown.



Upon the formation of a *p-n* junction, a number of impurity ions on each side of the junction become uncovered, *i.e.*, there are no free electrons or holes in their immediate vicinity. The region is referred to as the "depletion" region (Fig. 1C). If the collector-base reverse voltage bias is increased, the depletion region becomes wider and spreads farther into the base region. A point may be reached where the depletion region actually touches the emitter junction. This is called "punch-through" and the transistor breaks down.

Why New Transistors?

The first transistor available was the point-contact transistor which was soon superseded by a number of junction devices and the field-effect transistor. Two important reasons may be mentioned for the development of different transistor structures. One is economic and the other technical.

In the early days of transistor manufacture, the yield of usable transistors was quite low. For example, out of a batch of 100 units of a particular transistor type, perhaps only 5 met specifications. The remaining 95 units were worthless and consequently the cost of transistors was high. This spurred the semiconductor industry to develop new manufacturing techniques and transistor structures to realize a greater yield of devices at lower cost.

The frequency response of the first transistors was poor. The upper −3 db cut-off frequency f_β (for the grounded-emitter circuit) was on the order of 20 kc. This restricted their use to low-frequency applications. The frequency response can be increased by making the width of the base, w, smaller. In fact, the relationship between the upper cut-off frequency f_β and the base width w, is given by the simple expression $f_\beta = k/w^2$ where k is a proportionality factor.

For a given material, it then appears all one has to do to increase the upper cut-off frequency is to make the base width smaller. There are, however, some practical difficulties to overcome. For one thing, as the base width is decreased, punch-through will occur at a lower value of collector-base voltage. The maximum collector operating voltage is therefore reduced and the power rating of the transistor limited. Another factor is the smoothness of the junction boundary. If the boundaries are ragged, as shown in Fig. 2A, the maximum collector voltage can be limited by the minimum distance between the ragged peaks.

Transistors designed to handle appreciable amounts of current and power require large junction areas. Because capacitance is directly related to area, power transistors exhibit a greater collector-base capacitance than do small-signal devices. This tends to limit their cut-off frequency.

From the above discussion, there appears to be an inherent conflict between good frequency response and adequate power rating of a transistor. In attempting to solve this particular problem, device manufacturers have developed a fairly large number of different transistor types.

Point-Contact Transistor

As mentioned earlier, the first commercially available transistor was the point-contact device. A cross-sectional view of the transistor is illustrated in Fig. 2B. Two fine wires, the emitter and collector leads called the "cat's whiskers," make point contacts on one side of the *n*-type *Ge* wafer. The wire diameter can be as small as 0.001 inch and the separation between wires 0.002 inch or less. The bottom side of the wafer is attached to a non-rectifying or ohmic contact and becomes the base connection.

When the two leads are in place, they are pulsed by a high current for a short period of time. A weld is formed between each of the wires and the *n*-type material. Actually the theory of the point-contact transistor is not completely understood. One possible explanation assumes that during the welding process, certain impurities diffuse from the wires into the germanium wafer and a *p-n-p* type device is realized.

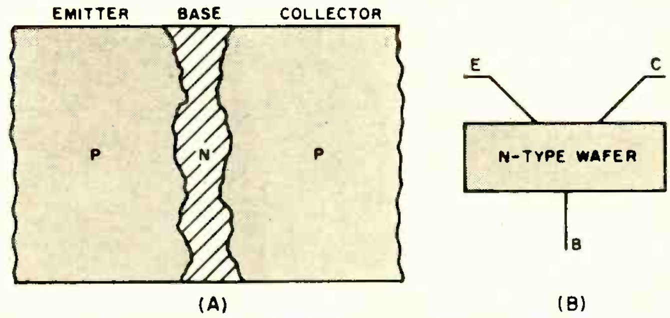


Fig. 2. (A) Possible ragged junction boundaries in transistor. (B) Cross-sectional view of point-contact transistor.

There are some significant differences between point-contact and junction transistors. The collector characteristics for the grounded-base configuration of these devices are shown in Fig. 3. Note that the collector curves for the point-contact unit are nonlinear compared to the junction transistor. Another significant difference is that the short-circuit grounded-base current gain α, is greater than unity for the point-contact transistor; it is less than one for a junction device. Because of this, the point-contact transistor is inherently unstable as an amplifying device.

Assume that the load resistor is less than the collector resistance of the transistor. The input resistance R_{in}, for a grounded-base amplifier may therefore be expressed by the simple equation: $R_{in}=r_b\,(1-\alpha)+r_e$, where r_b is the base resistance, r_e is the emitter resistance, and α is the gain. For a junction transistor, α is at all times less than one and R_{in} is always positive. However, in a point-contact transistor, α is greater than unity and there is a possibility of the input resistance becoming negative. For example, if $r_b=r_e=100$ ohms and $\alpha=2.5$, then $R_{in}=-50$ ohms. Negative input resistance denotes an unstable amplifier.

Point-contact transistors are no longer used in amplifier circuits. In the past they have found some limited use in switching networks, but the new junction devices have virtually supplanted them in all applications.

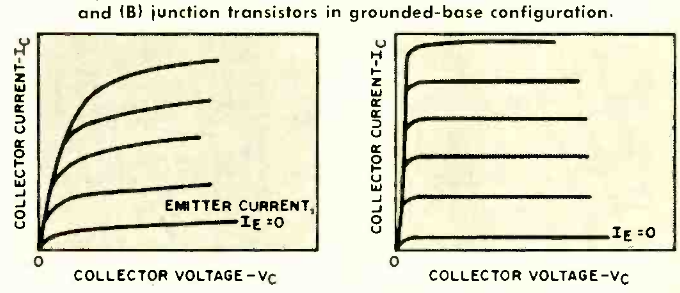
Junction Transistors

We will now consider some of the more important junction transistors. For purposes of classification, one can break down the different junction devices into four broad categories: *grown, alloyed, electrochemical,* and *diffused.*

Grown Transistor: In one of the first used processes, the double-doped process, a small piece of high-purity single-crystal *Si* or *Ge* called a seed, is introduced into the melt of the same type semiconductor. As the crystal is slowly withdrawn (Fig. 4), impurities are introduced into the melt to yield either *n*- or *p*-type material.

For example, assume the melt was originally doped to make it *n*-type. At a specific time sufficient *p*-type impurity is added to neutralize the *n*-type impurity and make the melt *p*-type. After further withdrawal, sufficient *n*-type impurity is added to counteract the *p*-type impurity in the melt. When the withdrawal is completed, a grown *n-p-n* transistor is obtained. If one starts with a *p*-melt, a *p-n-p* transistor is pro-

Fig. 3. The collector characteristics for (A) point-contact and (B) junction transistors in grounded-base configuration.



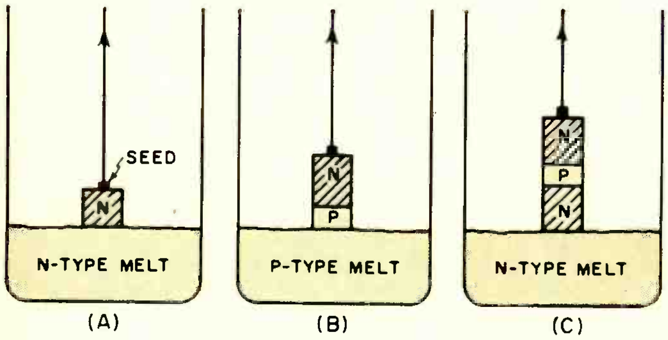


Fig. 4. Steps in making a grown-junction transistor.

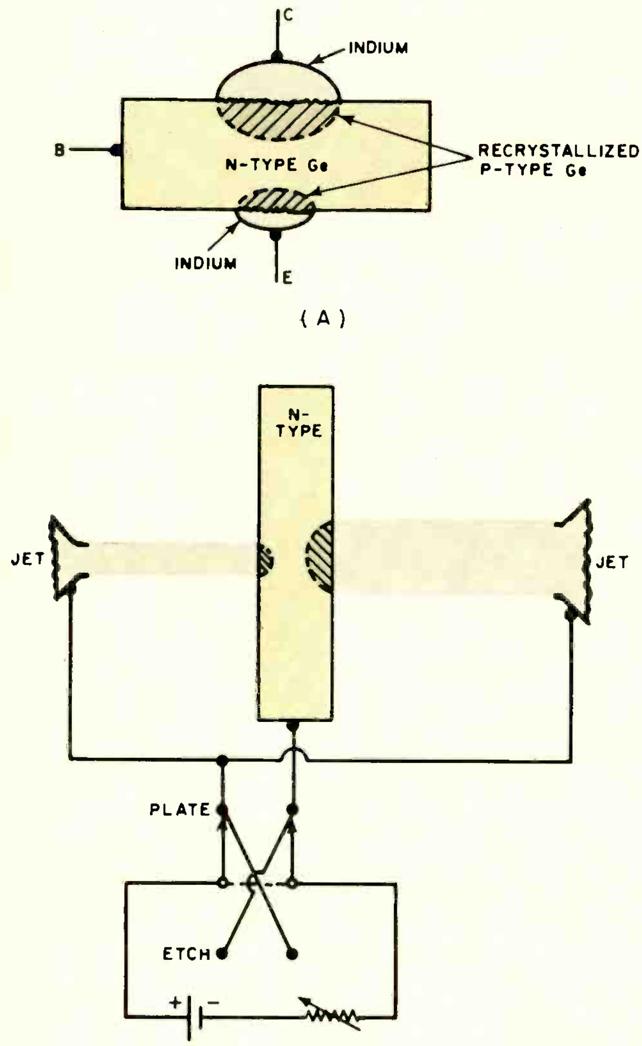
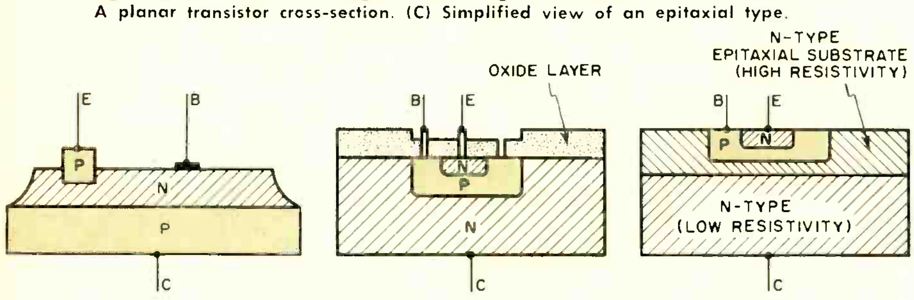


Fig. 5. (A) Formation of an alloy-junction transistor. (B) The formation of electrochemical type transistor.

Fig. 6. (A) Cross-sectional diagram illustrating a base-diffused mesa unit. (B) A planar transistor cross-section. (C) Simplified view of an epitaxial type.



duced. The *n-p-n* (or *p-n-p*) structure formed is then sliced and diced into individual transistors and packaged.

A variation of the grown-junction technique is the rate-grown process. In this method, the melt contains two impurities. For example, assume that gallium, a *p*-type impurity, and a larger amount of antimony, an *n*-type impurity, are in the melt. At normal temperature of seed withdrawal or pulling, *n*-type material results. However, if the temperature is suddenly raised, the gallium takes over and the melt appears as *p*-type. When the temperature is reduced to its normal value, the melt becomes *n*-type again.

The grown-junction process was one of the first successful methods used for making silicon transistors. However, the yield was low and the cost high. Because of device geometry, the frequency response was limited and, in most cases, the maximum collector-emitter voltage was on the order of thirty volts.

Alloy Transistor: The alloy process is well suited for making audio-type *Ge* transistors with good power ratings. Pellets of a *p*-type impurity, *e.g.*, indium, are fixed above and below an *n*-type wafer of *Ge* (Fig. 5A). The combination is heated and the indium alloys with the germanium. On cooling, the *Ge* in contact with the indium recrystallizes out as *p*-type germanium and a *p-n-p* transistor is obtained. The collector-base junction area is greater than the emitter-base junction area to permit high collector current ratings. The alloy process yields economical devices with limited frequency response.

Electrochemical Transistor: As indicated early in this article, to obtain a transistor with a high-frequency response, a thin base is necessary. In 1953 *Philco* developed the electrochemical technique for realizing high-frequency devices. A diagram of the process used for making surface-barrier transistors (SBT) is shown in Fig. 5B. An *n*-type *Ge* wafer is etched on opposite sides by a salt solution, such as indium chloride. In solution, indium chloride appears as positive indium ions and negative chlorine ions. When the wafer is held positive with respect to the jets, the germanium is converted into germanium chloride where the solution impinges on the wafer. Some germanium is etched away and an extremely thin and smooth base (*e.g.*, 0.1 mil thick) is formed. The polarity of the source is then reversed and the wafer is made negative with respect to the jets. Indium is deposited in the formed craters and a *p-n-p* transistor results, the action being similar to the alloy process. This technique can also be used to fabricate *n-p-n* as well as silicon devices.

The formed junctions are smooth and not rough as those produced by the grown and alloy techniques. This permits very high frequency transistors with voltage rating which make the electrochemical device particularly suited for high-speed switching circuits found in digital computers. However, the cost of silicon electrochemical transistors was high and the yield relatively low.

One variation of the SBT is realized by combining electrochemical and diffusion techniques. The resulting structure is called the micro-alloy diffused transistor (MADT). These units have a higher cut-off frequency than the SBT.

Diffused Transistor: The diffusion method provides mass-produced transistors at relative low cost with high-frequency, low capacitance, good power characteristics. Consider the *p-n-p* diffused-base mesa transistor of Fig. 6A. An *n*-type impurity is diffused into one side of the *p*-type wafer. This diffused region becomes the base of the transistor. By vacuum evaporation, aluminum, a *p*-type impurity, is deposited in the form of a stripe on the base layer to form the emitter by an alloy-type process. A gold-antimony stripe is used for the base contact. To reduce collector capacitance and to minimize leakage current, the undesired diffused areas are etched away and the mesa (flat-topped peak) structure obtained. In the double-diffused process, both the emitter-base and collector-base junctions are formed by diffusion.

Fairchild, in 1960, developed the *planar* process which is intended to improve the reliability of the mesa transistor. In this method, penetration of the impurity in other than the desired region is prevented by coating the surface of the wafer with an oxide compound, such as silicon oxide. This process is referred to as *surface passivation.*

Assume an *n-p-n* silicon planar transistor is to be made. First an *n*-type silicon wafer is coated with silicon oxide. An opening or "window" is etched in the oxide and the base is formed by diffusion of a *p*-type impurity. The oxide is reformed and a second opening is etched in the oxide. This is for the emitter which is formed by diffusion of an *n*-type impurity. The oxide is reformed again and a planar *n-p-n* transistor is produced (Fig. 6B).

Transistors used in switching circuits for computers very often require an extremely low voltage drop across the collector-emitter junction (V_{sat}) when the device is in the conducting or "on" state. It is like having a manual switch with clean contacts instead of dirty ones. To obtain a small V_{sat} the collector region has to be heavily doped. However, increasing the doping of the collector region reduces the maximum collector voltage at which the transistor can operate.

The epitaxial process permits the growing of a very thin, high-purity layer of semiconductor material on a heavily doped region of the same type. This allows the use of a highly doped collector region to obtain the V_{sat} and the maximum collector voltage is high. A simplified cross-sectional view of an epitaxial transistor is shown in Fig. 6C. Epitaxial-mesa (without the planar feature) transistors are also made.

A variation of the epitaxial-planar device is the epitaxial star planar transistor of Fig. 7A. The star geometery provides a maximum perimeter-to-area ratio. This structure yields a good power rated and high-frequency response device. For example, maximum collector dissipation of 3 watts (at room temperature) and a cut-off frequency of a few hundred megacycles are realizable with this type transistor.

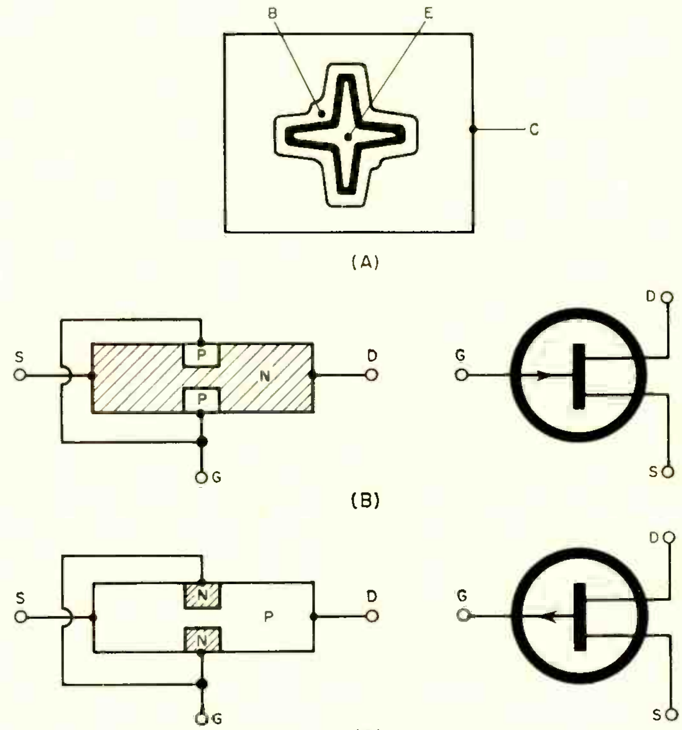


Fig. 7. (A) Top view of an epitaxial star planar transistor. (B) An "n"-channel FET, symbol. (C) "P"-channel FET, symbol.

Field-Effect Transistor (FET)

The field-effect transistor (FET), also referred to as the unipolar transistor, is a solid-state device with operating characteristics very similar to those of a pentode vacuum tube. Where the junction transistor is operated with the input circuit (emitter-base junction) forward biased, the FET is operated with its input circuit reverse biased. The FET thus exhibits a very high input impedance; the junction device, a low impedance.

A cross-sectional view of an *n*-channel FET is shown in Fig. 7B. The bar is made of *n*-type *Ge* or *Si*. Wires connected to the ends of the bar serve as the *source* (S) and *drain* (D) leads. The source is analogous to the emitter of a junction transistor or the cathode of a tube; the drain plays a role similar to the collector in a transistor or the plate of a vacuum tube.

In one possible structure, two *p*-regions are located in the center of the bar. These regions are connected together to form the *gate* (G). The gate has a function similar to that of a base of the transistor or a vacuum-tube grid. A *p*-channel FET is shown in Fig.7C.

The gate-source circuit is reverse biased for normal operation of the FET as an amplifier. For an *n*-channel FET the gate is made negative with respect to the source; for the *p*-channel device, the gate is held positive with respect to the source. When the gate-source circuit is reversed biased, a depletion region is formed as in the junction transistor (Fig. 8A). A depletion region is void of current carriers, *i.e.*, electrons or holes. As the (*Continued on page* 82)

Table 1. Brief summary of important characteristics of typical transistors.

TYPE	MAX. COLL.-EMTR. VOLT. (V.)	MAX. COLL. CURRENT (MA.)	MAX. COLL. DISS. (CASE TEMP. 25°C)	TYPICAL FREQUENCY RESPONSE
Grown Junction 2N333 (n-p-n Si)	40	25	150 mw.	$f_\beta \cong 300$ kc.
Alloy 2N1274 (p-n-p Ge)	25	150	150 mw.	$f_\beta \cong 40$ kc.
Electrochemical 2N496 (p-n-p Si)	10	50	150 mw.	$f_T = 20$ mc.
Diffused:				
Mesa 2N656 (n-p-n Si)	60	200	4 watts	$f_T = 15$ mc.
Expitaxial-Planar 2N706A (n-p-n Si)	20	50	300 mw.	turn-on time: 40 nsec. turn-off time: 75 nsec.
Epitaxial-Planar Star 2N2217 (n-p-n Si)	30	500	3 watts	turn-on time: 26 nsec. turn-off time: 68 nsec. $f_T = 400$ mc.
FET 2N2499 (p-channel Si)	Max. drain current: 10 ma.; Max. drain volt.: 20 v.; Max. drain dissipation (case temp. 25°C): 500 mw.			

Beginning where a slide rule leaves off, these computers solve equations, predict performance, and help in the original design of equipment.

SCIENTIFIC COMPUTERS

By ED BUKSTEIN
Northwestern TV & Electronics Institute

FOR the scientist, engineer, and mathematician, the digital computer is a labor-saving device that begins where the slide rule leaves off. Indeed, some of the calculations now being assigned to the computer have never before been attempted because, with slide-rule and adding-machine methods, the complete solution would involve many successive generations of mathematicians.

By programming the computer in accordance with the equations of interest and then inserting numerical values for the variables of the equation, the scientist can get answers that predict the performance of devices still on the drawing board. He can also obtain part values, dimensions, and other design parameters for the equipment or system he intends to build.

Although a few of the newer computers are so fast and powerful that they can be used for either business data processing or scientific calculation, computers heretofore have been designed for either one area or the other. In general, business data processors are characterized by a large complement of punched-card machines, magnetic-tape units, and other peripheral equipment. This profusion of input/output equipment is necessary because the computer may be required, for example, to read time cards and produce paychecks for 20,000 employees, or to print electric utility bills for all households in a large city. In such applications, each individual account involves relatively little calculation. In the payroll application as a typical example, the calculation for each employee is primarily a matter of multiplying the hours worked by the rate per hour and then subtracting the deductions.

By contrast, a scientific computer performs lengthy calculations on relatively little input data. The computer may run for hours with only an occasional printout of data. Furthermore, it must be able to handle conveniently the very large and very small numbers that so often enter into scientific calculation. The scientific computer is therefore characterized by a fast and powerful arithmetic section, while extensive peripheral equipment typifies the business data machine.

Iterative Calculations

The scientific computer must be a general-purpose machine. It may handle such varied problems as the design calculations for a nuclear reactor, solutions to problems in aerodynamics, calculation of projectile trajectories for various sets of conditions, determination of satellite orbits, etc. Scientific calculation often takes the form of an equation that is to be evaluated for many different sets of given values. Such problems, because of their *repetitive* or *iterative* nature, are easy fare for the computer. A simple example of this class of problem is the solution of the following equation: $M = YZ + X^2$, where M is to be calculated for all values of X from 1 to 500, in steps of 1.

A value of 1 is initially assigned to X, and this value along with the given values for Y and Z are stored in the memory of the computer. The calculation then proceeds through the steps indicated in the flow chart of Fig. 1. The computer multiplies Y by Z and stores this product for later use. It then calculates X^2, after which the product YZ is taken from storage and added to it. This yields the value of M which is now stored for later printout.

At this point the computer makes a decision. It examines the value of X to see if it is equal to 500. If not, it adds 1 to the value of X and then returns to the "calculate X^2" step of the procedure. In this manner, the computer enters a *loop* which causes it to calculate M over and over, increasing X by 1 for each successive calculation. After the computer has gone through this loop 500 times, X, when tested, is found to have a value of 500. This permits the computer to escape from the loop. It now prints the 500 calculated values of M and then halts.

The flow chart of Fig. 1 indicates the major steps of the computation. Before the computer can perform these steps, the operations represented by each block must be expressed as a series of coded instructions understandable by the computer. This is the responsibility of the programmer, although the computer itself may assist him in converting the English-language instructions that are required for a particular program into corresponding machine-language instructions.

Method of Successive Approximations

Because the computer performs only the basic arithmetic operations (addition, subtraction, multiplication, and division), the more complex operations and equations must be reduced to a series of additions, subtractions, etc. Fortunately, most scientific computations can be reduced in this manner.

If it can perform only the basic arithmetic operations, how does the computer perform such an operation as finding a square root? One method involves a technique which practically everyone has used at one time or another.

Suppose someone asks you for a quick estimate of the square root of 30. Your first thought might be that 5 is too small because 5^2 is only 25. Your next thought might be that 6 is too large. The square root of 30 must therefore be a number between 5 and 6. You might take 5.5 as an approximation, but if you square 5.5 either mentally or on paper you find that the answer is slightly too large (30.25). You might then take a somewhat smaller number, say 5.48, as a next approximation and then square it to see how close it comes to 30. From here, depending upon your patience and facility in handling numbers, you might go on to a still further approximation.

This method of successive approximations can be programmed into a computer so that each approximation is closer than the one before it. The process can be continued until the desired degree of accuracy has been reached. A procedure (Newton's method) for finding the square root of a number N by successive approximations is as follows:

1. Make a guess to obtain a first approximation of the square root of N.
2. Divide N by your approximation to obtain a quotient.
3. Calculate the average of this quotient and your approximation. This average is a *closer* approximation of the square root of N.
4. Using this new approximation, return to step 2.

Since you cannot tell the computer to "make a guess," the instructions for the first step must be made more specific. A method must therefore be specified for the computer to obtain its first approximation. One method is to divide N by 2. Also, the computer must be told when to stop or it will continue forever (until breakdown) in continual attempts to find better and better approximations. One method of terminating the process is to have the computer square each approximation and compare this to the value of N. If the difference is too large, the computer makes another approximation; if it is close enough, the computer halts. Of course, the programmer must tell the computer how close is "close enough."

The process is illustrated by the flow chart of Fig. 2. After each approximation is obtained, it is squared and N is subtracted from it. If the difference is less than a value specified by the programmer (.001 in Fig. 2), the answer is regarded as sufficiently accurate and the last approximation is printed out. If the difference is greater than the specified value, the computer returns to an earlier step and the latest approximation is used to obtain a still closer answer.

The machine instructions corresponding to the flow chart of Fig. 2 are stored in the memory of the computer. This series of instructions is known as a *subroutine* and can be referred to by the computer whenever a square-root operation is required in the course of a calculation. The availability of this subroutine saves the programmer's time and also conserves memory space by making it unnecessary to repeat the same series of instructions every time a square root is required. Other subroutines, for calculating trigonometric functions for example, are also available in the memory.

Compilers

Writing a program of instructions in the language of the computer is a lengthy and tedious procedure. The programmer writing these instructions must have a thorough understanding of the problem to be solved as well as extensive knowledge of the internal organization of the computer. He must express every step of the operation as a coded instruction in the language of the machine.

Although experienced programmers may become proficient in writing machine-language instructions, they rarely do so in practice. Instead, they use a *source* language which is faster and easier. In effect, the computer becomes an assistant programmer; it converts the source language used by the human programmer into machine language. Since each source-language instruction may represent a whole series of machine-language instructions, the work of the programmer is greatly reduced. Source-language programming is of particular interest to scientists and engineers who may be too busy or may not be sufficiently acquainted with the computer to write a meaningful machine-language program.

The use of source language (*Continued on page* 59)

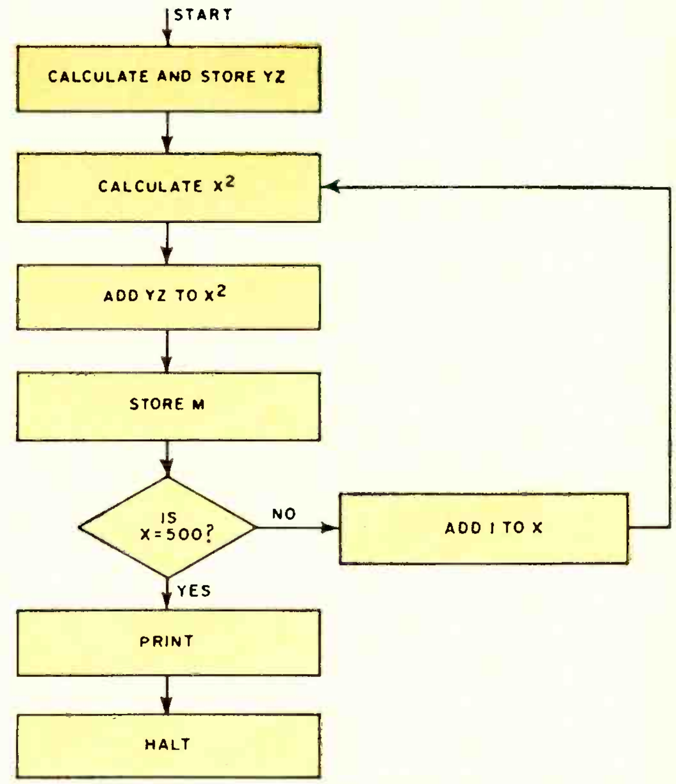
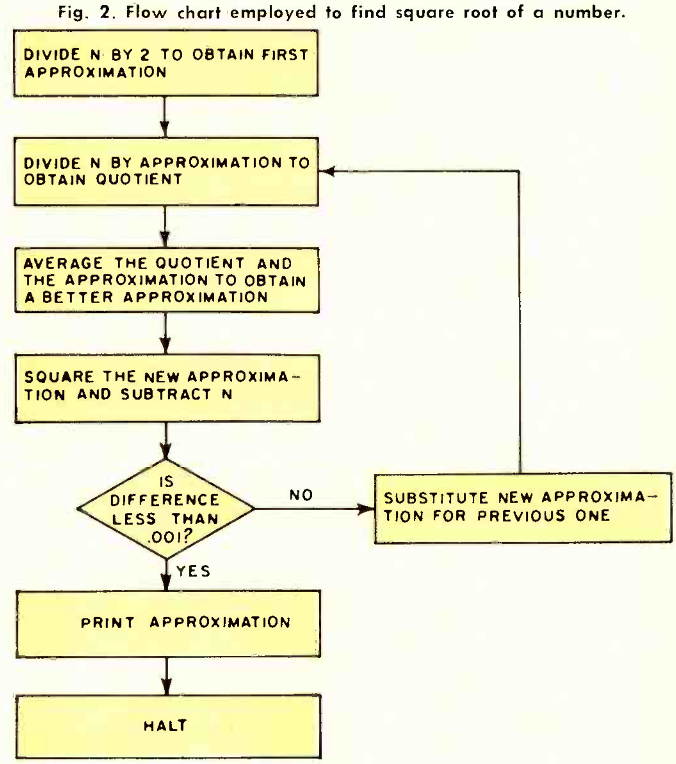
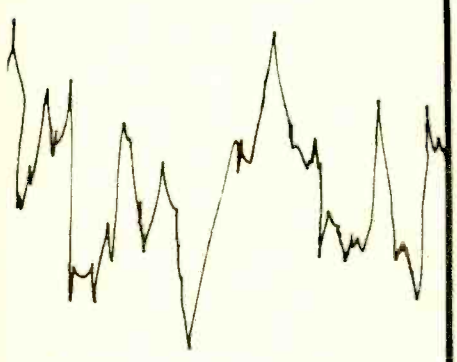


Fig. 1. Flow chart for calculation of equation $M = YZ + X^2$.

Fig. 2. Flow chart employed to find square root of a number.





ELIMINATING IMPULSE NOISE

By JIM KYLE

New design trends in circuits for effective noise quieting that are now being widely used in communications receivers.

ALMOST nobody likes noise; this is especially true of users of commercial communications equipment. Because of this, receiver design engineers have, for many years, carried on a running battle with radio noise in an effort to eliminate it from the received signal.

While the battle is not yet won, during the past several years a number of major advances have been made. It is now possible to operate communications receivers in noise environments which would have been considered virtually impossible as recently as 1954. Most of these advances, although incorporated only in recent models, are adaptable to older equipment as well.

Before the new techniques of noise elimination can be considered, however, an understanding of just what type of "noise" is under attack is needed. "Noise," unfortunately, is a word with many meanings in the radio communications field. For instance, one engineer may be referring to the hiss of thermal noise when he uses the term, while another may be talking of the sputter of auto ignition impulses. Although neither is using the term incorrectly, neither will he convey his true meaning to the other.

As used in this article, "noise" means impulse noise, of the type associated most commonly with auto ignition systems. It is also generated by aircraft and marine engines, by certain types of weather conditions, and, in fact, at any time that an electric current is interrupted. Its major characteristics are an unpredictable occurrence rate, an extremely short (1 to 10 microsecond) duration, and an exceedingly high amplitude.

Because of its rapid rise time, narrow duration, and high amplitude, this type of noise can be eliminated in a receiver by circuits which distinguish between noise and signal. Static bursts and other longer noise sources, on the other hand, still defy the equipment designers.

The Classic Approach

In the past, the classic approach to noise-pulse detection and elimination has been to rely upon the difference in amplitude between noise pulses and desired signals to operate a diode switch. The first such noise limiters used *shunt* diodes, as shown in Fig. 1A. In operation, the bias level was set to a point at which the signal just *failed* to switch the diode into conduction on peaks. Any noise pulse stronger than the peak value of the signal would switch the diode "on," shorting out the pulse as long as it remained stronger than the signal peak.

A variant on this limiter employed the diode as a *series* gate, as shown in Fig. 1B. With this limiter, bias was set so that signal peaks just failed to switch the diode *off*. Noise pulses stronger than the signal then switched the diode out of conduction, breaking the audio path for the duration of the pulse.

A major disadvantage of either of these limiters, of course, was the necessity for adjusting bias level to the correct point for each incoming signal. With a fading signal being received, if the limiting level were set during a fade, the signal itself would be limited and, in some cases, garbled beyond recognition as signal strength increased.

By taking the bias voltage from the receiver's a.v.c. line, however, the bias setting was made to vary automatically

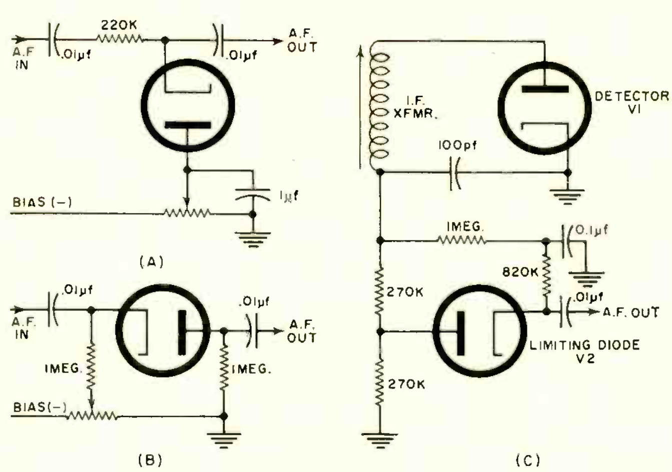


Fig. 1. (A) (B) Original, basic noise-limiter circuits. (C) Automatic series-gate noise limiter presently used.

with the strength of the received signal. A typical circuit is shown in Fig. 1C. This automatic series-gate limiter (known by a multitude of names but most commonly termed simply "a.n.l.") is virtually the standard of the industry today, but its performance leaves much to be desired under many circumstances. For one thing, it is a noise *limiter* rather than a noise *eliminator*. It limits the strength of the noise pulse to the peak value of the audio signal, but the pulse is still there to be heard. For another, strong noise pulses applied to extremely selective circuits cause ringing of the circuits, which distorts the received signals. The a.n.l., placed after most of the selective circuits, does nothing about this.

The new techniques of noise elimination all have the common objective of overcoming these major limitations of the a.n.l. Not all approach it in the same manner, however. Two basic approaches are employed: one operates like the a.n.l. and ignores the ringing problem, concentrating instead on complete elimination of noise pulses. The other operates on completely different principles and aims to overcome the ringing problem, at the expense of possibly having detectable pulses remain in the receiver output.

Rate-of-Change Limiter

The first of the new limiters to gain acceptance by U.S. engineers is known as the "rate-of-change" circuit, since it senses the presence of a noise pulse by virtue of the steep rise of the pulse rather than by its high amplitude.

Developed in England for TV audio-channel use (British TV uses AM for audio rather than FM as we do), the rate-of-change limiter can reduce ignition noise pulses as much as 90 db, nearly 300 times the reduction available from the conventional a.n.l.

The way in which it does this is shown in Fig. 2. Where the conventional a.n.l. merely limits the pulse to a value equal to the peak audio signal level, the rate-of-change limiter switches the audio output line to a series-resistor-capacitor circuit in which the capacitor is initially discharged. As the capacitor charges, the voltage across it rises exponentially, and this exponential voltage rise is applied to the limiter output as a substitute audio signal for the duration of the pulse. Thus there are no "stumps" of clipped noise in the output.

Since its popularization in the amateur-radio press in mid-1961, this circuit has been incorporated in several commercial receivers. Most notable of these applications has been in the "Outercom" line of commercial two-way equipment made by *Hammarlund Manufacturing Company*.

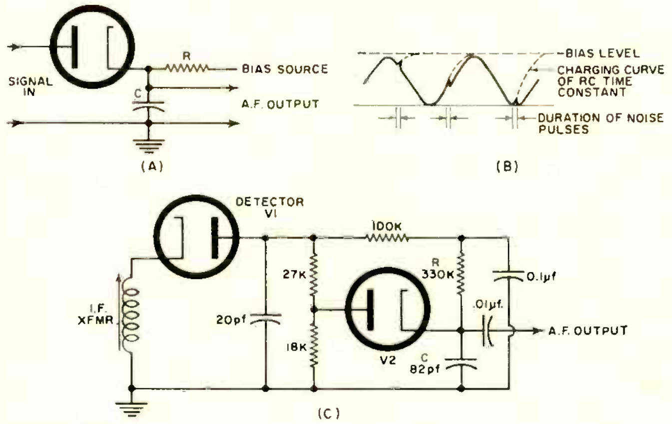
Amplitude Sampling

While the rate-of-change limiter accomplishes its goal by sensing the rise time of the noise pulse, equally efficient noise removal is possible with amplitude-sampling techniques. Proof of this is the circuit known as the Makino limiter, shown in Fig. 3A.

This circuit differs from the conventional a.n.l. in two important respects; one is that the d.c. and a.c. ground points are at the opposite ends of the detector load resistor, and the other is that the over-all impedance level is only a tenth of the normally used values.

Separation of the d.c. and a.c. ground points introduces a virtual phase reversal of the received noise pulse, and allows the gating diode to switch more positively. This is how it works:

Fig. 2. (A) Simplified basic circuit. (B) Waveform of audio output showing action. (C) Practical schematic with parts values. Bias voltage is obtained from carrier rectification. Ratio of two resistors at V2 plate determines switching level and amount of audio. With values shown, up to 90-db suppression of narrow noise pulses is possible without distorting audio. Load resistance should not be less than 1 meg and is often a 1-meg volume control in communications receivers.



With a noise-free signal being received, the i.f. current flow is through *V1A*, *R3*, and *R2*. Since *V1A* rectifies this current, a direct voltage is developed across *R2* and *R3* in series. Resistor *R1* provides a high-impedance path to ground for this voltage, and since *R1* is much larger than either *R2* or *R3*, the d.c. voltage level around the detector loop will remain virtually constant, proportional to the strength of the received signal, when measured with reference to ground.

Since *C2* is connected from the detector loop to ground, it charges to this voltage. This charging action establishes the voltage from the detector loop to ground at a relatively stable positive value.

This positive voltage, appearing at the junction of *R2* and *R3*, forward-biases gating diode *V1B*, allowing audio to pass through to the output. *C2* bypasses all audio to ground at its end of the *R2*-*R3* string, but the high impedance of *R1* and r.f. bypass *C1* permit the audio to be developed across the two load resistors. Thus the audio voltage at the junction of *R2* and *R3* represents half the available audio voltage, while the d.c. voltage at this point represents the average rectified signal level.

With this relationship, the limiter cannot distort the received signal since the incoming signal can never be large enough to turn the gating diode "off."

However, when a noise pulse arrives it tends to drive the instantaneous voltage at the junction of *R1* and *R2* highly negative. This time constant of *R3* and *C2* prevents the total voltage level from following this instantaneous excursion and, as a result, the noise pulse drives the plate of *V1B* negative, switching the diode off. It will remain in this condition as long as the noise pulse is stronger than the level to which *C2* is charged.

During the "off" condition, audio output drops to zero instead of rising to the clipping level as it does with the conventional a.n.l. The resulting "holes" in the signal are not detectable by the listener, although the spikes left by the conventional limiter are highly noticeable.

The Makino limiter was originally developed for an AM transceiver designed in Japan for helicopter use, and its originators reported ability to copy signals of less than 1 microvolt level, while the receiver was immersed in a 25,000-microvolt noise field.

In this country, it was initially popularized in the Citizens Radio Service and is currently offered as original equipment in several class D CB transceivers.

It is worth noting that both the Makino and the rate-of-change limiters use much lower resistance values than do the older circuits, and this has its side effects. Available d.c. output from the detector, which is often used for a.v.c., is greatly reduced when a conventional detector/a.n.l. is replaced by either circuit. This makes the Makino incompatible with some receivers, but proves to be no handicap with others. If no d.c. output from the detector is used, as is the case with a number of communications receivers featuring separate i.f. channels for a.v.c. development, either can be substituted for older designs.

After experimental installation of a Makino limiter in the lab prototype of one make of CB transceiver, which had used a conventional a.n.l., a series of experiments were initiated to find out the reason for the improved performance. The first step was to reduce the impedance level of the original a.n.l. by replacing all resistors of 1/10th the original value and multiplying all capacitor values by 10 to maintain the same time constants.

The engineers reported that after this modification, the conventional a.n.l. showed performance equal to the Makino. The tests were not continued, however, since the particular transceiver in hand was designed to be used with a pulse-type selective calling attachment—and the more-efficient limiter removed the selective-call pulses as well as ignition noise. Further experimentation in this area might prove to be well worth following up in greater depth for those interested.

I.F. Noise Limiter

Before moving to the noise blanker, which attempts to remove noise at the input of the receiver's i.f. strip rather than at the output and thus remove the problem of ringing as well, the "i.f. noise limiter" must be mentioned.

This circuit is not particularly new but has reappeared after many years of disfavor. It is shown in Fig. 3B. Its operation is, basically, similar to the shunt-diode limiter of Fig. 1A, except that it operates in the i.f. strip rather than at the audio level.

The secret of the circuit lies in the *RC* time constant of the resistor from anode to cathode and the total capacitance in parallel with this resistor. When the time constant is long compared to the period of the noise pulse, yet short compared to the period of the desired signal also applied, the diodes initially perform as a full-wave voltage doubler and charge the capacitors to the peak-to-peak value of the applied signal. Since the time constant is short compared to the period of this signal, the voltage across the capacitors follows the signal envelope, and the diodes then operate in the zero-bias region where they show nearly infinite resistance in either direction. This effectively cuts the limiter out of the circuit.

However, a noise pulse will drive one of the two diodes into forward conduction, which places a virtual short across the primary of the i.f. transformer and reduces stage gain to zero for the duration of the pulse. This prevents the pulse from being passed on to the next stage.

If the *RC* time constant is too long, audio distortion will result because the bias voltage can no longer follow the signal envelope. If too short, limiting will suffer. The correct value is fairly critical; values shown in Fig. 3B provide a starting point but may need modification.

It has been suggested recently that such limiters might be profitably employed in every i.f. stage of a receiver, although present usage normally limits it to one stage.

Commercial receivers using this type of limiter include the *Hallicrafters* SX-115 and SX-117; it has also been applied to many other communications receivers.

The i.f. limiter, if placed in the plate circuit of the first i.f. stage, will reduce the ringing problem. However, it is more usually placed in the last stage, where it has no effect on the ringing of previous stages. Normal procedure when ringing is considered to be a problem is to employ the "noise-blanker" technique, discussed below.

Noise Blanker

In its simplest form, a noise blanker consists of a system to detect noise pulses and to turn off the receiver signal circuits for the duration of the pulses, before the pulses reach the circuits.

One of the first commercial applications of the blanker approach was by *Collins Radio Company*. Its "noise blanker" consisted of a completely separate fixed-tuned v.h.f. receiver which picked up ignition and similar impulse noise pulses, amplified them, rectified them, and produced a gating pulse.

This pulse was then applied to a gate circuit in the communications receiver itself, to prevent the noise pulse from ever reaching the selective i.f. circuits and causing ringing. Major problem of the approach was to be sure the blanking pulse reached the gate before the received noise pulse could arrive through normal receiver circuits; phase and timing adjustments were critical.

A more recent version of this approach has been introduced by *Squires-Sanders, Inc.* in its model SS-1R communications receiver. The *Squires* circuit does away with the separate v.h.f. receiver, and develops a gating pulse directly from the receiver's mixer output. Output of the mixer is applied to a two-stage, high-gain amplifier with a .5-mc bandpass, then to an envelope detector, and the detector output is used to trigger a pulse-forming circuit.

The resulting gating pulse is applied to an i.f. gate between mixer and i.f. strip, which employs a bidirectional *n-p-n* switching transistor to produce some 80-db rejection of signal when noise pulses are present, yet appear virtually a short circuit in the absence of noise.

The wide-band techniques apparently overcome the problem of pulse delay, as the circuit's total attack time is on the order of a microsecond; it has been proven to completely remove noise pulses while passing signal unaffected. Fig. 4 is a block diagram of this system.

FM Systems

No discussion of new noise-limiting techniques should be considered complete without mention of noise limiting as applied to FM communications systems.

This may appear surprising, since one of the major advantages of FM over AM is supposedly its freedom from noise. In broadcasting, this is true. However, FM communications systems use much lower modulation indices, and consequently are more subject to noise interference.

It has been shown mathematically that a noise pulse, although predominantly amplitude modulated, will cause a momentary modulation of an FM signal which will, when detected, sound the same as the pulse does on an AM signal. However, if the incoming FM signal is strong, the "capture effect" will prevent the pulse (*Continued on page 76*)

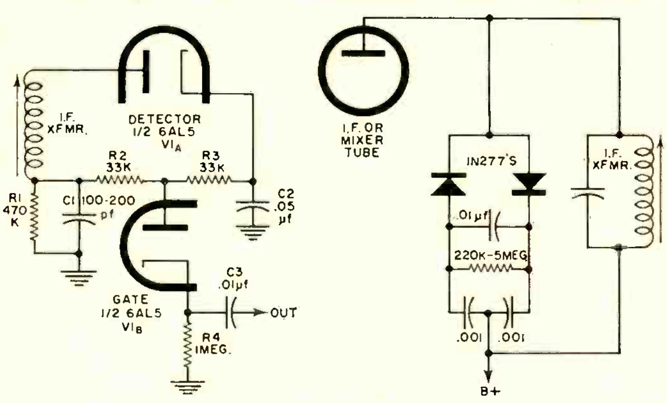
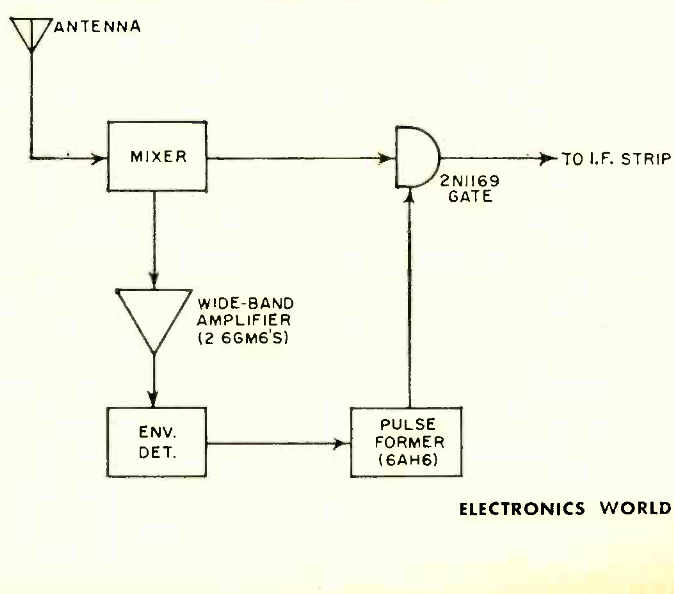


Fig. 3. (A) Makino noise limiter. By reversing both diodes, a.v.c. voltage can be obtained at ungrounded end of C2. Maximum voltage will be about —8 v. with typical receivers. (B) I.f. noise limiter. Normally used in plate circuit of final i.f. tube, but can be used in plate circuits of every i.f. and r.f. tube. Can also be employed in transistorized receivers.

Fig. 4. Noise blanker used in Squires-Sanders SS-1R receiver. Gate provides closed circuit from mixer to i.f. strip in absence of pulse. When pulse arrives from 6AH6, gate opens and signal transfer from mixer to i.f. is attenuated 80 db or more. Wide-band amplifier circuit is flat from 5 to 5.5 mc.



Electronic Timers *for automatic control*

By SIDNEY L. SILVER

Ever wonder how a complex automated assembly line is kept in step? Here is a breakdown of how their electronic timers work.

IN many automatic control processes, it is frequently necessary to introduce a series of precise time intervals into the operation of the many functions which comprise a complex control system. The operation involved may be a purely mechanical one such as the opening and closing of valves and switches, or the starting and stopping of electric motors; or it may be a combination of mechanical operations interlocked with automatic control instruments. To provide an accurate means of measurement, timing devices are employed to control the sequencing of a number of process variables such as temperature, pressure, and liquid level, in accordance with a predetermined time schedule. By this means, information fed to one part of the machine or process can be delayed by a controlled period of time before it initiates another operation or function.

A common method of obtaining the proper sequence of response signals as a function of time, is the use of electronic timers in a programmed time system. These devices employ electrical delay networks in conjunction with tubes or transistors (which in turn operate relay actuators) to control the preselected time period. With electronic timing units, accurate time delays over the range from .01 sec. to 300 sec. are available. In some applications where accuracy is not too critical, the timing range may be extended to as long as 10 min. These instruments are virtually unaffected by voltage fluctuations, temperature changes, and varying load conditions, and since there are no mechanical timing parts, their useful life is relatively unlimited. Among the numerous applications of electronic timers are process control in chemical laboratories, induction heating, timing exposure in photocopy machines, conveyor movement, plastic molding processes, and computer logic circuitry.

Theory of Operation

The heart of an electronic timing system is the classic *RC* network which utilizes the time required to produce transient voltage and current changes in the circuit. As shown in Fig. 1A, a d.c. voltage source is connected to the *RC* timing circuit when switch *S* is thrown to position 1, thus building up a charge of electrons on capacitor *C*. As the charge accumulates, a potential difference, increasing exponentially with time, is built up across the plates of the capacitor until the voltage across *C* is equal to the source voltage. The resistor *R* serves to limit the current flow so that an appreciable length of time is required for *C* to become fully charged. If switch *S* is then thrown to position 2, a discharge current will flow and start to discharge the capacitor at an exponential rate in a direction opposite to the charge current.

Fig. 1B shows a universal graph which indicates how the voltage rises or falls across the timing capacitor as it charges or discharges through the series resistor. The horizontal axis is the time scale which is set off in terms of the *RC* product, so that the curves apply for any value of *R* and *C*. The vertical axis indicates the percentage of maximum voltage with 100% representing the total voltage to which a capacitor can charge.

The *RC* product, or time constant, is a useful parameter in comparing the behavior of one network with that of another. It is expressed as a relative unit of time (in sec.) and defines the amount of time required for a capacitor to charge through a resistor to 63% of the source voltage; or the time required for a fully charged capacitor to discharge through a resistor to 37% of its initial value. The capacitor is, for all practical purposes, completely charged to the applied voltage after a time equal to 5*RC* seconds. Similarly, upon discharge, the capacitor is practically down to zero volts after 5*RC* seconds. Whereas the time constant specifies only the rate of charge or discharge, the period of time during which the capacitor can charge or discharge is determined by the source voltage.

The time (t) required to reach a specified voltage (e) can be calculated by $t = RC \ ln \ (E_s/E_s\text{-}e)$ where *ln* denotes the symbol of natural logarithms, t is the time interval in seconds, R is the resistance in ohms; C is the capacitance in farads, E_s is the source voltage in volts, and e is the capacitance voltage (usually expressed as % full voltage).

Operating Characteristics

According to application, there are numerous combinations of arranging the major components of a timer, depending on the design and adjustment of the instrument. Basically however, timing devices are composed of five primary elements which are common to all units.

Fig. 2 shows a functional block diagram of a control timer

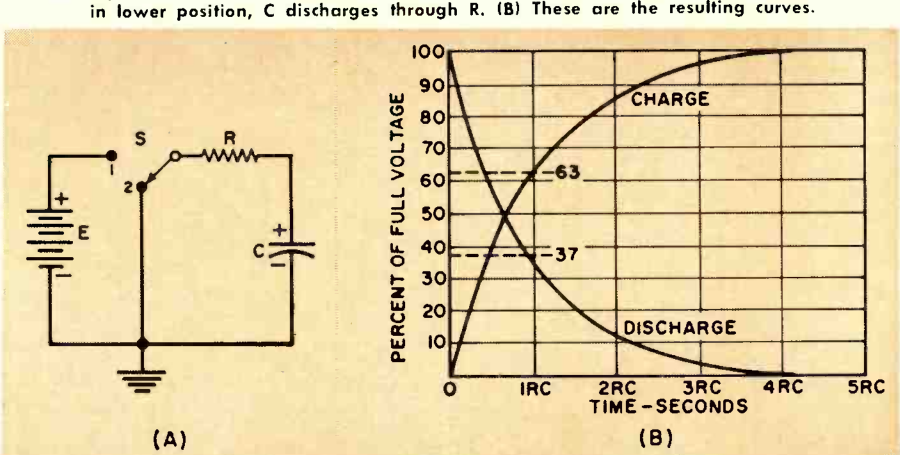


Fig. 1. (A) With the switch in upper position, C charges through R. With switch in lower position, C discharges through R. (B) These are the resulting curves.

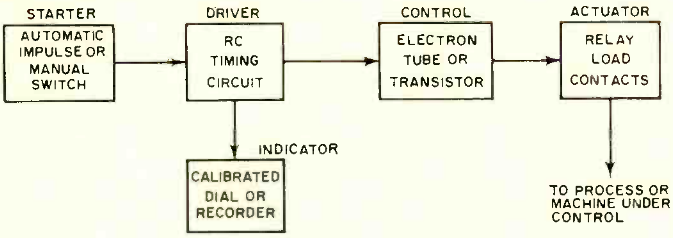


Fig. 2. Functional block diagram of a control timer unit.

in which the timing cycle may be started or triggered by manual or automatic means. To initiate the timing action, a starting impulse may be applied by means of a spring-return push-button switch if momentary contact is required, or by means of a maintained-action toggle switch for sustained contact. In some methods, an external signal is used to energize a solenoid so that the movement of the core mechanically triggers the timing device. In other cases, the normal electrical signal is a voltage impulse and the triggering action takes place by removing the voltage.

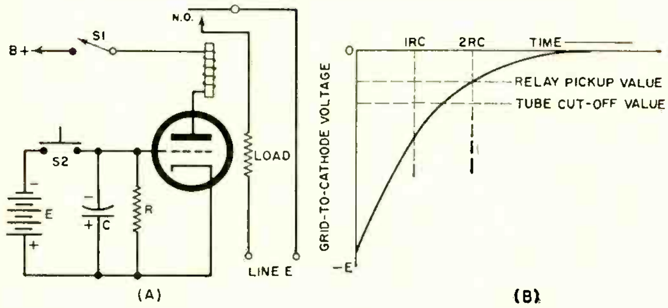
The driver is the component which determines the limits of the range and accuracy of the instrument and consists of the simple *RC* timing circuit previously described. Timing adjustment is obtained by switching to different values of fixed resistors, or by means of a suitable potentiometer. If the timer is located in an inaccessible or hazardous area, the pot may be mounted at a convenient remote point. In most cases, the *RC* network does not supply the energy directly to the output of the timing device, but uses the charge or discharge timing characteristic to feed a tube or transistor amplifier.

If the timing period is critical and requires occasional adjustment, the timing device must provide some form of visual representation of elapsed time. The most common indicator consists of a circular scale or dial (fixed or movable) which is accurately calibrated in units of time. If movable, the dial usually rotates as time progresses; and timing increments are determined by the position of preset trippers which are locked at the periphery of the timing disc. A fixed dial may be employed in which a pointer is manually set to the desired time period while another concentric pointer rotates during the timing interval to indicate the elapsed time. If it is desired to plot a time curve, a chart recorder may be connected to the timing device to provide a permanent record.

The final element of a timing instrument is the load-contact arrangement which serves as the link between the timer and the process or machine that it controls. The load contacts provide the means of controlling external circuits by turning electrical loads on or off in proper sequence. Such timing systems may range from the simple start-stop operation of a single circuit to the complex interlocking of many circuits in a timed program. In most control timers, the output response is produced by a multi-contact relay arrangement, although some units employ solid-state switching devices.

Timing devices may be used to perform a variety of functions depending on the initiating means, range of time intervals, driving arrangement, and load-contact operation. For example, an interval timer controls the time that a load is energized by holding a circuit closed for a preselected interval, and then returns the circuit to its original state. This type of timer may also be used as a delay timer by arranging the load contacts so that they provide a time lag before actuating a load. Another type is the repeat-cycle timer which runs through a single cycle upon closure of the starting contact; and repeats this cycle until power is interrupted, either by failure or by command. A reset timer, however, automatically returns to zero upon completion of its timing cycle or if power is removed during the cycle.

Fig. 3. (A) Basic circuit of timer using capacitive discharge for timing purpose. (B) The exponential rise of bias voltage.



Electron-Tube Timers

In industrial control systems, timing devices frequently take the form of electron-tube time-delay relays. Fig. 3A shows the basic circuit of a d.c.-operated relay in which the delay action is determined by the discharge of a timing capacitor in an *RC* network. When switch *S*1 is closed, plate current starts to flow and since the bias is zero, the tube conducts heavily thereby energizing the relay in the plate circuit. If push-button *S*2 is now depressed, the timing capacitor *C* charges very rapidly to the full bias voltage *E* and cuts off the tube almost instantly. At this point, the relay resets, or drops out and the load is de-energized. Upon releasing *S*2, the capacitor starts to discharge through resistance *R* and maintains the grid negative with respect to the cathode. As *C* continues to discharge, the grid-to-cathode voltage rises exponentially until it is above the cut-off value of the tube. Tube conduction then increases until the plate current is sufficiently high to trip the relay and energize the load. The total delay interval from reset to pickup of the relay is determined by the *RC* time constant and by the value of the bias voltage.

To obtain maximum timing accuracy, it is desirable to utilize the portion of the discharge time interval which energizes the relay during the first two time constants. During this time period, as shown in the discharge curve of Fig. 3B, a small change in voltage is produced in a comparatively short time interval. Beyond 2*RC*, a small voltage change occurs in a much longer time period. Thus, a small voltage change in the relay circuit will introduce a large timing error if the relay is tripped in the region beyond 2*RC* time constants.

Fig. 4 shows a typical commercial electronic timer which operates from an a.c. source and requires no d.c. power supply. When initiating switch *S*1 is open, the external circuit between plate and cathode is incomplete and since the tube is cut off, load 1 is energized through the normally closed (n.c.) relay contacts. An a.c. voltage, however, can be applied to the cathode-to-grid circuit of the tube. The amplitude of this voltage is determined by the setting of potentiometer *R*1. During those half-cycles when point "A" is positive with respect to "B," grid current flows and charges capacitor *C*1 with the polarity shown. The charging period continues during successive alternate half-cycles until the peak voltage is reached. During those alternations, however, when grid current does not flow, the charge on capacitor *C*1 is prevented from leaking off due to the large time constant of *R*2, *R*3, and *C*1.

When switch *S*1 is closed, the timing interval starts as *C*1 discharges through *R*2 and *R*3. After a definite period of time determined by the setting of *R*2, the grid voltage rises above the cut-off value of the tube, and plate current starts to flow. The tube conducts only during those half-cycles when the plate voltage is positive with respect to the cathode, and the relay pickup point occurs during a positive alternation of the applied voltage. Since the relay coil current is pulsating, a suitable capacitor (*C*2) across the coil provides sufficient filtering to prevent contact chatter. To reset the timer, it is necessary to open the initiating switch *S*1. The timing interval is adjusted by *R*2 which determines the minimum-to-maximum time-delay range, and a calibrated dial is provided

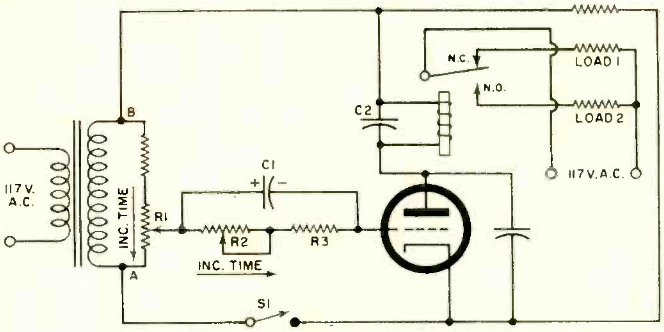


Fig. 4. A typical commercial a.c.-operated timing device.

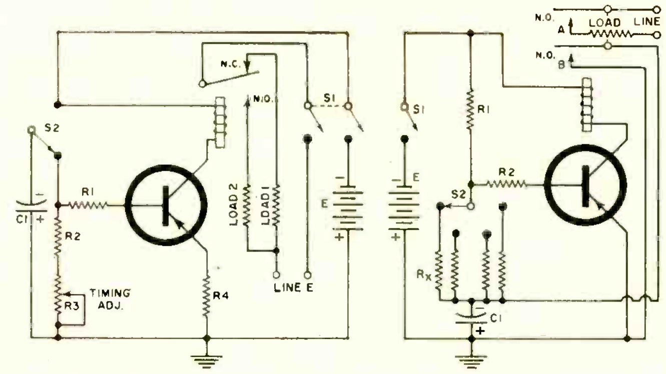


Fig. 5. (A) Transistor-operated timer. (B) Automatic recycler.

to indicate time-interval settings. $R1$ determines the percentage of increase or decrease of the calibrated time delay.

Owing to their inherently low deterioration with extreme conditions of environment and their low power requirements, transistors are ideal elements for timing circuits. Fig. 5A illustrates a transistorized timer which utilizes the discharge time of a capacitor through a series-parallel resistive network. When switch S1 is closed, load 1 is energized, but since the base-to-emitter voltage is zero, the collector current is cut off. To energize the relay, forward bias must be provided for the base-to-emitter circuit so that the emitter is maintained at a positive potential with respect to the base. This may be accomplished by throwing S2 (an instantaneous-release type switch) to the upper position, which instantly charges capacitor $C1$ to the source voltage. Upon releasing S2, the timing capacitor discharges through $R2$ and $R3$ and the shunt path comprising $R1$, R_{be}, and $R4$, where R_{be} is the base-to-emitter resistance. The circuit parameters are properly calculated so that the initial discharge current provides sufficient bias to energize the relay in the collector circuit. As capacitor $C1$ discharges, the discharge current decays exponentially until the collector current is reduced to a point below the dropout value of the relay, which then resets to its original condition.

Fig. 5B indicates an automatic recycling timer which requires no manual reset switch to discharge the timing capacitor. In this configuration, the resistive element of the timing network is switched by S2 to a value which provides the desired charge-time interval. When switch S1 is closed, capacitance $C1$ charges to the supply voltage E through $R1$, R_x, $R2$, and R_{be}. The circuit constants are chosen to supply sufficient base-to-emitter bias so that the resultant surge of collector current actuates the relay. Normally open contacts "A" close and the load is momentarily energized. When normally open contacts "B" close, timing capacitor $C1$ starts to discharge through the short and the relay drops out. The operating cycle is thus completed and another run starts.

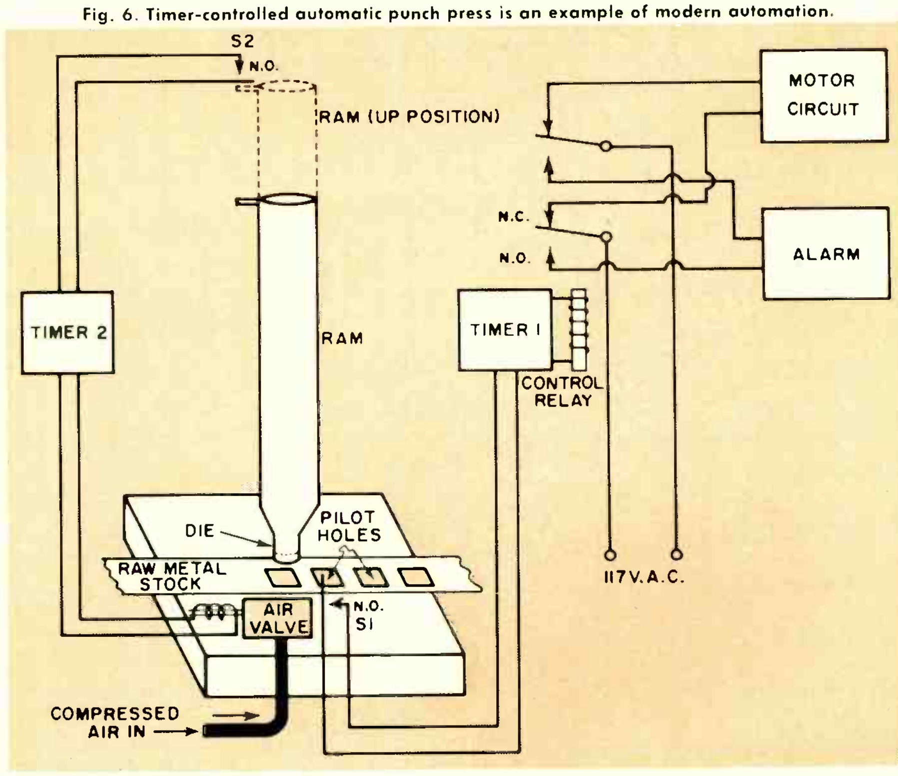
Practical Considerations

For precision timing, stable components must be selected for the RC network timing elements to minimize variations in value due to temperature changes. To obtain adequate compensation of parameter changes over the operating temperature range, it may be necessary to utilize components having temperature coefficients of opposite sign. For example, a negative-temperature-coefficient capacitor may be used with a positive-temperature-coefficient resistor in a timing network, so that the net drift of the circuit is reduced to a negligible value.

An important consideration in timing circuit design is the internal leakage resistance of the timing capacitor due to current flow between the plates. This undesirable effect represents an equivalent parallel resistance, and provides an unintentional discharge path which affects the timing characteristic of the RC network. Since leakage current is proportional to the voltage applied to the timing capacitor, it can be minimized by maintaining a low rate of final charge voltage to source voltage. For relatively large delays and wide temperature ranges, the use of solid tantalum capacitors is preferred since they permit large values of capacitance in a small physical space, yet maintain an extremely low leakage current.

Another phenomenon associated with timing capacitors is the residual loss of electrical energy caused by dielectric absorption. Although a timing capacitor should be fully charged at $5RC$ time constants, in many components the charge or discharge interval is lengthened by an amount proportional to the dielectric absorption. During this interval, a part of the charge is "absorbed" by the dielectric which introduces an unwanted time lag in the charging or discharging rate of the capacitor. For (*Continued on page* 72)

Fig. 6. Timer-controlled automatic punch press is an example of modern automation.



ASTROVISION

AN IN-FLIGHT ENTERTAINMENT SYSTEM

By L.C. KEENE
Chief Instruments & Electronics Engineer
and
T.E. Pierson
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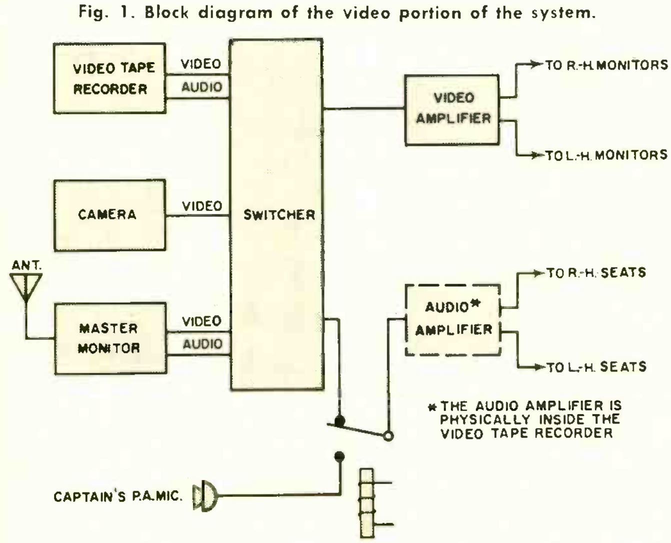
Stewardness instructs a passenger in use of Astrovision. At passenger's right elbow is earphone jack and volume control.

Closed-circuit TV, video tape recording, plus stereo audio tape recording are used in American Airlines' jets.

WHEN *American Airlines* decided to provide an in-flight entertainment system for its jet passengers, there were a number of basic premises set up that determined the final design. One of the first was that the passenger should have some degree of privacy. It was desirable that the passenger be given a choice of at least two forms of entertainment (one a full-length movie), but should also be free to follow his traditional habits of reading or working without serious intrusion by the entertainment selection of his fellow passengers. This precluded consideration of a big screen and movie projector set-up. It also ruled out any type of speaker system for transmission of audio.

Since the screen/projector approach had been ruled out, an alternative means of presenting visual entertainment to the individual passenger seemed to be possible through the use of the miniature TV sets that were already commercially available. The use of these small sets fitted very well with the primary requirements for the cabin installation, but created some "behind-the-scenes" problems. The most immediate problem, of course, was a source of video signals for these cabin sets. Studio-quality programming was a requirement, but the equipment to produce that quality had to fit in a plane.

Fig. 1. Block diagram of the video portion of the system.



An airplane is, of necessity, a highly efficient machine and has very little unused space within the hull. Weight is always a prime consideration of any equipment that goes into an aircraft. Unless a suitable video tape player could be obtained, a completely different concept would have to be used. The *Sony Corporation* had a unit designated as "Videocorder" Model PV-100 that had the basic characteristics required. The decision was made to work with *Sony* to provide a complete video system for the aircraft. The final design also included provisions for a TV camera input and for receiving broadcast television signals. (See Fig. 1.)

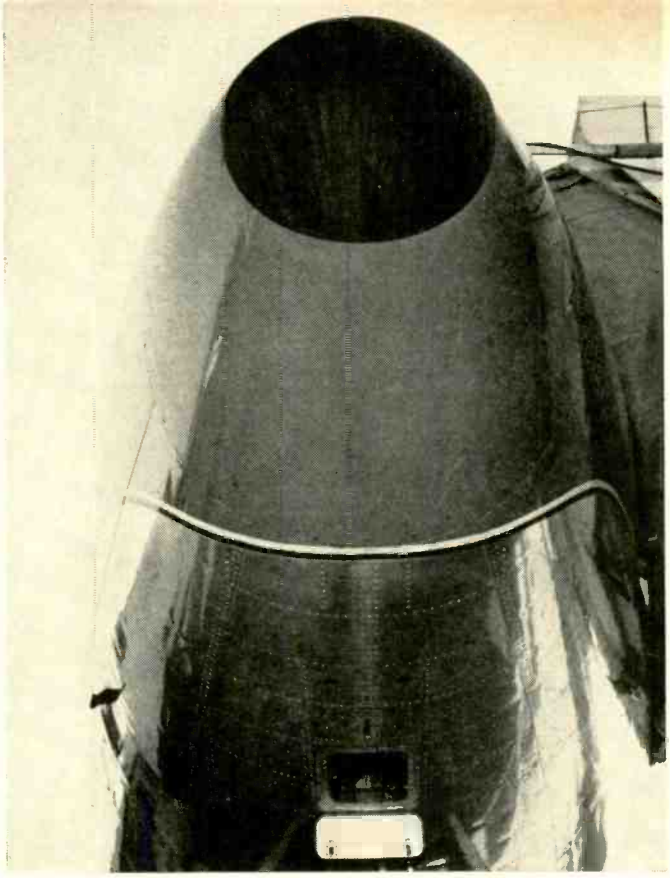
A stereophonic music system was selected as the alternate entertainment choice. We already had an existing tape-recorded music system that played through the cabin public-address system. It was not difficult to obtain the same basic tape machine equipped to play stereo tapes. The audio amplifiers in this system were separately mounted and used in pairs. Two complete channels of stereo were provided to give the passenger a choice of music. (See Fig. 2.)

The Video System

The heart of the visual system is the tape recorder. The unit was originally built not only to record but also to play back as well. Only the playback feature was used, of course. A two-inch-wide magnetic tape, recorded in a "slant-scan" system, plays at a speed of 5⅝ inches per second. At this speed, approximately 120 minutes of entertainment are provided on a single reel of tape. The tapes are provided especially for *American Airlines* from a *Sony* recording center in New York.

The video recorder is a completely transistorized unit of modular construction approximately 25 inches high, 17 inches wide, 17 inches deep, and weighs 145 pounds. This unit is shock-mounted on the bulkhead at the rear of the flight deck. This location not only provides the required space but

Airlines technician is shown changing tapes on the plane's video tape recorder. About 120 minutes of entertainment are provided on a single reel of specially prepared tape.



TV camera is located near the nose and beneath the fuselage. Camera, behind small rectangular opening, takes pictures of take-offs, landings, and terrain during the plane's flight.

also gives easy access for servicing, changing tapes, and cleaning pick-up heads.

The video distribution amplifier is mounted directly beneath the recorder. This amplifier is used to provide sufficient signal strength for all 26 monitors from any video input selected.

The stewardess may select video inputs from the tape, from the camera, or from local television broadcasts. The selection is made at a switching panel that also contains the master "On-Off" switches for the stereo system and the video system power supply. Adjacent to the switching panel is a 5-inch TV set identified as the master monitor. This is the only set in the system that is a complete unit and capable of receiving broadcast signals. When local TV mode is desired, the channel to be viewed is first selected on the master monitor, then is switched into the distribution amplifier and the coaxial cables to the cabin monitors.

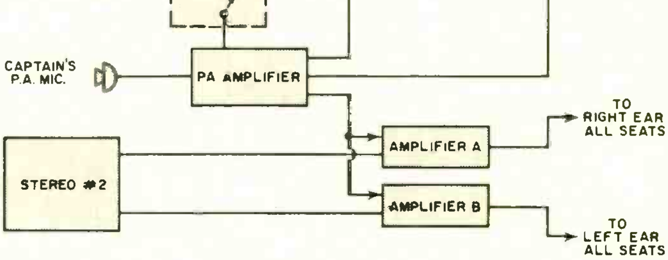
The antenna used with the master monitor is a blade-type antenna similar to the existing v.h.f. antenna and is mounted on top of the fuselage over the cockpit. Reception has been excellent on the ramp and at the terminal in most localities. In-flight reception has not been as consistently good as at the ramp and is subject to intermittent interference patterns, possibly from radar or v.h.f. transmissions. It is feasible, however, to present special events, such as a baseball or football game, to the passenger in flight with a reasonable expectation of adequately following the action. This does necessitate retuning one or more times, as 10 to 15 minutes is about as long as any given station can be retained when the receiver is moving at 600 miles per hour.

One of the most interesting features of the system is the TV camera. The camera is a small, lightweight, transistorized unit mounted forward of the nose gear in a pressurized area. The camera "sees" by means of a window and mirror arrangement. The mirror is solenoid-operated to provide two viewing angles. One is straight ahead parallel to the longitudinal axis of the fuselage; the other is down at a 45° angle. When the aircraft is on the ground and the mirror is in the straight-ahead position, the camera's view is from about six feet above the ground. This position is used during taxi-out and take-off and also during the final approach and landing. The 45° position is used for terrain observation after some altitude has been gained. The camera was originally equipped with a zoom lens for the purpose of bringing the view closer when the aircraft was cruising at 35,000 feet or above. It was noted that even at 39,000 feet the camera produced excellent detail without the zoom feature. Therefore, this item was deleted.

As protection for the vidicon against being damaged by the sun or other sources of intense light, a shutter is installed and is triggered when a photocell sensor detects 500 foot-candles. When the light level drops, the shutter automatically reopens. An iris adjustment is being explored for lengthening the viewing time.

Since the video recorder, video distribution amplifier, and the camera are commercial (*Continued on page* 69)

Fig. 2. Diagram of the two-program stereo-program system.



A 200-Watt Solid-State Stereo Amplifier

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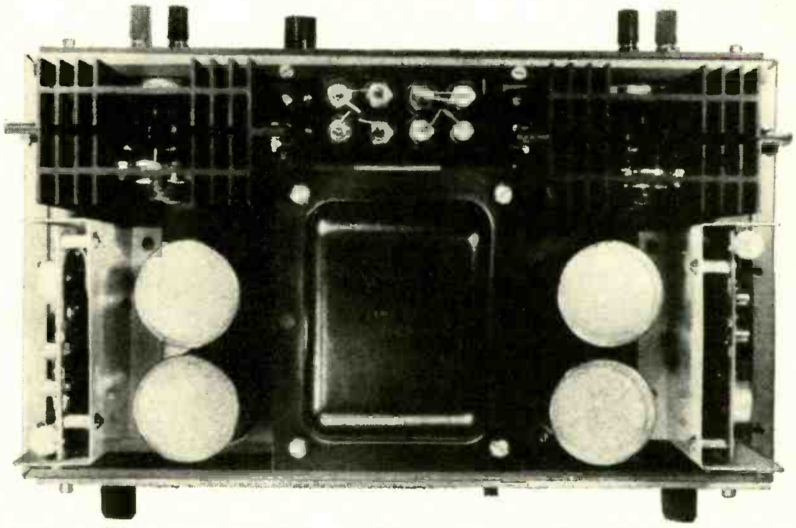
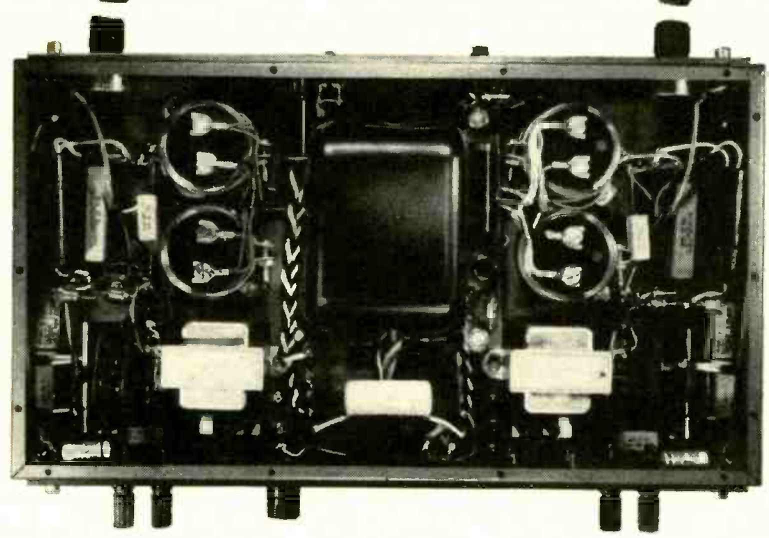




Top and bottom views of the Mattes SSP-200 basic power amplifier. The unit can be used with variety of stereo preamps. The preamp should be able to deliver 1 v. r.m.s. in order to obtain maximum rated output from the amplifier. The input impedance of the basic amplifier unit is 100,000 ohms.

New circuit advance provides rated power continuously at less than 0.1 percent intermodulation distortion.

WHEN transistor high-fidelity equipment first appeared a few years ago, high hopes were raised for the future of solid-state components. Transistor amplifiers would be small, powerful, deliver superb performance, and be inexpensive. Regular readers of ELECTRONICS WORLD need not be reminded that up to this time these hopes have not as yet been completely realized.

To some extent, the difficulties in designing high-quality power amplifiers with transistors have been due to inadequacies of the transistors available to the engineer; to some extent, the circuits used have imposed severe limitations. In this article, the authors will review the performance limits imposed by the problems inherent in designing power amplifiers with transistors, and introduce a new circuit design which largely overcomes these problems, while extending the state of the art of power-amplifier design.

Transistor Limitations

Although the design of a circuit usually begins with the establishment of performance requirements, it will be instructive to take as an example a good transistor and calculate the maximum performance which would be available from a pair of these used in a conventional circuit. The circuit chosen, for purposes of calculation, is a driver-transformer-coupled "totem-pole" class-B output stage using two transistors (Fig. 1A). The calculations are those to be found in any textbook on designing power-amplifiers using semiconductors.

For our transistor type let us take 2N3233 or 2N3055 silicon power transistors, which are readily available at low cost, and which because they may be operated at a higher junction temperature than germanium types, may allow us to draw more power from the circuit. Our answer works out to be approximately 50 watts per channel, using one 2-degree/watt heat sink for each transistor—about the practical limit in convection-cooled heat sinks of reasonable size.

It is important to point out that to achieve the 50-watt rating requires that the transistors be operated, under some conditions, at a junction temperature of exactly 200°C (392°F), and also that the maximum ambient temperature is 40°C (104°F), for the purposes of the example, although this maximum ambient rating is barely adequate for general consumer use.

Perhaps some engineers will be able to find ways to increase the continuous power rating beyond 50 watts, while others will wonder at our temerity. Let us say that the figure represents, in our opinion, a fair approximation of the maximum which can be expected when conventional circuits are used. Generally speaking, circuits without driver transformers will produce less power reliably. The use of non-linear biasing techniques might permit more than 50 watts, but at some cost in linearity. The major factor limiting the performance of a power amplifier using transistors is the change in characteristics which takes place with an increase in temperature, particularly the shifting of bias characteristics. These factors must be taken into account when the transistor dissipation calculations are made.

Principle of the New Circuit

If the need to bias the output transistors were eliminated, the calculations just performed would be somewhat simplified and would lead to a different result—about 125 watts continuous power per channel instead of 50. This is exactly the power output taken from a pair of 2N3055's in the circuit to be described which, in fact, eliminates the need to bias the output transistors. To accomplish this end, the circuit (upon which multiple U.S. and foreign patients are pending) employs two concepts which are new to high-fidelity solid-state power amplifier design. These are: (1) a power stage which is designed to operate with many of the characteristics of an Esaki (tunnel) diode, and (2) a system of latching diodes which serve a control function to be described below.

Due to its negative-input-impedance characteristics, a tunnel diode may be used as an amplifier with unity voltage gain but considerable power gain. Consider the combination of a low-power voltage amplifier, with very low distortion, coupled to a tunnel diode (Fig. 1B). With adequate feedback applied around the system, the result would be a linear power amplifier.

Many devices may be made to exhibit the negative-impedance characteristic shown by the tunnel diode. Such a device may also be simulated by a combination of more conventional components, an example of which is an oscillator that is just below its threshold of oscillation. Such a circuit, with its negative-impedance characteristics, has been used to make practical negative-impedance systems in which only current gain is desired, as in telephone repeater amplifiers and other specialized line amplifiers.

Assuming that the correct combination of components were employed for the purpose, the combination suggested above—the low-distortion voltage amplifier and the unity-gain negative-impedance stage—could be made to have high power and low distortion. Power would come to the load from the power supply through the negative-impedance device, while the signal voltage variation would be under the control of the highly linear voltage amplifier, which would also function as a driver amplifier.

The basic circuit of the new amplifier consists, then, of a low-distortion driver amplifier coupled both to the load and to a power oscillator, which is constantly on the brink of oscillation as its output is common to its input (Fig. 1C). The power oscillator is prevented from oscillating by making the driver amplifier of very low impedance so as to short-circuit the oscillator. The fact that the short-circuit is virtual, rather than real, is of no importance; the effect is the same.

Analysis of Operation

Analysis of circuits such as the one shown is rather lengthy, when rigor is required, but their operation is not really difficult to understand. While it leaves a great deal to be desired as a practical high-fidelity amplifier, let it be said at the outset that the schematic shown actually works. It is essentially the circuit used in the final commercial product, the *Mattes* SSP-200, although the SSP-200 also incorporates the latching-diode system to be described shortly. The easiest way to understand the operation of the circuit is to enumerate and consider the three different stages of operation during each cycle of signal.

1. At very low levels, the voltage across the secondaries of the driver transformer is insufficient to cause transistor action in the power transistors. Hence, the primary of the transformer and the power transistors are simply high impedances and do not affect signal flow. The driver amplifier drives the load entirely.

2. As the signal level increases, the power transistors begin to turn on and supply some current to the load. The driver continues to drive the load directly as well, although current is now drawn through the driver-transformer primary. The negative feedback loop adjusts the amount of drive to allow for current gain of the power transistors.

3. In the third stage of operation, the signal level has in-

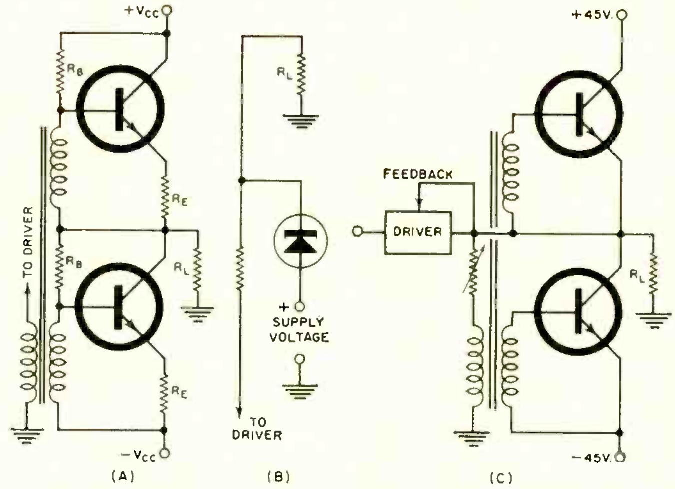
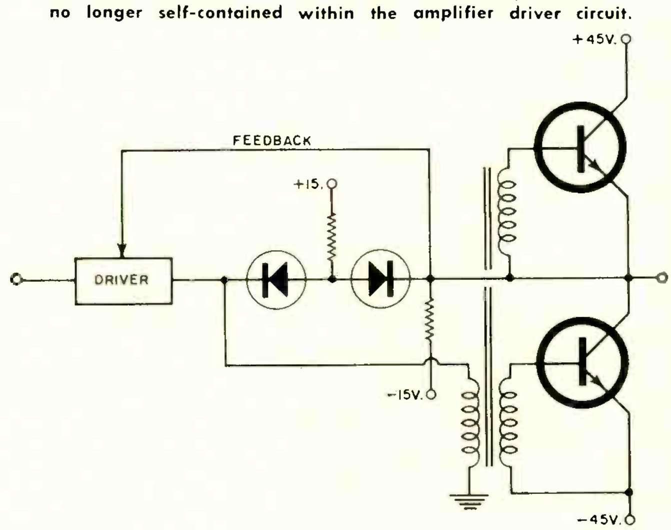


Fig. 1. (A) Typical transformer-driven output stage used in calculations. Emitter resistor value of 0.5 ohm is compromise between marginal stability and reduced efficiency. (B) Simplest form of tunnel-diode amplifier referred to in text. (C) Basic circuit of amplifier employing negative-impedance power-output stage. Negative-feedback loop is an integral part of driver amplifier; since output stage has one terminal for both input and output, feedback serves entire system.

Fig. 2. Latching-diode control circuit incorporated in basic amplifier. Separate power supplies may now be used for the driver and output sections thus obviating the need for costly low-level driver transistors. The feedback loop shown is no longer self-contained within the amplifier driver circuit.



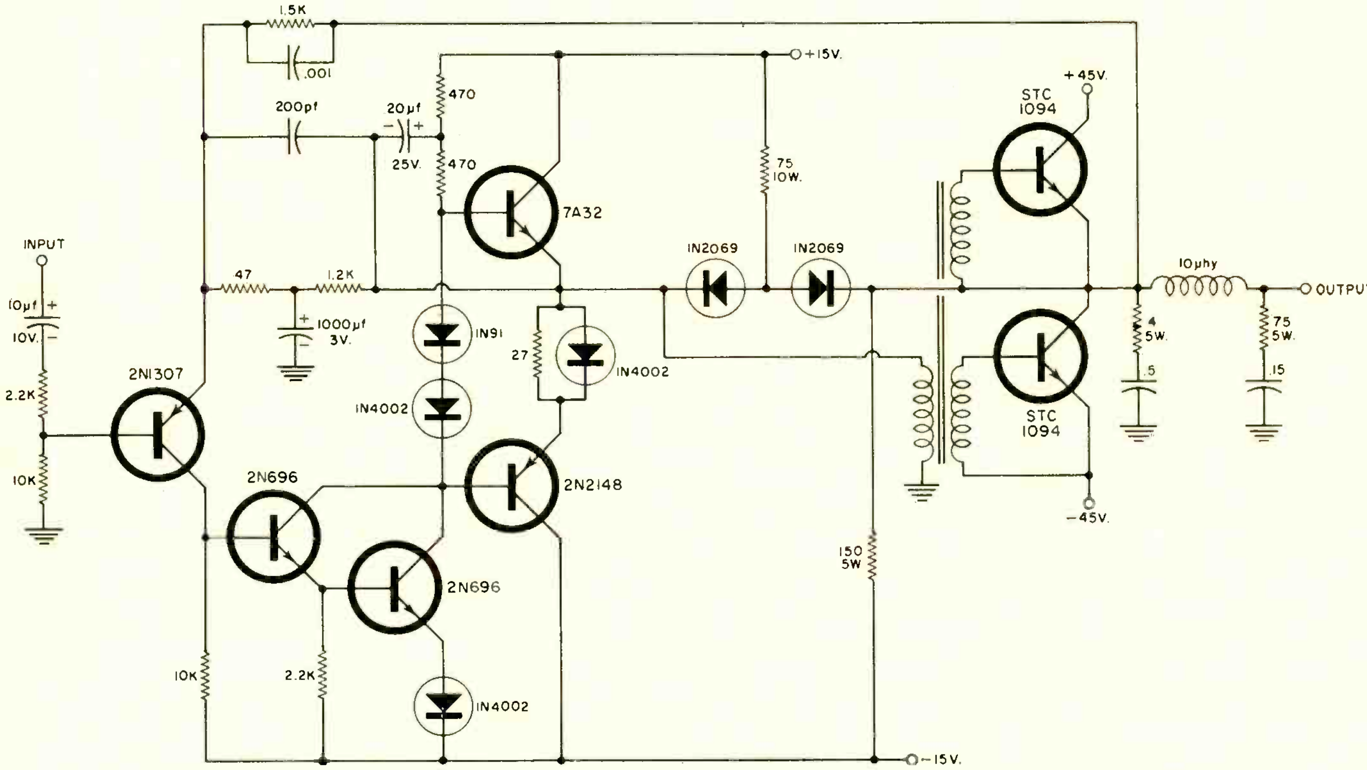


Fig. 3. Complete schematic of practical 100-watt-per-channel power amplifier. Note that only one of two identical stereo channels is shown and that the power-supply circuit has not been illustrated. Incidentally, the resale price of the output transistors shown is around $23 each, while the 2N3055 or 2N3233 mentioned in the text cost about $5 each. Because of the use of special, custom-built driver transformers and special wiring techniques, home construction is not recommended.

creased further, the power transistors are operating fully, and are supplying all the current to the load. Furthermore, current from the output stage is actually helping supply its own input, while the driver supplies no power to speak of, only a voltage control signal. As current comes backward toward the driver from the power stage, the apparent impedance of the load rises enormously. As a result, the driver, which would have been limited to the delivery of a volt or two across the low-impedance load, is now able to swing the full extent of the power supply, as it is not called upon to supply power to the load.

Although not practical, for reasons soon to be explained, the circuit just discussed does have several intriguing properties. One is that a short-circuit of the output terminals is actually a short-circuit of the driver, which immediately gives all of its power to the short-circuit, leaving the power transistors intact. Since the driver is power-limited, it is unharmed.

At low levels, the circuit is d.c.-coupled, permitting the application of d.c. feedback, thus stablizing the d.c. level at the output terminals. On the other hand, high-level signals are transformer-coupled, affording the design engineer a chance to eat his cake and have it too. The circuit is d.c.-stabilized by feedback, yet can be made to roll off at any desired low-frequency point by proper design of the driver transformer. Since there is no bias circuit to adjust, fluctuations in the power supply to the output transistors will have no effect upon distortion, but only upon maximum power output. Moreover, the output transistors may be switched from *p-n-p-* to *n-p-n* or one of each, at will, provided only that they are connected with proper polarity; there are no bias circuit adjustments to be made, since there is no bias.

There is one serious drawback, however. The maximum voltage swing across the load is determined by the driver transistor voltage ratings, not the ratings of the power transistors. This is because the gain of the power stage is unity, making the voltage swing across the driver and output terminals the same. Therefore, the driver transistors must have the same voltage rating as the power-stage transistors. Consequently, either costly low-level transistors must be employed to achieve high power output, or one must be content with the low power levels resulting from the use of reasonably priced driver transistors. To eliminate this difficulty, we operate the power stage from its own high-voltage supply, which requires a means of isolating the two halves of the amplifier—but only for part of the time.

Latching-Diode Control Circuit

The controlled isolation of the power stage of the amplifier from the driver is accomplished by the addition to the circuit of two diodes and two resistors, in the configuration shown in Fig. 2.

The operation described earlier takes place as stated. The new circuit comes into play when the voltage gain of the power transistors causes the voltage across the load to swing out-

Fig. 4. Intermodulation distortion with 8-ohm loads. At power levels from about 10 watts to beyond 100 watts per channel, the intermodulation distortion is below 0.1%

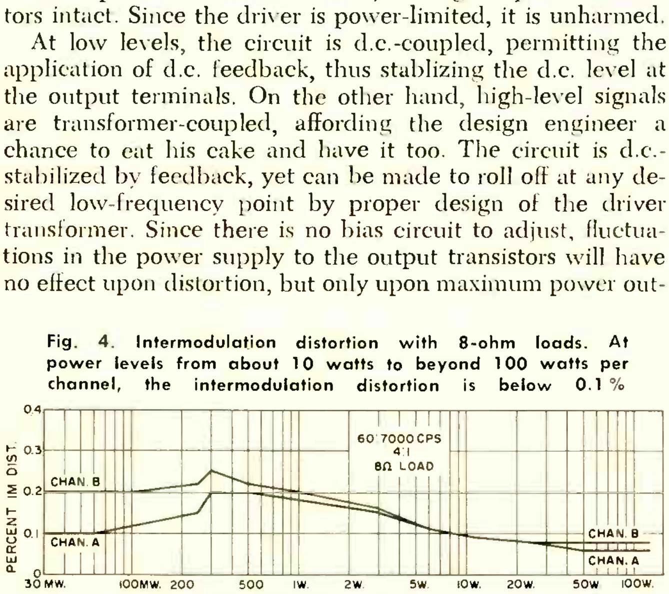
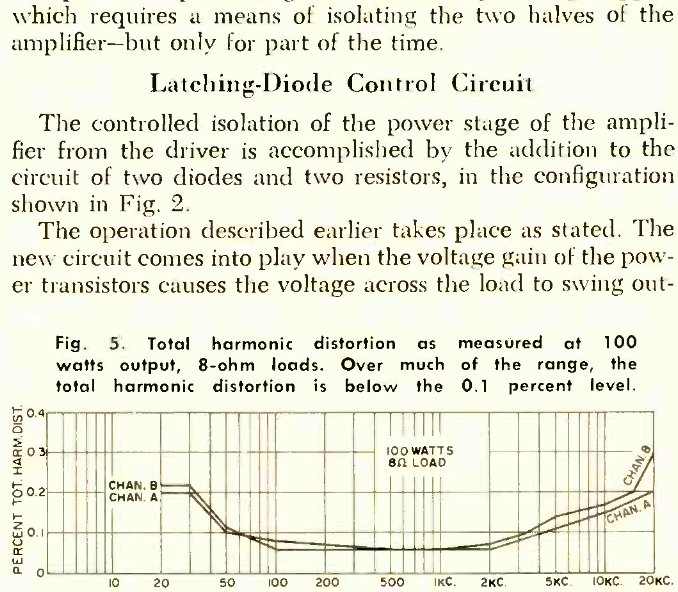


Fig. 5. Total harmonic distortion as measured at 100 watts output, 8-ohm loads. Over much of the range, the total harmonic distortion is below the 0.1 percent level.



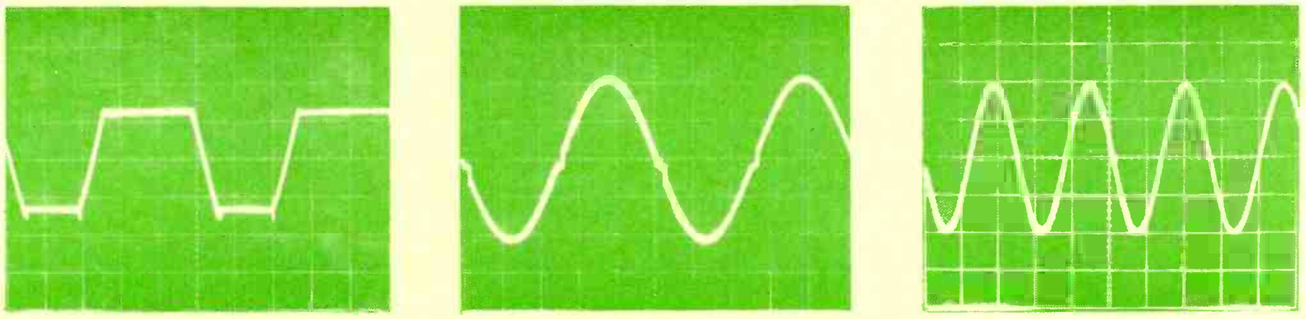


Fig. 6. (A) Output waveform of driver-amplifier during operation. (B) Output of power stage with latching diodes removed shows crossover-distortion notches. (C) With diodes inserted there is no discontinuity in the output waveform, which now measures less than 0.1 % total harmonic distortion.

side the domain of the driver power supply, which in this version is considerably less than that of the power stage. Under these conditions, the diodes appear as a high impedance, since they are reverse biased. This accomplishes the purpose of isolating the driver amplifier from the power transistors when this isolation is needed, while permitting the system to operate as the basic circuit, the rest of the time.

Complete Schematic

The complete schematic (Fig. 3) incorporates a few additional features which are worth explaining. One is the low-pass filter at the output. This has been used to remove very high frequency components from the signal which cannot be eliminated by feedback, due to the transit-time effects present in any power transistor. It has no audible or measurable effect upon performance.

The winding ratio chosen for the driver transformer is conventional—three to one. However, to take full advantage of the circuit's possibilities, the coupling must be extremely tight and the secondary windings must have as low a d.c. resistance as possible in order to achieve good transformer efficiency.

The circuit of the driver amplifier is relatively conventional and can be further simplified if higher distortion is tolerable. Its essential properties are very low output impedance, adequate power capability to drive the load through the crossover region when the power transistors are not yet conducting, as well as to drive the output transistors through the transformer, and d.c. coupling to allow feedback to minimize d.c. drift from input to output terminals.

Advantages of the Circuit

The most obvious advantage of the circuit is its ability to provide exceptionally high power at very low distortion across the entire band from 20 to 20,000 cps. See Figs. 4 through 6. The actual continuous power of 100 watts per channel is more than that of any other hi-fi amplifier of which we know.

The cost of such a circuit is not high, and makes possible the manufacture of high-quality power amplifiers at lower cost than has been possible until now. Accidental short-circuit of the output terminals during operation has no other effect than to turn off the signal to the loudspeakers until the short-circuit is removed. This is done without use of thermistors, light bulbs, relays, or special circuitry.

The efficiency of the power stage actually exceeds, by a small amount, the theoretical maximum of 78% usually cited by class-B circuits, since some of the power to the load (less than a watt) comes directly from the driver. No matched components are used at all—and no resistors are closer in tolerance than 10%. Except for the transformers and circuit boards, which are usually custom-made for any amplifier, all parts can be bought from electronic parts distributors' shelves without selection.

The power transistors chosen for the output stage must, however, be rated at 15 amperes collector current or higher, if the short-circuit-proof feature of the design is to be retained (Fig. 7). Otherwise, type 2N3233 transistors (*Silicon Transistor Corporation*) or type 2N3055 transistors (*RCA*) may be used.

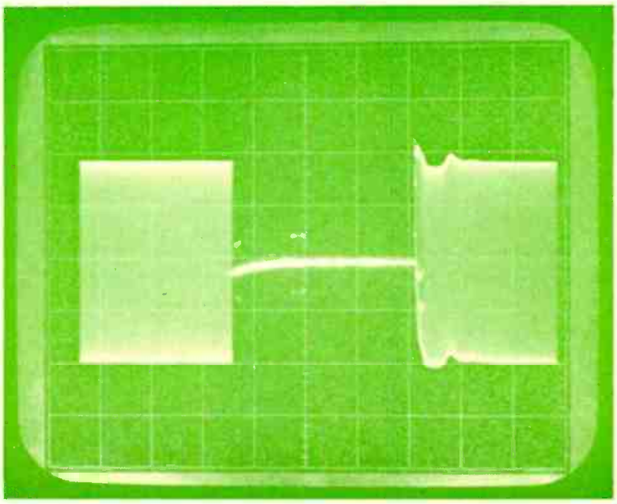
At very low levels, distortion remains low, unlike many other solid-state amplifier circuits, because the load is driven by the driver-amplifier, which has enough gain to permit negative feedback to correct distortion. Usually, the low gain of power transistors at low currents renders the feedback less effective at these levels. All adjustments have been eliminated, as may be seen from the schematic. Having dispensed with adjustments, it is possible to dispense with the meters provided to monitor these adjustments.

Final Note

Engineers interested in power stages operating without bias will probably find it interesting to read about an entirely different means to this end in a paper available as a reprint from *General Radio Company*, West Concord, Mass. The title of the paper, which originally appeared in *Solid State Journal*, December, 1961, is "High Impedance Drive for the Elimination of Crossover Distortion" by James J. Faran, Jr. and R. G. Fulks.

Readers are again reminded of the proprietary nature of the circuit discussed in this article, and its coverage in patent applications. ▲

Fig. 7. Scope record of amplifier behavior when output is short-circuited. The portion of the waveform at the left shows the 1-kc., 100-watt output of the amplifier. Then the output is shorted and output drops to zero. After about 10 sec., short is removed. Note that full output is restored immediately after brief starting transient.



NEW CITIZENS BAND CIRCUITS

By LEN BUCKWALTER

Description of a:

Solid-state vibrator replacement,
Tapered squelch circuit, and
"Raysistor" speech compressor.

(A)

(B)

(C)

SIGNS of progress are evident in the three CB circuits discussed this month—not the revolutionary type, but small circuit refinements to improve equipment life and performance. The "Transdapter" by *Sonar*, for example, replaces the mechanical vibrator in a mobile power supply with a solid-state device whose switching is electronic. It has no moving parts and can plug into an existing vibrator socket. Next is the *Biggs* "LaSalle" rig with "tapered" squelch. It is designed to give the CB operator a wider choice of squelch thresholds; mostly to permit the copying of signals down in the noise while still preserving squelch action between calls. Finally, there's a circuit by *USL* which appears to be a "first" in CB. It is the use of a *Raytheon* "Raysistor"—a photocell and light-bulb arrangement—which performs in a novel speech-compression circuit.

Sonar "Transdapter"

Since the power transformer in a mobile CB transceiver cannot operate directly from d.c. supplied by the car battery, a vibrator is frequently used to "chop" the supply voltage. The resulting pulsations may then be applied to the transformer for step-up to high "B+" voltages, typically around 250 volts. The mechanical nature of the vibrator, however, introduces several problems: limited life due to wear, arcing between contacts, and a tendency to generate vibrator "hash" in the receiver. Each of these difficulties is eliminated by solid-state switching, as done in the *Sonar* "Transdapter" (see photo A). This is a vibrator substitute designed to plug directly into a vibrator socket and perform the required chopping function, but with no moving parts. The plug supplied with the device is a four-prong type which is interchangeable with the 1601 vibrator that is employed in many CB sets.

The complete "Transdapter" schematic is shown in Fig. 1. An over-all view of the circuit reveals a push-pull two-transistor oscillator. The transistors are alternately switched on and off by feedback paths established by transformer *T1*. Circuit action begins when 12-volt d.c. from the car battery is picked up through pin 1 on the vibrator socket. It is applied to the emitters of both transistors (*Q1* and *Q2*). Consider next how the collectors are connected. Toward the right side of the schematic they are wired across the center-tapped primary of the vibrator transformer located in the CB transceiver, through pins 2 and 3. This winding forms the collector load. (The switch seen in the collector circuit disables the "Transdapter" whenever the set is powered by 117-volt a.c.)

With battery voltage applied to the emitters, current conduction begins. A small inequality in the circuit, however, causes one transistor to conduct more heavily than the other. The resulting current flow causes a magnetic field to build up in the primary of feedback transformer *T1*. The field cuts across the secondary and induces current in the transistor base circuits. The direction of current flow creates push-pull action in the base circuits; collector current of one transistor rises, while the other one falls. This effect increases rapidly as the transistor that is conducting heavily feeds back current to its base.

There will be a point, quickly attained, that saturates the feedback transformer. After current flow levels out, the magnetic field collapses and thus reverses direction. This switches polarity at the secondary winding and the other transistor begins conducting. The push-pull effect repeats and the resulting oscillation occurs at a frequency of approximately 200 to 300 cps.

As we have noted, collector currents flow through both feedback and vibrator transformers. Most of the flow, however, occurs in the vibrator-transformer primary. The feedback transformer requires relatively little power to energize the base circuits and *R1* is used to limit feedback to a safe value. Viewed on a scope, the waveform in the vibrator primary would appear as a 24-volt peak-to-peak a.c. signal. This provides the required 12-volt pulsations on each side of the vibrator transformer's center-tapped primary.

Also in the "Transdapter" circuit are *R2* and *R3* for establishing operating base bias at the transistors. Resistor *R4* and capacitor *C1* help stabilize the frequency of oscillation of the inverter circuit.

With the removal of mechanical components, the life of the device may be considered indefinite. Heat developed by the transistors is dissipated by air convection currents set up through the case. It is usually mounted on the rear of the CB cabinet and utilizes short phenolic spacers to keep the circuit properly ventilated and independent of temperatures developed by tubes in the CB set.

For copy of manufacturer's brochure, circle No. 62 on coupon (page 17).

"LaSalle" Tapered Squelch

In setting the squelch on a transceiver, the operator usually adjusts the control, with no signal being received, to a point just below where noise is heard. This mutes the receiver until an incoming signal triggers the squelch circuit. Audio stages unlock and the signal is heard. One popular system uses a diode for the control function. The diode generally blocks the audio signal until forward bias is supplied by the incoming signal. It's an efficient system but susceptible to some limitation when the operator wishes to copy extremely weak signals down in the noise. Since the diode circuit tends to be either on or off, it is not easily adjusted to the very critical point needed for weak-signal reception.

A "tapered" response in squelch action is achieved by the triode circuit used in the *Biggs* "LaSalle" transceiver (see photo B). It enables the operator to select a wider range of squelch thresholds. If he wants conventional squelch action, he sets the control at one point; only signals well above the noise open the receiver. If the operator is willing to tolerate a small amount of background bias, this level, too, may be selected. Here, signals do not "pop" in but increase the audio gain from a subdued level.

The partial schematic in Fig. 2 illustrates the related circuitry. A squelch triode appears at *V1A* followed by audio amplifier *V1B*. As the operator varies squelch control *R2*, he is changing the potential applied to the squelch-tube cathode. It is seen that the control forms a voltage divider across a "B+" source. In this arrangement, it is possible to select the operating point of the tube. Two other inputs are applied to the tube grid. One is the audio signal arriving from second detector and noise-limiter circuits. The other is a tap into the screen circuit of the i.f. amplifier tubes (through *R1*). Grid bias, therefore, will be a combination of squelch-control setting and the positive potential supplied by the i.f. screens.

Assuming that no signal is being received, the i.f. screen voltage is relatively low; the tubes are conducting much current in the absence of negative a.g.c. Lowered voltage is sensed by the squelch grid and audio amplification is reduced. This represents the muted condition of the receiver. An incoming signal, however, increases a.g.c. and raises the i.f. screens to a higher positive value. The squelch tube is now biased for increased amplification.

The point at which this unlocking action occurs depends on the squelch setting chosen by the operator. He may balance out positive grid voltage by an equal cathode bias. Since he has a range of cathode-bias settings and an extended range of operation provided by the triode over a diode, the squelch threshold is relatively non-critical, even for weak signals.

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USL Speech Compressor

Increasingly, CB units are being fitted with internal speech compressors to keep average modulation as close as possible to 100%. Many of these circuits create an a.g.c. action; part of the audio signal is rectified, filtered, and then fed back to control the gain of an amplifier. In this manner, low speaking levels produce high gain, whereas high speaking levels reverse the action. A novel approach to speech compression shows up in *United Scientific Lab's* new "Contact-All 23"

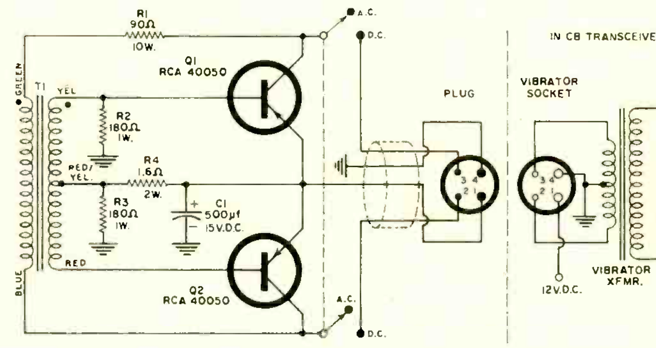

Fig. 1. Power oscillator (inverter) in Sonar "Transadapter".

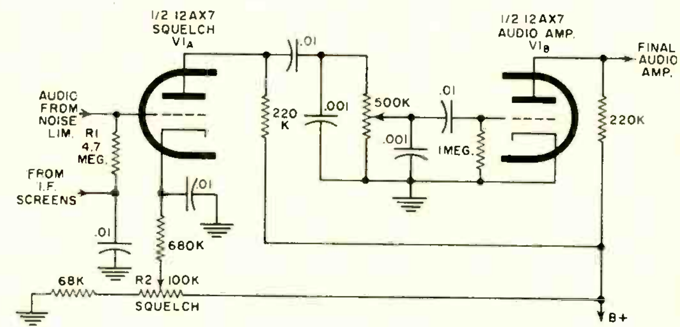

Fig. 2. Circuit diagram of the Biggs "LaSalle" tapered squelch.

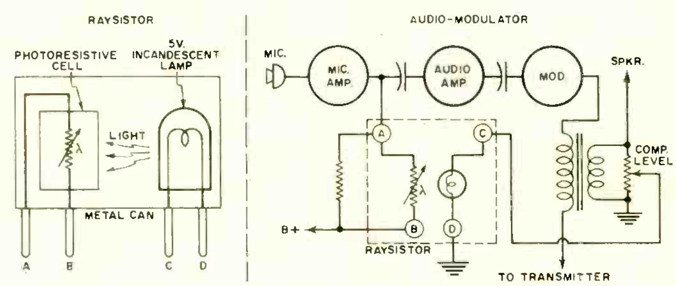

Fig. 3. Use of a "Raysistor" in the USL speech compressor.

rig (see photo C). It uses the *Raytheon* "Raysistor"—an electro-optical device—in an interesting compressor arrangement. (For additional information, refer to "New Light-Operated Switch" in our November, 1963 issue, page 47.)

Let us consider, first, the operation of the "Raysistor." Its basic function in this application is to convert a varying light source into corresponding resistance changes. Notice in Fig. 3 (left) that it consists of a 5-volt lamp positioned close to a cell of the photoresistive type. If light intensity is increased, resistance of the cell decreases. Now yet us apply the device in the *USL* circuit. Shown in Fig 3 is a block diagram of the transceiver's audio and modulator circuits. The power source to operate the lamp is tapped by a potentiometer across the transformer secondary. It permits adjustment of compression level. As the operator speaks into the microphone, the bulb glows according to voice level.

Note that the resistive photocell element is across the plate-load resistor of the microphone amplifier. When the audio signal at the modulation transformer is excessively high, the bulb glows brightly, dropping cell resistance. Since the cell is shunted across the plate load, resistance here is lowered and the gain of the microphone amplifier decreases correspondingly. The opposite effect occurs for low voice levels; full maximum amplification occurs. Thus, the desired compressor action is achieved and average modulation is maintained at high levels. Since no audio clipping or squaring off of the waveform occurs, the system is said to improve audio with no distortion. ▲

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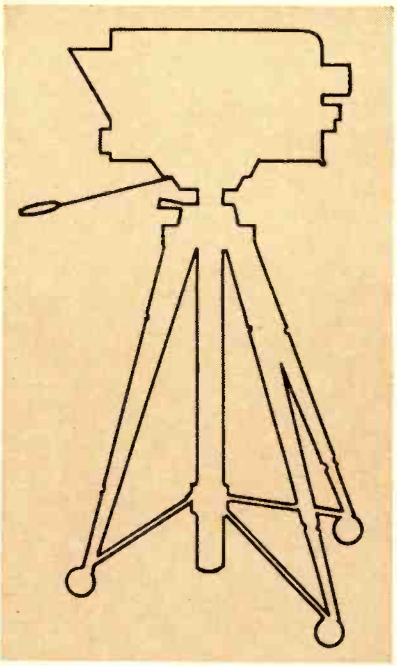


CHOOSING A Closed-Circuit TV Camera

By LEON A. WORTMAN/Author: "Closed Circuit Television Handbook"
Product Manager, Ampex Corp.

Requirements that must be met rather than manufacturer or price should be the main considerations in selecting a camera. Important factors are illumination, resolution, movement, mounting, environment, power, and duty cycle.

CLOSED-circuit television is a research instrument, a guardian of human safety and life, an educational tool, a form of business communication, a military weapon for defense, an industrial machine, a medical aide, a sales-promotion device, and an electronic baby sitter. Applications for closed-circuit television systems are varied and numerous. And, because of this fact, closed-circuit television is an industry.

The person charged with the responsibility of selecting, specifying, or purchasing a CCTV camera may become confused by the relatively large number of manufacturers, makes, and models of cameras available to him. How, then, does he gain maximum assurance that he is making the right choice when he submits his requisition to management? The answer is not obvious to the inexperienced. However, those who have been exposed to this situation state without reservation that the right choice begins with a realistic appraisal of the requirements of the application, rather than with an attempt to compare the cameras and prices of one manufacturer with those of another.

An evaluation of the requirements for any closed-circuit television camera should begin with a detailed review of a number of primary considerations. There is no order of importance, each being given equal weight in the primary stage of defining the requirements.

1. Scene Illumination—ambient and dynamic lighting conditions. Some applications require the use of a television camera in an area in which scene lighting is maintained at a constant level. Typical of these are indoor surveillance of traffic areas, reception rooms, production areas, bank floors, vaults, and merchandise warehouses. In such installations, artificial lighting is usually the primary source of scene lighting. It is independent of the presence or absence of sunlight, thereby reducing ambient effects. Further, it is normal in such applications that the cameras are not operated when the areas are vacated and the artificial light level is reduced. The significance is that the CCTV camera need not be equipped with automatic sensitivity control circuitry which is, in effect, an a.g.c. that adjusts the gain of the camera's preamplifier stages in an inverse relationship to the amount of light arriving at the vidicon's photosensitive target area.

There are, however, numerous outdoor applications for CCTV cameras. In these it is obvious that ambient light conditions and the dynamic range of available light for scene illumination are quite broad. A camera may be expected to detect and transmit images of a scene illuminated by direct sunlight and, within a short time interval, be required to transmit those same images during a dark thunderstorm; or, at night, by floodlights. It is not unusual for the dynamic range to reach 4000:1, although 2000:1 is quite regularly the requirement for 24-hour, around-the-clock outdoor operation.

If it is determined that the latter condition of lighting dynamics prevails, it is essential that the camera specified for the system be equipped with dependable automatic light compensation (a.l.c.). It should be pointed out that it is possible to manually adjust the controls of all CCTV cameras to permit compensation for lighting dynamics. However, the undesirability of such a situation when left in the hands of personnel whose specialty is not TV camera adjustment is quite obvious. And, it is poor economics to assign skilled personnel to continuous camera adjustment when simple electronic circuitry can dependably perform the function.

2. Image Detail—resolution and definition. Insufficient attention to this factor is probably responsible for more disappointments with system performance than is any other single consideration. The unsophisticated can be misled by the apparently excellent quality of picture reproduction viewed on commercial home-entertainment TV sets. On the basis of the specific fact that large titles of TV programs and station call letters are easily read, one may mistakenly generalize that all text can be read on a TV monitor comparable in quality to the TV set. Nothing could be further from the truth. It is as accurate in video reproduction as is a pocket transistor radio in music reproduction. Because of mental association, it is possible to listen to familiar music and musical instruments on a transistor radio with some degree of pleasure. However, if one were promised an introduction to a new composition played on new musical instruments, it is doubtful that one would want to listen to the premiere on a transistor radio. So, too, with home TV sets; one is familiar with certain text, lettering, and names, and, as a result of this association, the message is easily read. This is not dependable when the function is the transmission and reading of business documents or other finely detailed objects.

Resolution, the discernible number of television lines transmitted, is one of the keys to the successful application of CCTV cameras to the "reading" of detail. The number of resolvable lines is related to the bandwidth of the camera and, of course, the associated distribution system. The rule of thumb is that 80 television lines are resolved for every megacycle of bandwidth. Thus a peaked TV set with a true flat response of 4.5 mc. is capable of resolving a maximum of 360 lines. Experience has shown that for the transmission and reliable readout of data or print the size of the type on this page, the resolution must be increased to approximately 600 lines; a bandwidth approaching 8 mc. In microscopy or in the inspection of minute parts during a production process, 800 lines of resolution is desirable; a bandwidth approaching 10 mc. So much for image magnification. What about image reduction?

For example, should the application require the reading for identification of numerals, letters, or other information imprinted on the sides of a truck or railroad freight car, resolution becomes important for reasons of scene reduction to considerably less than life size.

If it is practicable to either use a telephoto lens or place the camera close to the object to be transmitted, a camera with 600-line resolution capability can be used. It should be added, that if it is not necessary for the data to be identified on the monitor screen, but only that the presence or absence of motion be observed and the outline of the moving or static object be recognized, a 300-350 line resolution capability is usually quite adequate.

Definition is an important consideration in a successful CCTV system. Unlike resolution, definition is a subjective characteristic that cannot be reduced to numbers. It is a combination of such camera characteristics as inherent noise, greyscale rendition, and beam geometry. The higher the signal-to-noise ratio, the more linear the grey scale, the truer the beam geometry across the entire scanning area of the vidicon's target, then the better is the definition and over-all quality of the image as viewed on a well adjusted monitor.

3. Movement of Images vs Static Subjects. The requirements for transmitting motion are significantly different from those for static or motionless images. It is seldom required that a camera be focused on a scene that contains absolutely no motion. There is a strong relationship between scene illumination and the useful transmission of moving images. When scene lighting and contrast between subject and background are poor, the tendency is to try to compensate for these undesirable conditions by adjusting beam intensity and contrast at the camera itself, rather than to correct the basic fault. This immediately causes a depreciation in the grey scale which, as has been pointed out in the discussion of definition, affects over-all performance adversely. Too, this depreciates the signal-to-noise, adding to the deterioration of definition. The expected result may very well be a capability for identification of a subject while at rest. However, the moment the subject goes into motion, "sticking" of the image, smearing, or "tailing," "ghosting," or other picture-destroying effects may be noted.

It is important, therefore, in evaluating published data for camera sensitivity to understand the conditions under which such data was obtained and to know whether or not the sensitivity applies to your specific use. Of course, the most reliable source for such information is the camera manufacturer's engineering department and the manufacturer's willingness to guarantee satisfaction in the application for which you may specify his camera.

Irrespective of the make or model of the camera finally specified, serious thought and practice must be devoted to scene illumination that conforms to the minimum requirements of the camera.

4. Camera Mounting. Surveillance situations involving CCTV cameras invariably require installations that place the cameras at high points or in other locations that make ready access to controls quite difficult. When such an application is contemplated, one must be aware of the potential need for periodic readjustment of controls as aging of components become obvious.

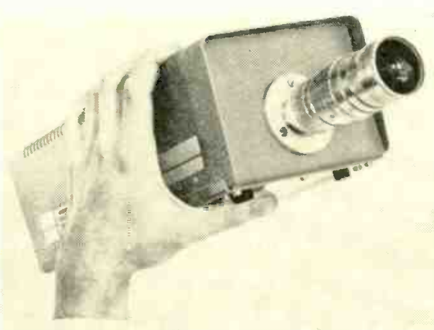
If the controls are integrated, located only at the camera housing itself, special problems may arise. For example, it is necessary to view a monitor's screen while adjusting the camera controls for optimum picture. Even the most comprehensive bench adjustments do not eliminate this final adjustment process. Thus, the person making the adjustments may be required to carry a monitor up to the camera's perch or bring the camera down from its true operating position. Neither choice represents a happy solution. The most desirable situation is one in which the camera is equipped with remote controls, or is fitted with extension cables for the controls. This makes it convenient to adjust the camera's electrical controls for focus, brilliance, and contrast from an advantageous position on the ground.

5. Environmental Conditions. Closed-circuit TV installations are extremely useful in situations involving dangers to humans. The ability to "see" from behind the complete safety of a barricade, or within a friendly environment observe an object's performance in a hostile environment, has introduced television cameras to applications involving extremes of temperature, humidity, and atmospheres. Television cameras are subjected to all sorts of environmental conditions. It is essential to examine the operational conditions for a television camera in the environment of the specific application. Is it too hot? too cold? too humid? too toxic? too combustible?

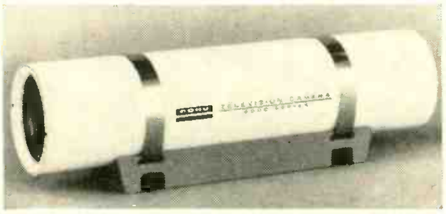
Sylvania Model 800. Rear panel is removable permitting use of extension cables for remote locations. Resolution: 800 lines. Bandwidth: 10 mc. A.l.c.: 4000 to 1. Voltage regulated. Transistor circuitry.

North American Philips, Norelco Model EL8000/11 closed-circuit television camera. Unit is compact, lightweight. Resolution: 450 lines. Bandwidth: 5.5 mc. A.l.c.: 15 to 1. Circuit is transistorized.

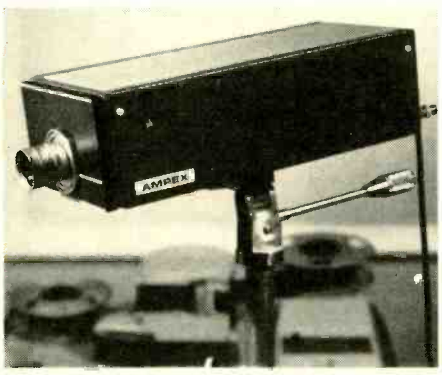
General Precision Labs Model GPL800. Camera and control chassis are separate for remote control. Resolution: 800+ lines. Bandwidth: 12 megacycles. A.l.c.: 6000 to 1. The circuit employed is a hybrid.



Fairchild-Dumont Model TC-175 transistorized camera. Resolution: 700 lines. A.l.c.: 2000 to 1. Circuit is voltage-regulated.

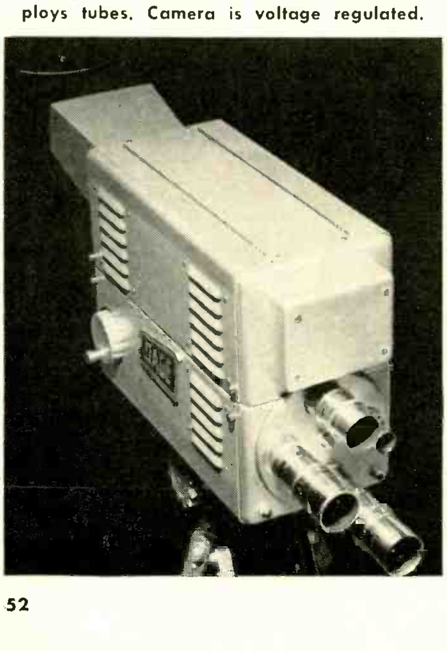


Cohu/KinTel Model 2000. In environmental housing for temperature, explosion, pressure, and humidity extremes. Narrow diameter for insertion into pipes. Resolution: 700+ lines. Bandwidth: 10 mc. A.l.c.: 4000 to 1. Voltage regulated, transistorized.



Ampex Model 322 closed-circuit camera. Resolution: 600 lines. Bandwidth: 7.5 megacycles. A.l.c. 2000 to 1. All transistor.

Dage Model 320B. Camera and control chassis are in separate housings for remote control. Resolution: 700 lines. Bandwidth: 8 mc. A.l.c.: 4000 to 1. The circuit employs tubes. Camera is voltage regulated.



Cameras are available as standard packages whose housings are especially designed to withstand severe environments of certain types. However, it is more conventional to provide a housing that offers only protection against the vertical fall of dust or moisture, and a shield for personnel against high-voltage circuits. An environmental consideration is in hospital use of cameras and monitors. Operating rooms have highly combustible atmospheres. Cameras and monitors used in such rooms must be completely enclosed, isolating them from the combustible atmosphere as a precaution against the dangerous result of an internal power-supply arc-over.

Cameras and monitors installed in the rooms of intensive-care patients, too, must be atmospherically isolated if the patients are receiving oxygen or gaseous anesthesia.

When a camera is to be used in a tightly confined area, such as the narrow diameter pipe inspection procedure, physical dimensions as well as heat, humidity, and other climatic exposures must be considered. Cameras that are configured to fit such narrow diameters are available with their own environmental housings. There are special housings manufactured for virtually every make of camera, to cope with virtually every environment.

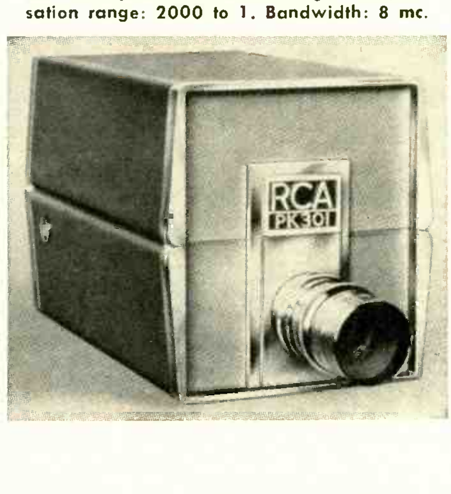
6. Power-Line Considerations—voltage regulation, r.f. interference. Cameras without voltage-regulated power supplies or which are operated from power supply lines with poor voltage regulation are unstable in operation. A change of as little as 2% in line voltage may be sufficient to alter the transmitted image in certain cameras. The apparent effects are a loss of electrical focus followed by changes in brilliance and contrast, and deteriorated definition. It is quite usual to find severe fluctuations in line voltage within factory areas in which heavy machinery is operated intermittently. In such cases several precautions must be taken. Where line-voltage fluctuations of ±2% or more are noted as electrical machinery is started and stopped, the camera should be equipped with internally regulated power supplies. Further, separate power lines with voltage regulators for individual cameras should be used.

Standard r.f. interference studies should be made at the proposed camera locations when they are to be used adjacent to electrical machinery. A practical approach is the temporary installation of a CCTV camera and monitor, using an r.f.-type camera and a conventional TV set. This must be done under "worst-case" conditions. Should noise and other transient and unwanted signals become apparent on the monitor screen and if the level of interference is not tolerable, the probable solution is to make certain the CCTV system is of the v.f. type rather than the r.f. type.

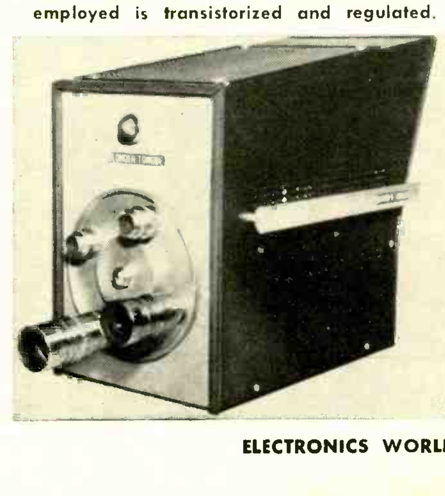
7. Duty Cycle. It is conceivable that the application requires intermittent rather than continuous operation. An actual example is found in surveillance of entrances to security areas where it is not unusual to use three television cameras for a single identification: (1) wide-angle view of the over-all area, (2) close-up view of person seeking entrance, and (3) extreme close-up of ID card to enable the security office to compare the pass-photo on the ID card with the person seeking entrance. The latter two cameras would be operated only during the moments of identification, while the first would be operated continuously. Transistorized cameras are exceptionally well suited to the last two installations, with filament power continuously applied to the vidicon for instant start with the "B+" turn-on. The first camera could be the same or an all-tube type.

(*Continued on page* 58)

RCA Model PK-301. Fully transistorized, uses new 1" electrostatic focus vidicon and provides 700-line resolution. Aperture and gamma correction. Light compensation range: 2000 to 1. Bandwidth: 8 mc.



Blonder-Tongue Model EV-1 viewfinder camera designed especially for educational TV. Resolution: 800 lines. Bandwidth: 10 mc. A.l.c.: 4000 to 1. The electronic circuit employed is transistorized and regulated.



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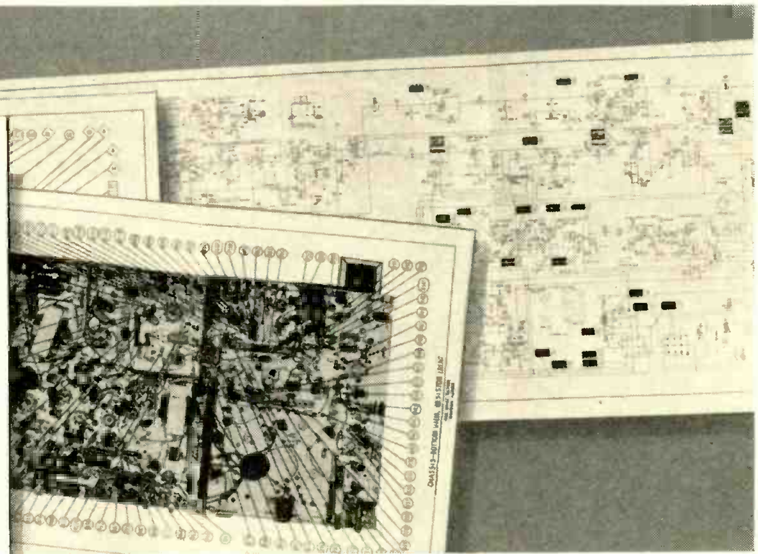

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252	RCA Victor	640	RCA Victor
259	Westinghouse	643	Andrea
262	Arvin	644	Westinghouse
265	Stromberg-Carlson	650	DuMont
283	Motorola	653	Magnavox
293	CBS-Columbia	655	Silvertone
299	Sparton	658	Sylvania
300	RCA Victor	660	Bradford
305	Hoffman	663	Zenith
314	RCA Victor	665	Curtis Mathes
320	Sentinel	670	Coronado
323	Magnavox	673	RCA Victor
324	Airline	678	General Electric
327	Capehart	680	Airline
344	Sentinel	683	Philco
346	Philco	685	Packard-Bell
353	RCA Victor	688	Zenith
357	Westinghouse	690	Westinghouse
358	RCA Victor	693	Sylvania
371	Motorola	695	Motorola
378	Raytheon	698	Philco
382	Truetone	700	Airline
383	Admiral	703	Admiral
385	Hoffman	705	Zenith
386	Packard-Bell	708	Magnavox
388	Silvertone	710	Magnavox
399	RCA Victor	713	Silvertone
412	Emerson	715	Setchell-Carlson
433	RCA Victor	716	Truetone
437	Westinghouse	717	Penncrest
459	RCA Victor	719	Emerson
495	Admiral	721	Motorola
517	RCA Victor	722	Zenith
540	Admiral	724	DuMont
546	Packard-Bell	726	Coronado
565	General Electric	727	Muntz
576	DuMont	729	General Electric
584	Silvertone	731	Olympic
588	Magnavox	732	Electrohome
592	Emerson	734	Andrea
596	Olympic	736	RCA Victor
599	Zenith	737	Catalina
614	Packard-Bell	739	Motorola
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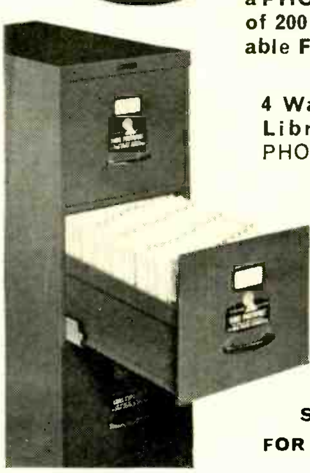

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JOHN FRYE

Today's electronics technician needs a solid foundation in mathematics, and it can be acquired in a variety of ways.

MATH AND THE TECHNICIAN

MATILDA, the office girl, was home nursing a bad cold; so before going to lunch, Barney had brought Mac some sandwiches and coffee in order that the shop might be kept open during the noon hour. When the youth returned, he found his employer still nibbling at a sandwich as he scowled down at a little brown book on the bench before him held open by a slide rule lying across its pages. The assistant technician turned the book over and read the title.

"*Calculus Made Easy*, huh," he said. "If it's so easy, why the knitted-brow bit?"

"That title's a misnomer if I ever saw one," Mac growled. "It starts easy enough, but it doesn't last. Some things just can't be made easy, and I'm convinced calculus is one of them. But the Englishman, Thompson, who wrote this book over fifty years ago has a surprisingly light and modern style; and I like his thesis printed on the flyleaf, which he gravely claims is 'an ancient Simian proverb.' It goes: 'What one fool has done, another can.' After taking several weeks to chew my way through the first half of the book, I'm not so sure."

"How come you're on this math kick? Do you plan to use it in our work?"

"That's part of it. Every technician must use some math, even if it's no more than the addition required to total up a customer's bill or to find the total resistance of two resistors hooked in series. But I'll not say a person couldn't become a reasonably good technician—at least in the past—with no more math than basic addition, subtraction, multiplication, and division *if*—and this is a big *if*—he obtained enough experience in a narrow field of service work. In a very real sense, practical mathematics is actually generalized experience reduced to a convenient shorthand."

"Hit me with that again, Big Daddy; I don't quite dig."

"Keep up that out-dated jive talk and I'll hit you with something else," Mac warned. "What I mean is that scientists study many, many measurements of an electrical or electronic phenomenon until they evolve a general law or formula that applies equally to all the results tabulated. Then the next time they encounter a similar situation they do not have to make the careful measurements of all phases of the phenomenon. They simply apply the formula and come up with the same answer they would have gotten if they had done all the measuring."

"How can a technician substitute experience for math?"

"Let's take an example. You know from experience a 10-365 picofarad variable capacitor with the proper coil will tune the broadcast band. If called upon to supply a capacitor to do this job, you simply apply your knowledge. But suppose you want to know what capacitor to use with a given inductance to tune from 1.7 to 4 megacycles. It's doubtful you would know the answer from experience. The person who must depend on his experience is like a mechanic who has made himself a large supply of end-wrenches, each designed to turn a certain size nut the mechanic has encountered in the past. As long as he runs into no new-type nuts, he's OK; but if he encounters a nut for which he has no wrench, he's in trouble. Math is a kind of crescent wrench that can easily be adjusted to fit a tremendous variety of nuts—old and new.

"In the case we were talking about, the technician who knows his math would simply plug the inductance value and the specified frequencies into a resonance formula and come up with the maximum and minimum capacities needed to tune the required range. And he could do exactly the same thing for any other specified range and value of inductance."

"I'd just get out my nomogram for inductance, capacitance, and reactance and solve the problem with a straightedge," Barney said smugly.

"Good!" Mac exclaimed. "That brings up a point I was going to make. The technician who doesn't have a good math background and who hates to work with formulas can still benefit from 'quick-frozen' math in the form of nomograms, charts, tables, graphs, etc. ELECTRONICS WORLD has published many of these, and you can round up others dealing with a variety of quantities: db *vs* voltage, current, and power ratios; centigrade *vs* Fahrenheit temperature readings; transformer-turns ratio *vs* impedance match; s.w.r. *vs* the ratio of forward and reflected voltage; inductance *vs* turns and diameter of single-layer coils; powers and roots of numbers; etc. There's absolutely nothing wrong with using these 'pictorials of formulas,' but you do have to have the proper nomogram or graph available where and when you need it. Fortunately several different publishers have quite recently brought out compilations of specialized electronic data which they variously call an 'electronics data handbook,' a 'handbook of electronic tables and formulas,' or something similar. We have three of these on the shelf, and I'm glad to see you referring to them quite often."

"Yep, I like these books. They contain practically all the reference material I frequently need: everything from resistor and capacitor color codes to logarithm tables, from neon- and dial-lamp characteristics to fractional db tables. However, I must admit they also include a great many formulas that still require some figuring."

"Right, and sooner or later the good technician feels a need for at least enough math to cope with these formulas. That means he needs algebra, the backbone of mathematics. With it, he need only remember a formula containing several different variables *in one form*. Algebra will permit him to re-write the formula to produce any unknown in terms of other known variables. For example, if he remembers $I=E/R$, he immediately knows that $E=IR$ and $R=E/I$."

Mac paused to light his pipe and then continued: "I said I was studying math partly with the idea of using it as a tool in our work, but math is much more than that to the electronics technician. It is both a means of clear and concise communication and a key to understanding with regard to electronics. The math-oriented technician can grasp new developments in his field much more quickly and completely than can the fellow who tries to understand the new device by means of imperfect analogies and his own experience. Now I'm not saying a really intelligent person with a good imagination cannot eventually grasp the basic idea of any complicated electronic phenomenon without reducing it to mathematical terms; I'm simply saying the phenomenon can be explained and understood much more easily when both the explainer and the student understand math."

"I imagine an electronics engineer trying to explain something to a person with no knowledge of math feels as impatient and frustrated as we do when some kid comes in here and wants us to show him how to 'hook up' a simple receiver," Barney suggested. "We start drawing a schematic diagram, but that means nothing to him. We have to settle for an awkward pictorial showing wires running between so many 'black boxes' as far as any indication of their function is concerned."

"Precisely!" Mac applauded. "That's why I say math deepens and strengthens the technician's understanding of electronics. A sine wave of line voltage displayed on a scope is just a recognized shape to a person with no mathematical knowledge. The trigonometry student knows why it is called a sine wave. He understands how the rotating generator armature creates a reciprocating voltage that, stretched out by time, becomes the figure on the scope face. The student of analytical geometry sees clearly that the trace is actually the equation for a sine wave displayed as a graph. The calculus student can calculate the power contained in the wave."

"What branches of mathematics do you think are most important for the electronics technician?"

"That's tough to answer because different branches of mathematics depend on one another. You need trigonometry to understand color circuits and to work with vector quantities, but trig depends in various degrees on geometry, algebra, and analytic geometry; so I'd say the serious technician needs a good grounding in at least these four branches. With these under his belt, he can easily take on some differential and integral calculus that will be of tremendous help in dealing with wave shapes."

"It sounds to me as though you're trying to make an engineer out of our poor old technician," Barney objected.

"Candidly, 'our poor old technician' is going to have to think and act more and more like an electronics engineer in the future," Mac answered. "As the equipment on which he works becomes more complicated and sophisticated with each passing day, his knowledge and understanding must keep pace."

"Where's he going to get this knowledge of math if he didn't get it in school?"

"Fortunately math is a subject that lends itself very well to self-instruction. If an old codger like me can teach himself college algebra, trigonometry, analytic geometry, and calculus, anyone can. All you need is a clearly written textbook with lots of illustrations and examples and with a great many exercises having answers in the back of the book. When you understand a principle, you work the exercises until you get the right answers. You won't need a teacher to tell you how you're doing."

Mac picked up the slide rule and ran his fingers fondly over its polished surface. "This thing has been a tremendous help to me in my do-it-yourself math instruction," he said. "It takes away most of the calculating drudgery that discourages many with math and allows me to concentrate on interesting principles. The rule's accuracy of one part in a thousand is more than sufficient for electronic problems where we're usually dealing with components having a plus-or-minus 10% tolerance."

"Lots of guys buy rules but soon quit using them," Barney offered.

"I suspect that's partly because the rules they buy are cheaply made and too simple. If a rule is hard to operate and has only a half-dozen scales and a four- or five-page manual, about all you can learn to do with it is multiply and divide, and you soon become bored. This Log Log Duplex Decitrig® rule has twenty-one scales and a 126-page manual expressly written for study without a teacher. If I ever learn the *how* and *why* of everything that can be done with it, I'll have a good math foundation right there. The rule is wonderful for solving equations or applying formulas, for working with decibels or vector quantities, for raising numbers to any power or extracting any root, for working with trigonometric functions, and for doing anything that can be done with a set of log tables—both common and natural. A good slide rule is as much a teacher as it is a tool."

"I guess you're saying math is a medicine that can be had in several different forms, according to your ability to take medicine," Barney mused; "but the serious technician has to down some of it, one way or another!" ▲

"Let me get this straight . . . It works better with daisies on it than it does with roses, right?"

Choosing a CCTV Camera

(Continued from page 52)

8. **Physical Considerations.** Cameras vary in weight from several pounds to dozens of pounds. If the camera is to be operated while being hand-held as might be the case in a remote outdoor pickup for video taping or microwave re-transmission, weight and size are important. There are cameras with separable vidicon and lens assemblies; being contained in housings separate from the main chassis. Thus, the cameraman is equipped with an easily portable "camera" connected by flexible cable to the signal generator and amplifier boards.

An additional and important consideration in camera selection is the application in which a large number of cameras and a larger number of monitors are used. In such applications it is vital that a central or master generator be provided to feed synchronizing information to all cameras and monitors simultaneously through a common bus. This eliminates a potentially enormous problem of maintaining sync among all cameras and monitors as cameras are switched in and out of the distribution system. This is mentioned because of the common practice of incorporating sync generators within the circuitry of CCTV cameras.

These, then, are the most important considerations for the man who must specify a make and model for a CCTV system camera. The cold facts of economics and equipment costs can only be evaluated by the individual most familiar with those aspects of his requirements. However, to specify a camera on the basis of price alone invites the probability of dissatisfaction with system performance—the intolerable result of "economy at any cost." ▲

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KinTel Division
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Continental Electronics
Subsidiary of Ling-Temco Vought, Inc.
Box 5024, Dallas, Texas

Craftsmen Instrument Labs., Inc.
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Woodside, Long Island, New York

Dage Television Company
Division of Harvey-Wells Corp.
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Electra Megadyne Inc.
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Electro-Visual Products Dept.
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Technical Products Operation
212 W. Division Street
Syracuse 3, New York

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15191 Bledsoe Street
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714 North Brookhurst Avenue
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North American Philips Company
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230 Duffy Avenue, Hicksville, New York

Packard Bell Electronics
1920 South Figueroa Street
Los Angeles, California

Radio Corporation of America
Broadcast & Communications Products Div.
Camden, New Jersey

Sarkes Tarzian Inc.
Broadcast Equipment Division
East Hillside Drive, Bloomington, Indiana

Sylvania Electric Products Inc.
730 Third Avenue, New York, New York

Video Systems of America, Inc.
445 Park Avenue, New York, New York 10022

Scientific Computers

(*Continued from page* 35)

presupposes that the computer has been previously programmed to perform the translation to machine language. This translator program is known as a *compiler*. Of particular interest in scientific computation is the FORTRAN compiler (from FORmula TRANslator). FORTRAN has been described as the most widely used programming language in the world, and its great popularity derives from the close resemblance of its source language to ordinary mathematical notation. Some source language symbols for mathematical operations are: for addition, (+); for subtraction, (−); multiplication, (*); division, (/); exponentiation, (**).

Thus, for example, a mathematical expression like: 6.28 divided by the quantity $(1-XY^3)$ is written in FORTRAN this way: 6.28/(1.−X*Y**3).

It can be seen from the above example that an engineer or scientist with little knowledge of computers can easily become proficient in writing FORTRAN programs. He can therefore communicate directly with the computer without requiring the services of an intermediary programmer. It is this ease of programming that accounts for the widespread and rapidly increasing uses of digital computers in scientific applications. ▲

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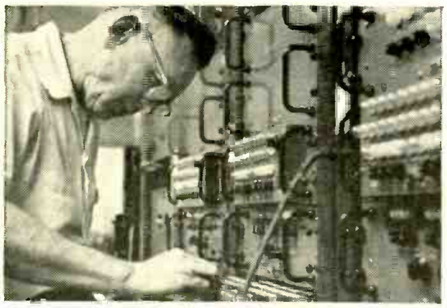

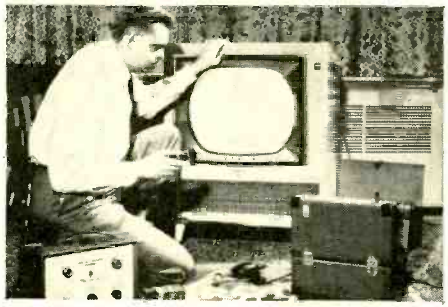

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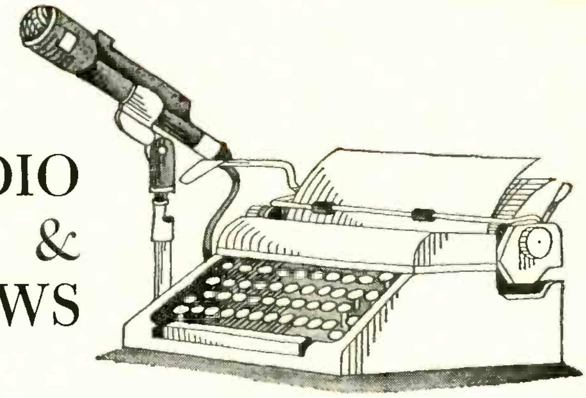


THE EIA has formally asked the Treasury Department to urge legislative repeal of the manufacturer's excise tax on radio and TV receivers, phonographs, and their components.

Besides seeking complete repeal of the excise tax at the earliest possible date, the EIA urged the Treasury Department to recommend that Congress enact legislation providing for floor-stock refunds of excise levies paid on radios, TV sets, and phonographs already off the production line to prevent any lull in sales while the proposal is being considered by Congress.

Similarly, EIA asked in a separate suggestion that the Treasury Department urge Congress to authorize income-tax credits to consumers who have purchased taxable sets and components retailing for the price of $100 or more.

The EIA claims that TV, radio, and phonographs are no longer luxuries, but are essential to daily living.

Projection Radar

A marine radar system which presents information in the form of a bright, stable picture, 27 inches in diameter on a flat, paper-covered surface suitable for plotting is being produced by a British firm.

In the system, called "Photoplot," the basic radar information is displayed in the normal way on a CRT. The display is photographed on a special 16-mm. film, processed in a few seconds, then projected on the underside of a translucent screen. The chemicals used for processing the film are blown on to it by a blast of compressed air in a pre-arranged sequence.

Targets are presented in black against a white background to form a picture that can be studied by several observers at the same time under both daylight and night conditions without the use of a viewing hood or visor.

The time interval between successive projected pictures can be set to 15 seconds, three minutes, or six minutes, according to the desired plotting requirements. In this way, the rotating trace of the radar present-position indicator is replaced by a picture in which all radar echoes, on all bearings, are seen at their maximum contrast at all viewing times.

The first shipborne display was installed on the 45,000-ton passenger liner "Canberra" of British registry.

Digital Voltmeter

A unique method of digitizing resistance measurements so that the value of an unknown resistor can be transmitted by telemetry has been developed by engineers at Goddard Space Flight Center.

The resistance to be determined is part of the not-known leg of a Wheatstone bridge. The bridge is then automatically nulled by adding binary values of resistance in series with the known leg.

A parallel digital word representing the unknown resistance is given by the state of the reed switches controlling the binary balancing resistance. Absolute accuracy of .05% has been obtained. Although a 20 cps clock frequency has been used, other, higher frequencies are possible.

The researchers conclude that proper application of this basic scheme will result in a system of outstanding accuracy, coupled with high efficiency and inherent reliability.

Portable Antenna Mast

Troops in the field, particularly in a jungle environment, would be very hampered if they had to haul 10-, 20-, or 30-foot sections of metal antenna mast with them. Yet, many a tactical situation can develop where a patrol or advance party will require a very high antenna mast to overcome terrain obstacles such as foliage or distance to communicate with their base or other groups.

Kearfott Div. of General Precision, Inc. has developed a line of 50- and 100-foot inflatable antenna masts that can be folded into small, lightweight packages. These self-supporting Mylar air-column structures are capable of retaining low-pressure air for at least 48 hours.

Pumps, gas-pressure cylinders, or plain old-fashioned huffing and puffing can be used for inflation.

By using conductive laminate on the upper section of the mast, the mast itself can be made to act as an antenna. When properly guyed, the 50-footer can withstand winds up to 50 m.p.h. ▲

REDUCING RECTIFIER INTERFERENCE

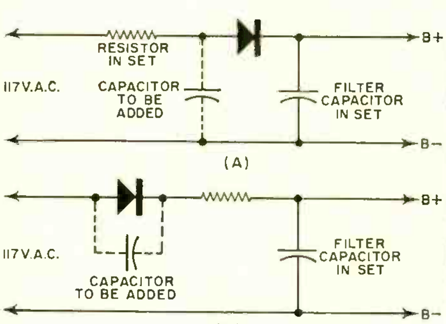
By GEORGE SCHERER

CARRIER-current communications systems, where r.f. energy is carried by the a.c. power line, are often subject to varying degrees of hum modulation of the carrier, often in the form of a buzzing sound, when other electronic equipment using line-connected rectifiers is operated from the same power line. Such interference can also disturb other electronic equipment.

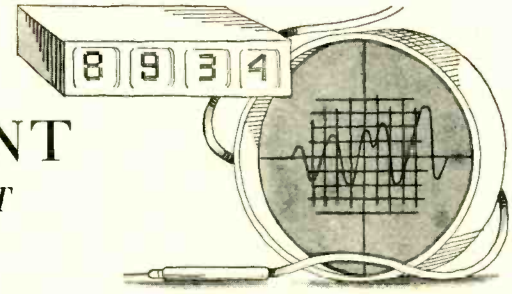
Silicon rectifiers are more likely to cause this trouble than are selenium or vacuum-tube rectifiers.

To remove such interference, a low-valued resistor should be placed in series with the rectifier (on the power-line side), and the side connected to the rectifier should be bypassed. The resistor should be between 10 and 47 ohms, ½ to 2 watts, depending on the drain of the unit. The lowest resistance and highest wattage should be used on a TV set, while the highest resistance and lowest wattage should be used for a one- or two-tube accessory. The bypass capacitor should be between .02 and .05 μf., preferably paper or plastic with a 600-volt rating.

Often, use can be made of existing circuitry. For instance, almost all half-wave rectifier TV sets and many a.c./d.c. radios have surge-limiting resistors in series with the rectifier. These resistors usually are similar to those specified in the preceding paragraph. If this resistor follows the rectifier, it should be removed and placed on the power-line side as shown in (A). Then, only the bypass capacitor need be added. In other circuits, there may be a larger valued resistor in series with the rectifier (B) to drop the voltage as well as limit current surges. If this resistor is 220 ohms or more and is ahead of the first filter capacitor or other bypasses, it is only necessary to connect a .02- to .05-μf. capacitor across the rectifier to reduce interference. ▲



TEST EQUIPMENT
PRODUCT REPORT



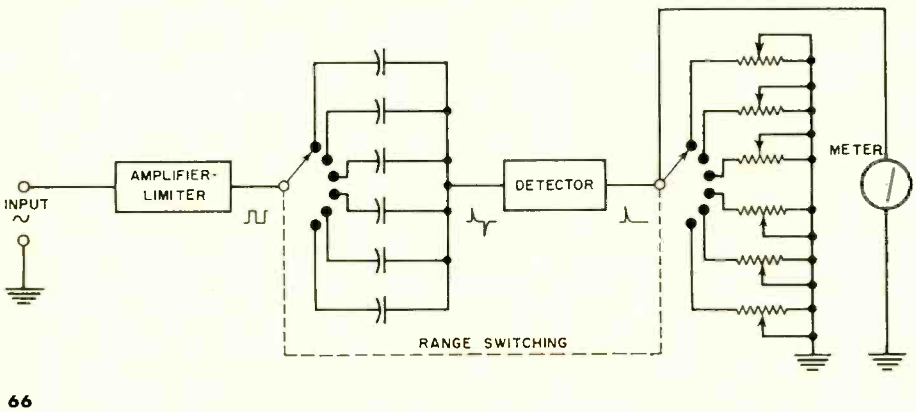
Electronic Research Frequency Meter

For copy of manufacturer's brochure, circle No. 65 on coupon (page 88).

A DIRECT-reading solid-state frequency meter has been announced by *Electronic Research Co.* The instrument measures the frequency of signals in six ranges from 10 cps to 200 kc., with each range individually adjustable for accurate calibration. Accuracy of the unit is 2% on all ranges. An output jack on the front panel permits connection of high-impedance phones or a scope for monitoring. Recorder output is available on request.

The meter was originally developed by the company for internal use in the production of piezoelectric crystals. By measuring the beat or difference frequency between a known standard frequency and that of a crystal unit being processed, it is possible to metal-plate the crystal through vacuum deposition to within a few cps of the standard. The meter is now being made available by the manufacturer for either a.c. operation (117 volts, 4.5 watts) or battery operation (12 volts, 25 ma.).

The input signal of unknown frequency is applied to a two-stage amplifier which drives a limiter stage to deliver a high-level square-wave output. Since rise time of the square wave is dependent on the amplitude of input signal at low levels, sampling circuits select the lower 20 percent of the limited waveform for coupling to the frequency discriminating circuit. This technique lowers the minimum input-level requirements for accurate frequency measurement. For example, any voltage input above 50 or 100 mv. r.m.s. (depending on frequency range to which the instrument is set) will produce an accurate frequency indication on the meter. Maximum input voltage is 100 v. r.m.s. on all ranges.



The frequency discriminator (detector) circuit converts differentiated, or sharply peaked, pulses into unidirectional pulses which are then applied to the metering circuit. Note that the final pulses have a constant width regardless of frequency. The output energy per unit time is now a function of input frequency only. The meter displays the time-averaged detector output directly in cycles per second.

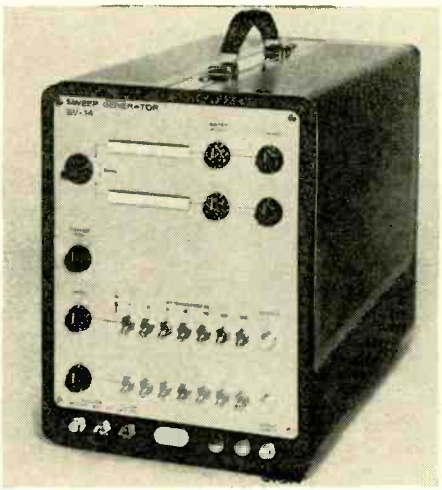
The frequency meter is available at a price of $149.50. ▲

Telonic SV-14 FM-Tuner Sweep Generator

For copy of manufacturer's brochure, circle No. 66 on coupon (page 88).

A NEW sweep generator for aligning FM tuners, Model SV-14, has been introduced by *Telonic Industries, Inc.* This instrument is designed for all phases of FM-radio manufacture—laboratory design, production testing and adjustment, and quality-control inspection. The SV-14 operates over the 98-mc. (r.f.) and the 10.7-mc. (i.f.) bands, which are selected by a front-panel switch.

Both r.f. oscillators are swept electrically by means of a saturable reactor. Separate attenuator systems and output connectors are provided for the two bands. This permits the full range of adjustments (r.f., local oscillator, and i.f.) to be made quickly without reconnecting cables to insert external attenuators. The simplicity of operation of the sweep generator saves time in production and inspection setups. One hand can be used for bandswitching and tuning while the other works on circuit alignment and adjustment.



Crystal-controlled pulse markers at customer-specified frequencies are standard equipment. Five markers are provided on the 98-mc. band and three on the 10.7-mc. band. Accuracy of the markers is ±0.05%. Fundamental-mode

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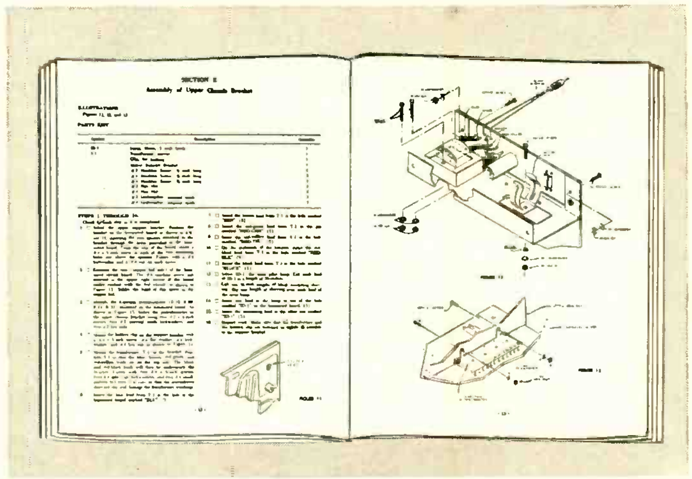

Each sub-assembly is described in a separate section with illustrations applying to that sub-assembly available at a glance. No cross referencing necessary.

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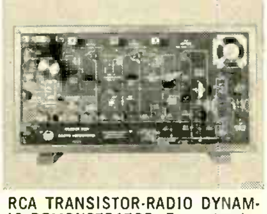
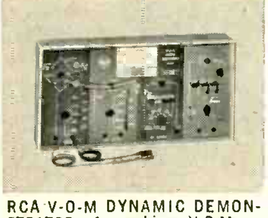


RCA TRANSISTOR-RADIO DYNAMIC DEMONSTRATOR. For schools. WE-93A(K). Kit price: $39.95*



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crystals are used to avoid spurious markers. The markers can be used for internal pulse modulation of the sweep oscillator or for y- or z-axis oscilloscope modulation.

The oscillators are swept electronically by applying a triangular waveform to the control winding of the saturable reactor. The resulting linear presentation on the oscilloscope allows for accurate frequency interpolation between markers.

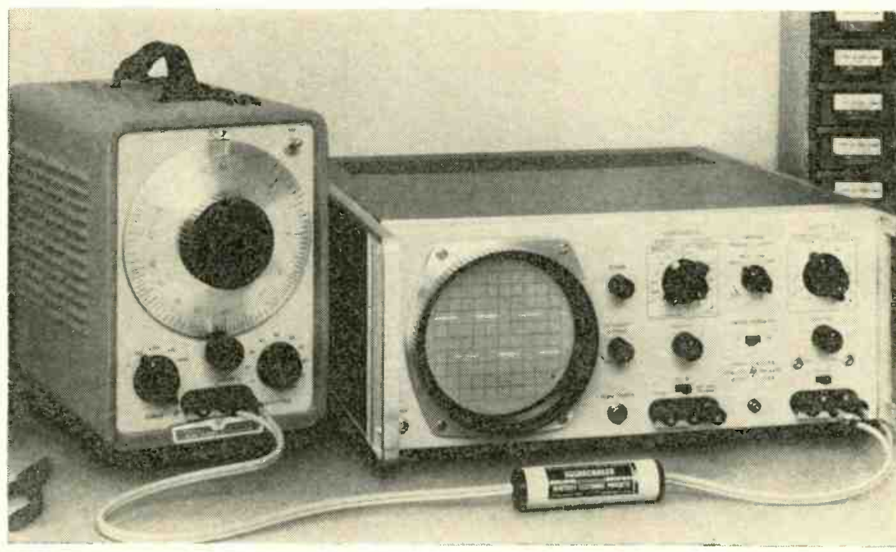
A vernier, which varies the "B+" in the oscillator circuit, controls the output level over a 0- to 10-db range. A toggle-switch attenuator provides another 0-99 db of signal reduction in 1-db steps. All switches and pads are individually shielded to eliminate leakage and to insure accuracy to ±1 db over the full attenuator range.

The SV-14 sweeps over a range of 86 to 110 mc. on the r.f. band and 10.2 to 11.2 mc. on i.f. Sweep width is variable from 4 to 24 mc. (r.f.) and 0.15 to 1.0 mc. (i.f.). Output is 3.5 microvolts to 1 volt r.m.s. into 75 ohms. Sweep rate is at 50 or 60 cps line frequency. Line voltage of 115 or 230 v.a.c. may be selected by means of an internal switch on the instrument.

The sweep generator measures 10½" wide x 13½" high x 18" deep and weighs 35 pounds. The aluminum front panel is gray anodized, with painted case. Price is approximately $750. ▲

Monterey ME-109 "Squaremaker"

For copy of manufacturer's brochure, circle No. 67 on coupon (pages 17 & 88).



THE Model ME-109 "Squaremaker" by *Monterey Electronic Products* is an inexpensive accessory that converts the sine-wave output of an audio oscillator into a fast risetime square wave. The unit consists of a two-stage transistor overdriven amplifier which uses frequency compensation and feedback in order to produce an excellent quality square waveform. Power for the transistor circuit is obtained by rectifying and filtering the sine-wave input by means of a two-diode voltage doubler. The entire circuitry is contained within a one-inch diameter tubular metal housing which is four inches long, with connecting leads. The "Squaremaker" resembles a slightly oversized scope probe.

The output frequency and amplitude of the output square wave are determined by controls on the audio oscillator. A maximum square-wave output voltage of 35 v. (p-p) is obtained with a 25 v. r.m.s. sine-wave input; satisfactory square waves may be obtained with inputs of less than 1 volt.

The risetime is better than 50 nsec. into a 2000-ohm load. The unit can be used over a frequency range from 1 cps to 1 mc., although it starts to show tilt (5%) at 15 cps and slight rounding (5%) at 500 kc. There is no observable overshoot or ringing.

The device can be used to supply square waves for hi-fi amplifier testing. Frequency response and transient performance of amplifiers can be compared quickly with such signals. Also, the unit can be used as a trigger source for operating and testing counters, timers, binaries, trigger, and multivibrator circuits. The square waves can also be employed to check quickly oscilloscope amplifiers. Because of the high harmonic content of the output signals, they can serve as a source of markers on a receiver or scope trace. For example, a 100-kc. input sine wave will produce r.f. calibrating signals every 100 kc. up to beyond 30 mc.

Still another use for the unit is educational. Pulse circuits may be studied and experiments can be performed with differentiators, integrators, clippers, clampers, sweep circuits, computer logic circuits, and industrial control networks.

The "Squaremaker" is available from the manufacturer at a price of $15.95. ▲

Astrovision

(*Continued from page* 43)

items, they are designed to operate from a single-phase, 115-volt, 60-cps power line. Our jets have an electrical generating system rated at 160 kva., 115/200 volts, three-phase, four-wire, 400 cps. A total demand of less than 500 watts in the video system dictated the use of a 400-cps to 60-cps converter rather than a redesign of the equipment for 400-cps use.

The converter was designed for this application by the *Unitron Corporation*. The converter is a static, silicon-rectifier, transistor-controlled device, operating on a three-phase, 200-volt, 400-cps input and producing a single-phase, 117-volt, 60-cps sine-wave output. Early experience indicated that a sine-wave power supply would be necessary for optimum performance from the recorder, although it did operate well on a square-wave input. The camera was completely unacceptable when used with a square-wave power supply.

The most difficult problem faced by the converter is the initial surge load caused by starting the recorder. This starting load is practically indistinguishable from a short circuit as far as the converter is concerned. It appears to be due to the large number of filter capacitors used in the recorder. An internal protective circuit occasionally prevented starting of the system during initial tests. It was determined that a time delay on the protective circuit would be required. A single flip-flop circuit allows the converter to feed an overload for two seconds. If the overload has not disappeared, the circuit is interrupted for two seconds, then automatically reinstated for another interval.

Stereo Audio System

Music is produced from two stereo tape reproducers, amplified, and distributed through shielded conductors to jacks at each passenger seat. The passenger is provided with an acoustic headset made of lightweight plastic in a stethoscope arrangement. The headset is connected by plastic tubes to a compact control unit containing two audio transducers and an individual volume control for each transducer. The control unit has a short lead terminating in a three-conductor phone plug which may be inserted in any one of the three jacks available to each passenger.

The stereo tape reproducer and amplifiers were built for this application by the *Gables Engineering Company*. The tape reproducer is basically an extension of the monophonic tape machine that has been in use on our jets for some time. The mono music was fed to the overhead speakers of the ship's p.a. system and was generally used on the ground. In the stereo version, a four-channel tape is used at a speed of 3¾ inches per second.

Unlike the conventional stereo tape player with two pickup heads that requires the tape reel to be removed and turned over, the *Gables* machine has four pickups, one tracking each channel on the tape. This allows continuous playing, with only a momentary interruption at the end of a reel due to reversing the direction of the motors and switching to the appropriate pickup head. The tape reproducer contains the preamplifiers, power supply, and the control and switching relays. Modular construction and solid-state circuits keep the physical size to a minimum.

The unit is mounted on a standard aircraft rack and is located in the electrical and electronics compartment of the aircraft below the cockpit floor, but in a pressurized area. Since these units were specifically designed for aircraft use, they operate on 400-cps power directly from the airplane's electrical system. The preamplifier output is routed to two amplifiers also located in the electrical compartment. Each amplifier is rated 40 watts at 1000 cps. Provisions are made for three audio inputs, two microphone inputs, and one music input. This allows the amplifier to be used as a stereo system amplifier or as a public-address system amplifier. The nominal music input level is 0.07 volt for rated output. The frequency response of the amplifiers is 100 cps to 10 kc. with a variation of not more than 4 db.

Aircraft safety requires that the captain be able to communicate with the passengers at any time. Normally this is accomplished by a public-address system. However, since the passenger might have a headset on and be listening to either of the two stereo systems or the television audio system, the captain's p.a. announcements must be switched into these three audio channels on a first-priority basis. In the case of the two stereo systems, this was relatively simple due to the audio amplifiers already having priority relays built in such that the microphone input overrides and cuts out the music input. For the television audio system it was necessary to add the priority relay in the ship's wiring system. This relay was installed in the circuit between the video tape recorder output and the audio distribution amplifier.

There is one additional feature of the music system that compensates for the removal of the old mono tape player. A relay controlled by the stewardess can switch stereo system #2 into the cabin overhead speakers. This allows the continued practice of having cabin music while passengers are deplaning or boarding. ▲

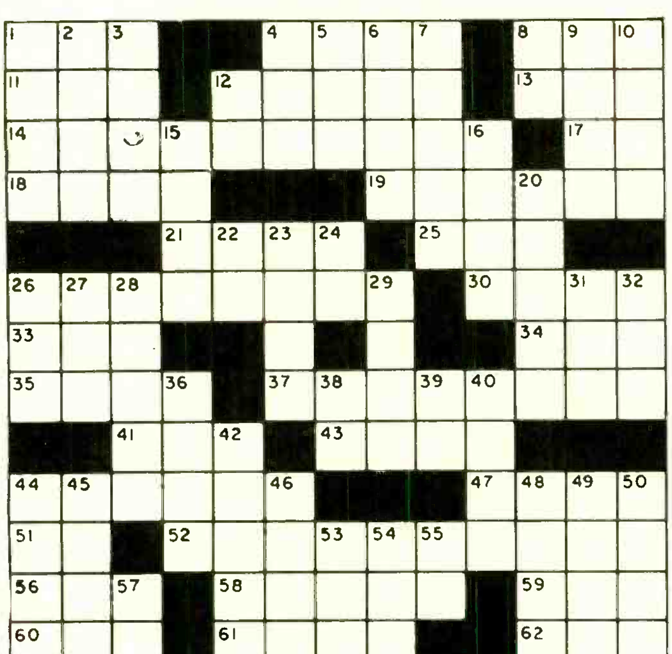
ELECTRONIC CROSSWORDS

By JAMES R. KIMSEY

(*Answer on page* 95)

ACROSS
1. To damage the surface.
4. Makes lace.
8. Hotel.
11. Raw metal.
12. "- - - - - amplifier," the stage feeding the antenna in a transmitter.
13. Enemy.
14. Insulating material between any two parts of an electronic unit.
17. An element (abbr.).
18. "- - - - currents," sometimes called Foucault currents.
19. Not closed.
21. Wood file.
25. Ticket situation at hit show.
26. Commonly the stage or circuit in a radio set that demodulates the r.f. signal into its audio or video component.
30. Always.
33. Organ of hearing.
34. Part of "to be."
35. Small upright support in wall framing.
37. An optical illusion which makes an object appear displaced when viewed from a different angle.
41. Female relative (slang).
43. Semiconductor type.
44. Property.
47. Auction.
51. A 10- or 12-inch, 33⅓ record (abbr.).
52. A solid-state device made from semiconductor materials.
56. Beret.
58. Native ruler in parts of Asia (var.).
59. Broad sash worn with a Japanese kimono.
60. Single unit.
61. Partially carbonized vegetable tissue.
62. Homo sapiens.

DOWN
1. A microwave term specifying the type of oscillation occurring in a waveguide, cavity, or tube.
2. Dry.
3. Vibrating wood sliver.
4. Muscular twitch.
5. Social insect.
6. Tropical plant.
7. Missteps.
8. Lower than r.f. (abbr.).
9. Musical tone, in writing.
10. Require.
12. Element (abbr.).
15. Musical instrument.
16. Area on bird's bill.
20. Miniature receiving tube having nine pins.
22. Type of current (abbr.).
23. "- - - - -up transformer," a transformer in which the secondary winding has more turns than the primary.
24. Radioactive element (abbr.).
26. "- - - Moines."
27. Consume.
28. Secure tightly.
29. Not common.
31. Period.
32. Masculine name.
36. Calorie counting.
38. The common system of radio broadcasting (abbr.).
39. Coin of the ancient Roman republic.
40. Young girl (Scottish).
42. A wire connected between segment ends in the anode of a cavity magnetron to promote operation in the desired mode.
44. Female voice range.
45. Space between two consecutive points of support in a conductor or cable.
46. Identical.
48. Smallest unit of any chemical element.
49. One of the loops in the radiation pattern of an antenna.
50. Ireland (poetic).
53. Educators' association.
54. To place a binary cell in the "1" state.
55. "- - drop," the voltage drop produced across a resistance by the flow of current through it.
57. Pronoun.



Electronic Timers

(*Continued from page* 41)

this reason, timing capacitors should be chosen for a very low dielectric-absorption characteristic to avoid degrading the timing network.

Electronic timing control is particularly suitable as a protective measure in the automatic metal stamping operation of small punch presses. Machines of this type operate at very high speeds and are subject to jam-up and buckling if the stampings are not ejected according to a preset time schedule. In the arrangement shown in Fig. 6, raw metal stock is continuously fed to the die of the machine and cut by the up-down stroke of a ram. As the stampings are punched out, microswitch S1 (normally open) is positioned so that its contacts close only when the actuating lever falls into one of the pilot holes. The switch functions as an initiating means to energize timer 1, which is adjusted so that the time delay is slightly longer than that required to pull in the relay. If the machine functions properly, the timer resets each time the control switch is actuated, and the motor is continuously energized through the normally closed contacts of the relay. If the switch remains closed for a period of time after the preset delay has elapsed (due to jamming or defect of the machine), the timer continues to cycle and the relay is energized. This action disconnects power from the motor, which shuts down the machine and simultaneously activates a warning alarm.

Automatic ejection of the stamped parts is accomplished by means of short blasts of compressed air. As the ram completes its up-stroke, limit switch S2 momentarily closes and initiates timer 2. After a preset interval, timer 2 energizes the solenoid-operated air valve, and the resulting air blast ejects the completed parts in the proper sequence.

Timing controls are also widely used in plastic molding processes to coordinate an entire cyclic operation involving electrical, hydraulic, and mechanical functions. In the simplified automatic injection molding machine shown in Fig. 7, granular plastic material is placed in a hopper and fed in measured amounts to a heating cylinder. There it attains a fluid consistency under constant temperature conditions. When the safety gate is manually closed, limit switch S1 is tripped and timer 1 is energized to initiate the over-all cycle of the molding process. Timer 1 actuates the solenoid of valve 1 which causes the valve spool to shift and admit hydraulic fluid (not shown) to the blind section of the closing cylinder. The hydraulically operated piston causes the mold to close, and when the faces of the molds meet, limit switch S2 is tripped to energize timer 2.

Timer 2 actuates the solenoid of valve 2 which causes the valve spool to shift and admit fluid to the blind section of the injection cylinder. The piston moves the plunger forward and forces the molten plastic through a nozzle into the mold cavities. After a preselected time interval, timer 2 completes its cycle, the spool of valve 2 is spring-returned to its original position, and fluid is now admitted to the rod section of the injection cylinder. During this period of time, the material in the mold is allowed to solidify and after a predetermined cooling period, timer 1 completes its cycle. The solenoid of valve 1 is de-energized and the valve spool is spring-returned to admit hydraulic fluid to the rod section of the closing cylinder. This action allows the mold to open and the completely solidified object is ready for ejection. In applications where it is necessary for the injection plunger to advance and return several times in succession in order to compact the plasticized material, an additional reset timer, or stroke counter, may be incorporated in the process.

The aforementioned examples represent only a few of the many different combinations of timing systems available for automated industrial processes. In most applications, timing units serve as the basic building blocks for such systems; and since there is a lack of standardization in this field, new systems must be designed for each particular requirement. ▲

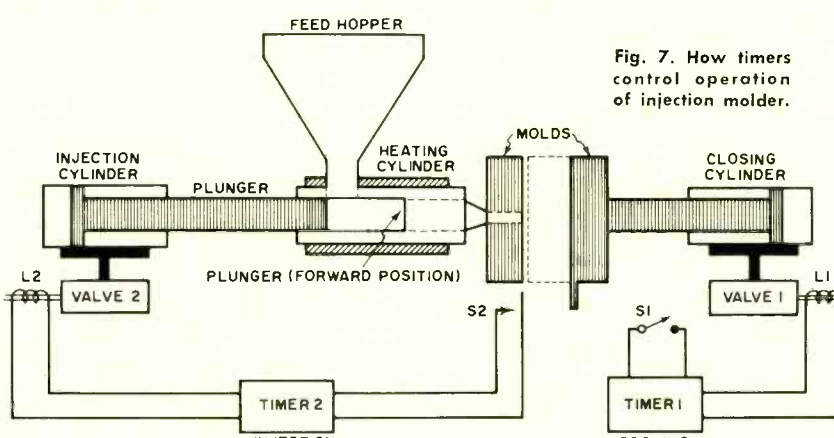


Fig. 7. How timers control operation of injection molder.

TRANSISTOR TESTING WITH AN OHMMETER

Resist the temptation to check transistors with an ohmmeter until you have read this item.

An ohmmeter can be an invaluable aid in the servicing of transistorized equipment, but it can also be a source of concern. The ohmmeter can be used to locate opens and shorts in transistors and, with a little experience and/or the use of comparative readings, can be used to check for abnormal readings.

If the meter polarity is known, the transistor type (*n-p-n* or *p-n-p*) can be determined quite rapidly from the ohmmeter. Since base-to-emitter and base-to-collector forward bias resistances are comparatively low, the type of base material (*n*-type, or *p*-type) can be readily identified by making forward and reverse bias readings between each pair of elements and assigning probe polarity to the element (base) that produces low value readings to the other two.

Before attempting to test a transistor with an ohmmeter, be sure that the voltage across the meter test probes does not exceed the maximum voltage ratings of the transistor, and that the series resistance of the meter is sufficient to limit the current through the junction under test to a safe value. When the maximum voltage ratings of the transistor are not available, refer to the schematic of the device being serviced to obtain the d.c. operating voltages which should be below manufacturer's maximum ratings.

Since the voltage and current ratings of many transistors used in home entertainment equipment are quite small, it is considered good practice, when testing these units, to use a 20,000-ohms-per-volt meter supplying not more than 1.5 volts across its test probes, and the use of the "R×100" scale to insure sufficient series resistance to limit junction current to values well below the maximum ratings of the unit being tested.

In no case should a meter containing a battery with a voltage rating exceeding 15 volts be used without the addition of a series resistor to protect the transistor from accidental damage.

This article does not constitute a recommendation for the use of an ohmmeter in lieu of a quality transistor checker, but is intended to prevent transistor damage when using an ohmmeter as a "go/no-go" transistor tester when reasonable precautions are taken.

The above information is from *G-E "Audio Notes."* ▲

HIGH-"Q" DETECTOR and NOISE-LIMITER SYSTEM

By RONALD L. IVES

A communications receiver circuit that results in improved selectivity and good impulse-noise limiting.

DESPITE its simplicity and wide acceptance, the familiar diode AM detector has many faults when used alone, and involves a large number of somewhat unhappy compromises when combined with an a.v.c. circuit and noise limiter. Chief among these faults, and the only major one which cannot be evaded by some expedient compromise, is the loading of the last tuned circuit by the diode and its attendant components. This has the same effect as a shunt resistance across the coil, lowering its effective "*Q*" and making it tune broadly.

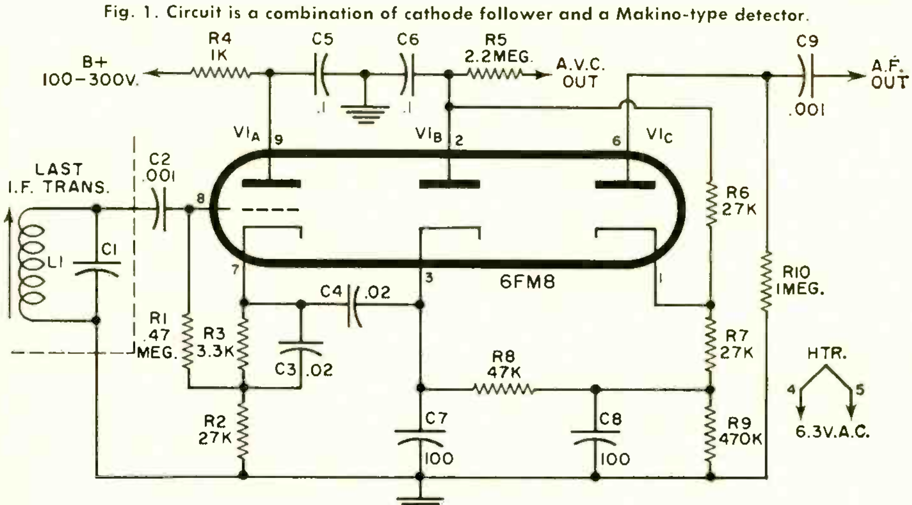
Although other detectors, such as the infinite-impedance type, have been proposed to eliminate this trouble, they do not, in general, permit easy derivation of an a.v.c. voltage; and many of the special detectors, despite their proven merits when used alone, are not easily compatible with standard impulse-noise limiters. In unhappy consequence, most receivers still use the diode detector, with all its faults.

With the increasing need for greater selectivity on all bands, and the proliferation of industrial-type noise in areas that only recently were orange groves or barren desert, need for an improved detector—noise-limiter system has become critical. Happily, both of these needs can be met by a simple combination of a cathode follower and a Makino-type detector, as shown in Fig. 1. This combination eliminates the diode loading on the last tuned circuit by interposing a cathode follower (which is actually a power amplifier) between the tuned circuit and the load, thereby increasing selectivity; and very greatly reduces impulse-type noise, through the action of the Makino-type detector, which also produces a.v.c. voltage.

Operation is as follows: The signal from the last tuned circuit (*L1, C1*) is power amplified in the cathode follower, *V1A*. This is an entirely conventional circuit, operating in a standard manner, and needs no special explanation.

The power-amplified signal is passed on to the rectifier diode (*V1B*) by a medium-sized coupling capacitor *C4*, here .02 μf. The negative signal envelope, through the diode, becomes a charge on *C6*, which supplies a.v.c. voltage to the system. The positive envelope, smoothed by the *RC* network (*R7,R8,R9,C7,C8*), goes to the cathode of the noise-limiting diode *V1C*. As the negative path to the cathode of *V1C* is of considerably lower resistance than the positive path, the

Fig. 1. Circuit is a combination of cathode follower and a Makino-type detector.



cathode is normally negative with respect to ground, and the diode conducts, its plate being returned to ground through $R10$. Variations in this conduction, at an audio rate (the modulation), are passed on to the audio amplifying system by $C9$. Variations at signal frequency are filtered out by the network $C7$, $R8$, $C8$.

Impulse noises, which are steep-sloped "spikes" superimposed on the signal waveform, are "filled in" from $C6$, by conduction through $V1B$, if negative-going, and do not reach the audio output. Those parts of the positive-going noise impulses that pass through the signal frequency filter ($C7$,$R8$,$C8$) reach the cathode of $V1C$ through $R7$, reducing or stopping conduction through that diode. As this signal cut off is of very short duration, the audio frequency effect of impulse noise with this circuit is almost imperceptible.

Despite the apparent "backwards" connection of the rectifier and noise-limiter diodes, this circuit, which is a vacuum-tube version of the Makino detector-noise limiter, performs the requisite detection, a.v.c. generation, and noise-limiting functions exceedingly well.

Constants shown here are for an i.f. of 455 kc., and the circuit, as shown, actually has less distortion than most diode detectors used without a noise limiter. Trouble will be experienced, however, with certain musical passages, as the noise-limiting function will mute the tympani.

Although a 6FM8 tube is specified, the circuit will work just about as well with any reasonable triode-dual diode combination, such as a 6C4 or a 6AL5. If desired, $V1B$ can be replaced by a germanium diode without impairing performance. A silicon diode, which has a "toe" on the characteristics, should not be used here, however.

Circuit constants are not at all critical, and 10% components are sufficiently precise for most installations. When this circuit is installed in a pre-existing receiver, the last tuned circuit will probably need readjusting, as it will now tune much sharper than with a conventional diode detector. If the receiver is unstable, it will be more so with this detector, as the last tuned circuit is now not loaded, and has a considerably higher effective "*Q*."

For most amateur, CB, and commercial phone receivers, this improved detector circuit seems ideal, giving somewhat improved tuning sharpness coupled with excellent impulse noise limiting. For the audiophile, who is interested in wideband tone reproduction rather than maximum speech intelligibility, the circuit is not recommended, as it will unavoidably narrow the bandwidth of the receiver and limit audio impulses, some of which are musically desirable. ▲

Eliminating Impulse Noise

(*Continued from page* 38)

from being heard. When incoming signals are weak, as is often the case in practical communications systems, FM is as subject to impulse noise interference as is amplitude-modulated systems.

The most practical approach to the problem depends, to a large degree, upon system requirements. *General Electric's* two-way FM equipment for commercial use favors the noise-blanker approach, detecting the noise pulse by AM techniques and using the resulting gate signal to blank the pulse from the FM circuits.

Hammarlund's "Outercom" Division, on the other hand, prefers to remove noise by use of the rate-of-change limiter, operating at audio frequency.

Both claim excellent results. In addition to these two approaches, almost any other noise-limiter circuit can be made to work for FM by detecting the pulses at audio frequency and eliminating them at that point in the receiver. ▲

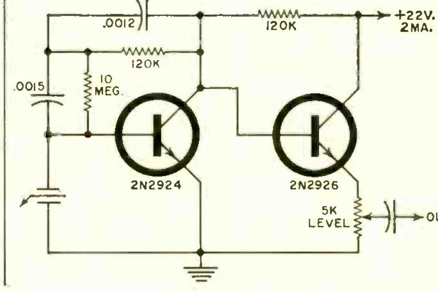
CERAMIC CARTRIDGE PHONO PREAMPLIFIER

THE schematic shown in the diagram, suggested by G-E, gives an RIAA equalized output when used with ceramic cartridges that have 1000 to 10,000 pf. capacitance. Feedback equalization from collector to base lowers the input impedance, which gives the circuit the advantage of accepting a wide range of cartridge capacitance and also makes it less susceptible to cable capacitance effects and noise pickup.

The input impedance, about 30,000 ohms at 40 cps, decreases with increasing frequency. This results in a velocity response from the cartridge, and thus the preamplifier frequency response is like that required for a magnetic cartridge.

Using an Astatic 137 cartridge (7800 pf.) and the London PS 131 stereophonic frequency test record, the output is equalized within 1.6 db from 40 cps to 12 kc. The output reference is 1¼ volts, which is 14 db below clipping and 70 db above the unweighted noise level. The 1-kc. total harmonic distortion is less than .1% at 1¼ volts output.

Using an Astatic 17 cartridge (1000 pf.), the preamplifier output is also equalized within 1.6 db, but about 10 db lower level. ▲



AUTOMATIC DEGAUSSER

Developed by G-E, this degausser works every time set is turned on.

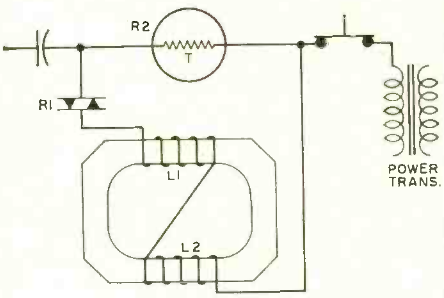
THE automatic degausser circuit used in the latest *G-E* color TV sets is shown in the diagram. The circuit is connected in the secondary of the power transformer. The purpose is to automatically degauss the picture tube shadow mask each time the receiver is turned on from a cold start.

The two coils, *L*1 and *L*2, are assembled on the picture tube shield. One coil is located at the top of the shield and the other at the bottom. The two coils are connected in series so that their fields are in the same direction.

The voltage-dependent resistor *R*1 is made from a special carbon and is a symmetrical (current flows equally well in either direction) and non-linear device which changes its resistance very rapidly with rapid changes in applied voltage (resistance goes down with increased voltage). Although it is a type of resistor, it has the characteristics of two diodes connected as shown.

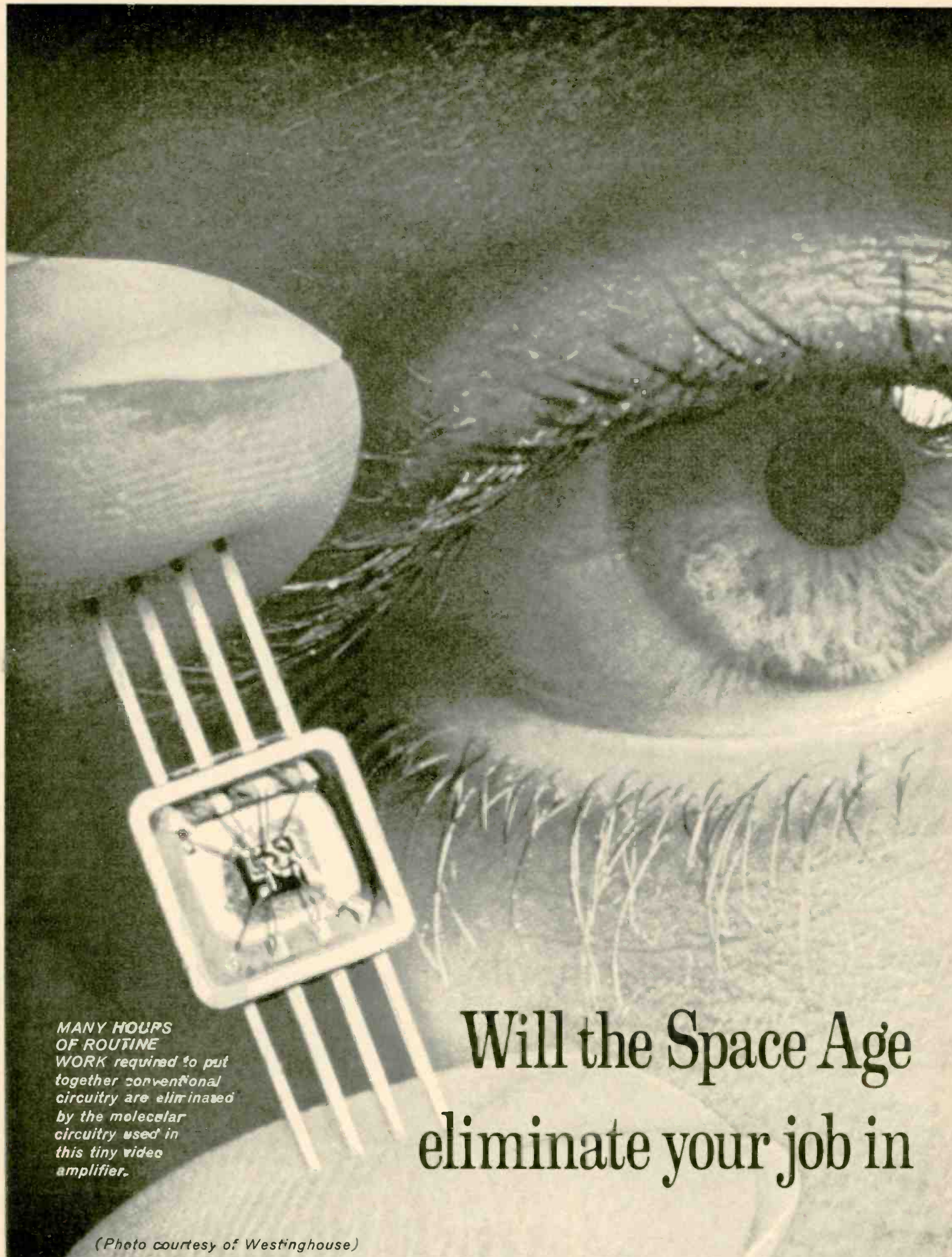
Thermistor *R*2 has a resistance of 120 ohms when cold and 2 ohms when hot.

The circuit operates as follows. At the



instant the receiver is turned on from a cold start, the resistance of *R*2 is high and approximately 60 volts a.c. is present at the junction of *L*1 and *R*1. With this voltage applied, the resistance of *R*1 is very low and approximately 2 amperes flow through *L*1 and *L*2 to produce the maximum a.c. magnetic field at the shadow mask. At the same instant, the current flowing through *R*2 causes it to heat, lowering its resistance and therefore the voltage being applied to the coil-*R*1 circuit. The resistance of *R*2 continues to decrease until it reaches its lowest resistance of about 2 ohms. At this point, the voltage across *R*1 has been reduced to about 1 volt and the current flowing through the coils is about .5 ma.

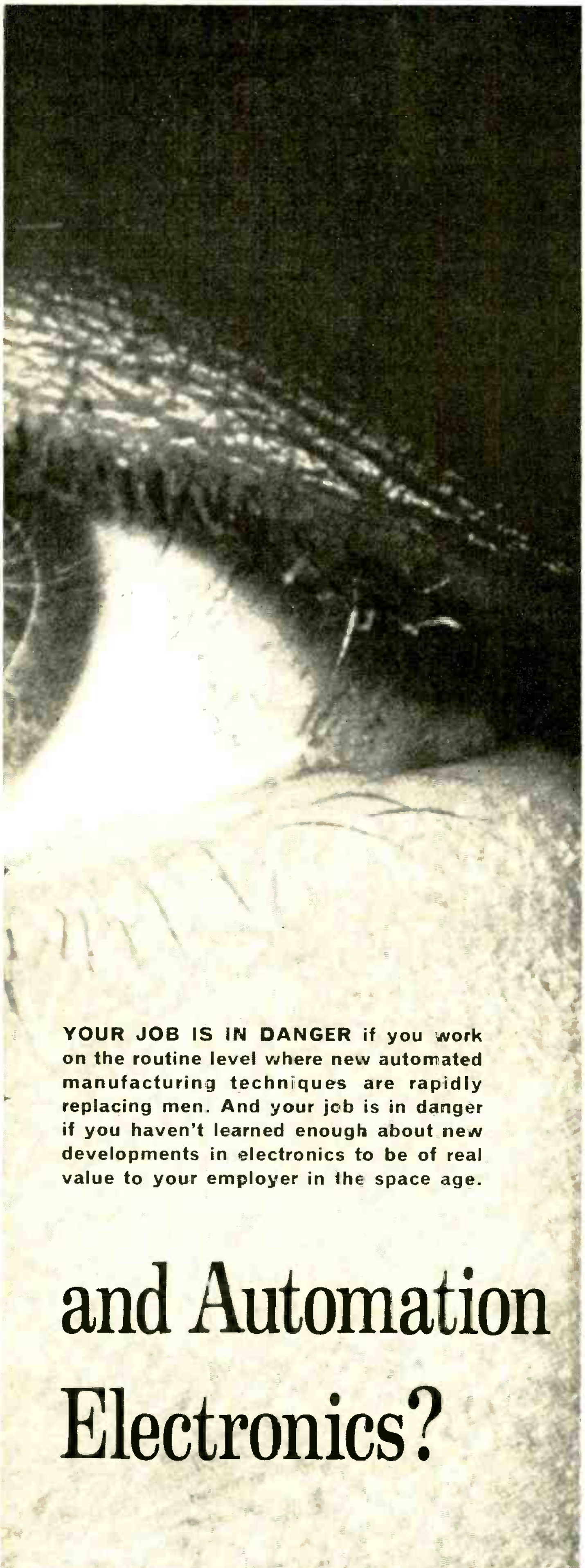
It takes about 20 seconds to go from maximum field at 60 volts, 2 amperes to an approximate zero field. ▲



Will the Space Age eliminate your job in

MANY HOURS OF ROUTINE WORK required to put together conventional circuitry are eliminated by the molecular circuitry used in this tiny video amplifier.

(Photo courtesy of Westinghouse)



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Evolving Transistor

(Continued from page 33)

reverse bias is increased, the depletion region extends farther into the *n*-type bar (Fig. 8B). The effective area of the channel is thus reduced and the resistance of the region increased. This is easily seen by recalling that the resistance, *R*, of a material of length L and area A is expressed by: $R = \rho L/A$ where ρ is the resistivity of the particular material used.

As the area of the channel is reduced, *R* increases and the drain current decreases. A point will be reached where both depletion regions touch and practically no drain current flows (Fig. 8C). This is called *pinch-off*.

The drain characteristics of a typical FET, shown in Fig. 9, are very similar to the plate characteristics of a pentode. In fact, the basic gain parameter of an FET, the transconductance g_m is defined in a manner similar to that for a pentode vacuum tube.

Field-effect devices are available with moderate drain-source voltage and current ratings (see Table 1). Their frequency response extends up to the low megacycle region. Variations of the FET, called the insulated-gate field effect transistor (IGFET) and the metal oxide semiconductor transistor (MOST), provide operation up to several hundreds of megacycles.

Selecting a Transistor

In conclusion, some attention will be directed to selecting transistors for a specific application. The important items to consider are: (1) Maximum operating ambient temperature of the equipment; (2) power requirements; (3) type of circuit, *i.e.*, amplifier or switching; and (4) frequency response or switching speed requirements.

Knowledge of the maximum operating ambient temperature will tell you whether to use germanium or silicon transistors. Germanium units are good up to temperatures of 85-100°C; silicon, 125-150°C.

Power requirements have to be examined carefully. Besides the maximum permitted voltage and current ratings, the collector dissipation power has to be considered. The maximum collector dissipation (for class A amplifier operation) occurs when the circuit is idling and is equal to the product of the quiescent collector voltage and current. The d.c. input power needed for biasing usually can be neglected. The allowable collector dissipation decreases with increasing temperature. The manufacturer generally supplies this information in the form of a derating curve.

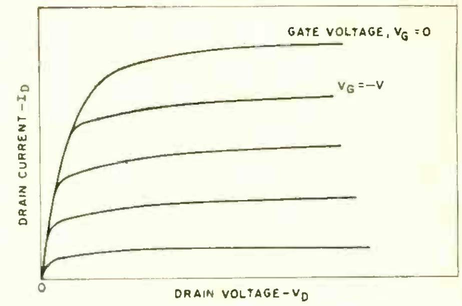


Fig. 9. Typical drain characteristics for field-effect transistor.

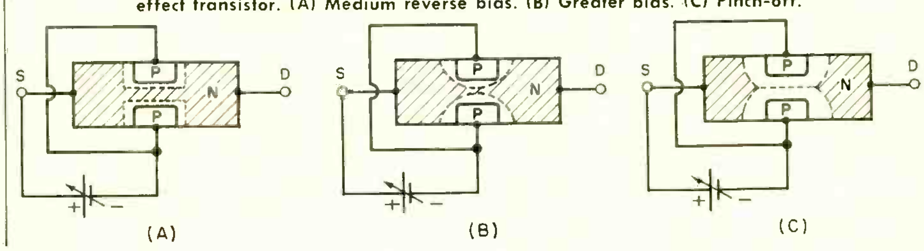
Because the junction transistor is a current-operated device, it exhibits a low impedance. Even an emitter follower has a relatively small input impedance compared to its vacuum-tube counterpart, the cathode follower. Therefore, if a high input impedance is required, then a field-effect device may be the answer.

If the circuit is operating as an amplifier, frequency response is an important consideration. For fast switching, as may be required for digital computer circuits, a high-frequency response is a necessary but not a sufficient condition. In addition, the transistor used as a switch must have small turn-on and turn-off times and a low saturation voltage. The epitaxial-planar and the star-planar transistors are well suited for this kind of operation.

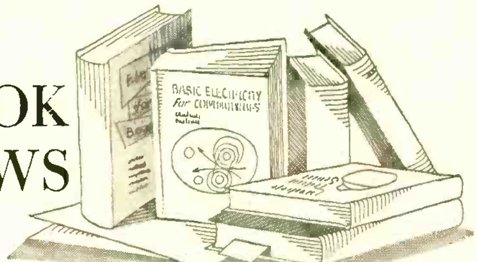
Besides f_β, the frequency response of a transistor is also expressed by f_T. This is the frequency at which *beta* is equal to unity, and is also referred to as the gain-bandwidth product of the transistor. The value of f_T is always greater than f_β.

Table 1 provides a concise summary of the important types of transistors considered in this article. It is intended to give the reader an idea of magnitude of some of the more common transistor parameters. The list is, consequently, incomplete and the reader should refer to the manufacturer's data sheets and catalogues for more complete information. ▲

Fig. 8. The effect of reverse biasing the gate-source circuit of a field-effect transistor. (A) Medium reverse bias. (B) Greater bias. (C) Pinch-off.



BOOK REVIEWS



"CLOSED-CIRCUIT TELEVISION HANDBOOK" by Leon A. Wortman. Published by *Howard W. Sams & Co., Inc.*, Indianapolis. 278 pages. Price $6.95.

This readable volume has been prepared to meet the increasing need for an all-around study of closed-circuit television. Aimed for the prospective installer and user, it covers the various types of cameras and monitors employed in a CCTV system, as well as kinescope and magnetic recording techniques.

Three chapters are devoted to the applications of CCTV in education, commerce, and industry; research, medicine, military; and public service. Well illustrated with photographs and diagrams, the book also contains a chapter providing hard-to-find information on the subject of lighting and optics for television.

A section on circuits and service is included for the more technical reader, and a glossary and listing of the various manufacturers supplying equipment complete the book.

* * *

"2-WAY MOBILE RADIO HANDBOOK" by Jack Helmi. Published by *Howard W. Sams & Co., Inc.*, Indianapolis. 215 pages. Price $3.95. Soft cover.

Since two-way radio has grown so impressively in the past few years, a need existed for an updated and revised edition of this 1960 handbook.

This volume offers a comprehensive story of mobile radio and is designed as a guide for those contemplating buying or using this type of equipment. The author deals with operational theory of the basic systems, receivers, transmitters; control systems, antenna, and power supplies as well as servicing, troubleshooting, and installation.

Information for those wishing to enter the two-way radio sales and service business is also included.

* * *

"BASIC ELECTRONICS" by Abraham Marcus. Published by *Prentice-Hall, Inc.* Englewood Cliffs, N. J. 603 pages. Price $9.00.

This is a beginner's text and no previous knowledge of the subject is assumed or prerequisite. Mathematics is of the elementary variety and where used is merely an amplification of a textual explanation.

The book is divided into six sections, each divided into a number of chapters. The sections cover electrical theory (as background for tube theory), the electron tube, how the electron tube is employed, the electron tube in industry, the electron tube in communication and entertainment, and semiconductor devices. Four appendices cover the EIA color code, how to identify the base pins of electron tubes, transistor shapes and lead identification, and graphic symbols for electronic diagrams.

Since the author has helped to educate almost a generation of electronics students, he is an expert at imparting complex information in easy-to-grasp form. This book is yet another example of his technique.

* * *

"TRANSISTORS & CIRCUIT TROUBLESHOOTING" prepared and published by *General Electric Company's* Radio & Television Division, Syracuse, N. Y. Price $14.25 (for 3 volumes).

This is the first in a three-volume programmed instruction course especially prepared by *General Electric* for service technicians working with home entertainment equipment.

Vol. 1 provides the background material requisite to an understanding of the actual troubleshooting procedures and circuitry covered in Vols. 2 and 3. This programmed manual covers an introduction to transistors, their advantages, bias voltage, diode operation, zener breakdown, solid-state diode/vacuum tube diode similarities, control of diode current flow, transistor-triode similarities, transistor circuit current flow, operation of *p-n-p* transistors, basic transistor configurations, transistor equivalents for v.t. circuits, common problems of semiconductors, common causes of semiconductor problems, stabilization, and classes of operation.

Like all programmed courses, the material is "self-checking" but a final exam folder is also included for classroom applications.

° ° °

"RADIO AND TELEVISION RECEIVER CIRCUITRY AND OPERATION" by Alfred A. Ghirardi & Jesse E. Dines. *Holt, Rinehart and Winston, Inc.*, New York. 539 pages. Price $10.00.

This is a completely rewritten edition of Ghirardi's 1951 classic textbook which has been revised to cover the advances in the field since the appearance of the original edition.

Designed as a home-study manual, a text for technical schools, or a refresher "course" for practicing technicians, the book contains over 300 illustrations and diagrams to supplement and amplify the text material. The book is divided into fourteen chapters covering amplitude modulation and AM signals; frequency modulation and FM signals; r.f. and i. f. amplifiers; AM detectors, a.v.c., and a.g.c.; a.f. and video amplifiers; the AM superhet; FM receivers and the TV sound section; TV principles and operation; TV sync and a.f.c. systems; TV sweep and high-voltage systems; the TV tuner; color television; low-voltage power-supply systems; and the transistor and its applications.

Review questions are included with each chapter with answers provided for the odd-numbered questions.

° ° °

"PULSE AND SWITCHING CIRCUITS" by Donald J. Ketchum & E. Charles Alvarez. Published by *McGraw-Hill Book Company*, New York. 305 pages. Price $8.50.

This is another in this publisher's Technical Education Series and is designed as a classroom text in electronic engineering courses. The book deals with the analysis of circuitry as applied to non-sinusoidal signals: pulse, switching, and timing circuits.

The text covers basic network methods needed to solve *R*, *L*, and *C* circuits and introduce tube and semiconductor concepts involving switching circuits needed to analyze basic pulse and switching circuits used in electronic equipment. Recent advances, including some of the newer switching devices such as tunnel and zener diodes are also covered, along with an analysis of a transistorized scope.

The book's thirteen chapters cover waveforms, networks, various types of *RCL* circuits, diode switching circuits, triode switches, bistable multivibrators, monostable and astable multivibrators, blocking oscillators, basic saw-tooth generators, gating circuits, delay circuits, special-purpose circuits, and applications. A copious appendix provides much useful information for the student.

When used as a college text, the instructor may assign some of the various problems which are appended to each chapter.

° ° °

"RCA PICT-O-GUIDE" edited by John R. Meagher. Published by Electronic Components and Devices, *Radio Corporation of America*, Harrison, N.J. 153 pages. Price $5.75.

This is a completely revised and updated edition which includes the latest advances in color-TV and servicing. Prepared especially for service technicians, the text material is supplemented by true-to-life color photographs and illustrated step-by-step servicing procedures.

One outstanding feature of this edition is the comprehensive instructions for setting up new color receivers. Simplified instructions for purity, convergence, and black-and-white adjustments are included. The troubleshooting sections have been expanded and oscilloscope waveforms added to help familiarize the technician with the electrical characteristics of the receiver.

The book contains twelve chapters, each packed with practical information for the practicing technician.

° ° °

"ENGINEERING COMMUNICATIONS" by Rosenstein, Rathbone & Schneerer. Published by *Prentice-Hall, Inc.*, Englewood Cliffs, N. J. 129 pages. Price $4.95.

Since all engineering is dependent upon the accurate, economical, and rapid transmission and processing of information, according to the authors, the engineer must learn to communicate with himself as well as others.

Part 1, on communication, has chapters on the role of communication in engineering design, the mathematical theory of communication, and communication systems. Part 2 covering communication practice, deals with the reader, the writer and the report, oral reporting, graphics in engineering design, how to sketch, techniques of sketching, charts, graphs and mathematic constructions, and presentation.

° ° °

"TAPE RECORDERS—HOW THEY WORK" by Charles G. Westcott & Richard F. Dubbe. Published by *Howard W. Sams & Co., Inc.*, Indianapolis. 218 pages. Price $3.95. Soft cover.

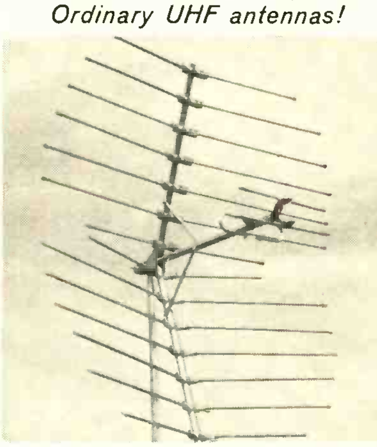
This is a revised and updated version of a 1956 handbook which enjoyed wide popularity with tape recorder owners of all degrees of technical sophistication. Since the volume is concerned with home-type tape recorders, the text is directed to the layman.

The book includes a short history of magnetic recording, the theory of magnetic recording, the motorboard-tape-transport mechanism, drive motors, volume indicators, bias oscillators, amplifiers, magnetic heads, and recording tape. There is also a chapter on test equipment and test procedures. ▲

"FUNDAMENTALS OF ELECTRONICS"

THE Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 has announced the availability of the 8-volume "Fundamentals of Electronics" which was written by the Navy as a textbook for the Electronics Technician School, Class A.

Priced at $14.25 for the 8-volumes, the titles include: Basic Electricity, Power Supplies and Amplifiers, Transmitter Circuit Applications, Receiver Circuit Applications, Oscilloscope Circuit Applications, Microwave Circuit Applications, Electromagnetic Circuits and Devices, and Tables and Master Index. An order form: GPO:1964 0-753-189, is available on request. ▲



EW Lab Tested

(*Continued from page 14*)

clipping level) was 45 watts into an 8-ohm load, 53 watts with a 4-ohm load, and 21 watts into 16 ohms.

The ruggedness of this amplifier was confirmed by the fact that we never succeeded in tripping its circuit breaker, even when it was driven well beyond the clipping point. Needless to say, there was no damage to the transistors or other components under these conditions, which have often proved disastrous to other transistor amplifiers intended for less arduous home music system usage. Even after 15 or more minutes of continuous full-power operation, the chassis did not become perceptibly warm.

In listening tests, the amplifier performed in the manner one would expect of any top-quality, high-powered amplifier. It drove low-efficiency speakers to ear-shattering levels without any break-up or strain. The lowest frequencies, in particular, were reproduced with complete solidity and clarity. The cooling fan, although not noisier than others of its type, is nevertheless quite audible when the amplifier is placed in the open. In most home installations the amplifier would be best installed in a cabinet where the sound of the fan would be absorbed.

The TR-2 amplifier is available in kit form at $69.95. Practically all the components are mounted on a single printed-circuit board, and assembly does not appear to be difficult. Of course, two amplifiers would be needed for stereo. ▲

Sonotone RM-1 Speaker System

For copy of manufacturer's brochure, circle No. 61 on coupon (page 17).

SONOTONE'S new "Sonomaster" speaker system, Model RM-1, is a powerful entry in the rapidly growing field of very compact, low-cost speaker systems. It is one of the smallest and lightest of the group, measuring 14½"x 10½"x7¼" deep, and weighing 12 pounds in its oiled-walnut enclosure.

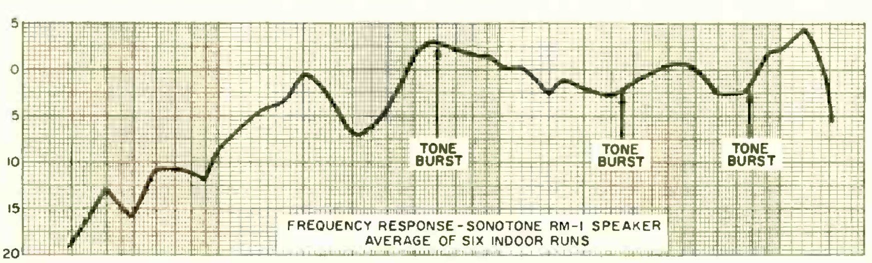
The completely sealed enclosure is constructed of ½-inch thick panels, with mitered and sealed joints. The grille cloth is of woven cane, acoustically "open" to allow free radiation of high frequencies.

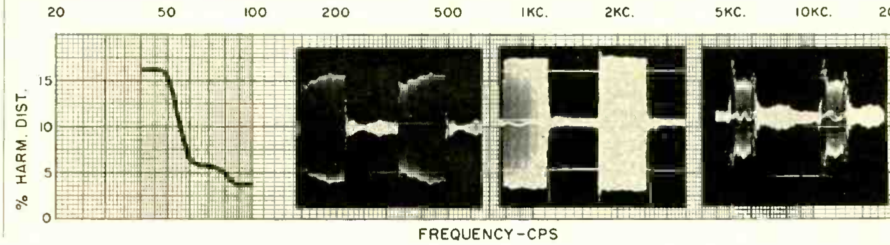
The RM-1 has a 6-inch woofer, with a high compliance cone suspension and a ceramic magnet. It may seem strange to refer to a 6-inch speaker as a "woofer," but this one really does perform the job usually allocated to a much larger unit. The free-air resonance of the woofer is 50 cps. At 5000 cps, a simple coil-capacitor crosses over to a 1½-inch cone tweeter, whose level is adjustable by means of a control on the rear of the cabinet.

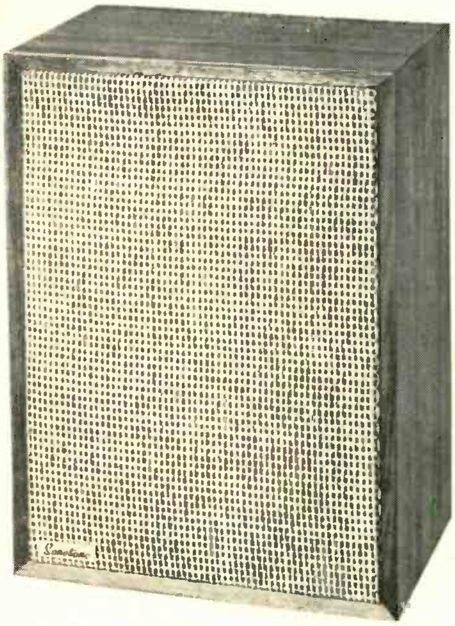
The speaker was mounted on a shelf on a 12-foot wall of a 12 x 30 foot room, as it would be in many home installations. Its response was measured with the microphone in six positions in the room, from 1 to 18 feet from the speaker, and at angles up to 45 degrees from the speaker axis. Averaging the curves produced a single plot which is indicative of the total response of the speaker.

The system has a frequency response flat within ±4 db from 400 to 15,000 cps, with the tweeter level set to the recommended "normal" position. At lower frequencies its output falls off, with a 7-db hole at 300 cps. Part of the low-frequency roll-off is a characteristic of the test room, but after making allowances for this, the speaker's output appears to be down about 6 db at 50 cps, compared to its mid-range output. Needless to say, this is excellent performance for a speaker having a 6-inch diameter cone.

The harmonic distortion, at a 1-watt nominal driving level, is reasonably low down to 60 cps, where it reaches about 6%. It rises sharply at lower frequencies, so that 60 cps may be considered as the effective lower limit of the speaker's response.







At most frequencies, the tone-burst response is excellent. The only significant "ringing" was found at about 7.5 kc., but elsewhere it was as good as we normally measure on some far more expensive speaker systems.

In listening tests, the unit proved to be a truly musical and pleasing reproducer. "A-B" comparisons against other bookshelf speaker systems of considerably greater price and size showed little or no difference. Paired with another well-known compact system, it produced a well-balanced stereo sound, which is a convincing demonstration of its inherent quality. The RM-1 has moderate efficiency and can be driven by any good 10-watt amplifier.

The unit is ideally suited to a low-cost music system, since it delivers very pleasing and listenable sound, which we would definitely call "high fidelity" despite its lack of low bass. This is the chief difference between this speaker and most of the bookshelf systems costing two or three times as much. If the user's system is later upgraded, the RM-1's can make fine extension speaker systems, so one's investment is protected. The RM-1 is unquestionably an excellent value at its price of $44.50. ▲

19-KC. GENERATOR ALIGNMENT

When aligning a stereo multiplex unit, an accurate 19-kc. signal source is required to properly tune the multiplex internal 19-kc. oscillator. In the absence of a crystal-controlled source, a conventional audio generator can be used.

Connect an antenna to the FM set and tune in a station known to be transmitting stereo. Inject the approximately 19-kc. audio signal through a 10,000-ohm isolating resistor into the circuit between the FM detector and the multiplex input. Adjust the generator frequency for zero beat as heard in the loudspeaker. The generator will now be set accurately to 19 kc. ▲

READER SERVICE PAGE

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

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

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

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

FOR GENERAL USE: In requesting information on products and services listed in the coupon on page 17, you may use your home address.

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

See Page 17 for "GENERAL USE" Coupon

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NEW PRODUCTS & LITERATURE

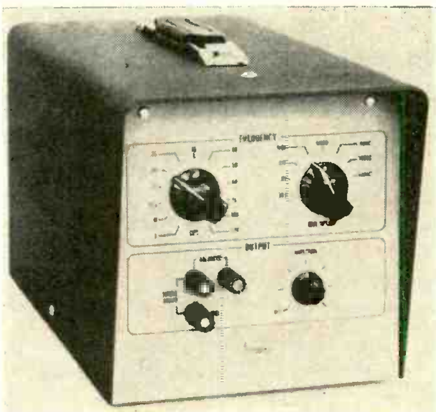
Additional information on the items covered in this section is available from the manufacturers. Each item is identified by a code number. To obtain further details, fill in coupons appearing on pages 17 and 88.

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

MULTIPLE FREQUENCY STANDARD

1 **Anadex Instruments Inc.** has announced a new portable, crystal-controlled frequency standard which provides frequencies ranging from 0.5 cps to 600 kc. The Model CU-2 has an accuracy of 0.0005%.

Frequency selection is by means of a 13-position selector switch and a four-decade multiplier switch. Output voltage is a square wave with



amplitude adjustable to 20 volts peak-to-peak. Both single-ended and balanced output signals are provided.

The instrument is housed in a 7" x 7" x 12" carrying case which comes complete with handle. Power requirements are 117 volts at 60 cps. An optional rack-mounted model is also available.

ELECTRO-OPTICAL WINDOW

2 **Marks Polarized Corporation** has introduced the "Varad" panel, a new electro-optical window that may be controlled electronically to change in clarity from various degrees of transparency to opaque.

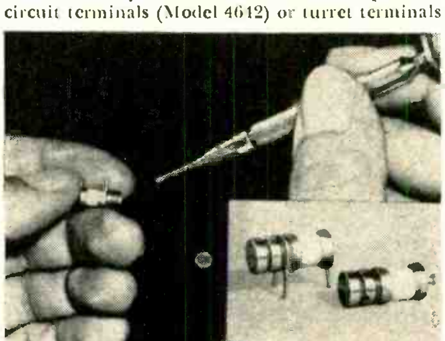
Utilizing a photocell, the dipole window may be electronically controlled so that it becomes dark in bright sunlight and transparent in the dark. The device can also be controlled manually.

The company suggests that these panels may also be used as camera shutters without size limitations, as welding glasses and sunglasses, for sun visors and automobile windshields, and for 2-D and 3-D flat pictures on a wall TV set.

VARIABLE AIR CAPACITOR

3 **Johanson Manufacturing Corporation** has introduced a new variable air capacitor which measures only 0.220" in diameter and 15/32" long but has a "Q" factor of better than 5000 at 100 mc.

The new capacitors are available with printed-circuit terminals (Model 4612) or turret terminals



(Model 4640). They are available in a capacity range of 0.4 pf. to 6 pf.

INDUSTRIAL TV RECORDER

4 **Winston Research Corporation,** a subsidiary of **Fairchild Camera and Instrument Corporation** has released details on its V-5000 TV magnetic tape recorder/reproducer which has wide application in both industrial and semi-professional usage.

Offered in portable, console, or 19-inch rack mounting configurations, the tape transport operates at 10 feet per second. Reels are of the standard amateur hub design with 11½" flange diameter. The tape runs 15 minutes per pass with four passes providing 1 hour of running time. There are four tracks, and heads include two record and one playback head for reproduce-after-record monitoring. There is a counter and track indicator to facilitate quick location of program material.

Input can be from a TV camera or TV monitor receiver. Outputs are video and audio for playback through TV monitor, and composite video and audio for tape dubbing on another TV recorder.

An extensive line of auxiliary equipment is also available for use with the recorder.

TWO-COLOR THIN CRT

5 **Video Color Corporation** is now marketing the Model 2C48 two-color "Thintube" CRT which offers a unique combination of color and compactness. The two colors are drawn by two separate guns on a 4" x 8" screen. The tube is only 2½ inches deep.

The development of the tube suggests a wide variety of experimental uses such as in the fields of sampling and measuring sets of related data

where two traces are intertwined. The circuitry supplied allows two separate inputs to be shown in time registry in two colors on the screen.

Phase and phase-shift comparisons, dual-performance characteristics, input versus output waveshapes, or friend or foe on radar scope display may all be shown with circuitry modification.

The tube is available in a wide variety of sizes and shapes. It features both ruggedness and brightness and can be provided with any two basic phosphors.

LOW-PROFILE HEAT SINK

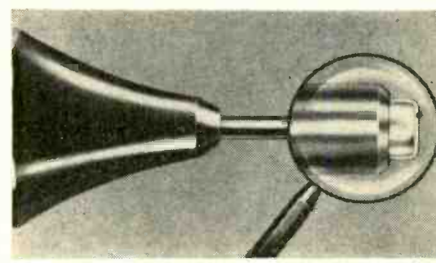
6 **Relco Products** is now marketing a new series of heat dissipators characterized by high thermal efficiency, low cost, and low profile which are specifically designed for printed-circuit applications.

Five basic types are included in the new "K-Series" with a free air thermal resistance from 6°C per watt to 18°C per watt. Extruded of aluminum alloy, the series is rectangular in shape and of patented design to cover heat dissipation from most all medium- and intermediate-range power transistors available today.

Surface area ranges from 5.8 to 23.2 square inches. Half-inch height permits installation in a wide variety of instrumentation and production assemblies. Weights are from ½ ounce to 2 ounces.

JEWEL-POINT TECHNICAL PENS

7 **Koh-i-Noor, Inc.** is now incorporating a precision jewel tip in the points of its "Rapidograph" technical fountain pens and drawing point sections. According to the company, long



usage on abrasive drafting film tends to buff or "polish" the jewel so that it wears down smoothly, without developing a rough or sharp edge. The firm claims that its smallest size point will outlast present points by more than 100 times on severely abrasive grades of drafting film.

The jewel points for "Rapidograph" technical fountain pens and drawing point sections are available in sizes 0 and 1.

IGNITION-COIL TESTER

8 **Rite Autotronics Corp.** has added an ignition-coil checker to its line of automotive test equipment.

A large, easy-to-read dial and step-by-step instructions make it simple to spot trouble in the coil and aid in troubleshooting capacitors, points, or any other defective ignition-system component.

The meter is self contained. It is designed for convenient, hand-held operation.

CABLE CLOSURE TOOL

9 **The Zippertubing Company** has developed the "Zip-Eze" heavy-duty closure tool in order to speed the opening and closing of cables jacketed or shielded with "Zippertubing." The tool reduces opening or closure time 50%. Non-slip handles are designed for comfortable gripping and reduced worker fatigue.

EXTENDED-RANGE COUNTERS

10 **Computer Measurements Company** has announced that its all-silicon solid-state counters and counter-timers have had their frequency range extended to 2.5 mc.

All models of the company's "600" series now have the new range, which is said to make them

eight times faster than any competitive instrument at comparable prices.

These instruments also feature printed-circuit mother-boards with plug-in circuit cards, replacing the basic circuit wiring harnesses. Display time in the "600" series is variable from approximately 0.2 second to 5 seconds and is independent of gate time. Memory or non-memory display mode may be selected by a front-panel switch. The count gate may be locally or remotely controlled.

400-VOLT SILICON TRANSISTORS

11 **Delco Radio Division** has available two new silicon power transistors with V_{CEO} ratings of 400 volts and collector current ratings of 1 and 2.5 amperes. The devices have been designated DTS-413 and DTS-423.

The company suggests their use in large-screen TV horizontal and vertical sweep circuits; for inductive switching where high induced e.m.f. is found, such as in large-screen TV horizontal outputs or high-voltage Darlington drivers; or in circuits where high energy output is required.

MEDICAL ELECTRONIC MONITOR

12 **Dallons Laboratories** has introduced a compact, modular-style "Master Monitor" for around-the-clock surveillance of coronary and other intensive-care patients.

The compact, modularized unit contains a 3" "Cardioscope," heart-rate meter, and body-temperature monitor which permits central monitoring of each individual patient's condition on a continuous basis. Should any change take place in the patient's condition, an automatic visual and audible alarm turns on to call attention to the change and summon aid.

In addition, the unit is also capable of automatically starting an electrocardiograph to record the heart condition and an electronic pacemaker which will keep the heart running at a predetermined rate.

HIGH-FREQUENCY TRANSISTOR

13 **Transitron Electronic Corporation** is now offering a new silicon planar epitaxial high-frequency "n-p-n" transistor, the 2N3633. The new unit delivers the highest guaranteed f_T (1300-mc. min.) available in a commercial high-speed silicon switching transistor. It is ultrasonically bonded with aluminum wire to eliminate purple plague at the chip.

The advanced design of the 2N3633 makes it highly resistant to nuclear particle irradiation. Typically h_{FE} is still greater than 10 after an equivalent neutron dose of 10^{15} neutrons/cm.^{2}

The transistor is available in a TO-18 package. Similar electrical equivalents are available in TO-52, TO-46, TO-51, pico, nano, dual TO-5, and dual flat-pack packages.

HI-FI AUDIO PRODUCTS

HIGH-GAIN FM ANTENNAS

14 **Jerrold Electronics Corporation** has added three new FM antennas to its "Paralog" line which has been specifically designed for maximum FM signal pickup. The new antennas are highly directional and may be used in both metropolitan and fringe areas. According to the manufacturer, not only is multipath distortion eliminated, but background noise and drift are minimized.

Mechanically, the new units feature "Cycolac," a tough plastic, and incorporate a unique "Wedge-Snap" lock which provides permanent joint connections which tighten with wind vibration.

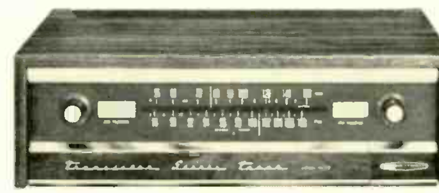
SENSITIVE TUNER/AMP

15 **Sherwood Electronic Laboratories, Inc.** is now offering the S-7700III, an 80-watt music power FM-stereo tuner/amplifier which incorporates circuitry and built-in test points for direct connection of an oscilloscope for on-the-spot visual display of incoming signal characteristics.

As with previous models, the new unit is a complete home entertainment control center, providing AM, FM, and FM-stereo broadcast reception as well as inputs for phono and tape deck. Two 40-watt music-power channels are provided with outputs for 4, 8, and 16 ohm speaker systems for stereo reproduction. A separate powered center-channel output is included for fill-in or for connecting extension speakers. A separate front-panel stereo headphone jack is also included.

ALL-TRANSISTOR STEREO TUNER

16 **Heath Company** has recently introduced a restyled version of its deluxe all-transistor AM-FM-FM-stereo tuner, the AJ-43C. Housed in a walnut cabinet with a matching walnut-finished hinged lower front panel, charcoal upper front panel, and soft-refracted panel lighting, the



hinged lower front panel also conceals all secondary controls.

The tuner features automatic switching to stereo, an automatic stereo indicator light, automatic frequency control for drift-free reception on the FM band, individual AM and FM tuning meters, and an easy-to-read illuminated slide-rule dial.

The circuit employs 25 transistors and 9 diodes. The kit features a factory assembled and aligned FM front-end and 5-stage FM i.f. circuit board.

DUAL-CHANNEL WIRELESS INTERCOM

17 **Fanon-Masco** has just introduced a transistorized wireless intercom which provides two-channel operation. The Model FW-60 offers two separate lines of communication permitting the user to select one or the other frequency to call one unit independent of other units in the system. Two 2-station systems can also be used independently of each other or, if placed on the same frequency, all stations may converse.

No installation is required. The Model FW-60 consists of components for two-station operation with additional stations hooked in as desired. A special transistor stage has been employed as a squelch circuit while an automatic volume control insures better selectivity and elimination of noise and distortion.

Each unit is approximately 6" x 5" x 3" and has a talk-listen switch that may be locked in the "talk" position for monitoring an area.

SOLID-STATE FM RECEIVER

18 **Harman-Kardon** has added the Model SR-300 FM receiver to its "Stratophonic" line, thus completing a series of solid-state audio equipment.

The receiver includes an FM-stereo tuner, plus

a stereo preamplifier and amplifier. The SR-300 is flat from 8 to 25,000 cps, IHF music power output is 36 watts, 18 watts per channel.

MOBILE SOUND SYSTEM

19 **Perma-Power Company** has added the "Sound Cruiser" to its line of mobile sound systems. According to the company, any car can be converted into a sound truck by plugging the "Ampli-Vox" into the car's cigarette lighter socket and clamping the speakers to the roof.

The system includes a 32-watt all-transistor amplifier, a noise-cancelling microphone, and two weatherproof horn speakers especially designed for voice penetration. Frequency response is 50-15,000 cps for maximum voice penetration and intelligibility with less than 5% distortion at full output. It has a master volume control, an auxiliary control, auxiliary standby switch, and tone control. There are two outputs, for 8 to 16 ohm speakers, and two inputs for microphone and auxiliary (radios, tuners, records, etc.).

COMMERCIAL AUDIO AMPLIFIER

20 **McMartin Industries, Inc.** is now offering a new and improved version of its 32-watt solid-state commercial amplifier as the Model LT-300A.

The new features include provisions for two plug-in microphone transformers. Also, the 25-v. and 70.7-v. speaker outputs are now balanced. Three-pin professional push-lock microphone connectors are also being offered on this new model.

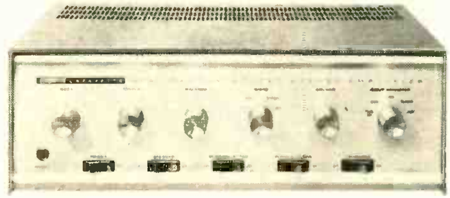
Basic features include: separate bass and treble controls, continuous boost and cut, separate volume controls for both microphone inputs and the program input, and optional plug-in preamps for tape head and magnetic phono program inputs. The MT-4 mike transformer also provides a balanced-bridge or optional 600-ohm program input.

50-WATT STEREO AMPLIFIER

21 **Lafayette Radio Electronics Corporation** is now marketing the Model LA-248, an all-transistor 50-watt stereo amplifier.

The LA-248 is a complete stereophonic preamplifier and dual 25-watt stereo amplifier on one chassis. There are no output or driver transformers, insuring low distortion and good transient response. A fast-action circuit protects the output transistors from overloads or shorts in the speaker line.

Deluxe controls include: scratch and rumble filters, separate "on-off" power switch, balance, speaker "on-off" switch, and phase switch. There is a front-panel stereo headphone receptacle.



Frequency response is 20-20,000 cps ±1 db. Harmonic distortion is 1% and hum and noise are −74 db on tuner, −54 db on magnetic phono.

The amplifier is housed in a brown textured metal cage which measures 13" w. x 4$\frac{3}{16}$" h. x 9" deep. The circuit is designed for 105-125 volt, 50/60 cps operation.

PORTABLE MEGAPHONE

22 **American Geloso Electronics Inc.** has introduced a new combination portable megaphone and p.a. system which has been tradenamed "Amplivoice 2583."

Featuring lightweight portability and long-range sound sharpness, the unit includes an external volume control, a 5-transistor amplifier which uses less battery power, and a completely shockproof case and microphone. All of the circuitry is weather airtight and sealed. A remote microphone with 9-foot cable attaches to the unit for fast and simple conversion to a portable p.a. system.

TWO-WAY SPEAKER SYSTEM

23 **Audio Dynamics Corp.** has developed a new two-way speaker system which eliminates conventional crossover networks in its design.

The Model 303A "Brentwood" is a bookshelf speaker which provides a frequency response of 35-20,000 cps ±3 db. Harmonic distortion, with a 1-watt electrical input, remains below 5% down to 33 cps. The speaker offers full-range performance, including extreme high and low frequencies, without the resonance, phase shift, and distortion often associated with elaborate crossover networks in multiple-speaker systems, according to the company.

The non-ported, fully sealed enclosure is of oiled walnut and measures 23¾" x 13" x 11¾".

70-WATT STEREO RECEIVER

24 **Allied Radio Corporation** is now marketing the "Knight" Model KN-370 FM-AM-FM-stereo tuner/amplifier. The unit combines on a single compact chassis a 35-watt-per-channel stereo amplifier, individual FM and AM tuning

sections, special multiplex circuitry that automatically switches to stereo, dual preamps for records and tapes, and a full set of controls and inputs.

The sensitivity of the FM section is 2.5 μv. for 20 db of quieting. Sensitivity of the AM section is 4 μv. for 20 db signal-to-noise ratio. Frequency response of the amplifier is 20-20,000 cps ±1 db at full rated power. Harmonic distortion is less than 0.6% at full rated power.

The receiver measures 5¼" x 15$\frac{15}{16}$" x 15". A walnut wood case or a brown metal case are available as accessories.

COMPACT SPEAKER DESIGNS

25 **The R.T. Bozak Manufacturing Co.** is now offering the "Concerto II" and "Concerto III," compact speaker systems which feature full-size components in "bookshelf" size. Both cabinets are matte-finished walnut with natural linen grille cloth. Both can be used either horizontally or vertically.

The Models B-312 and B-313 both measure 24½" x 17¼" x 12¼" deep. The B-312 is a two-way system based on the B-207A coaxial speaker having a response from 45 to 16,000 cps with a 6 db-per-octave crossover at 2500 cps. The B-313 has an added midrange speaker and crossover network. This three-way system has a range of 45-16,000 cps and crossovers at 6 db-per-octave at 800 and 2500 cps. Both units are rated at 8 ohms impedance. Recommended amplifier power is 20 watts r.m.s. or more. The "Concerto II" can be converted into a three-way system at a later date, if desired.

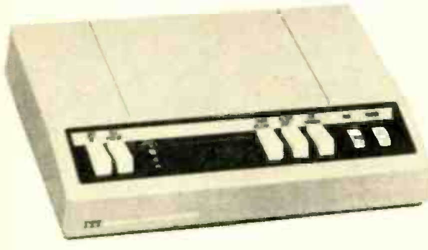
TAPE RECORDER

26 **Bell Sound Division** is now offering a complete audio tape recorder as the T-67A. The unit includes tape deck, motors, and cabinet. The new unit features an exclusive tape duplication feature. It can play back 4-track stereo or mono pre-recorded tapes, record 4-track stereo or mono, record stereo or mono with echo, record duo-sound, and record sound-on-sound (mono). With the DK-1 accessory, it can duplicate stereo and mono tapes and record sound-on-sound in stereo. The recorder will accommodate up to 10½" reels.

DICTATING/TRANSCRIBING UNIT

27 **ITT Distributor Products Division** has added the "Minifon Office" to its line of compact, lightweght tape recorders.

The new unit features a 60-minute reusable



tape cartridge. The device is fully transistorized and includes automatic word repetition, rapid-erase facilities, and fingertip controls.

A full line of accessories, including dictating microphone, foot and hand controls, earphone set, telephone pickup, and monitoring loudspeaker, is also available.

CB-HAM-COMMUNICATIONS

CB SIGNAL GENERATOR

28 **Ferris Instrument Company** is currently introducing the Model 24FS Microvolter, a high-precision signal generator designed especially for production checking and servicing of receivers operating in the CB service and/or

frequencies from 35-36 and 43-44 mc. allocated to paging systems. Twenty-seven frequencies are supplied with five additional positions available. Each frequency is controlled by individual crystals operating on fundamentals and multiplied. Frequency accuracy is 0.002% and stability is 0.001%.

Output is metered from 0.1 µv. to 1 volt, into 50 ohms. Internal and external modulation is metered and adjustable from 0 to 100%.

The instrument is housed in a cabinet 16¾" wide x 10¾" high x 13¼" deep. A rack version is 19" wide. The unit operates from 115 volts ±10%, 60 cycles and draws 60 watts.

CB TRANSCEIVER

29 **Metrotek Electronics, Inc.** is now marketing a low-cost CB transceiver which has been tradenamed the "Mustang." The new unit has six crystal-controlled transmit channels and is tunable to receive all 23 CB channels.

In the transmit mode, plug-in crystals,

mounted on the chassis, can be changed to give any desired frequency. Power output is 3 watts minimum. High-level 95% speech clipping is built in.

The receiver is a superhet with a tuned r.f. stage for a sensitivity of 0.3 µv. usable. The crystal receiver local oscillator is 455 kc. above channel frequency while the tunable receiver oscillator is 455 kc. below channel frequency. Audio output is 3.5 watts maximum.

The unit which measures 5⅛" high x 11⁹⁄₁₆" wide and 6¾" deep can be powered either by 117 volt a.c. or from a 12-volt d.c. external power supply for mobile applications.

CB TRANSCEIVER TESTER

30 **Lafayette Radio Electronics Corporation** has introduced a CB transceiver and antenna performance tester as Stock No. 42-0126.

Designed for the in-circuit testing of transceivers by CB operators, technicians, and servicemen, the instrument permits normal antenna connections during tests. Full testing facilities include measurement of r.f. power output, relative field strength, standing wave ratio, percent modulation, and relative crystal activity. It generates a crystal-controlled r.f. signal, modulated audio, and 1-kc. audio signal. There are front-panel jacks for aural and visual transmitter monitoring with a scope.

An easy-to-read d'Arsonval meter gives direct measurements of transmitters up to 6 watts. The instrument is 7⅞" x 5⅜" x 2⅞" and comes complete with 9-volt battery and 30" telescoping antenna.

U.H.F. PORTABLE

31 **Motorola Inc.** is now offering a single-piece, lightweight portable two-way radio operating in the 450-470 mc. band. Designed to provide communications to supervisory, construction, and maintenance personnel on foot, the fully transistorized "Handie-Talkie" can also be adapted for low-power mobile use.

Weighing only 35 ounces, the radio is completely self-contained and includes the transmitter, receiver, speaker, antenna, and battery within a single case measuring 3⅛" x 8" x 1⅝".

Power for the unit is supplied by a single rechargeable nickel cadmium battery or an interchangeable mercury cell. Transmitter r.f. power is 0.7 watt and receiver sensitivity is 0.8 microvolt. A full 0.5 watt of audio power enables reception of messages in high-noise-level areas.

CB CONVERSION MODULE

32 **Pearce-Simpson** is now marketing the "Sea-B-Mate," a self-contained CB module that converts the firm's "Catalina" 68-watt marine radiotelephone to a dual-system marine/CB two-way radio.

According to the company, this provides an extra margin of safety by doubling the number of effective communications channels for immediate use—a total of 11 channels (5 marine and 6 CB).

The unit is salt- and fungus-proofed and housed in an "Iridited" aluminum cabinet and chassis for maximum corrosion protection. Overall dimensions are 3⁵⁄₁₆" wide x 6⅞" high x 12½" deep. It weighs 3 pounds, 11 ounces and comes complete with noise-canceling, push-to-talk microphone and crystals.

HAM ACCESSORY

33 **Kahn Research Laboratories, Inc.** is now offering a new version of its "Echoplex" designed especially for use by radio amateurs and in low-cost communications systems.

The system is an audio processing device which encodes the speech wave by separating it into six frequency segments with six bandpass audio filters. Two of the filter outputs are fed directly to the associated transmitter, two of the filter outputs are passed through a one-second time delay, and the remaining two frequency segments are fed to a two-second time delay. The inverse is accomplished at the receive end.

The system offers a power gain of 7 db, a diversity gain in that redundant information is trans-

mitted at three different time intervals, and a re-arrangement of the delays to provide privacy for non-amateur applications.

TUNABLE NOTCH FILTER

34 **Delta Electronics, Inc.** has recently introduced the TNF-2 consisting of two passive tunable notch filters for use in the 2-30 mc. frequency range. The filters are designed for use between a receiving antenna and a receiver or multicoupler at locations where transmitters

operated in close proximity to the receiving antennas may cause overloading, intermodulation products, or damage to equipment. The unit provides a rejection of as much as 50 db at an undesired frequency and at the same time attenuates other frequencies less than 1.5 db.

FM TWO-WAY RADIO

35 **The Hallicrafters Co.** is now marketing the MT-20, an FM two-way radio designed for mobile and fixed-station operation in the 148-174 mc. band.

The receiver/transmitter chassis and speaker are housed in a cabinet which measures only 4½" x 10¾" x 10" deep including control knobs. The 12-volt d.c.-powered mobile unit is especially suited for underdash mounting in cars, trucks, and buses. A 117-volt, 50-60 cps a.c. model, BT-20, for base-station use, is also available. The mobile version may be used with either negative or positive systems.

Both models are shipped tuned and aligned to existing purchaser frequencies when the units are bought as "add-ons" to a currently operating system: or to the allocated frequency when the system is an initial installation.

62-WATT MARINE RADIOTELEPHONE

36 **Sonar Radio Corporation** is now offering the "Challenger" Model 62, a 62-watt transistorized marine radiotelephone which meets FCC requirements for commercial charter boats which carry six or more passengers.

The unit covers six marine channels as well as the broadcast band. It features front-panel tuning with antenna r.f. current indicator and r.f. sensitivity control. The plug-in microphone and

plug-in power cable are quickly detachable. There are also provisions for remote control of the entire unit.

Power input is 62 watts and output is 34 watts into a standard FCC dummy load. Frequency range is 2000-6000 kc. for both transmitter and receiver. The basic unit measures 13½" long x 10⅝" wide x 6¼" high. Crystals, remote control, antennas, and a deluxe dial-type remote are all extra.

RADIO PAGING SYSTEM

37 **Round Hill Associates** has developed a low cost tone-plus-voice radio paging system for limited-range communications within a building or surrounding area.

Known as "Page-Mate," the system consists of a compact transmitter, microphone, antenna, control unit, and any number of receivers which are transistorized and so compact—they are the size of a cigarette pack and weigh only 4½ ounces—they can be comfortably carried in a shirt or jacket pocket.

MANUFACTURERS' LITERATURE

NICKEL-CADMIUM BATTERIES

38 **Sonotone Corporation** has recently published a booklet for the general reader describing the care and maintenance of rechargeable nickel-cadmium batteries.

Entitled "How to Use Nickel-Cadmium Batteries," the pamphlet is illustrated in cartoon fashion and explains technical matters in a light vein.

D.C. VOLTAGE STANDARD

39 **Cohu Electronics, Kin Tel Division,** has made available a 4-page, 2-color technical data sheet on its "Kin Tel" Model 304 d.c. voltage standard.

Illustrated with charts and block diagrams, the brochure provides complete technical specifications and calibration procedures.

SWITCHING TRANSISTORS

40 **The Bendix Corporation** has published a new 6-page applications note describing the SOAR (Safe Operating ARea) principle for selecting the proper transistor to use in switching for d.c. applications.

Tables are provided showing the application of this principle to the company's line of diffused-alloy power and germanium "p-n-p" transistors.

OSCILLOGRAPHS

41 **Honeywell Inc.** is now distributing a series of case histories that describe how direct-writing oscillographs can be applied by industry to record high-speed phenomena for immediate readout.

ANTENNA EQUIPMENT

42 **Andrew Corporation** is now distributing its Catalog 23, a 96-page publication covering complete product information, performance data, and engineering information on antennas, antenna equipment, and transmission lines.

Fully illustrated, the catalogue presents the latest in antenna positioners, flexible elliptical waveguides, microwave and telemetry antennas, coaxial switching matrices, and high-powered flexible coaxial cables.

SONIC TRANSDUCER MATERIALS

43 **Commander Laboratories, Inc.** has recently published a 10-page illustrated brochure describing the company's line of piezoelectric ceramic compositions and a new magnetostrictive ferrite material for solid-state sonic transducer applications.

Complete electrical and mechanical specifications are provided for all materials discussed.

PHOTOELECTRIC CONTROL

44 **Tung-Sol Electric Inc.** is now making available a comprehensive brochure discussing the company's new SL 1120 photoelectric control which is suitable for use in highway, street, area, and residential lighting applications.

Brochure T-406 covers the construction of the unit and outlines the various reliability tests to which the device is subjected.

R.F. INTERFERENCE

45 **Hallett Manufacturing Company** has published an illustrated 24-page booklet describing the problems and solutions of r.f. interference on mobile rigs. Topics discussed include the sources of engine electrical noise, as well as pulse noises and their elimination through the use of suppression kits, filtering, and complete shielded ignition systems, with particular attention to the automotive and marine fields.

VIBRATOR REPLACEMENT

46 **Cornell-Dubilier Electronics** is currently offering an 8-page vibrator replacement guide for vibrators used in communications and Citizens Band equipment.

Listings are by manufacturer's name or trade name and part number, and the corresponding **Cornell-Dubilier** type number. Included are 24 manufacturers of communications vibrators and 50 makers of vibrators for use in a large number of Citizens Band transceivers.

DIGITAL VOLTMETER

47 **Non-Linear Systems, Inc.** has issued a 5-page illustrated bulletin describing its new Model 2917 integrating digital voltmeter. Operating principles, advantages, and applications of integrating digital voltmeters are fully explained, and complete specifications for the Model 2917 are provided.

PHOTOELECTRIC CONTROLS

48 **General Electric Company** has published a 10-page illustrated brochure describing the firm's line of transistorized photoelectric controls.

Complete electrical and mechanical specifications are given, as well as information on sensing heads and accessories, scanners, and optional equipment.

RELAY CATALOGUE

49 **Universal Relay Corp.** is now distributing its 1965 relay catalogue, a 60-page illustrated publication. Included are plate circuit relays, high-voltage relays, stepping switches, telephone-type relays, timing devices, and multiple-contact relays.

LOGIC CIRCUITS

50 **CBS Laboratories** is making available a 4-page technical bulletin describing its Series A standard logic circuits which operate in the microwatt range rather than the standard milliwatt range.

Bulletin 1000 discusses eight circuit types, giving logic description, circuit schematic, and power dissipation for each type.

POWER SEMICONDUCTORS

51 **General Electric Company's** Rectifier Components Department has made available an 8-page brochure which abstracts 47 technical application notes, manuals, and reprints involving the selection, application, and testing of power semiconductors.

Subjects covered include the new "Triac" a.c. switch, gate turn-off switch, and light-activated SCR.

WIRING BOARD CATALOGUE

52 **Vero Electronics, Inc.** has announced the availability of a new 2-color, 24-page catalogue featuring complete ordering information and technical data on "Veroboard" and its accessories.

The booklet, illustrated with photographs and line drawings, explains the selection, design method, and layout procedure for this universal wiring board.

RESISTANCE VALUES

53 **Metavac, Inc.** is now offering a chart which supplies resistance values for symmetrical T-pads with a characteristic impedance of 50 ohms. Covering the attenuation range of 0.1 to 40 db, the chart simplifies specification of thin-film resistance elements required for terminations and attenuators.

The reference guide is aimed for circuit engineers involved in high-frequency design work.

TRANSFER LETTERING

54 **Chart-Pak, Inc.** has issued an illustrated folder describing the specifications, alphabet samples, and uses of "Deca-Dry" transfer lettering. Draftsmen, technical illustrators, and designers can choose from 16 styles available in four colors in a wide range of sizes. Capital and lower-case letters as well as numbers are available.

Uses include statistical graphs, work-flow and data-processing charts, and scale models.

POWER TRANSISTORS

55 **Motorola Semiconductor Products Inc.** has published a new 6-page power-transistor selection chart and cross-reference guide. Chart PP 102 R8 contains information on the selection of germanium and silicon transistors for consumer, industrial, and military applications.

Close to 1000 device types are described, with references to EIA registered numbers and closest available company equivalents.

CARTRIDGE REPLACEMENT

56 **Sonotone Corporation** has made available a new cross-reference crystal-cartridge replacement chart listing 146 competitive models which the company's line will replace. Intended for dealers, the cross-reference guide (No. SAC-28) includes both mono and stereo cartridges.

INDICATOR LIGHTS

57 **Dialight Corporation** is now making available a 12-page illustrated catalogue presenting its complete line of subminiature indicator lights that meet or exceed the requirements of MIL-L-6723 and MIL-L-3661. Complete specifications and mounting information are given for neon and incandescent lights.

V.L.F. COMPARATOR

58 **Hewlett-Packard Company's** "Journal" (Vol. 16, No. 2) is devoted to a description of the firm's Model 117A v.l.f. phase comparator. Illustrated with photographs and diagrams, the publication discusses the use of the device for relating local frequency to United States frequency standards.

Complete specifications for the unit are provided, as well as a brief section on the company's "Dymec" Model DY-2365B tunable v.l.f. comparator.

ZENER DIODES

59 **Motorola Semiconductor Products Inc.** is now distributing a new 12-page illustrated brochure containing the latest information on the company's line of zener diodes. Manufacturing, process control, test and high-reliability assurance procedures and facilities are discussed in this brochure.

Device selection charts are included, as well as a section on application hints. ▲

MARINER IV PASSES 92-MILLION-MILE MARK

ON January 20 this year, NASA's "Mariner IV" spacecraft had passed the 92-million-mile mark on its 325-million-mile flight to the planet Mars.

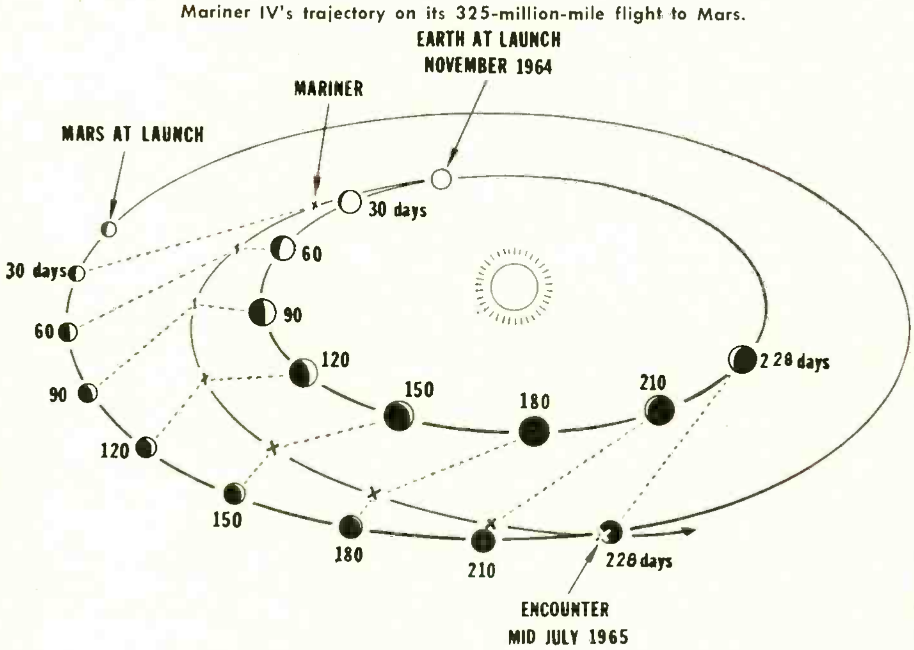
Ever since December 17th, the spacecraft has been locked on the star Canopus after a ground command. During its first 29 days of flight, Mariner IV made nearly 10 million scientific and engineering measurements in space outside the Earth's orbit. It had been transmitting 33⅓ bits of information per second since launch on November 28th, but on January 3, 1965 the bit rate was switched to 8⅓ per second because of the increasing distance between the Earth and the spacecraft.

At 9 p.m., January 20th, the straight line distance between Earth and Mariner IV was 9,855,315 miles. This was about one-tenth the distance the spacecraft had actually traveled in its arcing interplanetary orbit (see diagram below). It was moving at a velocity of 10,519 miles per hour relative to the Earth and 68,381 miles an hour relative to the Sun. The actual distance traveled was 92,219,961 miles as of 3 a.m. EST on Wednesday, January 20.

The Earth and Mariner IV are moving, in their respective orbits, in essentially the same direction around the Sun. Later in the mission, the Earth will begin to pull away from Mariner, rapidly increasing the Earth-Mariner transmitting distance.

On July 14th, when Mariner has traveled some 325-million miles to fly by Mars, the transmission distance will be about 140-million miles. ▲

Mariner IV's trajectory on its 325-million-mile flight to Mars.



Answer to Electronics Crosswords

(Appearing on page 71)

M	A	R			T	A	T	S		I	N	N
O	R	E		F	I	N	A	L		F	O	E
D	I	E	L	E	C	T	R	I	C		T	E
E	D	D	Y				O	P	E	N	E	D
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		S	I	S		M	E	S	A			
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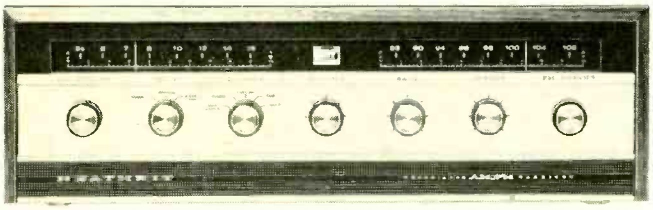

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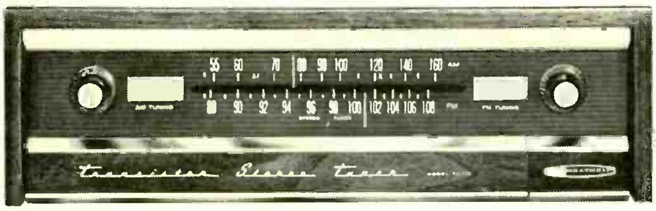

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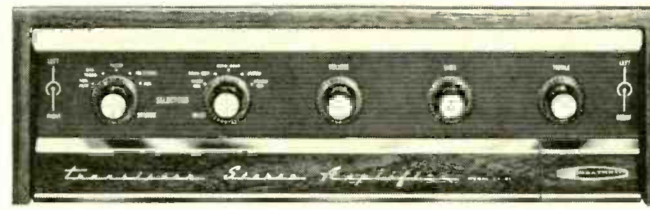

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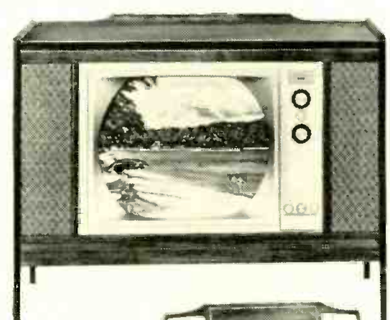

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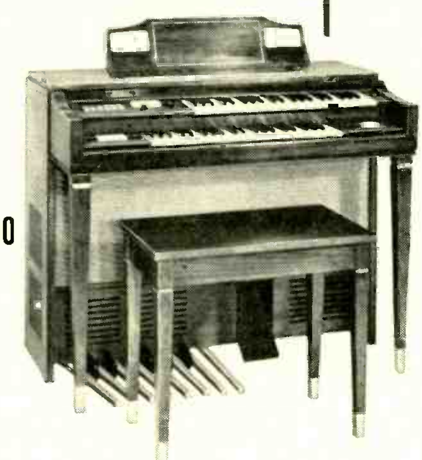

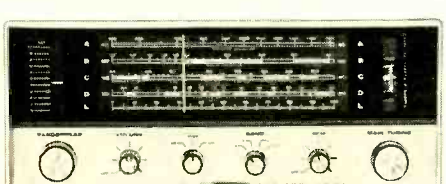

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35	.70	2.05	1.35	1.50
100	1.65	1.00	2.50	3.15
240	3.75	4.75	5.75	8.75

D.C. Amps	300 Piv 210 Rms	400 Piv 280 Rms	500 Piv 350 Rms	600 Piv 420 Rms
3	.29	.30	.40	.48
12	1.00	1.35	1.45	1.70
18**	1.00	1.50	Query	Query
35	2.15	2.45	2.75	3.33
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150	1.00	1.65	2.00	500	3.25	3.60	4.00
200	1.30	1.90	2.30	600	3.50	4.35	4.60

"Volt-Tab" 600 watt speed control & light dimmer, 115 VAC $4.50 @, 2 for $8.00

"TAB" TERMS: Money Back Guarantee! Our 20th year. $2 Min. order F.O.B. N.Y.C. Add shpg charges or for C.O.D. 25% Dep. Prices shown subject to change.
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CIRCLE NO. 225 ON READER SERVICE PAGE

The NEW 'POP' RiveTool with Interchangeable Heads for "INSTANT" RIVETING

- NO ANVIL OR HAMMERING
- NO SPECIAL SKILL REQUIRED
- A STRONG, NEAT FASTENING EVERY TIME

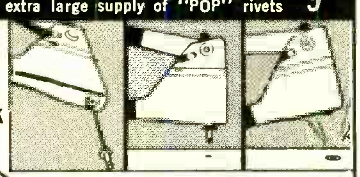
Cadmium Plated Steel Rivets replace screws, bolts, soldering, etc. in repairs or workshop projects. Use on appliances, TV antennas, gutters and downspouts, toys, bicycles, ductwork, chassis - virtually anything from hardwoods to plastic, leather, metals, etc.

ONLY **$5.95**

COMPLETE KIT WITH "POP" RIVETS

DELUXE GIFT KIT in metal box with extra large supply of "POP" rivets $9.95

HOW THEY WORK



1. Insert rivet in tool.
2. Place rivet in hole of materials to be fastened.
3. Squeeze handles to set rivet.

IT'S THAT SIMPLE.

NOW for the first time! New interchangeable heads allow use of light and heavy duty rivets. Order form for additional rivets (available in six sizes) enclosed with kit.

CONSUMER SERVICE COMPANY
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Enclosed is $______. Please ship me the following:

______RiveTool kits at $5.95 ea. plus 35¢ ea. for postage and handling.

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(N. Y. C. residents please add 4% sales tax). Foreign orders $1.00 additional.

Name______ (PLEASE PRINT) EW-35

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City______ State______ Zip Code______

Sorry—No charges or C.O.D. orders.

15 DISTANCE One-tube plans—25¢. "One Tube Handbook"—50¢. Includes Data sheets, catalog. Laboratories, 1131-H Valota, Redwood City, Calif.

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TUBES—TV, Radio Transmitting And Industrial Types At Sensibly Low Prices. New, Guaranteed, 1st Quality. Top Name Brands Only. Write For Free Catalog or Call WAlker 5-7000, Barry Electronics, 512 Broadway, New York N.Y. 10012.

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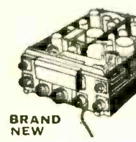
15 Tubes 435 to 500 MC



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. 15 tubes (tubes alone worth more than sale price!): 4—7F7, 4—7H7, 2—7E6, 2—6F6, 2—955 and 1—WE-316A. Now covers 460 to 490 mc. Brand new BC-645 with tubes, less power supply in factory carton. Shipping weight 25 lbs. SPECIAL! **$19.50**

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Equipped with original calibration charts. 125 Kc to 20,000 Kc with crystal check points in all ranges. Excel. Used with original Calibration Book. Crystal, and all tables. CHECKED OUT!

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195 to 420 Kc. made by Setchel-Carlson. Works on 24-28 volts DC. 135 Kc. IF. Complete with 5 tubes. Size 4" x 4" x 6". Wt. 4 lbs.
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BC946 Receiver 550-1500 Kc Complete with all tubes, Brand New, in original backing .... P.U.R.
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110 Volt AC Power Supply Kit for all 274-N and ARC-5 Receivers. Complete with metal case, instructions **$8.95**
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Please include 25% Deposit with order—Balance C.O.D., or Remittance in Full. 50¢ Handling Charges on all orders under $5.00. All shipments F.O.B. Our Warehouse, N.Y.C. All Merchandise subject to Prior Sale and Price Change.

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CIRCLE NO. 183 ON READER SERVICE PAGE

GET IT from GOODHEART!

BROADCAST-BAND COMMAND RECEIVER: ARC Type 12, #R-22. Late type! 540-1600 kc. 6 tubes: RF. converter, 2 IF's & AVC, det. & Noise Limiter, & AF. 2 uv sensit. Needs external pwr sply & control ckts & has no tuning dial. With spline tuning knob, schematic, pwr sply schematic, electrically checked OK **17.95**
(Add $3 for extra-clean selected unit.)

ARC-5 Q-5'er Rcvr 190-550 kc w/85 kc IF's. Use as 2nd converter for above or other rcvrs. Checked electrically, w/lots of tech. data. w/spline knob. 9 lbs fob Los Ang. **14.95**
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(Also see Jan. ad page 100 for other Tekt.)
HEWL.-PACK. No. 400AB AC VTVM **89.50**
And #400D AC VTVM **150.00**
And #330BR Distortion Analyzer **325.00**
And #608B VHF Signal Generator **475.00**
(See Jan. p. 100 for other Hewl.-Pack.)
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ROLLIN #20 LF Signal Gen., 12 W Po **1295.00**
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CIRCLE NO. 243 ON READER SERVICE PAGE

POEMS Wanted for songs and records. Send poems. Crown Music, 49-RB West 32, New York 1.

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6AB4, 6AC7, 6AF4, 6AG5, 6AG7, 6AH4GT, 6AH6, 6AK5, 6AL5, 6AL7, 6AM8, 6AN8, 6AQ5, 6AQ6, GAQ7GT, 6AR5, 6AS5, 6AT6, 6AT8, 6AU4GT, 6AU5GT, 6AU6, 6AU8, 6AV5GT, 6AV6, 6AW8, 6AX4GT, 6AX5GT, 6B8, 6BA6, 6BC5, 6BC8, 6BD6, 6BE6, 6BF5, 6BF6, 6BG6G, 6BH6, 6BJ6, 6BK5, 6BK7, 6BL7GT, 6BN6, 6BQ6GT, 6BQ7, 5BY5G, 6BZ6

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2N179	2N351A	2N1291
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CIRCLE NO. 198 ON READER SERVICE PAGE

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URM-23 Attenuators—1000 to 4000 MC...New:	14.95
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TS-118/AP RF Wattmeter ....Used:	39.50
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TS-34/AP Oscilloscope ....Used:	39.50
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RAX-1 Receiver—200 to 1500 KC........Used:	29.95
BC-348 200 to 500 KC—1.5 to 18 MC....Used:	89.50
R-23/ARC-5 190 to 550 KC ....Used:	14.95
R-25/ARC-5 1.5 to 3 MC ....New:	19.95
R-77/ARC-3 100 to 156 MC............Used:	22.50
BC-1206 Receiver—200 to 400 KC......Used:	9.95
BC-229 200 to 400 KC—2500-7700 KC...Used:	8.95
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CIRCLE NO. 181 ON READER SERVICE PAGE

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LOW LEAKAGE FULL LEAD LENGTH

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PIV/RMS 400/280 .20 ea	PIV/RMS 500/350 .24 ea	PIV/RMS 600/420 .32 ea	PIV/RMS 700/490 .40 ea
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SILICON POWER DIODE STUDS

D.C. AMPS	50 PIV 35 RMS	100 PIV 70 RMS	150 PIV 105 RMS	200 PIV 140 RMS
3	.12	.18	.22	.30
12	.45	.65	.75	.90
35	.90	1.15	1.50	1.70
50	1.60	1.90	2.30	2.80
100	1.75	2.15	2.55	3.15

D.C. AMPS	300 PIV 210 RMS	400 PIV 280 RMS	500 PIV 350 RMS	600 PIV 450 RMS
3	.40	.45	.55	.65
12	1.10	1.35	1.50	1.70
35	2.35	2.55	3.00	3.50
50	3.50	4.20	5.25	7.00
100	3.75	4.60	5.65	8.00

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PRV	7 AMP	16 AMP	25 AMP	PRV	7 AMP	16 AMP	25 AMP
25	.50	.85	1.20	250	2.30	2.65	3.10
50	.85	1.20	1.40	300	2.60	3.00	3.40
100	1.35	1.80	2.20	400	3.00	3.40	4.15
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148-172mc RCA CMC 60B
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If crystals and tuning is desired, add $40.00.

We also have the proper chargers for these units, GE Model #4EP27A10, Price: $18.

If additional nickel cadmium Battery Packs are required, they are available at a price of $25.00 each.

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25-50mc 20F3 Emission TX narrow banded 12 volt, 50 watt. Complete with all accessories, less crystals and antenna. **$128**

Add $40 for crystals, tuning and brand new antenna—ready to go on your frequency, also available in dual frequency Tx & Rx add $30 for tuning of second frequency

We Buy Late Model Equipment for Cash —Write; Wire or Phone!

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CIRCLE NO. 185 ON READER SERVICE PAGE

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CIRCLE NO. 133 ON READER SERVICE PAGE →

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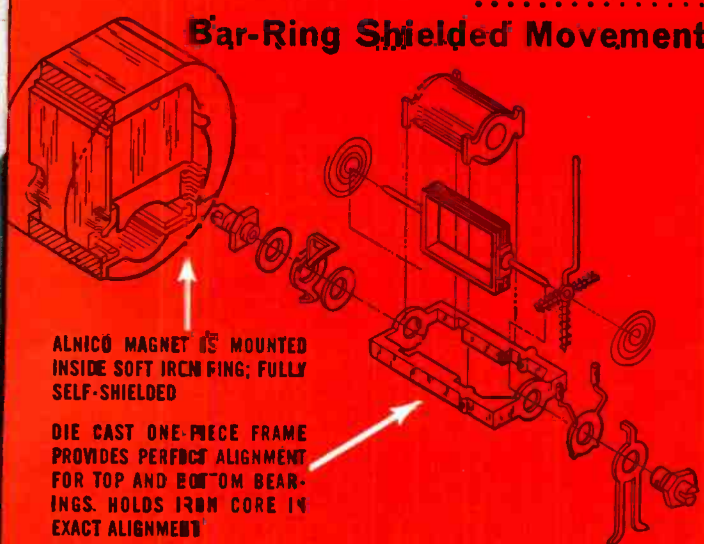

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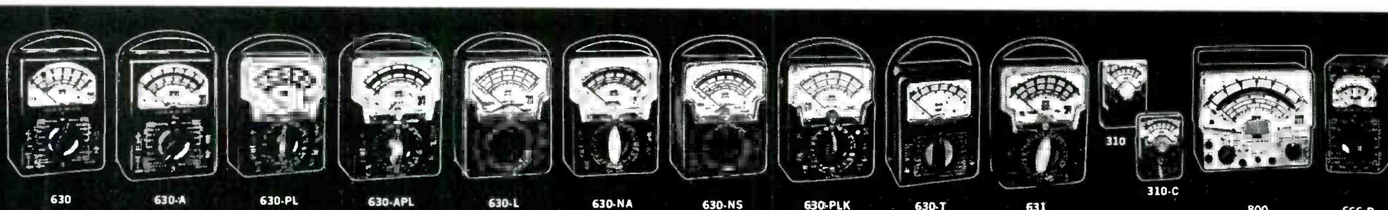

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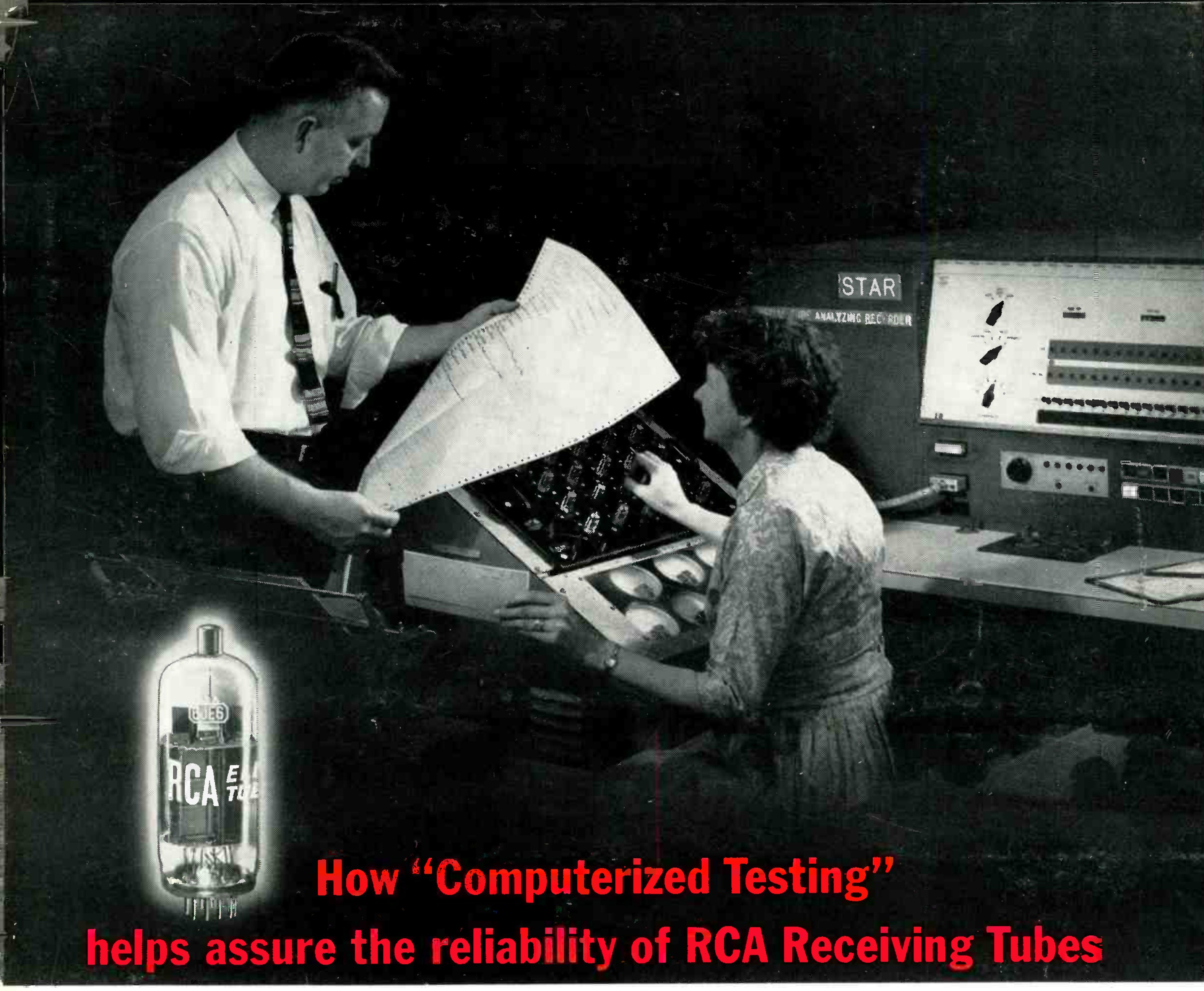

How "Computerized Testing" helps assure the reliability of RCA Receiving Tubes

This engineer is studying final test results of another production run of RCA Receiving Tubes. Nothing surprising here . . . except for one thing: the production run had been completed only hours before!

A few years ago, a thorough quality evaluation of a day's production run of a certain tube type took days, even weeks. But now, at RCA, it's done automatically, with computers, the same day.

Computers in conjunction with the Special Tube Analyzing Recorder (STAR) accumulate and store test data on every receiving tube type we make.

Sample tubes from the production lot are individually analyzed on STAR. As many as 60 tests may be made quickly and automatically on each tube depending on the type. Test results are recorded simultaneously on a test sheet and on punched cards. The computers compare the results with predetermined standards, make "accept" or "reject" decisions and then add the results to the historical record of the tube type.

Thus, in a mere half-hour of running time each night, a full day's receiving-tube output can be evaluated before it is released for shipment. Equally important, the test data for any day's production of a particular tube type together with the historical record for that tube type are on the desks of the production, quality-control and design engineers the following morning. With these data, the engineers can evaluate performance, analyze trends and quickly initiate any corrective measures necessary to assure the consistent quality of RCA Receiving Tubes.

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