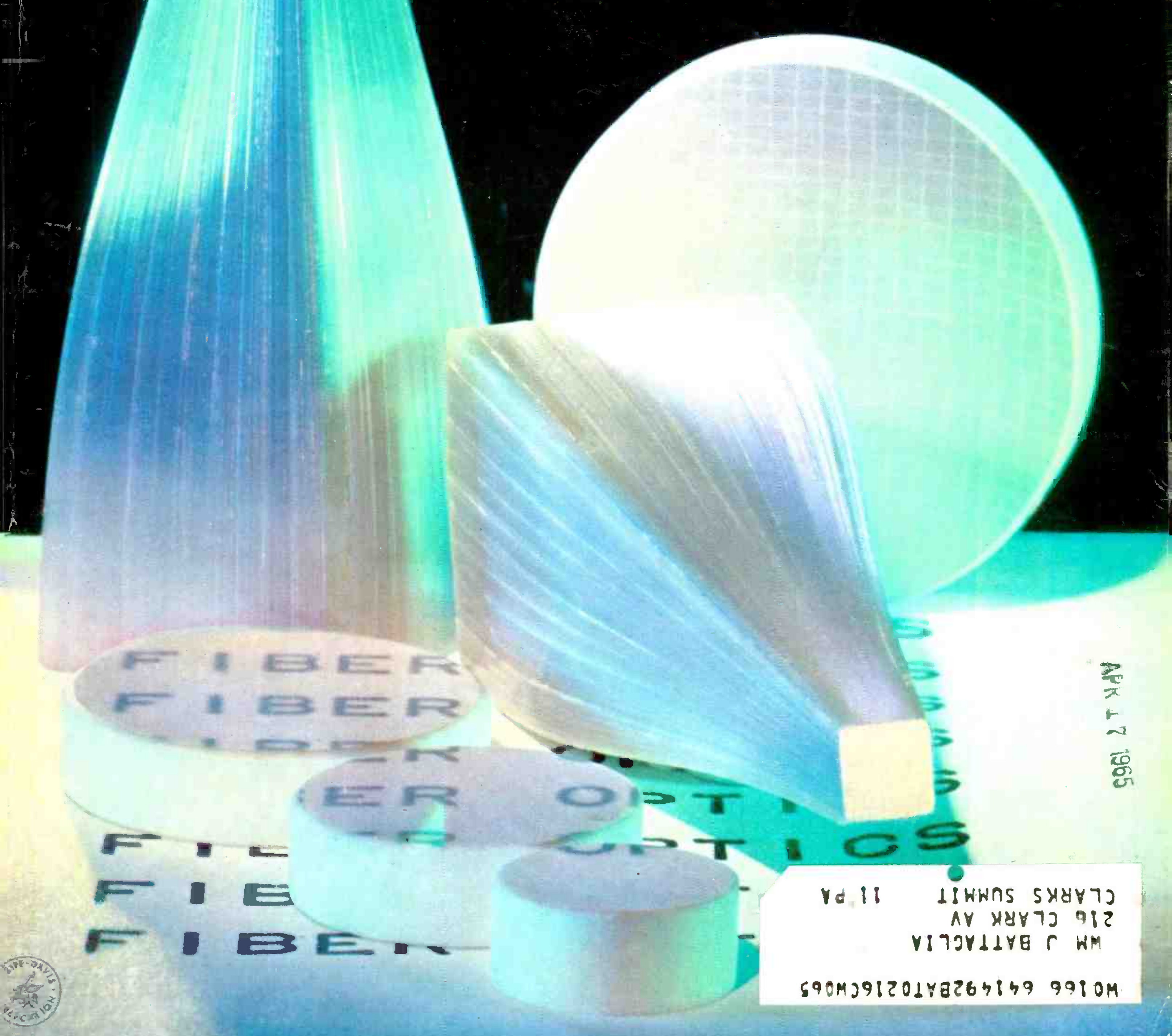
Electronics World

MAY, 1965
50 CENTS

SSB COMES TO MARINE RADIO
SOLVING FM TUNER DESIGN PROBLEMS
SOLID-STATE DIMMERS & POWER CONTROLS
TUNING FORKS AS ELECTRONIC COMPONENTS



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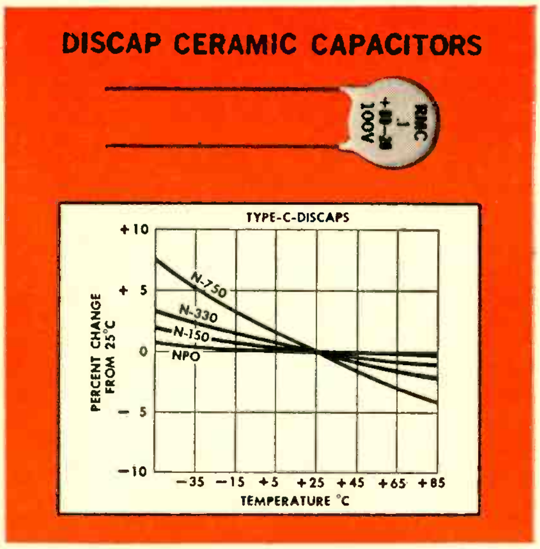
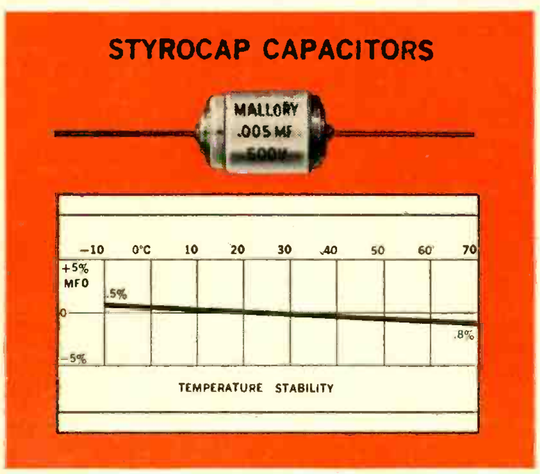
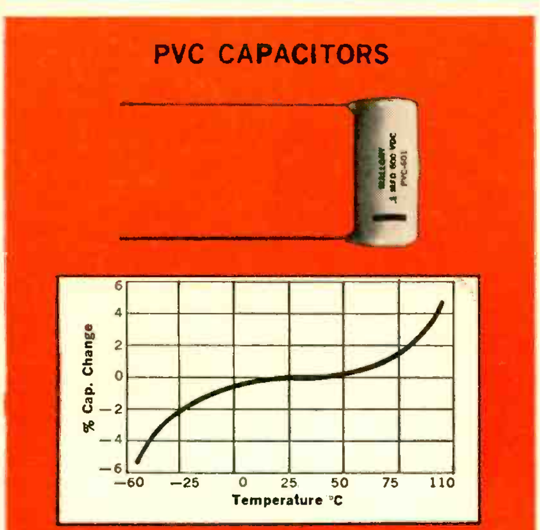
CIRCLE NO. 180 ON READER SERVICE PAGE

MALLORY Tips for Technicians

What you should know about capacitor stability







Why worry about capacitor stability? After all, aren't all capacitors pretty much alike? Well, as we all know, capacitors aren't "all alike". Matter of fact, there are many circuits where you wouldn't want capacitance to change with either temperature or time. For example, tuned circuits or RC timing networks. And this is especially true in color TV, because the eye notices even minor shifts that would pass unnoticed in black and white. Therefore, capacitor stability *is* important.

The trouble with most "static" capacitors is that capacitance increases as temperature increases. In other words, they have a *positive* temperature coefficient. And so do most inductance coils. Put these two creatures together and you'll see why frequency and timing can drift as the set warms up.

Now—what can you do about it? For small capacitance values, your best bet is a DISCAP® disc ceramic capacitor (made by Radio Materials Company, a Mallory division). DISCAPS are available in a vast array of temperature coefficients to exactly match circuit requirements. DISCAP temperature coefficients can be chosen so that they exactly offset the positive drift of coils (or other components). Thus, circuit characteristics stay constant regardless of temperature change. There are NPO (zero change) and up to N1500 (very sharp *negative* temperature coefficient) types. You'll find these listed in the 1965 Mallory General Catalog.

A brand new type of ultra-stable capacitor is now available. It's called the STYROCAP™. It's a new type of polystyrene capacitor that offers both temperature and time stability. The temperature coefficient is comparable to an N150 DISCAP. And capacitance change vs. time is practically zero. STYROCAPS are made from a unique form of stretched and fused polystyrene. They're transparent. You can look right through the clear plastic and actually *see* the aluminum foil! They're available from 5pF to .01 mfd. They're rated 500 WVDC and sizes and prices are right down there with comparable values in ceramics or molded film capacitors.

Styrocaps can be successfully substituted for all sorts of other capacitor types: mica, ceramic, paper, film, or anything else in their capacity and voltage range. But don't think of Styrocaps as substitutes. They're not. They're new. And they're better . . . especially where stability is downright important.

On the other hand you may really need a Mylar* type capacitor. When you do, take a look at the terrific Mallory PVC. These are available in a whole host of values and they're unbeatable in their class. The blue polyvinylchloride coating is just plain *moistureproof*.

And one more tip. Your Mallory distributor now has the new 1965 Mallory General Catalog. Ask him for your copy today. Mallory Distributor Products Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.

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CIRCLE NO. 129 ON READER SERVICE PAGE

Electronics World

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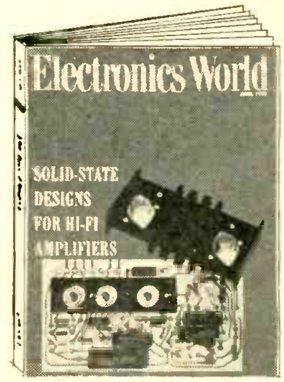
ON OUR COVER: Fiber-optic plates in disc form are drawn from "roots" made up of bundles of minute, discrete fibers of glass, each clad with a glass of a different refractive index. Fiber-optic devices transmit light with extremely low loss of visible energy and without diffusion. This gives the effect of raising the printing underneath to the top surface of the plates. This new technology has promising electro-optical applications in military, medical, and other fields. For further details, refer to our lead article "Fiber Optics in Electronics" on page 25 . . . (Cover photo: Corning Glass Works.)

COMING NEXT MONTH



SOLID-STATE DESIGNS FOR HI-FI AMPLIFIERS

Paul Marcus and Larry Zide have surveyed the field of semiconductors as applied to power amp designs, with emphasis on the output stages. The authors cite the advantages and disadvantages of semiconductor circuitry and offer an analysis of the best applications for semiconductors in audio circuits.

ELECTRONIC INTRUSION ALARMS

Such protecting and detecting devices are in the news as Congress investigates "electronic eavesdropping" and other applications of electronics to surveillance and law enforcement. This article covers several methods of detecting the presence of unlawful intruders within a protected area, how they indicate such intrusions, and how the different systems work.

RECEIVER REQUIREMENTS FOR MONITORING GEMINI

In order to pick up voice transmissions from astronauts in the Gemini space capsule, receiver designs involve calculations of orbital distance, space attenuation, and Doppler shift. The design of a four-channel transistorized receiver that takes all these factors into account is also included.

LIQUID FLOW MEASUREMENTS

Since liquids can have different electrical properties, different viscosities, can be corrosive, boiling, or cryogenic, each property must be taken into account for best results with flow measurements. John R. Collins explains these various factors and how they are handled.

SEMICONDUCTOR SWEEPS FOR LARGE-SCREEN TV

Some entirely new concepts in sweep-circuit design will have to be made before reasonably priced, large-screen transistorized TV sets hit the market. Here are some suggestions on possible designs.

SILK-SCREENED CIRCUIT BOARDS

A simple and inexpensive technique for processing prototype boards or small-to-medium production runs is described in detail by John Marchetti of Roanwell Corp. The technique and the materials required to fabricate the boards are within the range of anyone.

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

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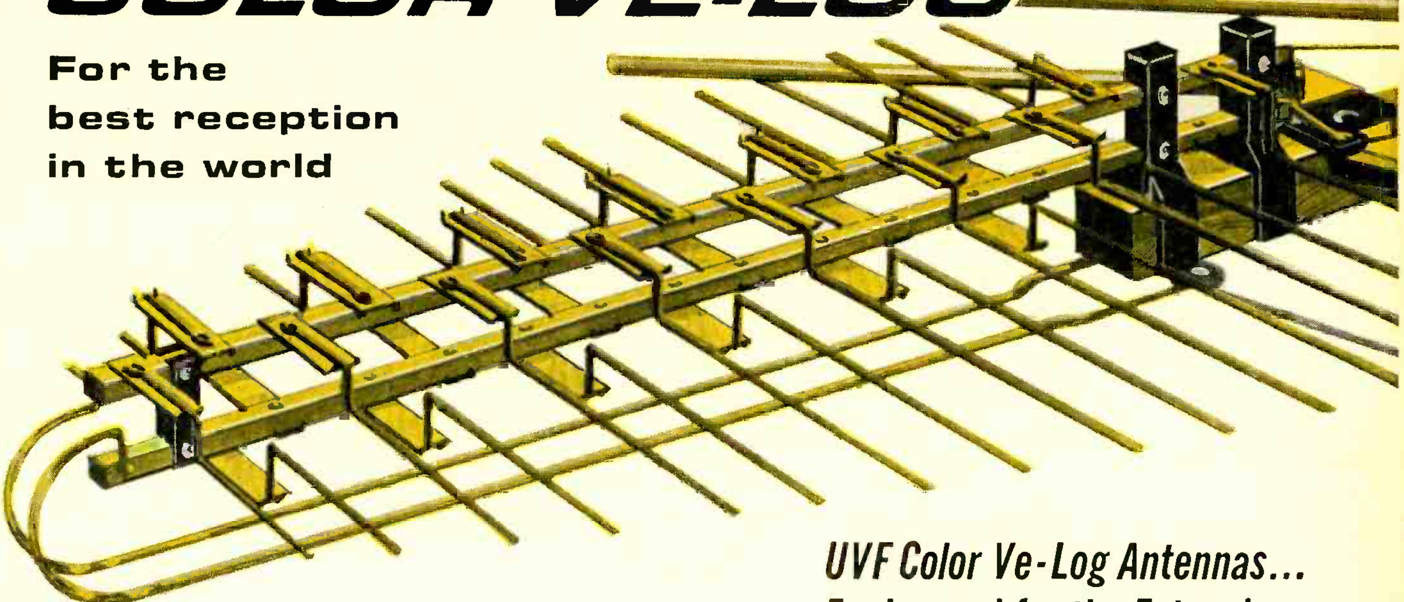

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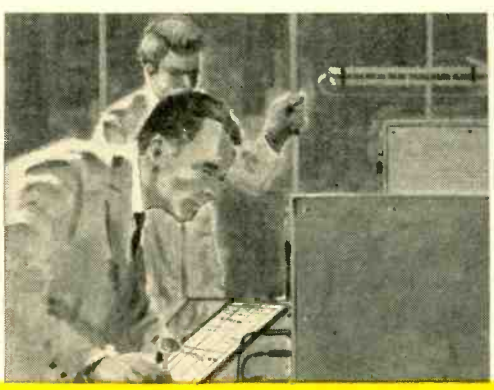

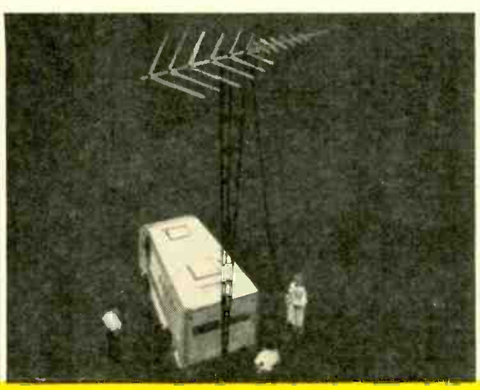

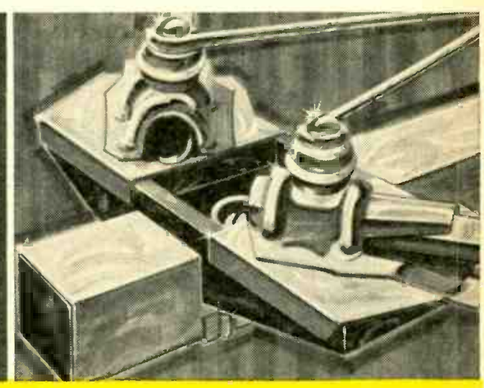

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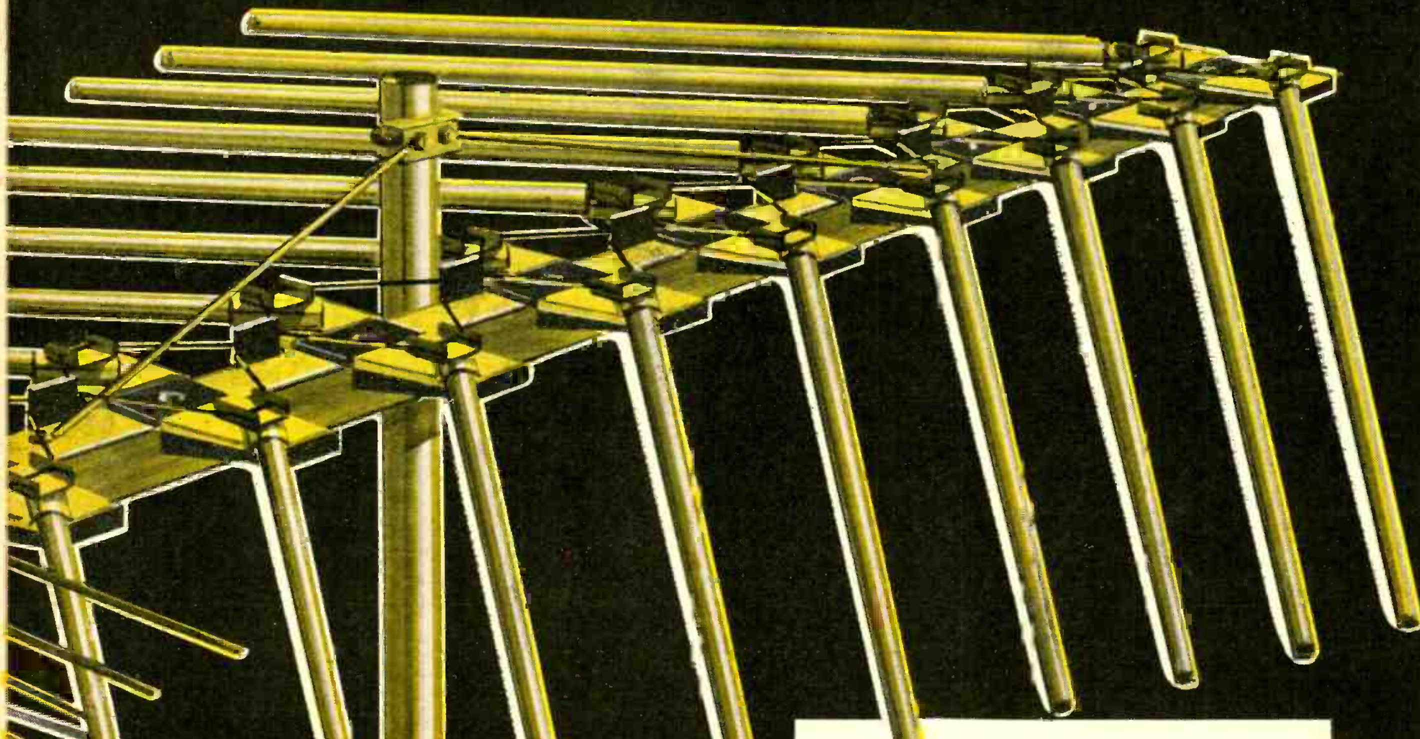

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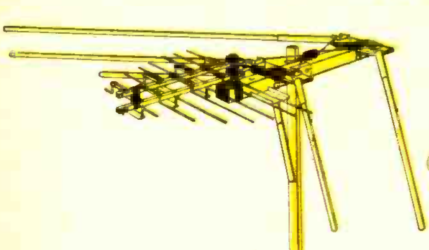

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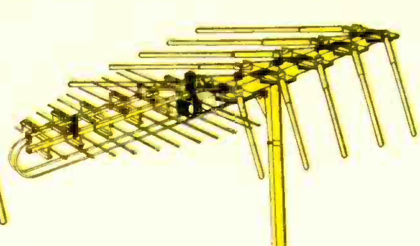

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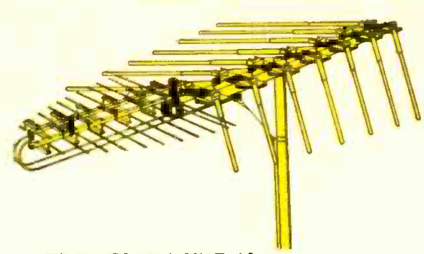

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CIRCLE NO. 246 ON READER SERVICE PAGE

For the record

WM. A. STOCKLIN, EDITOR

NEW CB RULES—"HELP"

THE long-awaited FCC decision on the tightening of the class-D Citizens Radio Service rules and regulations has just been announced. In essence, the set of rules adopted last July has been affirmed in all significant respects and will become effective on April 26.* Many will recall the confusion, excitement, and concern when the FCC originally presented its new rules last July. Although they were to have become effective last November 1st, a great number of petitions opposing certain aspects of the proposed changes were presented. These resulted in a postponement at that time.

In announcing its latest decision, the FCC has again emphasized that the primary purpose of the class-D Citizens Radio authorization is to afford a means of communications between units of a single licensee and to put an end to hobby-type operation.

Communications between units of different licensees, *i.e.*, inter-station operation, will be permitted only under certain conditions and is restricted to seven designated frequencies instead of permitting this type of operation on all 23 channels. Inter-station operation is allowed only on channels 9, 10, 11, 12, 13, 14, and 23.

Licensees are specifically prohibited from engaging in radio communications as a hobby or diversion, that is, operating the radio station as an activity in and of itself. Also, all inter-station communications will be limited to no more than five consecutive minutes with a silent period of at least five minutes before another transmission will be permitted. The FCC again emphasizes that communications to stations of other licensees relating to technical performance, capabilities, testing of any transmitter (including transmissions concerning signal strength or frequency stability of transmitters) will be definitely prohibited. All CB licensees are expected to comply.

Obviously these new rules will affect every CB operator. For the legitimate operator who has not abused his privilege of transmitting on the CB band, the stricter rules will be a decided advantage. They will help materially in guaranteeing better communications without undue interference. To those who have abused their privilege and who have operated selfishly without concern for others and strictly as a hobby, the rules will be a great disappointment.

The CB band was never intended—although some may argue the point—for hobby communications. The FCC feels, and rightly so, that this type of operation should be confined to the ham bands.

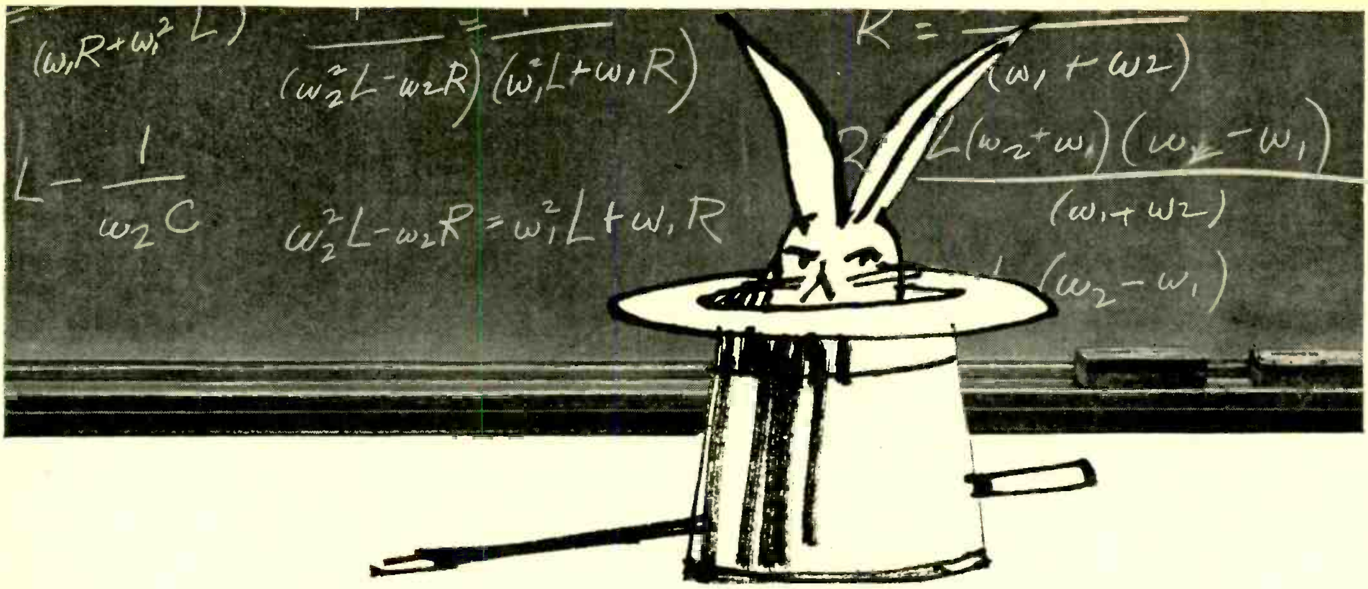
As to the over-all effect on the CB industry, time alone will tell. Many manufacturers feel that, with more reliable communications, more equipment will be marketed. There are others, of course, who rely strongly on the hobby customer and there is no doubt that these manufacturers will suffer.

Now that the FCC seems to have solved one of its major problems, it is confronted with a new one. The Automobile Manufacturers Association (AMA) has petitioned the FCC for exclusive allocation of the frequencies 27.235 mc. and 27.245 mc. (at the upper end of the Citizens Band) for use in their "HELP" (Highway Emergency Locating Plan) program. This is a cooperative nationwide program in which motorists in distress could communicate through the use of 2-way radio equipment to obtain assistance in the event of an accident or mechanical failure. Automobile manufacturers hope to supply this equipment as an accessory, and if sufficient interest is shown, it may become standard equipment on all cars.

Certainly a good case can be presented in favor of such a program. One has simply to cite many of the outstanding achievements of CB operators today in helping distressed motorists. Just consider the western part of this country with its wide open spaces where one can travel for miles on end without encountering another car or a service station. Communications here would prove invaluable. However, most motorists who drive in metropolitan areas where phones are readily available would be unlikely to pay anything extra for such a system. This, however, is beside the point. If there are individuals who would find a real need, then every effort should be made to supply the service.

Obviously, the equipment must be fool-proof, crystal-controlled, FCC-approved, with the servicing and adjustment handled only by authorized personnel. It seems that the use of a single channel might be preferable to the two requested. On the other hand, if this equipment will be used for inter-car hobby-type communications rather than for emergencies, we will have a situation similar to that which had existed in the regular CB band. In reviewing this petition, the FCC should also take into account its ability to properly police the new service. If it can't do an adequate job, operation on these frequencies could be chaotic. ▲

*See "Citizens Radio Rules Tightened" in our October, 1964 issue and "Comments on the New CB Rules" in our November, 1964 issue.



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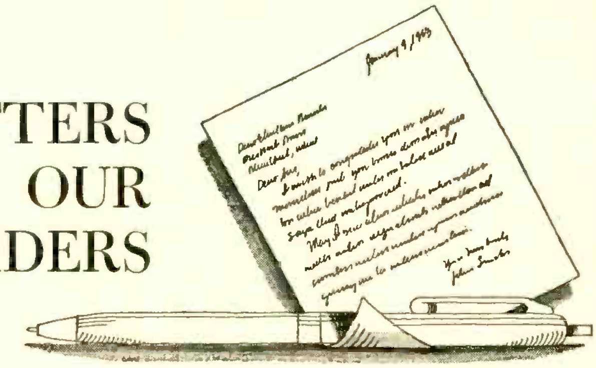
LETTERS FROM OUR READERS



GARAGE-DOOR OPENER

Following is a portion of a letter sent to us commenting on John Frye's article "A New Garage-Door Opener" in our February issue. The article included a description of the new Heath *GDA-20-4 which operates between 230 and 290 mc.*

To the Editors:

An association of manufacturers in the radio garage-door opener industry (DORCMA) has for several years been seeking changes in the FCC Rules that would make them more satisfactory for operation of controls in the 200- to 300-mc. range. In preparing its argument, the association relied heavily on pointing out the difficulties of operating door controls in the 27-mc. Citizens Band. We certainly recognize the difficulties of operation in this band and have in fact petitioned the FCC for relief until such time as proper enforcement of the Rules leads to an end of the abuse and misuse with which this service is plagued.

In the meanwhile we redoubled our efforts to produce equipment capable of operating in the Citizens Band without significantly increasing its cost. We are certain we have succeeded with our new generation of "pulse-tone modulation" controls and that we are offering competitively priced, reliable, and interference-free equipment for operation in this band.

Like the members of DORCMA, your article is directed toward solving the problems of radio door control operation in the Citizens Band by deserting the band and hoping that operation elsewhere will be given the blessing of legitimacy. Let us examine the "legitimacy" of the control described in your article.

The Rules require a timing device to provide a 30-second silent period following each transmission of one second maximum duration. According to the description of the circuit performance, the transmitter will act like a blocking oscillator having approximately a 3% duty cycle and a 30-second repetition rate. *However, releasing the button after one second permits another signal to be sent immediately.* (*Our italics–Ed.*)

I wonder if anyone has bothered to secure a written statement from the FCC indicating that this kind of operation is in conformity with the Rules. If such a statement has been secured, it is of extreme interest to DORCMA, whose members proposed this kind of operation quite some time ago. Apparently, the FCC regards this operation as providing continuous transmission, which indeed it does. For instance, a very effective telemetry system could be set up if the interpretation allowed further transmission after a break in the signal, rather than a strict 30-second silent period.

It would seem therefore that the transmitter, as it is being offered, is designed with a built-in mechanism to "dodge the Rules." I do not see how a manufacturer can put the certification label required by the FCC on the transmitter described in your article. I cannot believe the FCC would agree that this unit does comply with the Rules. If the manufacturer is certifying the device, I think that he has a responsibility to the buyer to insure him that he will not be violating the Rules when he uses it and would have confirmed compliance by communicating with the FCC. A special responsibility certainly exists with the publisher of ELECTRONICS WORLD whose readers have a right to expect the most accurate and knowledgeable information possible. If what I have pointed out is true, an explanation is certainly due the readers.

The matter of signal strength produced by the transmitter is also a problem. Unless the transmitter and receiver you described are vastly superior to similar units now on the market, it is not possible to obtain adequate operating range unless the transmitter can produce the legal maximum field strength when placed inside an automobile. Most manufacturers certify these transmitters by measuring them after placement inside an automobile. These same units outside the car produce field strengths averaging four or five times greater than legal maximum. Will the FCC agree that such a transmitter is in conformity with the Rules? I think not.

RICHARD GOLDSTEIN
Perma-Power Company
Chicago, Ill.

Mr. Goldstein's entire letter, from which the above excerpts were taken, was forwarded directly to Heath. *Since the units in question had been shipped to* Heath *by their vendor in fully assembled form complete with a label stating that they comply with FCC regulations,* Heath *has commented: "We were not aware of the problem until Dick Goldstein's letter came to our attention. In checking with the FCC, we were advised that there are changes in FCC Rules and Regulations concerning these devices to be announced shortly. In view of this we will have, at that time, a redesigned version of the garage-door opener which will comply completely with the new Rules. From what we gather, the changes will involve eliminating the 30-second pause in exchange for a more stringent field-strength limitation."—Editors.*

* * *

UHER 8000 LAB TEST

To the Editors:

Permit me to draw your attention to a misleading statement in your report on the *Uher* 8000 tape recorder (December issue). Although you correctly state that the machine ". . . will record or play back four-track mono or stereo tapes," it *does not have* "separate recording and playback systems so that a program can be monitored from the tape as it is being recorded." In stereo mode, the tape-monitor facility is non-existent, being available only for mono recordings.

A further minor error is that the vu-type meters do not "monitor" recording *and* playback levels, as you state.

I should add that I own several *Uher* recorders and believe them to be first-class products, the 8000 in particular, but I have had the sad experience of finding out that this machine will not tape-monitor stereo recordings.

Jack K. Burgess
Wheaton, Md.

* * *

REGULATOR OPERATION

To the Editors:

Regarding the February, 1965 issue of Electronics World, the description of the operation of the 12-volt regulator on page 60 is incorrect. It should read something as follows:

*Q*2 is an *n-p-n* silicon transistor that functions as an error amplifier. It will respond to voltage variations appearing at the collector of *Q*1 and adjusts the base bias of *Q*1 to maintain the output voltage constant. The base voltage for *Q*2 is supplied from the series voltage divider consisting of *R*1, *R*2, and *R*3. A constant reference voltage of 6.3 v.d.c. is developed across zener diode *D*1. The *emitter* voltage of *Q*2 will always be equal to the difference between the collector voltage of *Q*1 and 6.3 v.d.c.

If the power-line voltage rises, the power-supply voltage will rise, causing the collector voltage of *Q*1 to tend to rise. This will cause the *emitter* voltage of *Q*2 to tend to go more positive than the normal base-emitter voltage of *Q*2 (about 0.6 volt). This *decreases* the amount of forward bias that is applied across the base-emitter junction of the transistor.

This *lowers* the collector-emitter current of *Q*2, which also flows through the base-emitter junction of *Q*1. This current change will decrease the amount of forward bias applied to the base-emitter junction of *Q*1 and the transistor will not conduct as heavily.

My qualifications: I have designed and am designing regulators and reference sources (super-regulated regulators) for a local telemetry company.

James Wright Beville III
Sarasota, Florida

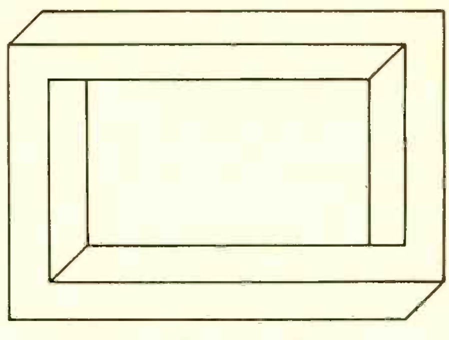
The remainder of the explanation and the final results were correct as described. However, the operation of Q2 was just opposite to our explanation.—Editors.

* * *

PROBLEM-BRACE BOX

To the Editors:

I noticed the drawing of the "problem



brace" on page 96 of your February issue and decided that if *IMC Magnetics Corp.* was going to manufacture and ship any of these, they would need a suitable case to ship them in. Here is my design.

James C. Morgan, Jr.
Westinghouse Molecular Electronics
Baltimore, Md.

* * *

SEMICONDUCTOR HEAT SINKS

To the Editors:

The article "Semiconductor Heat Sink Design Chart" on page 28 of the January issue of your magazine contains an error in conversion of Fahrenheit degrees to Centigrade. The fourth paragraph in the second column and the caption for the graph state that a 55°F temperature rise is equivalent to 13°C. This is not so, since the temperature rise is not related to any reference point, and therefore, subtraction of 32° does not apply but only multiplication by the factor of 5/9. Consequently, the temperature rise of 55°F corresponds to a temperature rise of 30.5°C.

K. S. Jablonski
Dollard des Ormeaux, Que. ▲

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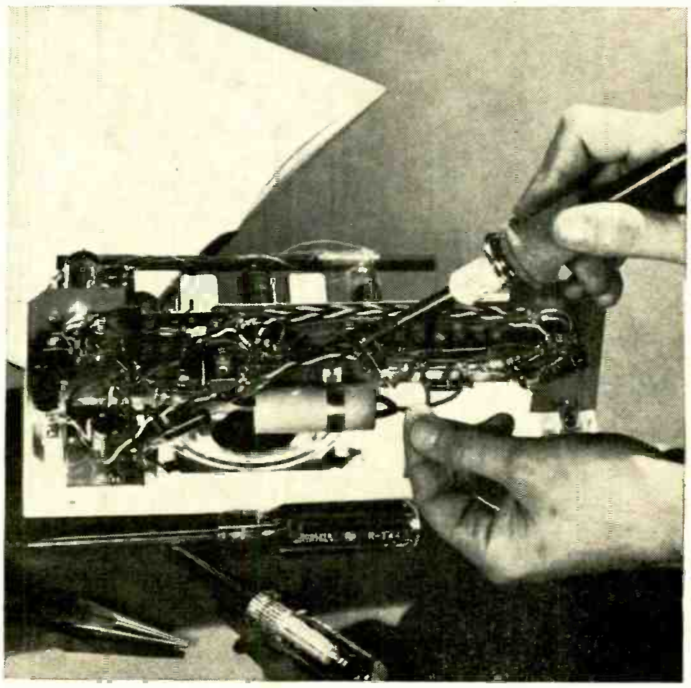


HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

Scott Model 344 Stereo Receiver
Shure M55E Stereo Phono Cartridge

Scott Model 344 Stereo Receiver

For copy of the manufacturer's brochure, circle No. 51 on coupon (page 15).

THE first transistorized stereo receivers were considerably more costly than their vacuum-tube counterparts and, frequently, were at least as bulky. In the few years since transistors entered the high-fidelity scene, there have been some remarkable reductions in price and size, with a corresponding increase in reliability and quality of performance. The new *Scott* Model 344 solid-state receiver is an excellent example of this trend.

The receiver is an unusually compact, complete stereo receiver. Except for four nuvistor tubes in the FM tuner front-end, it is completely transistorized. Measuring only 15" wide by 4½" high by 14" deep, it is little larger than an ordinary FM tuner. The Model 344 contains an FM-stereo tuner, with automatic stereo/mono switching; a stereo preamplifier with inputs for a phono cartridge, tape head, and a high-level source; and a stereo power amplifier rated at 25 watts per channel (IHF Music Power). It is handsomely styled with an illuminated tuning meter, softly lit slide-rule dial, and a neon FM-stereo indicator light.

The controls are sufficiently flexible for any home music system requirements, yet are laid out logically so as not to confuse the non-technical user. The basic knob-operated controls are the input selector, loudness control (combined with "on-off" switch), bass and treble tone controls (ganged for simultaneous adjustment of both channels, but with slip clutches for differential adjustment), and the tuning knob. In addition to the inputs from external sources through rear connectors, there are input selector positions for FM and FM with sub-channel filter (SCA).

Less often used functions are handled by six slide switches, with dots marked on the panel to indicate the normal or recommended settings. The tape-monitor switch connects the playback amplifiers of a tape recorder to the amplifier, in any position of the input selector switch. With a recorder having separate recording and playback systems, this allows monitoring from the tape while making a recording. A loudness-compensation switch applies low- and high-frequency boost to the amplifier at low volume settings, for more pleasing sound under background-music conditions.

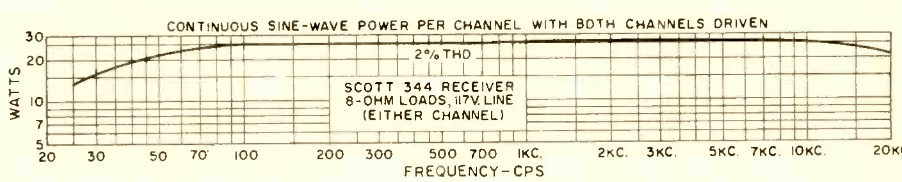
Volume adjustment is by means of a pair of concentric controls so that the levels of the two channels may be independently adjusted for balance. A unique patented "balance"-switch system is incorporated and used to balance the power output levels for stereo reproduction. In use, a mono record or program material is applied to the unit, and by operating the "balance" switch back and forth all the sound is channeled to one loudspeaker and then the other. The volume controls are used to obtain proper audible balance. This has been a feature of many *Scott* amplifiers and works very well.

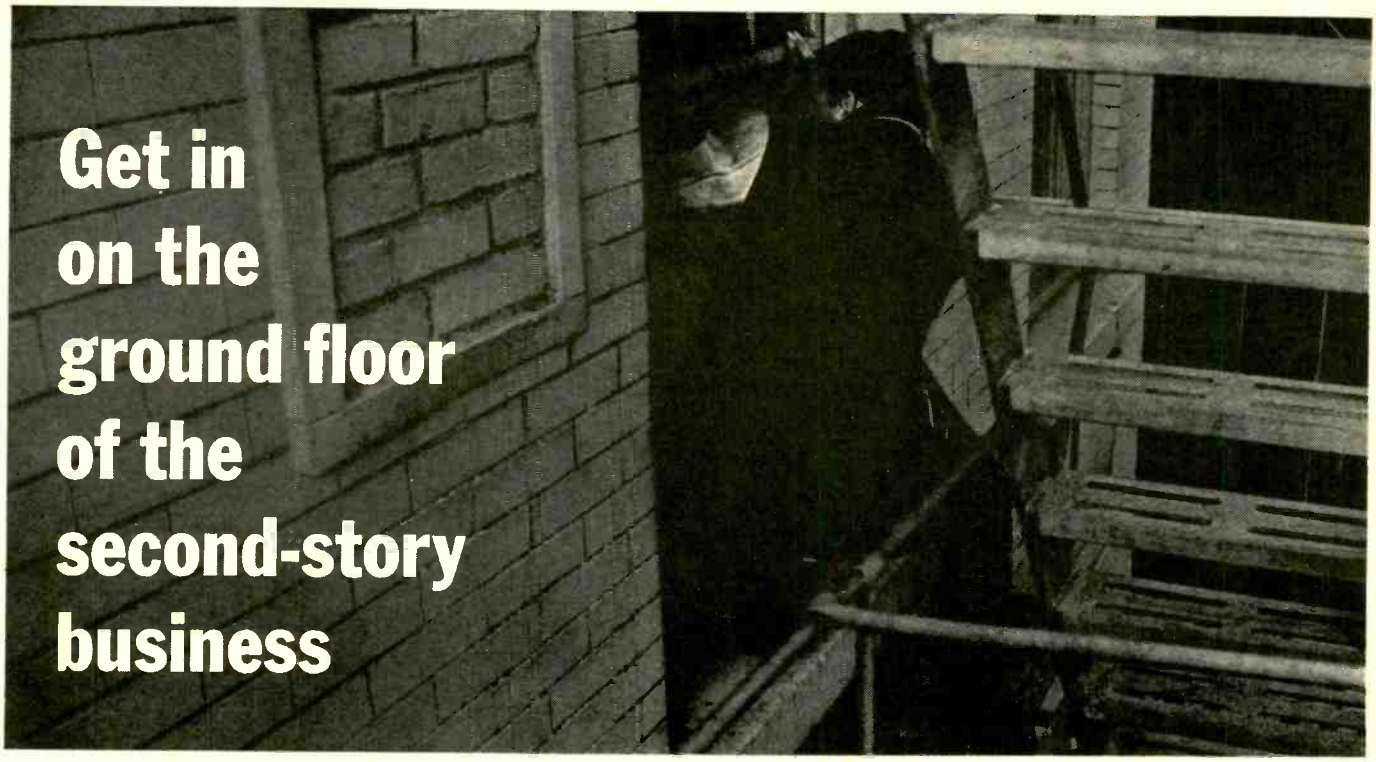
The "Stereo/Mono" switch, effective on all inputs, parallels both channels for mono listening. This is the proper way to listen to a mono record with a stereo pickup, since it cancels any vertical rumble picked up from the turntable. When it is used in FM reception, it also disables the multiplex circuits and shuts off the neon stereo indicator light. It is rarely necessary to use this switch in FM reception since the presence of a pilot carrier automatically switches the set to stereo. However, a weak FM station may be too noisy to receive in stereo, in which case the switch may be used to override the automatic circuits.

The "Noise Filter" is a high-cut filter with a gradual slope of 3 db/octave above 3000 cps. It is very mild in its action. Finally, a three-position speaker switch connects the receiver output to either of two pairs of speakers, or cuts off all speakers for headphone listening through the front-panel headphone jack.

The tone controls have a measured range of +12, −15 db at 50 cps and ±12 db at 10,000 cps. The loudness control provides a gentle boost of low and high frequencies, not exaggerated to the point of unnaturalness, yet sufficient to add body to low-level background music. The frequency response of the audio amplifier is flat within ± 1 db from 40 to 20,000 cps. It has a built-in roll-off below 20 cps to filter out subsonic rumble and transients which might overload the amplifier or damage the speakers. This filter has only a slight effect at 60 cps, dropping the response by 2.5 db at 20 cps.

The RIAA phono equalization is very accurate, within ± 0.5 db from 80 to 15,000 cps, and down 2.5 db at 30 cps. The NAB tape playback equalization





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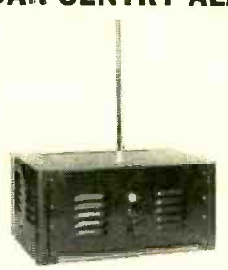

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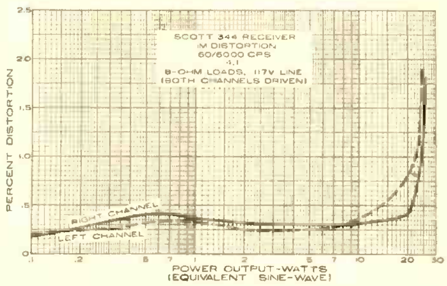
was within ±0.75 db from 70 to 15,000 cps, and down 3.5 db at 30 cps.

The hum level of the unit was inaudible on all inputs. At high volume levels some hiss could be heard on the low-level inputs, but these, too, were dead silent at normal gain settings. The phono input had a three-position sensitivity switch in the rear of the unit



which provides a sensitivity of 2.8 mv., 5.0 mv., and 7.8 mv. for 10 watts output. This allows the phono level to be matched approximately to the tuner level and reduces the chances of overloading the preamplifier on loud passages.

The power amplifiers are conservatively rated. The measured output was about 26 watts per channel, continuous, sine-wave at 2% distortion, with both channels driven, over most of the frequency range. It fell to 14 watts at 25 cps and to 21 watts at 20,000 cps. The maximum continuous output into a 4-ohm load is limited by the 2-amp speaker fuse to about 16 watts. At 16-ohm loads, power output was lower. This type of power output variation is typical of the operation of transistor amplifiers. Note that these are continuous sine-wave powers; the output on music peaks would be substantially higher.

The IM distortion is as shown in the figure. There are individual bias and adjustments for each channel. We found we were able to alter the shape of the IM curves, particularly at low power levels, by adjusting these pots.

The FM tuner (the same as used in the Model 312) is rated at 2.2 μv. sensitivity (IHF). We measured the usable sensitivity at 2.6 μv., which is within the range of normal measurement errors. The capture ratio, rated at 6 db, measured 5.3 db. The hum level was −61 db, which is the residual hum of our signal generator. The FM frequency response on mono was within ±0.5 db from 30 to 15,000 cps, and was down only 2.5 db between 10,000 and 15,000 cps on stereo. The channel separation was unusually good, about −35 db between 1000 cps and 10,000 cps, and better than −18 db over the entire range of 30 to 15,000 cps. We were unable to check the effect of the SCA filter in removing interference, since we do not experience this form of inter-

(*Continued on page* 62)

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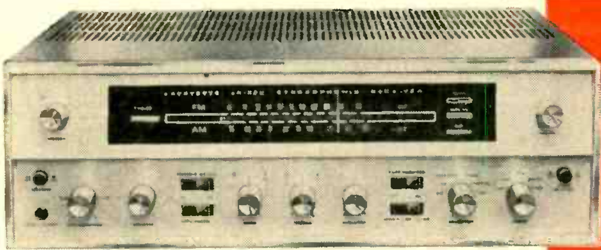

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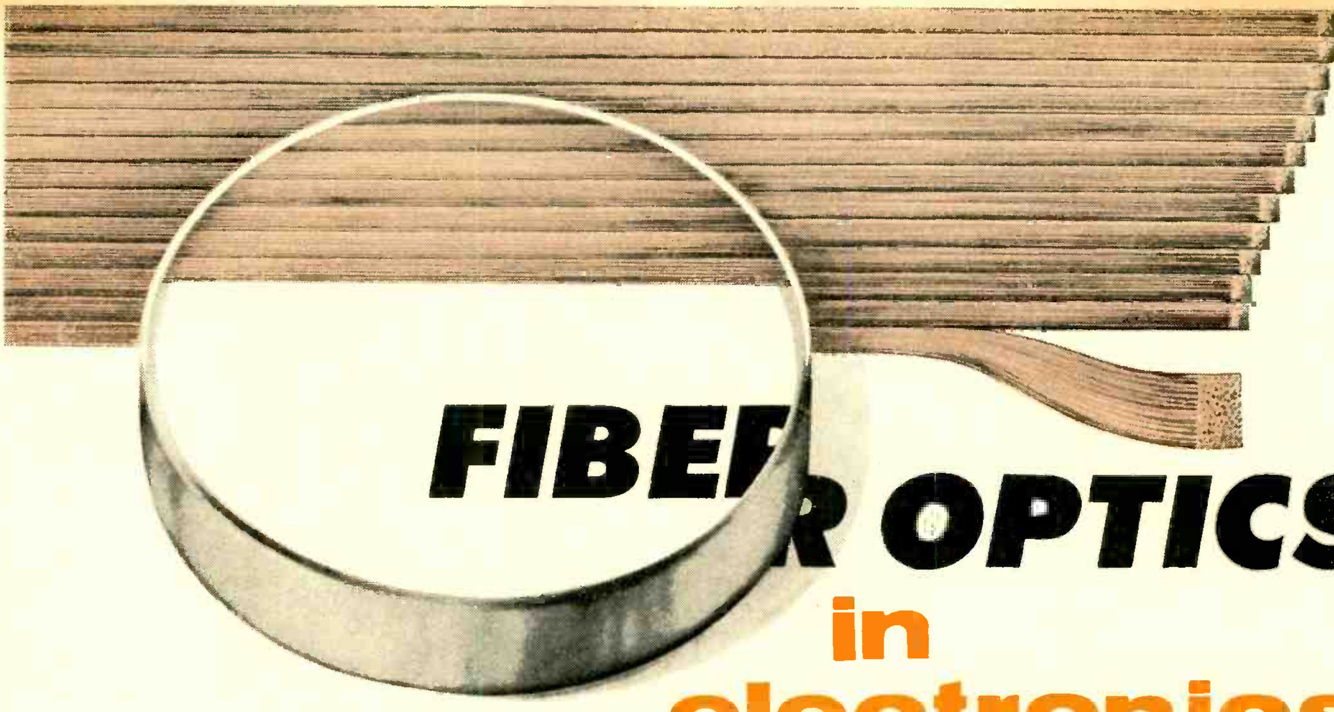


FIBER OPTICS in electronics

By FRITZ O. KAHL/ Senior Product Specialist, Corning Glass Works

Optical fibers efficiently transmit light and images around bends and in controlled paths. They are used in inspection tools and in special cathode ray tubes, image intensifiers, and vidicons. This article surveys present state of the art, giving the operating principles, characteristics, along with some current and potential applications in the electronics field.

THE unique optical properties of transparent glass fibers permit the gathering and efficient transfer of light or image information with little loss of energy. Although fiber-optic applications were proposed for electronics nearly 30 years ago, only recently have practical devices and systems evolved. Now, optical fibers are available in long, flexible or fixed bundles, in conventional lens shapes, and in fused, vacuum-tight electron-tube faceplates. Their applications range from simple inspection tools to special cathode-ray tubes to complex, experimental lasers. Some day, optical fibers may revolutionize computer construction.

Applications

Because of their ability to transmit light to inaccessible areas, one of the first uses for fiber optics was in medicine. Devices are available for looking into the stomach; movies have shown action inside a dog's heart; a hypodermic syringe enables a view of living tissue. By combining laser radiation and optical-fiber bundles, phototherapy may some day be applied to remote organ sites. These applications, while not electronic in themselves, typify the broad role of fiber optics.

The ability of a fiber-optic plate to act as a field flattener is important in many electronic-tube applications. In an electromagnetically deflected cathode-ray tube with a flat faceplate, considerable error and edge defocussing is introduced at the extreme angles of deflection. A fiber-optic faceplate ground with a suitable spherical inner surface can eliminate this error and present a flat plane on the outside for recording. See Fig. 1.

Sometimes it is desirable to mount a plate internally and use it as a target substrate, thereby avoiding the cost of vacuum-tightness. Here, one side is coated with a suitable phosphor and the other with a photoconductive or photoemissive layer. Information "written" on the phosphor side is channeled efficiently by the fibers to the other side where it can be "read" or accelerated to a final screen. At least one tube manufacturer makes a scan converter this way.

Perhaps the most common application is the cathode-ray tube that uses a fiber-optic faceplate for recording information directly on film or sensitized paper. The faceplate may consist entirely of fused fibers, or a conventional faceplate may be used which has a smaller fiber-optic plate sealed into it. The shape and size depends on the method of scan, frame size, etc. Again, a phosphor coating is deposited on the inside surface, and its emission is carried by the fibers to the outside. The recording medium need not contact the outside of the plate, the actual separation depending on the plate's light-gathering power and resulting depth of focus.

In a conventional system, the cathode-ray tube emits light in all directions. A lens gathers only a small portion of this light, which is additionally attenuated by the mirrors and field flatteners used. Fiber-optic systems have demonstrated 20 to 40 times the brightness over conventional optics.

Similar tubes, with larger diameter faceplates, can be used for direct viewing. Examples are oscilloscopes and radar screens. However, since plates over five inches in diameter are very costly, the improvement in resolution and contrast must be justified.

The development of the gallium arsenide *p-n* junction as an infrared light source has generated major investigations into the use of optical interconnections for transferring electrical signals from one circuit to another. Using light pipes in place of electrical conductors gives advantages of complete electrical isolation and freedom from feedback between input and output circuitry. Several practical devices have been introduced and many more are in development (Fig. 2). One outcome could be the construction of a computer based on this concept.

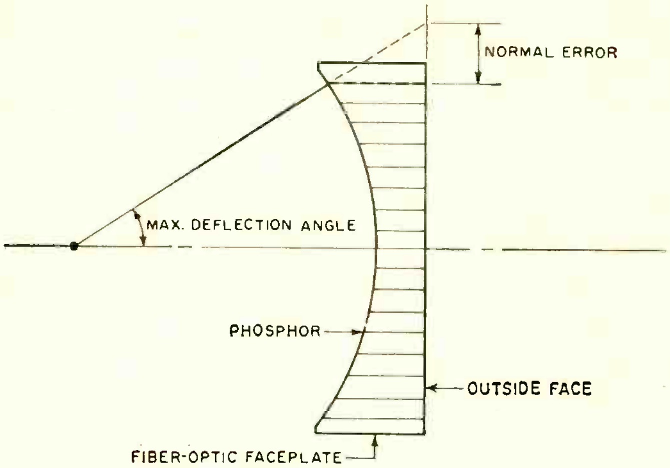


Fig. 1. Fiber-optic faceplate used as field flattener.

Also, a series of devices is available either as separate photon sources and detectors or as a photon-coupled amplifier. In each case, a fiber-optic image conduit channels the high-intensity emission from the input diode to the detector, or to the outside of the package when the two are used separately. The detector's output current or voltage is then proportional to the infrared diode's input. Proposed application include linear amplifiers, high-voltage regulated power supplies, cathode-ray tube modulators, oscillators, multiplexers, and high-speed relays.

An application in the power field combines fiber optics with a laser. A low-power gallium arsenide solid-state laser produces a coherent light signal that is proportional to line current. The signal is transmitted by a flexible fiber-optic bundle a quarter-inch in diameter to a light-sensitive transistor. The transistor then converts the light energy back to a 60-cycle electrical signal. The device is capable of monitoring line current in high-voltage transmission systems from zero load through 20 times full load. It has a response time of one nanosecond.

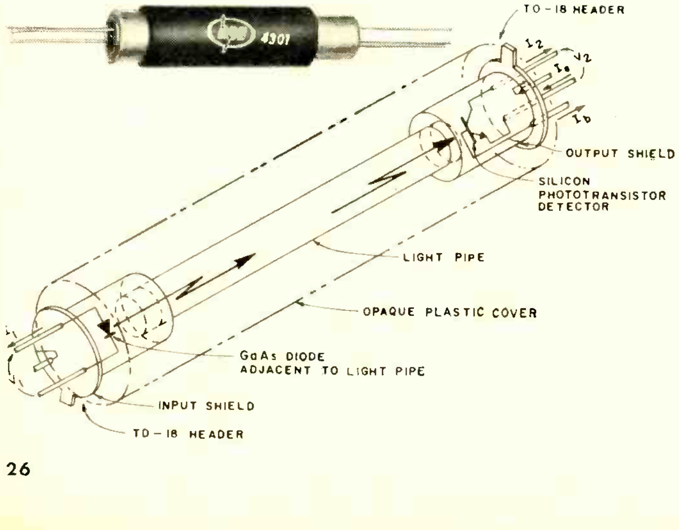
Experimenters are exploring the use of fiber lasers utilizing neodymium-doped glass. In one study, 10-micron cores were clad, then wound in a helix to fit over the flash tube. The signal to be amplified was provided by a solid glass laser rod.

In another study using neodymium-doped glass, resonant transfer of energy was achieved between parallel active laser fibers and passive fibers. Although amplification has been obtained in both cases, the studies have not yet progressed to the stage of practicality.

Principles of Operation

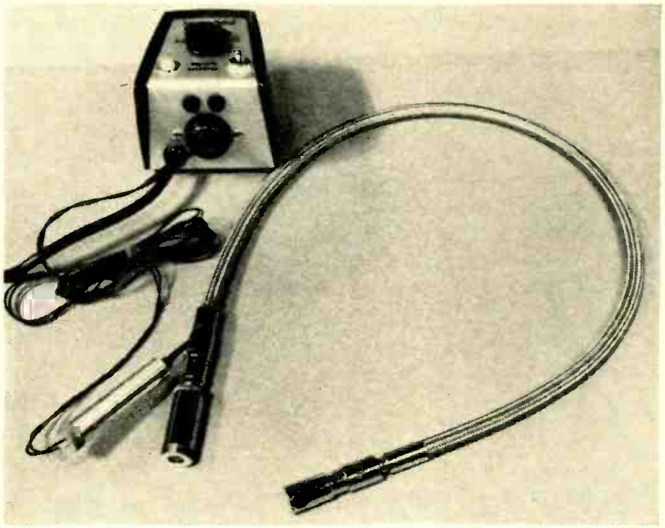
To take advantage of this new technology, the electronics engineer should familiarize himself with the design parameters that cannot be overlooked when working in the field of fiber optics.

Fig. 2. An optic amplifier using a fiber-optic light pipe. An input signal varies the amount of infrared light produced by diode. This light is carried by the light pipe to the photodetector, whose output is amplified replica of signal.



The basic mechanism that makes optical fibers behave the way they do is known as *total internal reflection.* Light striking the end of a glass fiber or rod will be totally reflected from the sides as it travels toward exit at the other end. As a light ray enters the end of the fiber at a given angle, it is refracted and travels toward the outer surface. When it reaches this interface between the fiber and the surrounding medium, it may be again refracted or reflected. If the angle at which it is incident to the interface is greater than some critical angle, as measured from the perpendicular, it will be totally reflected and cannot escape. See Fig. 3. A light ray entering at an angle which causes it to be incident at less than the critical angle will penetrate and leave the fiber.

The critical angle depends on the ratio of the indices of refraction of the two media that affect the light; for example, the glass that makes up the fiber or rod and the air that surrounds the glass. In practice, air is generally not the second medium. Contamination degrades the surface of the glass fiber, so for protection it is clad with another glass. Thus, the critical angle will depend on the refractive indices of two different glasses, one a core glass and the other a cladding glass.



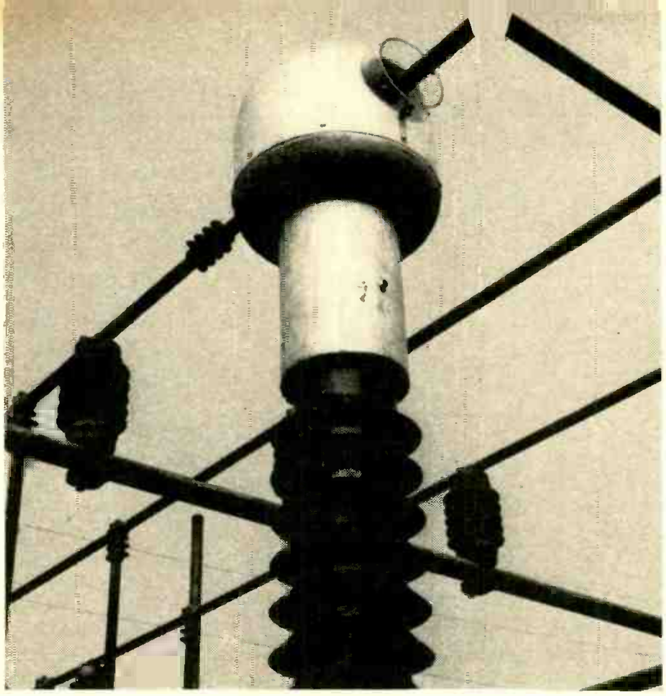
Flexible fiber-optic inspection tool, with built-in light source, employed for viewing normally inaccessible areas.

In fiber drawing—*i.e.*, elongating the fibers to make them smaller—the core and cladding glasses are drawn together. At the minimum, the cladding is a mere one-half to one micron (39 millionths of an inch) thick. It can be seen that the drawing operation has to be precise, since the interface between the core glass and the cladding glass must be kept as nearly perfect as possible to obtain maximum optical efficiency. A ray which enters an optical fiber of 10-micron diameter and is refracted at an angle of 30° will be reflected a minimum of 50,000 times per foot before emerging. Therefore, little or no losses can be tolerated at each reflection.

The fiber size must be smaller than the finest detail to be resolved, thus it is the limiting factor in resolution. In a static viewing situation without magnification, the resolution can be further affected by the mosaic structure itself. Dynamic scanning of the image is often employed in order to appreciably increase the resolution.

Numerical Aperture

One of the great advantages of optical fibers is their light-gathering power. This property, termed "numerical aperture," is dependent on the maximum cone or acceptance angle at which the fiber can trap and reflect light. It equals



A high-voltage transmission line monitoring system which employs a fiber-optic light pipe. A sample of the line current is inductively picked off and applied to a gallium arsenide laser. The resultant varying beam of infrared light is transmitted through a fiber-optic rod to a photosensitive transistor at base of the assembly where it is converted to an electrical signal to operate remote instrumentation or controls.

$\sin\theta_1$ in Fig. 3, and is expressed: $NA = \sin\theta_1 = \sqrt{n_1^2 - n_2^2}$ where n_1 and n_2 are the indices of refraction of the core and cladding glasses respectively, and the incident ray is traveling in air.

It can be seen that the greater the difference in the indices the greater the acceptance angle will be. Also, apparently slight changes in refractive index will cause very rapid changes in NA.

Some typical values for combinations of commercial glasses include:

$n_1 = 1.700$; $n_2 = 1.512$; $NA = 0.78$; $\theta_1 = 51°$

$n_1 = 1.650$; $n_2 = 1.560$; $NA = 0.54$; $\theta_1 = 32°$

With proper selection of glasses, it is possible to obtain a theoretical value for NA of more than 1.0. However, in practice this value is not often achieved because of fiber imperfections and other losses. Nonetheless, a high-NA fiber-optic mosaic can have more light-gathering power, or "speed," than a good conventional lens.

A bundle of flexible glass fibers such as would be used in an inspection tool. Light from the candle flame is transmitted from one end of the bundle to the other with minimum loss.

This relationship is expressed by the formula: $f_{lens} = 1/2NA$.

As with conventional lenses, the greater the aperture of the fiber optic the shorter the depth of focus. This can be important, for example, where direct recording on film is taken of information from a fiber-optic cathode-ray tube.

Light Transmission

The principal optical factors affecting light transmission in a single fiber are: the absorption coefficient of the core glass, and reflection losses at entrance and exit faces. Thus, in attempting to ascertain the light transmission, the nature of the incident light should be known. The wavelength will determine the absorption coefficient, and the angle of incidence will determine the reflection losses and amount of contact with the absorbing medium. The angle of incidence also determines the optical path length of the fiber and, consequently, the absorption losses.

The gross transmission of a fused array of fibers is further affected by the ratio of the cross-section surface area represented by the core glass to the total cross-section of the array. This is called the "packing fraction," and can range from 60 to 85 percent.

Many applications utilize the output of settled phosphors, from which the emitted light is essentially Lambertian, *i.e.*, equally bright from all directions. In these applications, the Lambertian or diffuse transmittance of the plate is important for maximum efficiency. As seen earlier, a high NA is necessary to accept light from the broadest angle possible; in this case, however, higher reflection losses due to the higher index core glass must be taken into consideration. These losses can amount to 25 percent total from both faces. Absorption losses can also be greater, in that high-index glasses have characteristically higher absorption coefficients.

As seen above, spectral transmission can be important in some applications. Most commercial glasses perform satisfactorily in the 4000-9000 Å range. Some glasses, such as fused quartz, transmit well in the ultraviolet region. However, they generally have a low coefficient of expansion and a low refractive index, and suitable cladding glasses are non-existent. For the infrared region, arsenic trisulfide glasses are useful, and transmission up to about six microns has been reported.

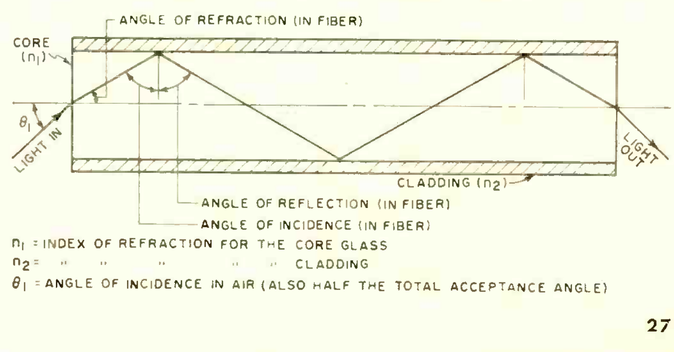
Types of Fiber Optics

The simplest fiber optic is a single fiber. It might be unclad, or clad to any reasonable diameter to facilitate handling. The unclad fiber might be found in use only when no suitable cladding can be applied.

Single fibers transmit only light, not images. Thus, these fibers are used for remote illumination, inspecting, or detecting. Their core diameter can range from several microns to one-quarter inch. Lengths are limited only by the size of the original drawing rod and the method of collecting the finished fiber, such as winding.

The smaller diameters are quite flexible. The larger sizes

Fig. 3. Light-ray pathway in an individual optical fiber.



This special CRT puts single-line scans from high-resolution radar directly onto film—producing permanent records of near-photographic quality. The raised portion of the tube face contains the fiber-optic element that touches the photographic film.

are frequently pre-bent by the manufacturer, or can be formed in place with a torch. The literature states that the short-term bending radius for fibers under .04 inch is: $R=50d+1000d^2$ where R is the radius and d is the fiber diameter, both in inches.

Fiber "bundles"—assemblies of many fibers—take numerous forms. If the fibers are precisely aligned so that the relationship of each fiber is the same at both ends, the assembly is called a *coherent*, or oriented bundle. Such bundles can transmit an image. This is because each segment of the total image transmitted by each fiber will be kept in relationship with each other from one end to the other. But if the fibers are not oriented in the same way at each end of the bundle, then it is *non-coherent*, and can be used only for transmitting light. Often the two types are combined in an inspection tool, with light-carrying fibers surrounding an image-carrying bundle.

Both types can be either rigid or flexible. To obtain rigidity, the cladding is fused. A rigid bundle, like a single fiber, can be bent under heat. In the flexible form, only the ends are fixed and the remainder of the bundle, usually sheathed in protective plastic or metal, is free to conform to any desired path. The sheath often terminates in a fitting for an eyepiece or other hardware.

Fibers in a flexible bundle can slide on one another and break from abrasion. Anti-friction fluids, such as silicone, can be applied. However, little has been published about the interaction of thousands of fibers flexing in a given manner.

Many fiber bundles are available "off-the-shelf" from several manufacturers. They come in diameters from .020 inch to .500 inch and in lengths up to six feet, with individual fiber diameters ranging from 10 microns (about .4 mil) to 3 mils. (The latter is about the (*Continued on page* 77)

A grouping of sensitive, high-resolution cathode-ray tubes that employ fiber-optic faceplates. Through the use of fiber optics, optical distortions are reduced and the light transfer from the glowing phosphor layer to the tube's outer surface is increased.

GLOSSARY OF OPTICAL TERMS

Acceptance Angle: The maximum angle at which a fiber can trap and reflect light.

Angle of Incidence: The angle between a ray of light meeting a surface and the normal (the perpendicular) to the surface at that point.

Angle of Refraction: The angle between the refracted ray and the normal to the surface at the point of refraction.

Coherent Bundles: Assemblies in which the fibers are arranged at both ends of the assembly in the same relationship.

Core Glass & Cladding Glass: A light ray is transmitted within a fiber from one end to the other by repeated internal reflections off the fiber's outer surface. This is because the glass of the fiber, called the core glass, has a different refractive index than the medium surrounding the fiber. The surrounding medium could be air, for example, but for protection it is usually a sheath of glass having a different refractive index than the core glass. This sheath of glass is called the cladding glass.

Critical Angle: At the boundary separating two optical media, the critical angle is the smallest angle of incidence, in the medium of greater index, for which light is totally reflected.

Diffuse Transmission: The total net transmission, by a medium or device, of light that is neither perfectly Lambertian nor parallel. Often used interchangeably with the term "gross transmission."

Fiber-Optic Bundles: Assemblies of optical fibers.

Fiber Optics: The optical technology of utilizing transparent fibers for carrying light or image information. Sometimes the term is used interchangeably with the terms "optical fibers" and "optical fiber bundles."

Lambertian Source Plane: A plane that emits a flux proportional to the cosine of the angle from the normal. Examples are a dense opal glass or a phosphor coating.

Non-Coherent Bundles: Assemblies in which the fibers have a random relationship at each end.

Numerical Aperture (NA): A measure of a fiber optic's light-gathering power, equal to the sine of the acceptance angle, which thus makes it a function of the refractive indices of the fiber's core and cladding materials.

Optical Density: If one medium has a greater refractive index than another for light of a given wavelength, then it has greater optical density for that wavelength.

Optical Fibers: Transparent fibers, usually glass, used in fiber optics. Literally, "light pipes."

Photocathode: An electrode used for obtaining photoelectric emission.

Photoconductive Effect: A photoelectric effect in which the electrical conductivity of certain substances increases with the intensity of the light to which the substance is exposed. This kind of substance can serve as a coating on fiber optic plate.

Photoelectric Effect: In general, any effect arising as a result of a transfer of energy from light incident on a substance to electrons in the substance. An example in fiber optics that utilizes the effect is when light striking one side of a fiber-optic plate is carried by the fibers through the plate to the other side, which is coated with a material that ejects electrons under the stimulus of light.

Photoelectric Emission (or Photoemission): The ejection of electrons from a solid or a liquid.

Refraction: When a ray of light travels obliquely from one medium to another, it is bent or refracted at the surface separating the two media.

Refractive Index of a Medium: The ratio of the sine of the angle of incidence to the sine of the angle of refraction when light is refracted into the medium from a vacuum (or, to a very close approximation, from air).

Total Internal Reflection: When light passes from one medium to another which is optically less dense, e.g., from glass to air, the ray is bent away from the normal. If the incident ray meets the surface at such an angle that the refracted ray must be bent away at an angle of more than 90 degrees, the light cannot emerge at all, and is totally internally reflected.

POWER-OUTPUT NOMOGRAM

By MAX H. APPLEBAUM
Warwick Electronics Inc.
Pacific Mercury Div.

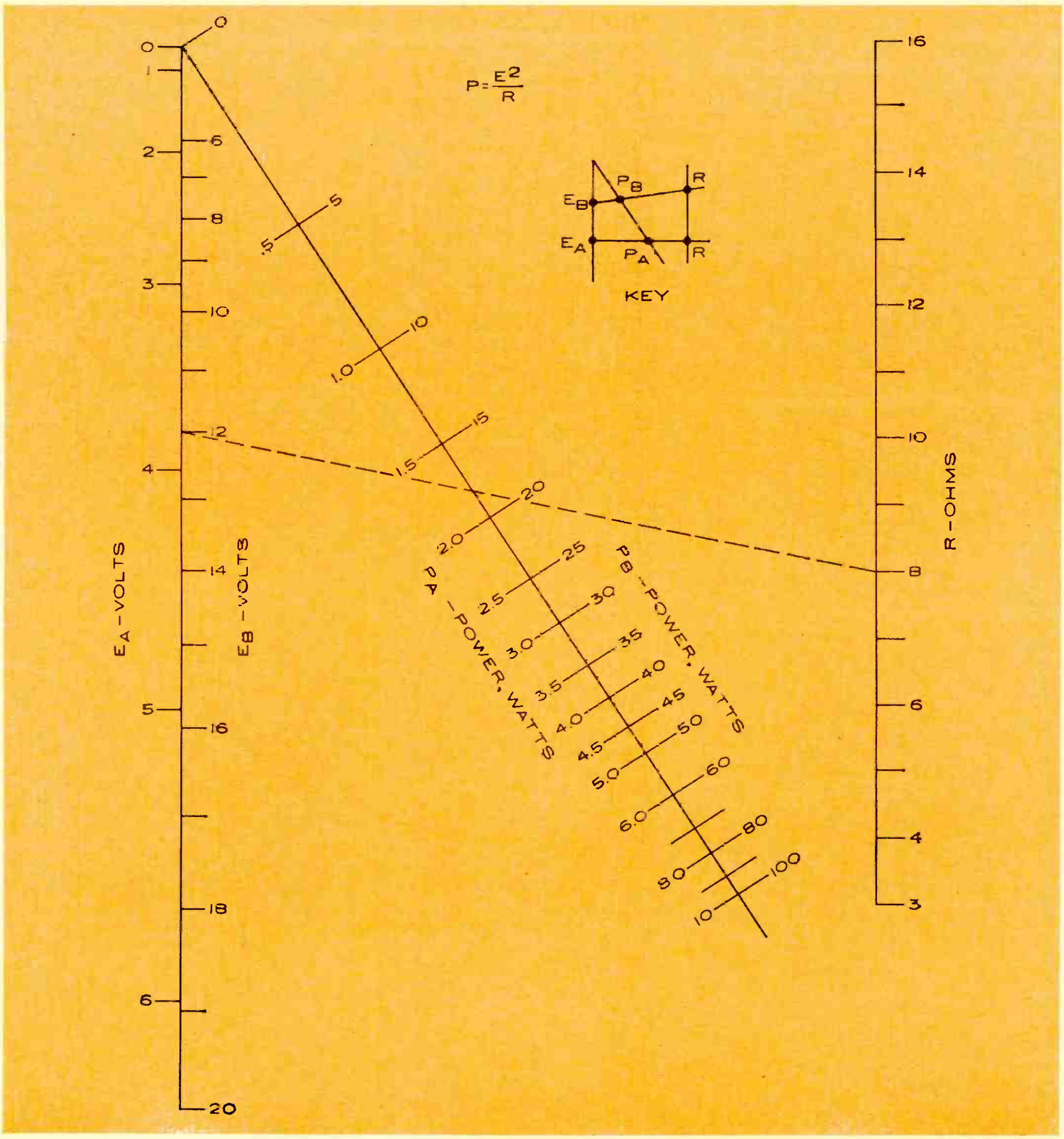
The audio amplifier output power in common loudspeaker impedances can be determined with a straightedge.

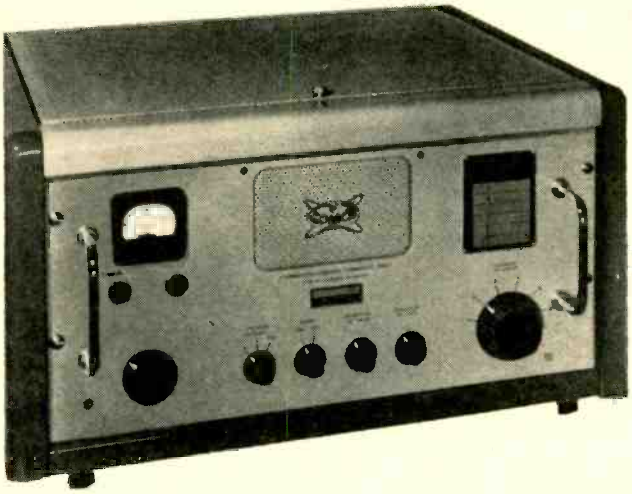
THIS nomogram provides a rapid means of determining the power output of audio amplifiers. The values of R are given in the range of speaker impedances. Voltages are in r.m.s. values.

For output voltages less than 6, use E_A and P_A scales. For voltages more than 6, use E_B and P_B scales.

Example: An amplifier has a 12-volt drop across a dummy load of 8 ohms. Find the power output of the amplifier.

Solution: Lay a straightedge across the three scales, touching E_B scale at 12 and the R scale at 8. The straightedge crosses the P_B scale at 18. This is the answer, with the power in watts. ▲





Single-sideband/compatible AM marine radiotelephone for use in both the medium- and high-frequency communications bands.

Single-sideband is coming to the marine frequencies as is a move towards the v.h.f. bands. Here is a review of some of these new FCC rules and an explanation of how single-sideband works.

By LEO G. SANDS

SSB COMES TO MARINE RADIO

THE adoption of new rules by the FCC has changed the course of marine radio. After some three decades of AM, marine radiotelephones will now be allowed to employ SSB (single sideband). The rules permit use of SSB now, and it looks like SSB will be almost universal within a decade in the medium- (m.f.) and high-frequency (h.f.) bands. And there will be a mass move from these bands to the v.h.f. (very-high-frequency) marine band by boats whose communicating-range requirement is less than 50 miles.

Marine-Band Congestion

As it is now, the m.f. marine band is congested, almost to the point of making the band useless in some areas during the boating season. The safety calling channel, 2182 kc., is swamped by commercial vessels and pleasure craft. Often it is only the boat with a high-power rig that can get through the bedlam.

Commercial shipping interests, the Radio Technical Commission for Marine Services, and the FCC have joined forces in an attempt to restore marine radio so that it will be useful to all concerned.

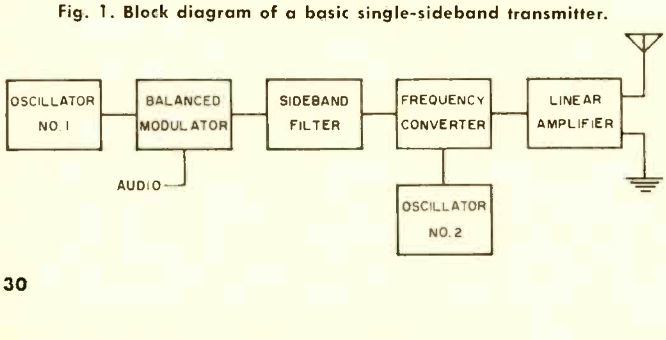
The first step is to move as many vessels as possible from the m.f. and h.f. bands to the virtually static-free and uncongested v.h.f. band. The second step will be to convert from AM to SSB those m.f. and h.f. marine-band users whose needs cannot be met in the v.h.f. band.

Single Sideband

SSB, with carrier suppressed, is said to be eight times more effective than conventional AM when compared on the basis of watts input. When conventional AM is used, only 50% of the radiated power conveys intelligence; the other 50% is wasted in the carrier which conveys no intelligence. Both sidebands convey identical intelligence and represent 50% of the total radiated power, 25% in each sideband.

But only one of the sidebands is required. By eliminating the carrier and one of the sidebands, all of the available power can be utilized to convey intelligence. At the same time, the band occupancy of the signal is cut in half, making room for more channels.

Fig. 1. Block diagram of a basic single-sideband transmitter.



An SSB transmitter is a simple device but costs more to produce than an AM transmitter because it employs an expensive filter and requires much more stable frequency control.

There are usually two oscillators in an SSB marine transmitter, as shown in Fig. 1. Oscillator No. 1 operates at a relatively low frequency and is crystal-controlled. Its c.w. output is fed to a balanced modulator in which the carrier signal (from oscillator No. 1) is mixed with the audio-modulating signal. The carrier signal is balanced out in the modulator stage and the two sidebands remain. Fig. 2 is a simplified schematic of a balanced modulator.

When the grid of $V1$ is swung positive by the carrier signal, its plate current rises. At the same time, the grid of $V2$ is being swung negative by the carrier signal and its plate current falls. Hence, the current through $L3$ remains steady and, if $L3$ is tuned to the carrier frequency, no r.f. is developed across it.

If at the same time an audio-modulating signal is applied to the grids of $V1$ and $V2$ through $L2$, both grids are swung in the same direction simultaneously by the audio signal.

Thus, the interaction of the carrier signal, which drives the grids push-pull, and the audio signal which drives the grids in phase causes new output signals to be developed across $L3$ which are equal to the sum and difference of the two input signals. If, for example, the carrier frequency is 100 kc. and the audio signal is a 3000-cycle tone, the output signal will consist of two sidebands, one at a frequency of 103 kc. and the other 97 kc. But the 100-kc. carrier signal will be absent.

We now have a *double-sideband*, suppressed-carrier signal. By passing the signal through a sideband filter, as shown in Fig. 1, one sideband is removed. Usually the upper sideband is passed by the filter and the lower sideband is attenuated.

The SSB signal is then fed to a frequency converter where it is mixed with a signal from oscillator No. 2. The resulting SSB signal is then fed to a linear amplifier and the antenna.

Oscillator No. 2 is also crystal-controlled and is the channel-frequency determining stage. Its frequency can be changed by switching crystals. For example, to operate at 2003 kc. when oscillator No. 1 operates at 100 kc., oscillator No. 2 would operate at 1903 or 2103 kc. to produce the desired signal. The output of the frequency converter and the linear amplifier is tuned to 2004.2 kc., the approximate midpoint of the transmitted sideband.

To demodulate the SSB signal, the carrier must be reinserted at the receiver, as shown in Fig. 3. The incoming SSB signal is heterodyned down to an i.f. such as 455 or 1650 kc. A local carrier oscillator (b.f.o.) operating at the sum or difference of the missing carrier frequency and the receiver's local oscillator frequency (i.f.) feeds its signal into a product detector. The missing carrier is thus added to the SSB signal and the composite signal is then demodulated.

An SSB signal can be demodulated by a conventional AM receiver equipped with a b.f.o., but the maximum benefits of SSB can best be realized with a receiver designed specifically for the SSB mode of radiotelephone reception.

Frequency Stability

The new FCC rules require marine SSB transmitters to stay on frequency with 50 cps to preserve voice quality. The effect of frequency variation is easy to understand. For instance, if the frequency of the generated (but absent) carrier or the receiver i.f. carrier-insertion oscillator (b.f.o.) drifts 50 cps, the pitch of the audio will be raised or lowered by that amount.

This is an insignificant amount, but should the transmitter tolerance be 0.02%, the amount allowed an AM transmitter, the pitch of the audio signal could be as much as 400 cycles above or below its normal value. This can produce distortion.

It is the cost of developing and mass producing transmitter oscillators whose combined drift produces less than 50 cycles of frequency error that will increase the price of future m.f. and h.f. marine radiotelephones.

AM Compatibility

Marine radiotelephones must also be capable of communicating with AM stations which will continue to exist for several years. This can be done by making the receiver convertible from AM to SSB at the flick of a switch. It is much easier at the transmitter. To make its signal useful to a conventional AM receiver, the carrier signal is inserted at the transmitter, causing a *compatible-AM* signal to be transmitted. This signal consists of only one sideband and the carrier and occupies half the bandspace of a conventional AM signal.

The use of AM or compatible-AM on 2182 kc. (safety and calling channel) and some of the intership channels will be required until all marine stations convert to SSB. In fact, radiotelephones must be designed so that selection of either SSB or compatible-AM operation will be automatic depending upon the channel selected.

Most of the marine channels within the 1.6- to 25-mc. range are available for SSB transmission and will be compulsory on most frequencies above 4 mc. in the near future.

SSB marine radiotelephones are not a future dream. They already exist but cost around $2500 as compared with $300 to $1000 for AM sets. Prices will come down as demand increases. At present, commercial vessels are the prime markets for single-sideband radiotelephone equipment.

V.h.f. Marine Band

The move from the m.f. and h.f. bands to the 152- to 162-mc. v.h.f. band started almost 20 years ago. But it has been a gradual shift which will accelerate as more v.h.f. Coast Guard and Public Coast stations go on the air. In many areas, the Coast Guard is already monitoring 156.8 mc., the v.h.f. marine-band calling channel.

The v.h.f. band is superior to the m.f. and h.f. bands for short-range communication. Static is almost completely absent as is long-distance ship interference. Communicating range is usually limited to 50 miles but greater range has often been reported.

A v.h.f. marine radiotelephone employs wide-band FM

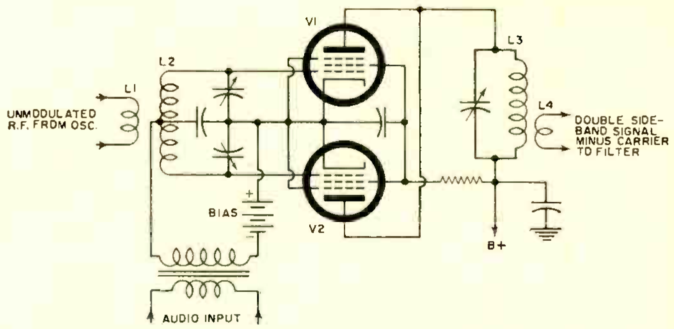


Fig. 2. In a balanced modulator, the r.f. is fed in push-pull and audio in parallel. Output is sidebands without carrier.

(±15 kc. deviation) and is usually operable on several channels. Power input is limited to 100 watts. However, on the bridge-to-bridge channel (156.65 mc.) the power limit is 15 watts.

At least two channels must be provided, 156.8 mc. for calling and 156.3 mc. for ship-to-ship communications. Other channels are available for communicating with limited and Public Coast stations, including 156.45 mc. which is available to yacht clubs for communicating with members and moorage operators for communicating with their customers.

A single-channel v.h.f. unit may be used on a boat operating two-frequency simplex (transmit on one frequency and receive on another) when only telephone service is required. The unit may be licensed under Part 83, FCC Rules and Regulations, for maritime telephone service, or under Part 21 for telephone service *via* land mobile telephone stations authorized to serve ships or for message-relaying and dispatching service *via* a Radio Common Carrier station.

A v.h.f. marine radiotelephone is electrically much the same as a land mobile radio unit. In fact, land mobile equipment can be readily adapted for marine use. Wide-band FM equipment which can no longer be used in the land mobile services but which meets the technical requirements of v.h.f. marine service is available second-hand at low prices. New FM mobile radio equipment can usually be furnished by the manufacturer for either narrow- or wide-band FM operation.

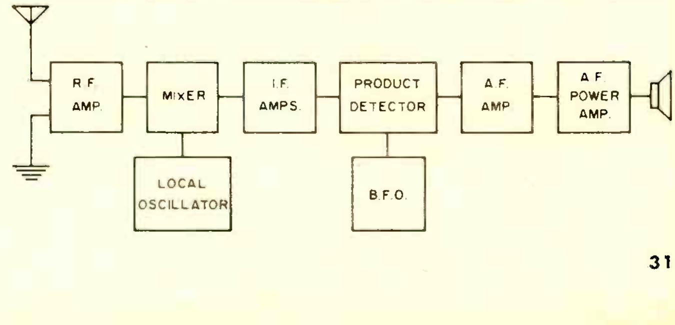
Advantages of V.h.f.

The range of an m.f. or m.f./h.f. marine radiotelephone depends to a great extent upon the antenna system. The ground connection is extremely important. The efficiency of a typical small-boat antenna system is usually around 10%.

No ground connection is required for a v.h.f. marine radiotelephone since the ground is an integral part of the antenna. Instead of exhibiting a loss, a good v.h.f. antenna can contribute gain. A 6-db gain antenna, for example, can increase the effective radiated power four times, making a 15-watt transmitter look like a 60-watt job.

The shift to SSB in the m.f. band and particularly in the h.f. band is inevitable because of SSB's superior performance and will be spurred on by the reduction in the number of channels that will remain available for AM use. The shift to the v.h.f. band by craft operating close to shore is also going to accelerate as boat owners discover the advantages of v.h.f. and FM and that they can get away from the congestion in the m.f. band. ▲

Fig. 3. Simplified block diagram of a single-sideband receiver.

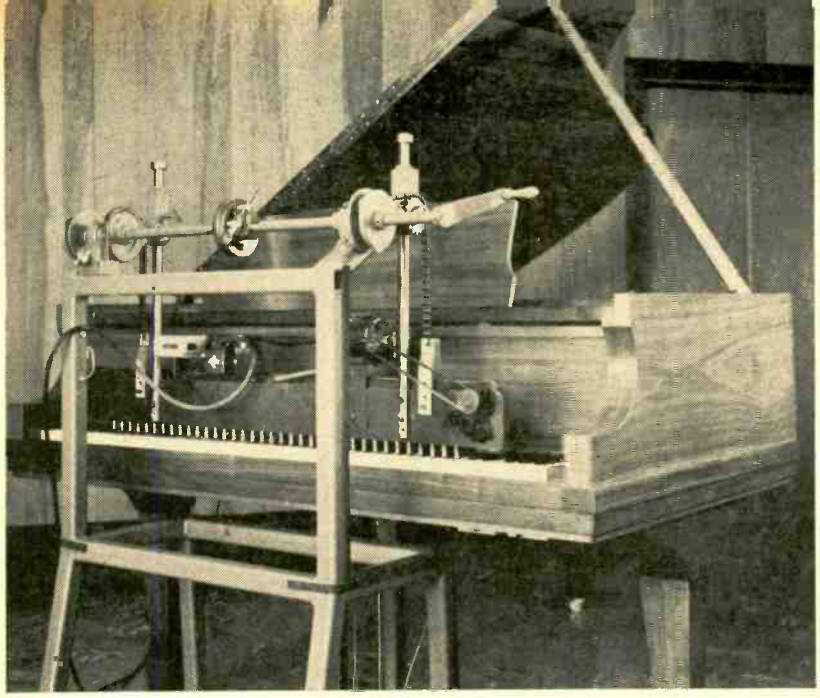


Reconnaissance Radar. (Left) A test pilot took this photograph with radar equipment despite a heavy cloud cover over Baltimore City harbor on the day it was taken some 7 years ago. Since then the photo has been classified and only recently has it been cleared for release. It shows the capability of the Westinghouse-built side-looking radar employed by Naval reconnaissance planes. The company is now building far more advanced radar equipment for the Vigilante aircraft, which is capable of making pictures of even greater clarity. The radar beam fans out over the landscape from a long cigar-shaped antenna under the plane's fuselage. The radar can slice through the darkest night or heaviest cloud cover and take pictures of enemy territory miles away from the flight path of the airplane.

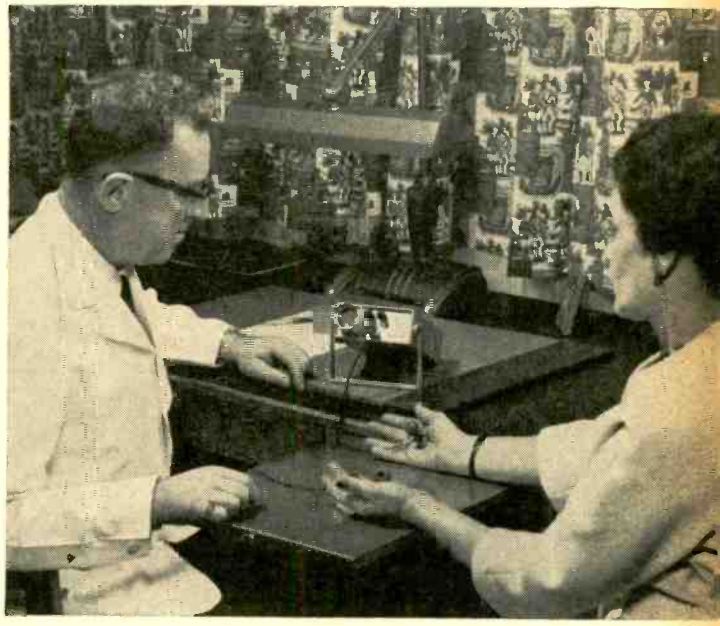
RECENT DEVELOPMENTS in ELECTRONICS

Barrel-Shaped Magnet. (Above) A large, barrel-shaped magnet assembly made of an improved magnetic alloy, Alnico 8, has been developed for use with super-power klystron tubes. The magnet, made by Arnold Engineering, is 27½" high and weighs ½ ton. Previous assemblies made for the microwave industry weighed from 1200 to 1400 lbs. but used a lower-energy Alnico 8. The new alloy, like others in the same family, is heat-treated in a magnetic field to develop its high coercive force and energy product. The main axial klystron cavity magnetic field is more than 1050 gauss with a very low cross field.

Low-Cost CCTV Video Tape Recorder. (Below) A new compact TV recorder designed for closed-circuit systems is being marketed by Ampex at about half the cost of previously available comparable equipment. The recorder is priced just under $4000. The unit uses a single stationary video head that lays a longitudinal track along the length of the ¼" tape, which moves at 100 ips. A 12½" reel of 12,600 feet of special ½-mil video tape will provide a playing time of 25 minutes. The tape direction then reverses and another 25 minutes of playing are available. A reel of tape sells for $58. The video bandwidth of the new recorder is 250 cps to 1.5 mc. (at −3 db).



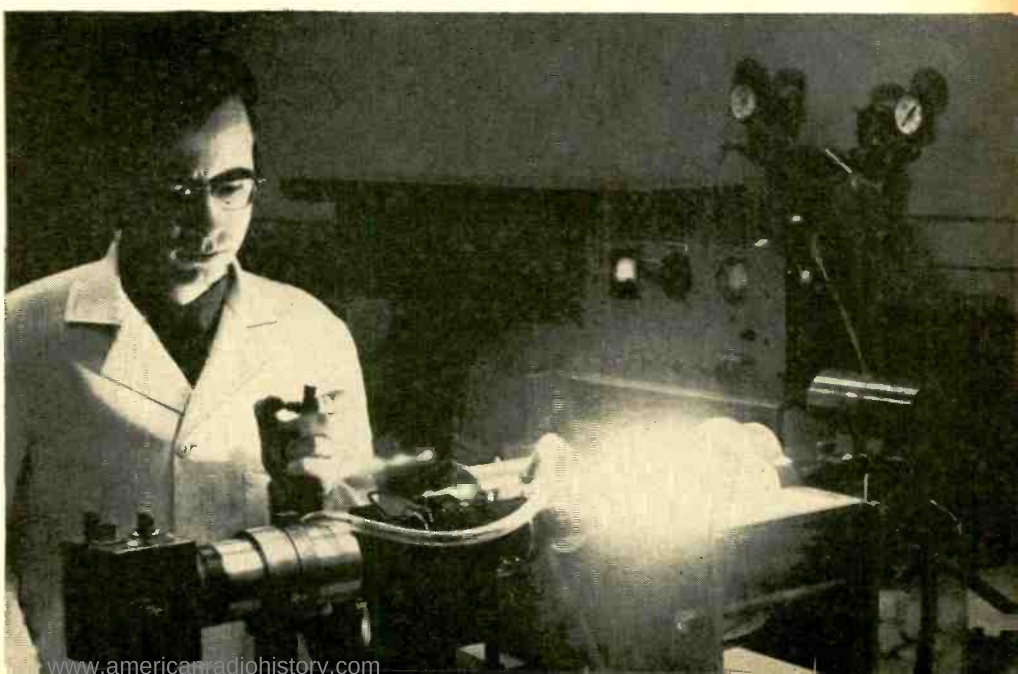
Electronic Piano. (Left) The world's first purely electronic piano is shown here undergoing final tests. The instrument uses all-electronic tone generators; there are no vibrating strings or bars. During the tests, a mechanized device strikes the keys substantially the way a pianist does. Operating 24 hours a day for at least 2 months, each key is struck 40 times a minute simulating an average playing time of 12 to 15 years. Because the piano does not rely on size and shape of its case for its performance, much smaller cabinet sizes are possible at no change in sound quality. Allen Organ Co. makes the unit.



Portable EKG Scope. (Above) A lightweight, portable device that visually records the complete electrical activity of the heart has been introduced by Westinghouse. Weighing only 3 lbs., the unit, called the "Miniscope," is a miniaturized, easy-to-carry oscilloscope powered by 4 flashlight cells. To use the unit, the doctor connects the leads via small suction cup contacts, to the palms of the patient's hands. The EKG signal is magnified from the instrument's very small fluorescent screen.

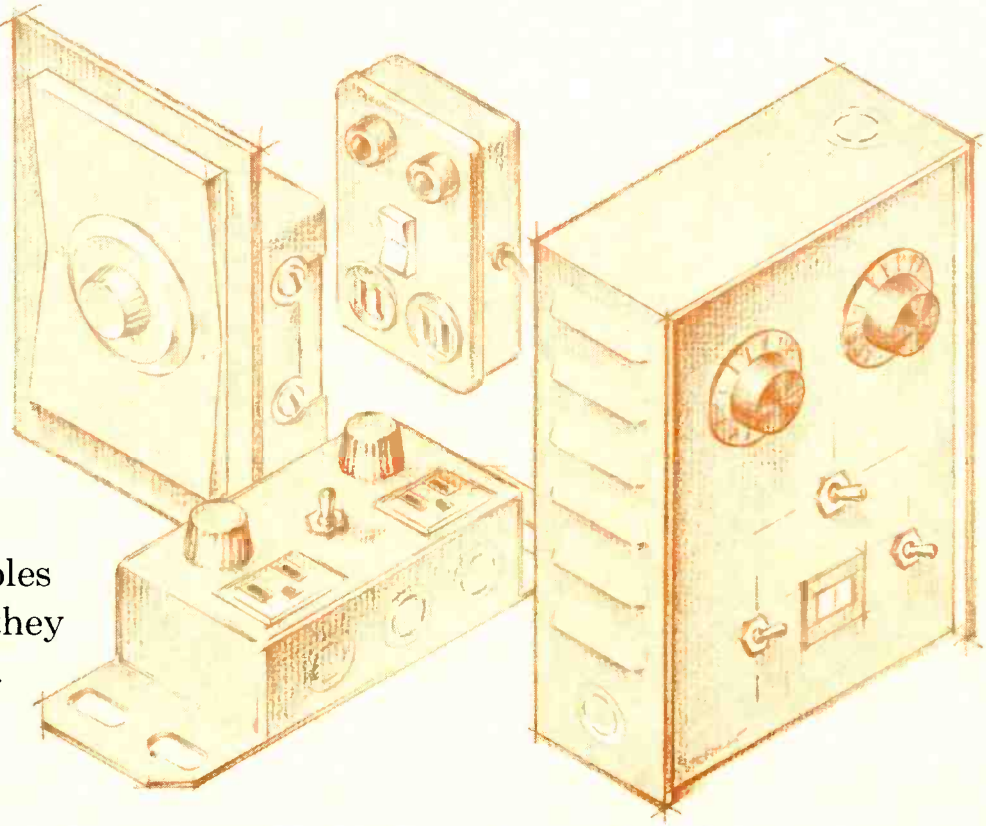
Transistorized 350-watt P. A. Amplifier. (Below) A very high power mobile public-address amplifier has been introduced that is able to project sound 1½ miles with good intelligibility. The amplifier is being used by the U.S. for missile-range surveillance, psychological warfare, air-sea rescue, crowd control, and towed cargo handling. The unit, made by Applied Electro Mechanics Inc., weighs 10 lbs., occupies less than ⅙ cu. ft., and draws 15 amps from a 32-volt battery supply at full power. The amplifier is being sold for $975.

Room-Temperature Liquid Laser. (Right) A liquid laser has been developed which produces light pulses at normal room temperatures. While previous liquid lasers required a temperature of −150°F, the new laser produces light pulses at 68°F. This represents a major step toward the ultimate development of a practical liquid laser with a continuous light beam required for communications applications. In the new laser, developed at GT&E Laboratories, the active material is the rare-earth element europium in an organic compound (called a chelate) dissolved in an organic solvent. A spiral flash tube, cooled by flowing water, provides ultraviolet excitation for the liquid laser.



Solid-State Dimmers & Power Controls

By DONALD LANCASTER



Part 1. Roundup of new controls, their capabilities and their limitations. Basic operating principles and the types of load they can handle are covered.

IT is a rare home indeed that has water faucets than can only be turned "off" or "on," with no possibility of adjustment. Yet for years people have been putting up with single-brightness lamps; single-speed power tools; single-heat driers, soldering equipment, and heaters; and a wide variety of other appliances that can only be turned "on" or "off." The little control equipment that did exist was limited to inefficient rheostats, bulky autotransformers, switching and tapping schemes, and mechanical adjustments such as pulleys, transmissions, and multiple belts. To change the amount of light in a room, you had to change the number or size of the bulbs in use.

There is a quiet revolution going on in the power semiconductor field that will relegate many of these crude control devices to the museum. New semiconductor power controls that give instant and precise control of virtually any lamp, appliance, power tool, or heating device are rapidly becoming available. These controls are small in size and low in cost. They can control 117-volt a.c. power far in excess of most home requirements, typical units being capable of 600 or 1000 watts of power control, with industrial units going as high as several hundred kilowatts.

Today the large-quantity manufacturing cost of adding a dimmer to an ordinary table lamp is under three dollars; it will ultimately fall below a dollar as component prices drop with increased usage. From a component standpoint, one variety of control circuit requires only four low-cost electronic parts to give full-range, symmetric, 1-kilowatt a.c. control.

It would be rather foolish to run a comparison of the capabilities of dimmer "A" *versus* power-tool control "B," comparing the makes and models currently available. Some of these circuits are already obsolete or unnecessarily complex. Some use parts that are expensive and give only a limited control range. This is due to the rapid pace at which new components and control techniques have become available, particularly in the past year or so. There is keen competition among manufacturers of components to promote their particular components and control schemes to the power-control market.

Of more interest are the basic principles behind these controls, the loads which they can and cannot control. There is a wide variety of packages for these controls, some of which are highly specialized. This determines the utility of the control from a user's standpoint. There is a large number of power-control semiconductors in use, many of which are based on the silicon controlled rectifier (SCR). A wide spread of control circuitry exists, ranging anywhere from a single neon lamp to exotic multiple semiconductor circuitry. Finally, there are the special circuit capabilities; controls that handle fluorescents; tool controls that use feedback to maintain constant torque or speed despite a varying load; and controls that are designed to respond to external input information such as light, a d.c. control signal, or audio.

Principles of Operation

The basic problem is simple. You must vary the amount of power reaching a load. As Fig. 1 shows, there are two possible ways of doing this. Either you can vary the voltage or you can rapidly switch the load on and off, either applying full voltage or no voltage for a certain percentage of the time. The greater the ratio of on-to-off, the greater the power reaching the load. This "on-off-on-off" sequence is carried out so rapidly that the load can only respond to the average value, resulting in a smooth power flow. The inertia of the load, whether thermal or mechanical, accounts for this smoothing. This particular switching mode is invariably employed in the semiconductor power controls.

The big advantage with switching mode is that it is lossless, at least theoretically. The device doing the switching is either "off" or "on"; in neither state does the switching element consume power.

Compare this with a rheostat adjusted so that the load receives half voltage. The efficiency of this setting would be only 50% since the dissipation in the rheostat is *equal* to the dissipation in the load. This heat costs money and must be dissipated in some manner—which is not a simple problem at the kilowatt power level. Obviously, the rheostat must also be physically large to have a power dissipation in excess of that required at high levels. By the same token, an autotransformer must also be large and bulky, if it is to be used for voltage adjustment, because of the amount of iron and copper required for efficient power conversion at high power levels.

Actually, the semiconductor switches used are not quite perfect, but typical losses amount to less than one percent of the total load power rating, giving a power-control efficiency in excess of 99 percent. Because of this small heat loss and the temperature limitations of all semiconductors, a small heatsink is essential for any control rated above 250 watts.

Twice each a.c. cycle, the a.c. line goes through zero volts. It is most convenient to use these "zeros" to turn the switch that is producing the "on-off-on-off" sequence "off." In fact, some of the semiconductors *must* be turned off in this manner; there is no other convenient way. This means that the switch turn-on must somehow be synchronized to the a.c. line. If this were not so, the output power would be quite random as more or less of each half cycle was passed to the load. (There are several electronic novelty items which make use of this random non-synchronous operation to simulate candle and flame effects. The power variations flicker at about the same rate with the same random brilliance.)

Let us see what happens as we delay the turn-on time of the switch with respect to the a.c. "zeros" (Fig. 2). Assume that the switch is turned on very shortly *after* each a.c. zero, and then stays on for the remainder of the a.c. half cycle. The switch is "on" most of the time and nearly full power reaches the load. Next suppose the turn-on was delayed only about half the way between zeros. The switch is now on half the time and about half-power reaches the load. Similarly, a very late turn-on means that very little average power reaches the load. Obviously, if the turn-on is delayed so long that it never occurs during a half cycle, no power at all reaches the load and the circuit is essentially "off."

This basic control principle is called "a.c. phase control" and is common to all of the currently popular power controls. Back in the days of thyratrons, this same technique was used to give similar control of power in certain industrial controls.

It probably has occurred to the reader that there might be an easier way to do this—perhaps by turning entire cycles of voltage on and off or by operating only on one-half of each a.c. cycle and either allowing the entire other half-cycle to reach, or not reach, the load. This can be done and has led to some interesting and economical circuits, but there are serious drawbacks. Skipping cycles (called "skip cycling") causes an annoying flicker in any lamp as it goes on and off at a rate below the persistence of vision. This lamp operation is completely unacceptable. Skip cycling is quite useful in heating devices and other resistive loads that have a long thermal time-constant which can average out over a burst of many cycles.

This technique also has uses in certain motor controls where the counter-e.m.f. of the motor is used as a reference voltage for the next cycle, giving a smooth, constant-torque operation. The mechanical inertia of the load must be high enough to average out the power bursts. This technique is often used in industrial applications, but finds little use in the home power-control field.

The concept of working only on one-half of each a.c. cycle

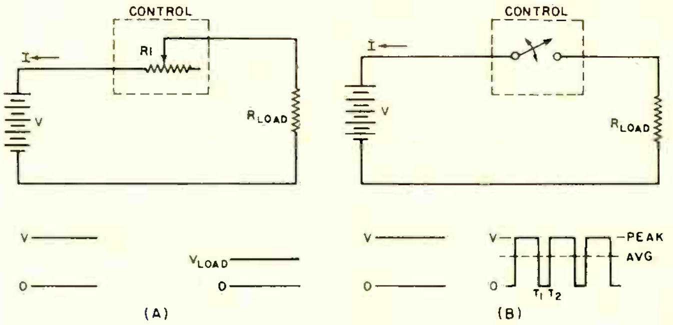


Fig. 1. Methods of controlling the amount of power reaching a load. (A) Resistive-loss method. (B) Switching duty cycle method which is employed by all the solid-state control units.

and passing or not passing the other half in its entirety, is currently very popular. However, there is a big disadvantage to this mode of control. There is invariably a d.c. component in the output waveform. Feed this to a transformer or other inductance and no current limiting can be provided, resulting either in damage to the control or to the load. This d.c. component limits the utility of such circuits and has a devastating effect on fluorescent lights.

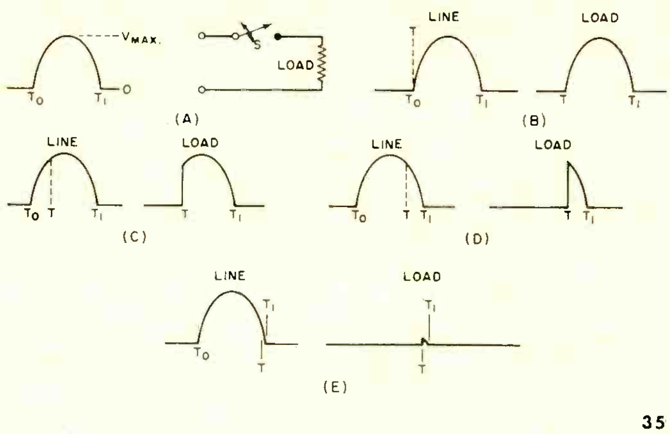
Any control that provides the same delayed turn-on in each alternate half-cycle is called a "symmetrical" control, while those that don't are called "asymmetric" controls. To date, the symmetrical controls have been more expensive than the asymmetric ones, but have a considerably wider range of acceptable loads, as we shall see shortly. Fig. 3 shows the differences in a symmetric and asymmetric control waveform.

Types of Loads

Just what loads will these power controls handle? Normal power levels may range from 10 watts to 2 kilowatts, typically 600 watts or 1 kilowatt maximum power level. Certain loads can be permanently damaged or can ruin the control if they are used incorrectly or on the wrong control. There are several classes of load which *can* or *cannot* be used with these controls:

Incandescent Lamps: All of the controls can handle any incandescent lamp within their ratings. This includes all desk, table, and overhead lamps; three-way lamps; and photofloods. Very tiny bulbs (3 watts or less) might not operate properly unless enough of them are used to meet the minimum load rating of the control. There are two special effects which could be annoying in certain circumstances. Certain very large bulbs (driveway spots, etc.) will tend to buzz at a 60- or 120-cycle rate at very low brilliance levels. This is due to the sudden expansion and gradual contraction of the large

Fig. 2. (A) A.c. phase control with a semiconductor being used as a switch that may be turned on any time from T_0 to T_1 but always turns off at the a.c. zero. (B) If S closes immediately after T_0, practically all the available power reaches load. (C), (D) As the closing times are delayed, less power reaches the load. (E) If S is closed very near to T_1, very little power gets to load. Finally, if T does not occur between T_0 and T_1, then the circuit is off and no power at all reaches the load.



filament. Also, as the brilliance of any incandescent bulb is reduced, the spectral output shifts from a fairly uniform white to an output favoring the orange and red spectrum. This can cause a shift in colors of all objects being illuminated by the lamp. Photographers would have to correct for the lower color temperature of the bulbs, especially on color shots.

Neon, Electroluminescent Panels: These devices consume far too little current and have a very non-linear volt-ampere characteristic to give any sort of smooth or predictable control. Sometimes, adding an ordinary 25-watt incandescent bulb to provide a minimum load for the control will smooth out operation to the point where it will be useful.

Fluorescents: Assymetric power controls will cause permanent damage to fluorescent lights as the ballast cannot limit a d.c. current. Symmetric controls will operate fluorescents over a limited range. Special fluorescent-only dimmers are available which permit full-range operation by means of waveform distortion. Some of the power-factor correction circuitry in expensive (corrected) fluorescents can damage some of the older symmetrical controls.

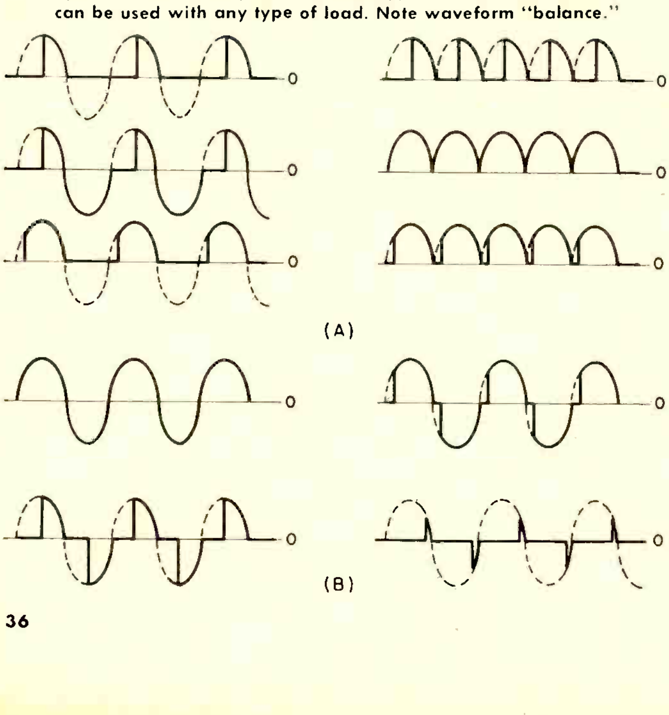
Heaters: The controls are ideal for any resistive device within control ratings. Thermostats or thermistors may be added for stable temperature control. This application includes dryers that have universal motors and soldering irons that have no transformers.

Soldering Guns and Transformer-Type Soldering Irons: Any symmetrical control with enough power rating will give ideal control. *Permanent damage can result from operating a soldering gun with an asymmetric control.* This also applies to transformer-operated soldering irons and, incidentally, to those new high-intensity lamps that have a transformer in the base.

Capacitive Loads: Never use controls for such loads. Suddenly switching a capacitor across a voltage source can produce current transients large enough to permanently ruin the control. Under certain circumstances, a small noise-filtering capacitor across a resistive or inductive load is permissible, especially if some current limiting is provided.

Inductive Loads: As any inductance cannot block direct current, only symmetrical controls may be used with highly inductive loads. If the power factor is more than 0.8, either control type may be used. Less than 0.8 means that only the symmetrical type may be used. Certain turn-on circuitry may have its range restricted by highly inductive loads. An important problem in some applications is the tremendous

Fig. 3. (A) Typical waveforms produced by asymmetric controls. These controls add a d.c. term to the load waveform which can damage transformer-operated or inductance-limited loads. (B) Symmetric controls produce these typical waveforms. These can be used with any type of load. Note waveform "balance."



reverse kick produced if the current in an inductance is suddenly stopped. This could happen due to a power failure or if the main switch were turned off. Newer, symmetrical devices simply turn on when reverse-biased, protecting themselves and the rest of the circuit. This is also true of the recent controlled avalanche devices. It is *not* true of ordinary SCR's and some sort of protection must be provided. This is especially important in solenoid drives and similar highly inductive applications.

Transformer Input Power Supplies: These may be used with symmetric controls, *but permanent damage can result if asymmetric controls are used.* Best results are obtained when the transformer is run fully loaded or nearly so, otherwise the control range might be restricted or non-linear. Obviously, if the transformer is of the self-regulating type, no control over its operation is possible.

Motors: Here is where the trouble comes in. As a general rule, if the motor has brushes and a wound armature, either type of control may be used. This applies to all a.c.-d.c. "universal" motors, such as found on electric drills, sewing machines, hand-held power tools, etc. *Any motor that does not have brushes will be permanently damaged by either type of control.* The control may also be ruined if this is tried.

There is a definite reason for this. The no-load speed of a.c.-only motors (synchronous, repulsion-induction, squirrel-cage induction, hysteresis-synchronous, etc.) is determined only by the motor geometry and the line *frequency* and *not* the line voltage. This also applies to the "washing machine" or electric-saw type of ¼-horsepower motor, usually rated at 1725 rpm, as well as all other a.c.-only motors of this type. Other examples are clock, phonograph, and tape-recorder motors, as well as certain sanders and other vibrating type power tools. Reducing the applied voltage of these motors simply reduces the available torque. If the voltage (or the voltage duty cycle) is reduced too much, the motor either breaks synchronization or goes into a stall. Either of these high-current modes can cause motor burnout.

The only way to change the speed of this type of motor is to change the operating frequency. This is why electric clocks keep perfect time—their speed is precisely controlled by the frequency standard at the power company. Even changing frequency can only provide a limited speed range since the reactance of the winding will increase or decrease with frequency, changing the currents in the motor.

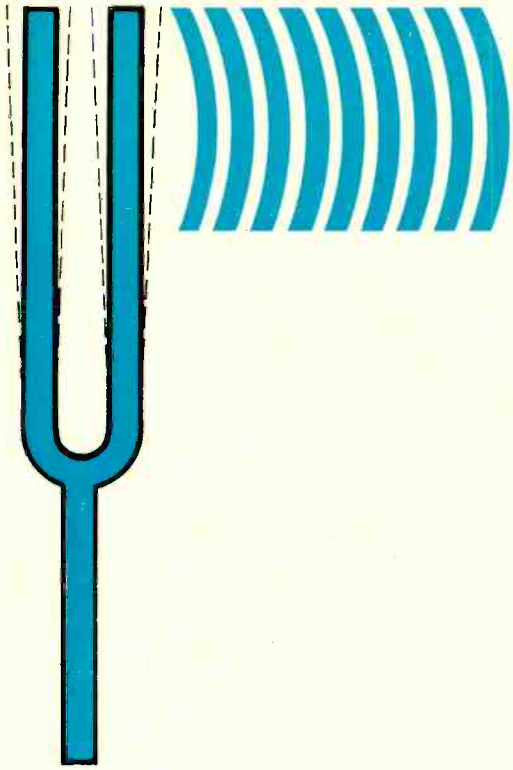
There are, of course, exceptions to any rule and certain obscure industrial or surplus motors without brushes might be controllable but the rule holds good for virtually any motor that is likely to be found in home appliances.

Control Packages

The choice of a control package can have a major influence on the utility of a control. Some current types of packages are illustrated at the beginning of this article.

One type is an "in-the-box" dimmer, intended for permanent installation as a replacement for an ordinary light switch. This is the oldest form of control package. The major advantage is its built-in control of room lights, replacing the older, bulkier, and more expensive autotransformer control. There are some disadvantages to this package. Few living rooms have ceiling fixtures these days. The installation is expensive, unless you do it yourself, and once installed the control cannot be "borrowed" for a drilling job in the workshop or a spot-dimming application for a night light.

Other new designs just plug in and mount directly on an electric outlet. The beauty of this design is its inconspicuous appearance and its portability. It is ideal for desk and table lamps and can also be used in kitchens and workshops for mixers, heaters, and tools. The small package, which is also the heatsink, limits power to 600 watts at most. One drawback of this control is the location of some outlets very near the floor or behind furniture, (*Continued on page* 85)



THE TUNING FORK AS AN ELECTRONIC COMPONENT

By JOSEPH VERRUSO
Facsimile Dept., Westrex Communications Div.
Litton Industries

Possessed of inherent high-"Q" and long-term stability, the tuning fork finds many applications in electronics.

FROM the time the tuning fork was first discovered by John Shore in 1711, it has been a classic example of frequency generation by mechanical vibration. The application of the tuning fork as a frequency-selective component in an oscillator circuit dates back as early as 1900. It was discovered then that a tuning fork used in this configuration led to greater accuracy and stability in the audio-frequency range.

Tuning forks, as electromechanical resonators, provide tuned circuits of high-"Q" and intrinsic long-term stability. They are ruggedly constructed of steel, and some tuning forks are permanently sealed in a vacuum, protected by a stainless-steel enclosure. In a preferred design, the tuning fork is laminated by bonding a nickel-steel alloy to carbon steel. The thermoelastic coefficients of these two metals are in opposite directions over most of the normal operating temperature range. By adjusting the ratio between the thickness of the carbon and nickel steels, proper temperature compensation is achieved.

The manufacturing process of adjusting the tuning fork to an exact frequency is a combination of art and science. It requires from two to six months to properly adjust a fork. However, once the fork is adjusted it will remain stable indefinitely. The frequency-drift rate is very, very low as compared with most other types of oscillators and is often rated in parts per million per year.

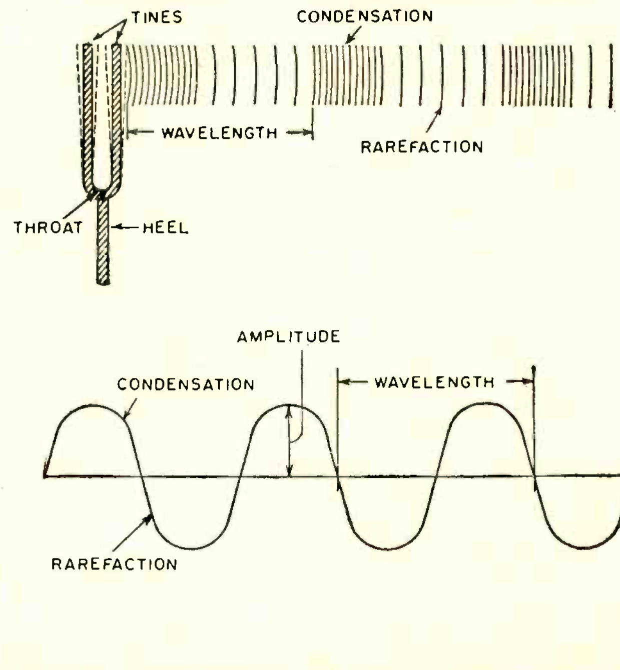
The tuning fork as an electronic component offers certain advantages in long-term stability, accuracy, and high-"Q". As development work improves tuning-fork performance, more and more applications will unfold. At the present time, the specifications given for stability and accuracy apply to the frequency range of 1000 to 5000 cps, in which there are years of experience and reliable use. It is expected that the frequency range will be extended to cover 400 cps to above 10 kc. However, below 10 kc., the tuning fork still remains the most stable resonator for these frequencies.

Tuning-Fork Characteristics

The basic principle of the tuning fork is simple and can be easily understood by referring to Fig. 1. The classroom tuning fork may be excited by plucking it with the finger or striking it against an object, causing the air to be compressed and expanded, resulting in an audible sound. The sound heard is the fundamental (or resonant) frequency of the tuning fork and is determined by the number of times per second the air is compressed and expanded.

The resonant frequency of the tuning fork is inversely proportional to the length of the tines. Therefore, by reducing the length of the tines it is possible to increase the frequency of the tuning fork. The frequency of the tuning fork can be decreased by grinding the area around the throat of the fork. By using the two methods described, it is possible to adjust the frequency with accuracy. Even the most accurate tuning fork can be affected by temperature. How-

Fig. 1. Basic principles of operation of a tuning fork. Fork resonant frequency is inversely proportional to tine length.



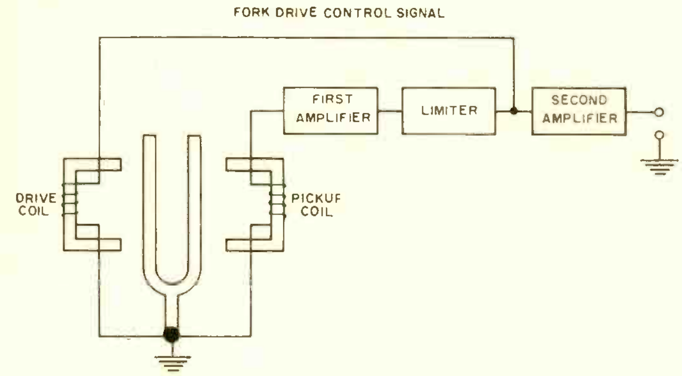


Fig. 2. Fork acts as high-"Q" feedback element for the oscillator.

ever, the bimetallic (combination of two metals) tuning forks afford greater frequency stability than monometallic forks when subjected to changes in temperature. This frequency stability is achieved during the manufacturing process when the resonant frequency is obtained while testing the tuning fork at different temperatures. The particular process will condition the tuning fork to operate over a specific temperature range with a minimum change in frequency.

Many commercial tuning forks designed to operate in both stationary and mobile equipment are placed in a vacuum chamber so that barometric and humidity changes will have no effect on the frequency stability. Tuning forks are balanced, so that positioning will have little or no effect on the frequency. The fork is also dynamically balanced so that very little vibration energy reaches the heel of the fork. Should vibration reach the heel of the fork, the mount would become part of the vibratory system and, therefore, anything that affected the mount would affect the frequency. Proper balancing of the tuning fork avoids this undesirable effect.

Fork Oscillator Circuits

The tuning-fork assembly, as shown in Fig. 2, uses a separate transducer for drive and pickup. Each transducer consists of a coil wound around a small U-shaped Alnico magnet. The fork oscillator circuit consists of two triode class-A amplifiers. The input of the first amplifier is magnetically coupled (*via* the pickup coil) to one tine of the tuning fork. This stage amplifies the signal and applies it to the limiter (a zener diode) which removes any amplitude variations of the drive signal that would affect the frequency stability of the tuning fork. The output of the limiter is magnetically coupled (*via* the drive coil) to the other tine of the tuning fork through the fork-drive control.

Starting of the tuning fork is achieved by transients which occur when initial power is applied to the fork oscillator circuit. These transients are amplified and coupled through the oscillator to the drive coil, causing the tines to move in relation to the transient pulses. This movement will result in an e.m.f. being generated in the pickup coil, which is amplified and coupled through the oscillator back to the drive coil. This feedback loop will cause the tuning-fork signal to increase in amplitude until limited by the oscillator circuit. The fork output is taken from the second amplifier. The tuning-fork circuitry is simple and reliable; the limiter circuit shows no change in frequency with anode-supply variations from 200 to 400 volts and heater-supply voltages from 5.0 to 7.5 volts. The fork-drive control is a potentiometer which controls the output level of the limiter. When this control is set at minimum resistance, a maximum signal will be delivered to the drive coil which will cause the fork to vibrate at a slightly lower frequency. When the control is adjusted for maximum resistance, a minimum signal will be applied to the drive coil and the fork will vibrate at a slightly higher frequency. The frequency stability of tuning-fork standards, such as the one described, are stated in parts per million (PPM) and are calibrated on this basis.

Temperature and Stability

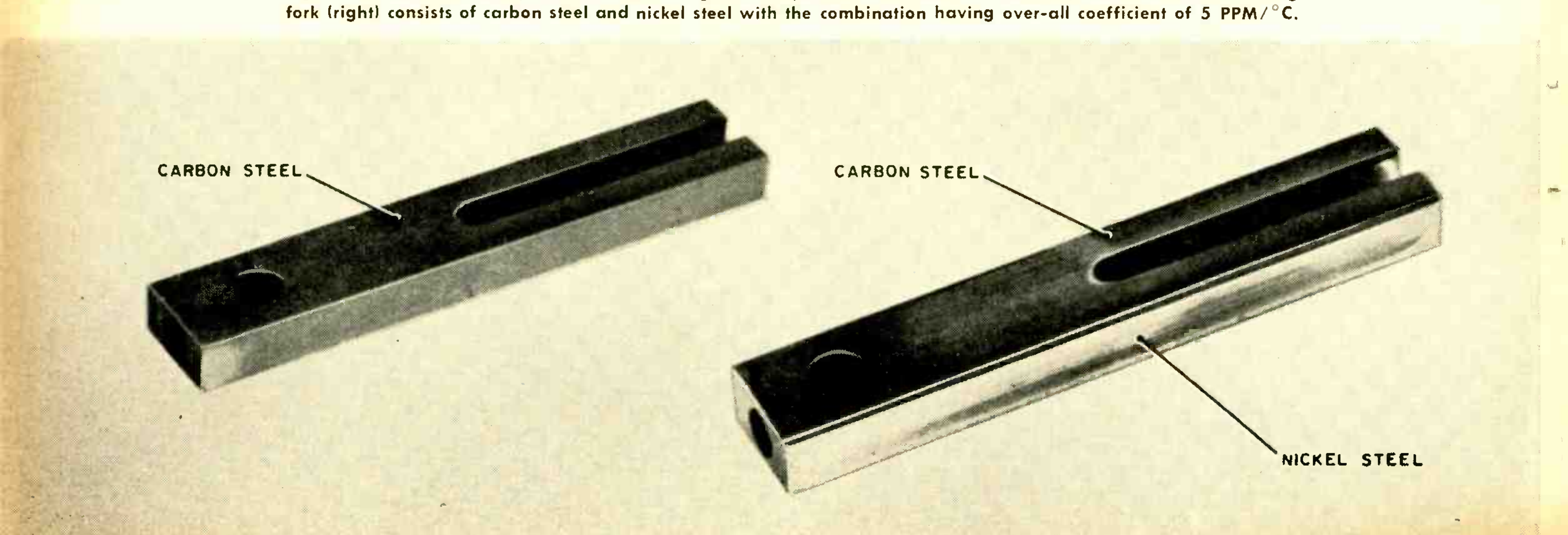
The frequency stability of the tuning fork is a function of temperature and those components used in the fork oscillator that are affected by temperature changes. In good oscillator design, the frequency is practically independent of changes in value components other than the fork itself. The metallic alloys used in the construction of the tuning fork are of prime importance in achieving frequency stability.

The monometallic tuning fork constructed of carbon steel (refer to Fig. 3) has a negative temperature coefficient such that the frequency decreases with temperature at the rate of approximately 100 PPM/°C. The Invar type of alloy such as Magnivar, Elinvar, and Nickel-Span-C are steel combined with nickel to provide the tuning fork with frequency coefficients as low as ± 5 PPM/°C. The use of a bimetallic fork leads to a better stability with time since alloys may be selected which do not vary their characteristics with heat treatment.

A bimetallic tuning fork such as the one shown in Fig. 3 is a combination of nickel steel and carbon steel. The carbon steel with its negative thermoelastic coefficient occupies only a small cross-sectional area of the tuning fork. However, this area is of prime importance, for the thickness of the two combined alloys can be calculated, so that combined, their thermal coefficients of modulus of elasticity tend to cancel. This combination results in a fork whose frequency is stable to ± 1 part in 10^{5}, with an operating temperature range from 0 to 65°C.

Greater frequency stability can be obtained when the complete fork oscillator and the tuning fork are placed within an electronically temperature-controlled oven. Tuning forks

Fig. 3. Monometallic tuning fork (left) has a negative temperature coefficient of 100 PPM/°C. The bimetallic tuning fork (right) consists of carbon steel and nickel steel with the combination having over-all coefficient of 5 PPM/°C.



that are to be operated within an oven are compensated for the specific temperature of the oven, resulting in even greater accuracy and stability. A tuning-fork frequency standard can be expected to remain stable to within ±1 part in 10⁵ or better per month when enclosed within an oven.

Bandwidth or "Q"

The bandwidth or "Q" is a direct function of the mechanical resonant properties of the tuning fork. The bandwidth and "Q" are interrelated, for as the "Q" of the tuning fork increases the bandwidth decreases. The "Q" of a tuning fork may vary from a minimum of about 5000 for a 1-kc. fork to about 23,000. The tuning-fork "Q" will decrease as amplitude of its motion is increased. This decrease of "Q" with increasing amplitude is caused by the internal friction, hysteresis, and eddy-current losses caused by the magnetic transducers. To compensate for this effect, the pickup and drive coils are loosely coupled to the fork. Many fork oscillator circuits incorporate an amplitude limiter. Changes in drive amplitude that might otherwise occur in the fork oscillator circuit are prevented by the limiter which maintains the voltage drop across it constant over a wide range of current.

A review of tuning-fork applications is not only informative but may suggest many more new and imaginative applications. The equipment to be described are only a few of the many applications that incorporate tuning forks.

Facsimile Systems

The development of the modern tuning fork was brought about by the need for synchronizing in facsimile transmission. Facsimile communications pertain to the transmission and reproduction of graphic or visual intelligence. One of the basic principles of facsimile is that the speed of the transmitter and recorder must be exactly the same. Prior to the use of tuning-fork oscillators for matching the speeds of the transmitter and recorder, a synchronizing signal (or carrier) was transmitted over the channel, usually a telephone line.

Frequently on long telephone-carrier circuits, difficulty was encountered because the carrier oscillators were not synchronized. A transmitted 1800-cycle carrier came out several cycles off frequency at the receiving station and manually controlled compensators had to be used for frequency correction. So in addition to requiring skill or training of the operator, valuable transmission time was lost. Today these drawbacks are avoided by the use of precision tuning-fork oscillators at the transmitting and receiving stations.

Frequency Standards

The tuning-fork oscillator is a precision oscillator and can be used as a secondary standard in the audio-frequency range. With the use of transistors, a miniaturized fork oscillator was developed as a self-contained portable tuning-fork standard. This standard can also be placed within an oven for greater accuracy and long-term stability.

Where more than one frequency is required, frequency dividers or multipliers can be used so that two, three, or more frequencies can be made available from one tuning fork.

Chronometers

The most obvious by-product of the facsimile tuning fork is a chronometer controlled by the tuning fork. The clock mechanisms are driven by a synchronous motor powered by an amplifier between the fork and the motor. This chronometer is used quite extensively in geophysical, astronomical, navigational, and shipboard applications.

The chronometer (refer to Fig. 4) uses a synchronous motor to drive a *Wickes* clock movement which displays the time on a numerical readout system. Hours, minutes, and seconds are shown. A sweep wheel makes one rotation per second, so that time can be measured to an accuracy of 0.01 second if photographic means are used for observation. In

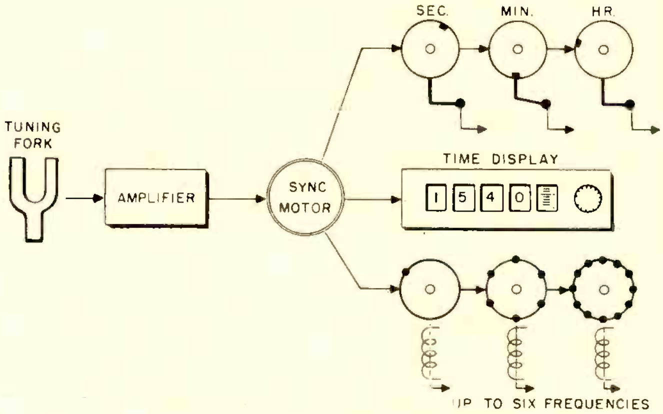


Fig. 4. In the fork-controlled chronometer, the fork controls the speed of a synchronous motor that operates the time readout, time-switching contacts, and several frequency generators.

addition to displaying time, a system of contacts operates to close external control circuits once a second, once a minute, or once an hour. The chronometer is also provided with a shaft which rotates at ten revolutions a second. Generator wheels may be furnished on this shaft to generate pulses or sine-wave signals at any frequency in multiples of 10 up to 1000 cycles. A special feature of the chronometer is that it may be easily set to Bureau of Standards time (WWV, for example) by means of time-setting clutch and rotation of the sync motor stator. The accuracy of the chronometer is better than one second in twelve days. An accuracy of one second in 120 days can be assured if the fork is placed in an oven.

Sonar Recorder

Fifty fathoms, more or less, was the accuracy of deep-sea soundings prior to the time the Lamont Geological Observatory and *Times Facsimile* (now *Westrex*) developed the precision depth recorder. A precision depth recorder is essentially a signal recorder provided with switching systems to control the pulses transmitted by the sonar transducer and switch-gating systems to eliminate most of the unwanted noise. Precision of the recorder is derived from a tuning fork.

The newer and more complex versions record other data, such as magnetometer readings, where the x-axis of the chart paper can be calibrated in nautical miles. Such a recorder was used on the atomic submarine "Nautilus" during its trip under the Arctic ice cap several years ago.

Tuning-Fork Filters

The tuning fork has found many applications in filter networks. It is particularly suited to this type of application because of its high-"Q" which is on the order of 10,000 to 20,000. The tuning fork has found uses in other types of filters which do not need such high values of "Q" but require frequency stability and accuracy. One such filter is the "comb filter." The term comb filter is generally associated with a group of filters used to cover a certain frequency band of interest, with a predetermined resolution, and consisting of a number of equally and closely spaced filter elements, each tuned to a particular frequency.

Discriminators

Several designs have been developed using the tuning fork in a discriminator circuit. The "Q" of the fork can be controlled in various ways to give the desired discriminator slope. The Foster-Seeley type of discriminator has been used in one particular application. The varying d.c. output can be calibrated in parts per million and may be used with a reactance tube to control an oscillator.

The author wishes to express his gratitude to K. R. McConnell, J. Shonnard, Vivian Verruso, and other members of the *Westrex* Facsimile Department. ▲

RELIABILITY OF ELECTRONIC COMPONENTS

By JOSEPH H. WUJEK, JR.

How reliability is estimated and how equipment is designed for reliability improvement. Typical failure rates are included.

IN the author's previous article "Basic Principles of Reliability" (February, 1965 issue), the basic ideas of reliability in electronics were introduced and discussed. This article extends those ideas to show how reliability may be estimated and gives some general principles for designing for reliability improvement. Some typical failure rates for electronic parts are also given and used in an example.

Failure-Rate Determination

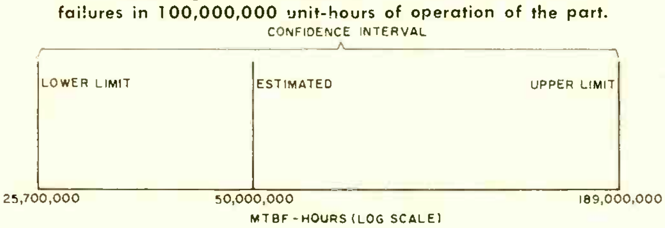
In general, there are two methods available to us for determining the failure rate or *M*ean *T*ime *B*etween *F*ailures (MTBF) of an electronic system. The first method is simply to test the system until it fails, then repair it and continue testing. If we operate enough systems for a long enough time, then we will have some measure of the MTBF. But this "brute-force" method is very costly, and it's an "after-the-fact" approach to the problem. A better way would be to *estimate* the MTBF *before* we build the system. If the MTBF as estimated by calculation is not good enough, we can then examine our design and try to improve the reliability.

It is all well and good to have an idea of the MTBF before we produce the system, but how is this done? The answer lies in testing the individual parts that go into the system as a whole. Fortunately, many manufacturers have carried out extensive component test programs, so we can, in most cases, avoid doing our own parts testing.

If we test 10,000 resistors for 10,000 hours and experience two failures, we have 10,000 × 10,000 or 100,000,000 unit-hours of operation. The unit-hours divided by the failures gives an *estimate* of the MTBF, so MTBF equals 100,000,000/2 or 50,000,000 hours.

Now an *estimated* MTBF of 50,000,000 hours corresponds to a failure rate of 1/50,000,000 or 0.00000002 per hour, or 0.00002 per thousand hours, or 0.002% per thousand hours. We must emphasize that this is an *estimate*. Statisticians can tell us how good an estimate we have by calculating a *confidence interval* for a given *confidence level*. The *confidence level* is just the probability that our estimate is within the *confidence interval*. The method used to calculate these values will not be given here and will depend upon the manner in which failures are observed. Fig. 1 shows how these results are interpreted for the estimate we performed above. Fig. 1 may also be read, "In nine out of ten tests, our estimated MTBF will be between 25,700,000 and 189,000,000 hours." This is quite a spread in values, but we must recognize that we are dealing with a problem which defies pinpointing. We can only talk about chance, the *probability* of an event.

Fig. 1. Showing 90% confidence level and interval for two failures in 100,000,000 unit-hours of operation of the part.



We need not be too concerned with the idea of confidence interval but we should be aware of its existence. Usually, we are only concerned with the lower limit. We want to be "sure" ("sure" meaning a high probability) that our MTBF exceeds some *minimum*. As Fig. 1 shows, our estimated MTBF must be well beyond the lower limit if we are to have much (0.9 probability) assurance. The more confidence we wish, the greater must be the gap between the lower limit and the estimated MTBF. Intuition tells us that the more unit hours we have with fewer failures, the higher the MTBF and confidence level. A statement of failure rate or MTBF is always more meaningful when a confidence interval or confidence level is given.

If we had a shipment of 50,000 lamps and wanted to know how many defective lamps there were in the lot, we obviously could test all the lamps. But if we took a random sample, a pretty good estimate could be had. Measuring *all* the lamps would enable us to make a statement with *confidence level* 1, or 100%. If we test only a few, we can only make a statement with low confidence about the quality of the lot. A larger sample for testing enables us to be more confident. As a result of this kind of testing, the statistician might make a statement as follows: "I'm 90% sure that no more than 100 lamps are bad, but I'm only 10% sure that no more than 25 lamps are bad." The higher the confidence level, the more conservative is the statement. Table 1 shows how the lower limit of MTBF *decreases* as confidence level *increases*. These values were computed by means of "chi-square distribution" methods. Other methods are used for other failure-analysis schemes but all lead to similar statements.

We should point out that "failure" must be defined for each particular testing program. For some parts, a failure might mean either an open or short circuit. These are usually classified as *catastrophic* failures. For other parts, a change in some characteristic, such as a 10% change in resistance, might be defined as a failure. These failures are termed *drift* failures. It is also possible to estimate failure rate even though *no* failures are observed during the test, but this is beyond the scope of this article. Notice also that Table 1 shows the large number of unit-hours that must be accumulated before a significant statement about the parts can be made. Testing 100 parts for one year and having one failure does not establish a very high reliability level. It only gives what could be a false feeling of confidence in the part. Statisticians tell about one of their members who drowned in a river where the average depth was one foot. The river was only six inches deep in most places, but he stepped off into a hole ten feet deep!

Table 2 gives some typical failure rates for electronic components. These values reflect the results of tests by many manufacturers and will be discussed further when we talk about improving reliability of over-all systems.

The Reliability Estimate

In the author's previous article, it was shown that reliability is given by $R=e^{-t/MTBF}$ or, since failure rate (usually designated by the Greek letter lambda, λ) is the reciprocal of MTBF, $R=e^{-\lambda t}$. The method we are about to describe is called the "part-count" model and is probably the method most used today. In applying this method to digital computers, the author has found reasonable (for this kind of work) agreement between estimated and measured MTBF. Generally, the calculations yield an MTBF that is four or five times *worse* than that measured in later tests.

The fundamental assumption here is that a failure of any one part will cause the system to fail. This means a "series" failure dependence, even when the parts are connected in any complicated manner. This argument centers about the notion that if a part can fail without causing the system to fail, then why have the part in the system? Also, this model does not take into account redundancy. A redundant system will have more than one part performing the same function. If a certain diode tends to fail "open," then better reliability can be achieved by having two diodes in parallel. If the diode tends to fail "short circuit," then two diodes in series will give redundancy and hence a definite improvement in reliability.

To calculate the reliability of a system, we need to know the total number of each kind of part in the system, as well as the failure rate (or MTBF). Multiply the total number of each particular part used by its failure rate. Do this for each part. Then add all these part-failure rates to get the system-failure rate (or system MTBF). This value is then used in the equation $R=e^{-\lambda t}$.

The method is illustrated by calculating the MTBF of a TV set. This particular set is about ten years old. A listing of the major parts will be given. Since we are primarily interested in method rather than detail, we'll keep the calculation short by assuming that all capacitors are of one type (say paper) rather than distinguishing between types (ceramic, electrolytic, etc.). We also assume that all resistors are of carbon composition.

This set consists of 22 tubes, 117 resistors, 8 potentiometers, 45 chokes and coils, 7 transformers, and 127 capacitors (assume all paper). We now multiply the number of parts by the failure rate for the part as given in Table 2. Tubes—$22\times5=110$; resistors—$117\times0.001=0.1$ (rounded off); pots—$8\times0.2=1.6$; chokes and coils—$45\times0.2=9.0$; transformers—$7\times0.2=1.4$; and capacitors—$127\times0.01=1.3$ for a total of 123.4% per thousand hours, or 1.23 per thousand hours, or 0.00123 per hour. Then the MTBF is just 1/0.00123 or 813 hours. Recall that in the previous article we showed that reliability is about 0.9, or nine chances out of ten to be operational, when the time is MTBF/10. So for our TV set we are 90% sure of being operational 81.3 hours after our last repair. This calculation is in surprisingly good agreement with experience for this set. This means that the MTBF is about 18 months if the set is used one to two hours a day. Notice also that vacuum-tube failures contribute about 90% of the total failure rate, which also agrees with experience.

CONFIDENCE LEVEL

	1%	5%	10%	25%	50%	75%	90%	95%	99%	99½%
MTBF in millions of hours	668	282	189	104	59.5	37.1	25.7	21.1	15.0	13.4

Table 1. Lower limit of MTBF at various confidence levels. Given are two failures in 100,000,000 unit-hours operation.

Limitations of the Estimation

A calculation is only as good as the numbers used, and the failure rates we used are only typical. As we shall see, failure rates are influenced by many factors. Also, a TV set that plays for 100 hours continuously will tend to be in better condition than one which has been on an hour, off an hour, on an hour, etc. Then, too, by the nature of the problem we must be satisfied with being within a factor of four or five (and sometimes ten) of what we experience. Quality of workmanship, soldering, etc. is not considered here, nor is input signal level. A set in a fringe area may have a very poor picture due to decreased gain, whereas in a strong-signal area it may present a satisfactory picture.

Improvement of Reliability

As mentioned earlier, redundancy will improve reliability. However, redundancy is not always feasible, particularly in commercial equipment, but other means exist.

Simplicity of design improves reliability. From the calculation we performed above, it should be clear that the fewer parts used the better the reliability. Avoid elegant designs using many parts; keep the design simple.

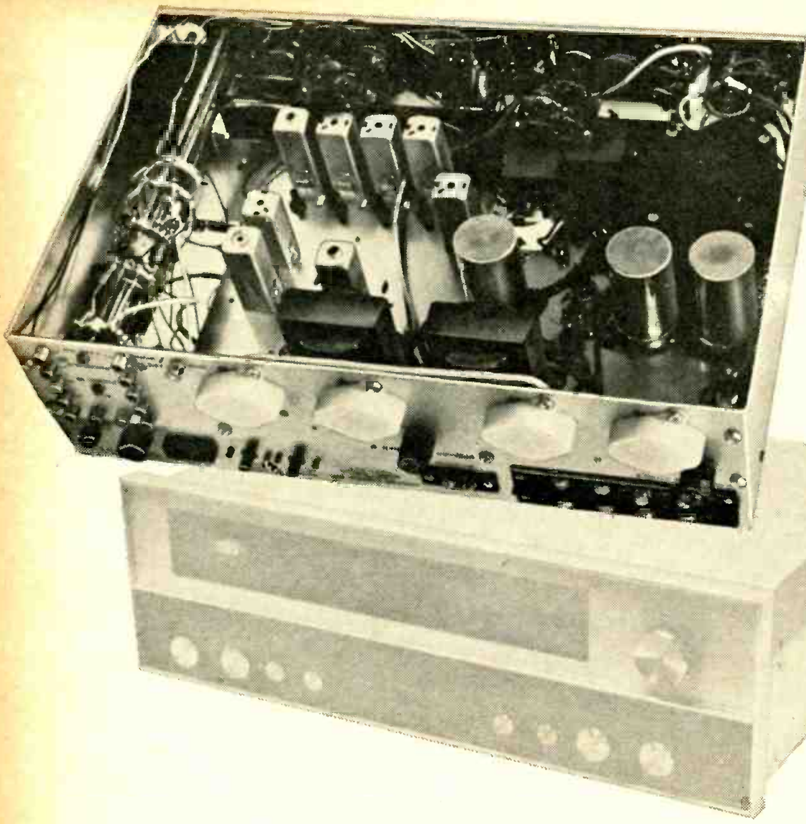
Careful design is a step towards reliability. A design should work for variations in conditions such as changes in supply voltage, degradation of parts, temperature changes, or high humidity. Circuit layout also influences reliability.

Use of high-quality parts improves reliability. Rugged tubes, resistors and capacitors with tight tolerances, and use of parts qualified to a MIL Spec (Military Specification) are examples of this approach. Cost may be a consideration here, as these parts generally cost (*Continued on page* 82)

Table 2. Some typical failure rates for components at room temperature and operated at 75 percent of their rated level.

Component	Failure Rate @ 60% Confidence Level (% per thousand hours)
Resistor, composition	0.001
Resistor, film	0.002
Capacitor, paper	0.01
Capacitor, molded mica	0.003
Capacitor, ceramic	0.001
Capacitor, electrolytic	0.03
Chokes	0.2
Transformers	0.2
Potentiometer, composition	0.2
Transistors	0.04
Semiconductor diodes	0.02
Tubes	5.0

$$\text{MTBF in hours} = \frac{100{,}000}{\text{Failure rate (\% per thousand hours)}}$$



Over-all and inside views of Harman-Kardon SR900 receiver. Note that inside view is looking up from bottom and various transformers, transistors, and electrolytics are mounted upside down compared to the usual arrangement; wiring is on the opposite side of the chassis pan. The preamplifier transistors are wired directly to function switch. Output transistors (on rear flange) are covered with nylon shields to prevent accidental grounding.

SOLVING HI-FI FM TUNER DESIGN PROBLEMS

Front-end overloading and crosstalk have been serious problems to date in the design of all-solid-state FM tuners. Here is how these problems and others have just been solved by one component high-fidelity manufacturer.

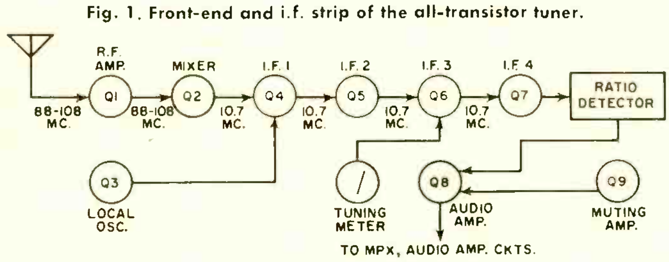
By DAVID WALKER

"I AM convinced that one year from now, tubes will no longer be a factor on the FM receiver scene." This prediction on the current issue of tubes *vs* transistors was made recently by Robert E. Furst. As *Harman-Kardon's* vice-president in charge of engineering, he thus emphasized the company's total commitment to solid-state. Tubes were first eliminated in audio circuitry and now they have been designed out of r.f. circuits. All of the firm's tuners are transistorized, including the front-end where tubes have traditionally appeared.

How this changeover was accomplished can be seen by considering the circuitry of the SR900, an all-transistor FM receiver. It contains tuner and audio amplifier sections integrated within a single cabinet. The tuner portion alone is considered here. It is this section, especially the front-end, which was the last hold-out in the transition from tubes to transistors.

In general, the problems which beset r.f. solid-state circuitry originate with the nature of the transistor. The semiconductor is able to provide needed functions in the tuner —amplification, oscillation, and mixing—but it also introduces special characteristics of its own. Unlike the tube, the transistor contains junctions which, under certain circumstances, perform as diodes. A stage intended for straight amplification could, therefore, introduce diode mixing action. The result might be "crosstalk," a charge frequently leveled against the transistor tuners. Diode action, along with characteristics described later, re-emphasizes that the transistor is no mere vacuum-tube substitute. It is a generic device with compelling advantages, but one which requires careful attention to its limitations.

Fig. 1. Front-end and i.f. strip of the all-transistor tuner.



Why, then, did *Harman-Kardon* elect to be one of the earliest producers of an all-transistor tuner? The assumption was that semiconductors could, potentially, do any job better than tubes, and with more sophistication. This thinking logically extended itself to r.f. circuits. In fact, it was decided to bypass the conventional three-step approach: from tubes, to hybrid, to all-transistors, as it was felt that the hybrid has drawbacks. It produces a tube-and-transistor design mix that may not necessarily add up to sound engineering practice. The power supply, for example, is of necessity more complex in order to meet the requirements of two generically distinct devices. The hybrid, too, sacrifices certain good features of the semiconductor. Furthermore, it was believed that the transistor had been unjustly accused of causing front-end problems which really originated elsewhere in the tuner. An inability to pinpoint those problems has delayed broader usage of the transistor in front-end applications.

Benefits of Transistorization

With the solution of these problems, the transistor could yield significant benefits. A major one is reduced power dissipation. In the SR900, a scant one watt is consumed between the antenna input and the detector. Not only does it create negligible heating, but it distributes dissipation over a physically large area. Tuning drift is minimized since critical components can operate steadily at room temperature. Low wattage also reduces drift problems due to power-supply fluctuation. Just a small zener-diode regulator can strap voltages to constant level. Another advantage with semiconductors is the absence of the tube filaments. This eliminates a notorious feedback path for regeneration and instability in i.f. stages.

Signal radiation is also reduced. As a low-impedance device, the transistor is less prone to stray coupling and pickup between adjacent circuits. Small physical size also makes a contribution, but not for the usual reason, *i.e.*, the reduction in equipment size. Small dimensions permit added flexibility in physical layout to achieve good electrical isolation between components and wiring. So much for the benefits of semiconductors. Consider, now, the problems which arose during the development of the practical FM receiver.

Fig. 1 is a block diagram of the receiver's r.f. and i.f. sections. Superficially, it appears to have the same general stages as any conventional FM tuner. The functions, too, are similar. A notable difference occurs in the i.f. strip—there are four stages, more than are customarily found in tube-type tuners. There is no automatic frequency control (a.f.c.) circuit. An incoming signal is properly tuned and retained in the i.f. strip with the aid of the tuning meter and low inherent frequency drift. An 800-kc. bandwidth in the ratio detector is ample to handle small shifts in local oscillator frequency, should they occur.

Absent is any automatic gain control (a.g.c.) in the conventional d.c. feedback arrangement. Signal strength will be controlled by limiting, which will be described later. The final i.f. stages are not identified as "limiters." This function, as well as a.g.c. action, is achieved in successive stages through the tuner. The ratio detector also helps strip away AM interference by virtue of built-in limiting action.

The Front-End

Let's look at specific circuit sections which have proven troublesome in early prototypes. Consider the front-end, shown in the partial schematic of Fig. 2 (left). The front-end has been celebrated as the tuner designer's major stumbling block in working with solid-state components. The frequent comment is that the transistor is a crosstalk generator, giving rise to spurious products during strong-signal reception. Tuning becomes difficult as specious audio signals occur between stations on the dial. In fact, several phenomena may be happening simultaneously. That crosstalk is not a single problem may be seen by close examination of the front-end circuits.

As shown in Fig. 2, transistor Q1 is the input r.f. amplifier. It is connected in grounded-base configuration. Like its grounded-grid tube counterpart, it isolates input and output sides of the transistor, eliminating the need for neutralizing interelectrode capacitance. But an important difference between tube and transistor also occurs here. The base-emitter junction of transistor Q1 is, unavoidably, a diode. In the presence of strong incoming signals there is a possibility that normal transistor amplification could be accompanied by diode mixing action. Offending signals or crosstalk are created.

A design tactic to reduce this action imparts a high degree of selectivity to the front-end. It can significantly reduce the strength of undesired signals before they can mix in the transistor junction. A close inspection of Fig. 2 reveals an important difference between the front-end shown and that of most tube tuners. There is an extra tuning section—*four* variable capacitors instead of the usual three. The extra section is in the preselector which contains antenna-input circuitry to the transistor. The higher sharpness of tuning ("Q") introduced by the double-tuned input contributes toward a rated 85-db rejection of spurious responses.

The second troublesome source tended to occur in the mixer (Q2). Due to the mixer's inability to handle large input signals, consequent overload could place signals over the complete FM band. (By its very nature as a non-linear device, the mixer readily creates new frequency products.) Part of the solution is to reduce the mixer's ability to overload which is accomplished by reducing the gain of the stage. This is achieved by careful selection of component values. Manipulating collector current, and thus the operating point of the mixer, provides an optimum compromise between essential mixer operation and the generation of spurious signals.

In any discussion of the mixer, the local oscillator cannot be overlooked. It nominally couples a signal to the mixer which is 10.7-mc. above the incoming signal. The mixing action should occur between two signals of discrete frequency, but the local oscillator also creates harmonics—frequency multiples which tend to produce new and objectionable mixtures. The answer is to design the oscillator with a "clean" output signal. Adjusting values in the oscillator was a process designed to obtain the most sinusoidal, and therefore pure, output signal. Oscillator output voltage was also carefully adjusted.

The mixer is involved in another problem stemming from transistor operation. Unlike the vacuum tube, the transistor is susceptible to bi-directional flow. After the signal has traveled from input to output, it may couple back to the input *via* the semiconductor material. A critical effect is the return of 10.7-mc. energy from mixer output back to the input. (Mixer input should contain only FM signal frequency plus local oscillator signal.) Any 10.7-mc. intrusion in the reverse direction aggravates the spurious mixing problem. An additional element is introduced into the circuit to prevent such feedback: it is the "I.F. Trap" between mixer input and ground. Series-resonant to 10.7-mc., it effectively short-circuits reverse feedthrough in the mixer.

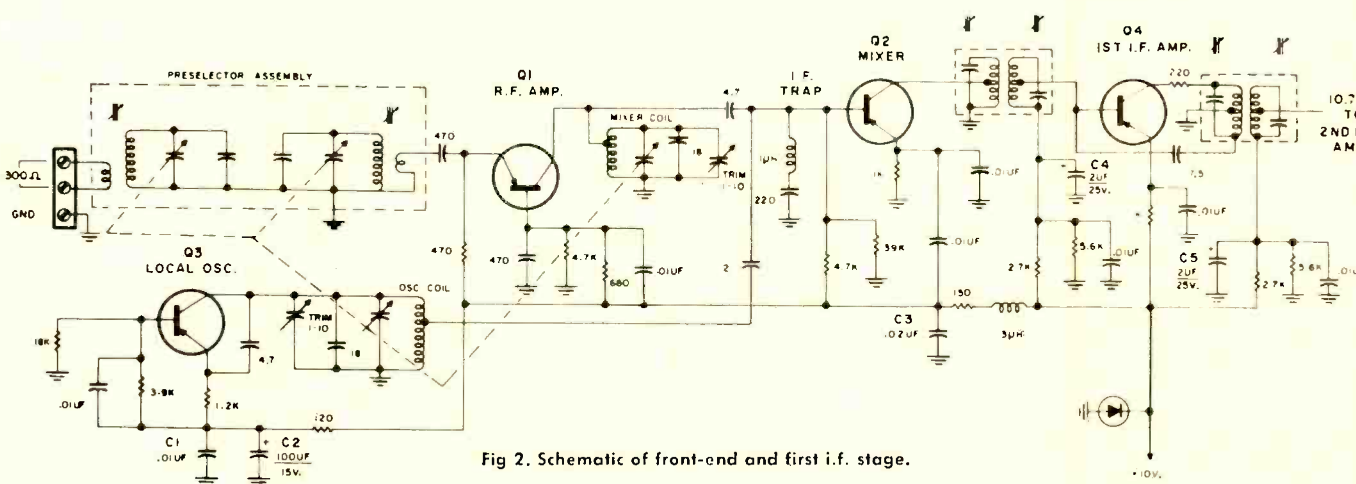


Fig 2. Schematic of front-end and first i.f. stage.

To the design stratagems outlined can be added another major consideration: undesirable coupling between various front-end stages due to common connection across the power supply. Although well-known in tube circuits, it assumes special importance in the transistorized front-end. Semiconductors, as low-impedance devices, require more care in decoupling, filtering, and bypassing, otherwise the appearance of signal voltages at an undesired point encourages false mixtures.

To keep the supply leg (+10 v. in Fig. 2) at extremely low impedance, large r.f. bypasses are placed along the positive bus: $C1$ and $C3$, for example. They assure ample grounding of r.f. signals which may appear here. While such bypassing is conventional in tube tuners, the transistor version introduces another technique. It is bypassing at *audio* frequencies. Note $C2$ at the lower left of the schematic. As a 100-μf. capacitor, it is far greater in value than in the tube r.f. circuit. This is done to anticipate the possibility of audio products created in the semiconductor junctions. Heavy bypassing here can be considered as being audio filtering, forming a low-impedance circuit pathway to ground if such audio products should appear in the front-end.

Physical Aspects

Several physical aspects of the front-end layout can be seen in the tuner's top view shown in Fig. 3. An innovation is the use of two separate ganged tuning capacitors, identified as "Preselector" and "Osc./Mixer" at upper left. These make up the required four variable capacitors mentioned earlier. By splitting the tuning gangs into separate sections, electrical isolation between stages is improved; there are no circulating currents in the capacitor frames. Two tuning drums are found on the chassis instead of the usual single unit. Both drums are driven synchronously by one dial cord strung around their circumferences. Note that the preselector gang, the dual-capacitor for the r.f. amplifier, is some distance from the transistor Q1. This is possible due to the low-impedance input of the transistor. It permits output of the tuned circuit at the tuning gang to run through a link coupling which is little affected by length.

Another feature of the physical layout is in the i.f. strip along the top right. Instead of the usual placement of tubes *between* i.f. transformer cans, the transistors mount at the side. The whole arrangement permits short leads and is, therefore, less prone to instability due to stray coupling.

The I.F. Circuit

The i.f. circuits of the tuner also demand special attention because of the transistor characteristics. Two important effects to be avoided are slope detection in the i.f. stages and signal feedthrough. Let us consider the first i.f. stage as shown in the partial schematic of Fig. 2 (right). A signal entering the i.f. transformer is amplified by Q4, then passed out of the stage through the next i.f. transformer. In the case of exceedingly strong signals or mistuning, there is a possibility that a portion of the signal will spill outside the bandwidth of the i.f. transformer. As the signal shifts in frequency (due to modulation) voltages at an audio rate could ultimately develop. It commences as the i.f. signal varies along the slope of the i.f. transformer bandpass curve. Instead of passing uniformly through the mid-point of the tuned circuit, signal voltages change with frequency. If these variations are applied to a non-linear device, detection to audio would follow. The transistor can present the non-linear device in the form of its base-emitter junction. Diode rectification occurs and the signal reverts to audio in slope-detector fashion.

Measures which improve linearity in the i.f. stage help suppress this undesirable effect.

Four stages of i.f. amplification are used, in contrast to a lesser number in tube tuners. This permits individual stages in the transistorized i.f. strip to operate at decreased gain and improved linearity. Lower supply voltages and collector currents contribute to the desired result. Note, too, in Fig. 2 that heavy bypassing—$C4$ and $C5$—is provided to check any development of audio voltages in the i.f. strip of the tuner.

The four i.f. stages also aid in developing proper limiting action, which would be defeated by any tendency of the semiconductor material to capacitively couple signals from input to output. No one stage is singled out for the limiting function, as it was discovered that the action is best distributed over the complete succession of i.f. stages (plus the ratio detector). With all i.f. transistors operating at relatively low potentials, even the very first intermediate-frequency stage will produce some limiting action.

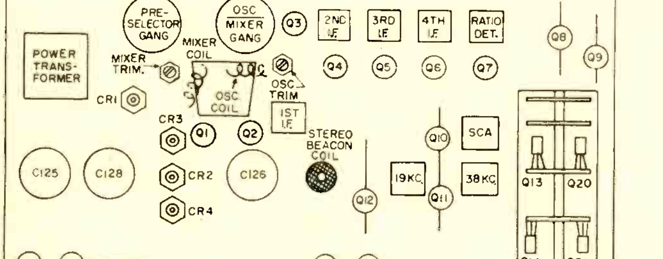
General Conclusions

Some general conclusions can be drawn about the final version of the tuner circuits. Perhaps the most significant is that it does not represent any spectacular "breakthrough" technology—no magic formula provided the answers. Rather, the tuner's development followed a tortuous path of isolating, then treating, a specific problem. It may be that the transistor in the front-end has been wrongfully blamed for generating cross modulation when actually the trouble source is frequently inadequate bypassing in the power supply circuits.

Difficulty in tuning the receiver and the intrusion of false signals also suggest transistor front-end problems. These, however, can be handled by the techniques just discussed: increased selectivity, filtering, and careful component selection to avoid non-linear action. Careful neutralization of the i.f. transistors, even to the point of optimizing taps on an i.f. transformer, typify the kind of detailed approach which characterized the tuner's development. One incidental boost was given by transistor manufacturers. Early tuner models displayed poor uniformity in stage gain, although transistor testing revealed no apparent differences. This elusive problem disappeared as semiconductor producers adopted more precise selection techniques, and gain variations are no longer troublesome.

Harman-Kardon looks for further advances in FM tuner design based on transistors. Semiconductors are undergoing refinement, promising even lower noise levels, and suitable silicon units are being examined as possible replacements for the present germanium types. Higher *beta*, lower current transistors are in the offing. Until that time, however, it is the company's conviction that its solid-state SR900 will perform with the sensitivity and selectivity of a high-quality tube-type tuner. ▲

Fig. 3. Top view of receiver. The tuner transistors and circuits are at the left center and toward the front of the chassis. The multiplex-circuit transistors are at right center. The audio preamp transistors are at the extreme right while the audio output transistors are mounted on the rear flange.



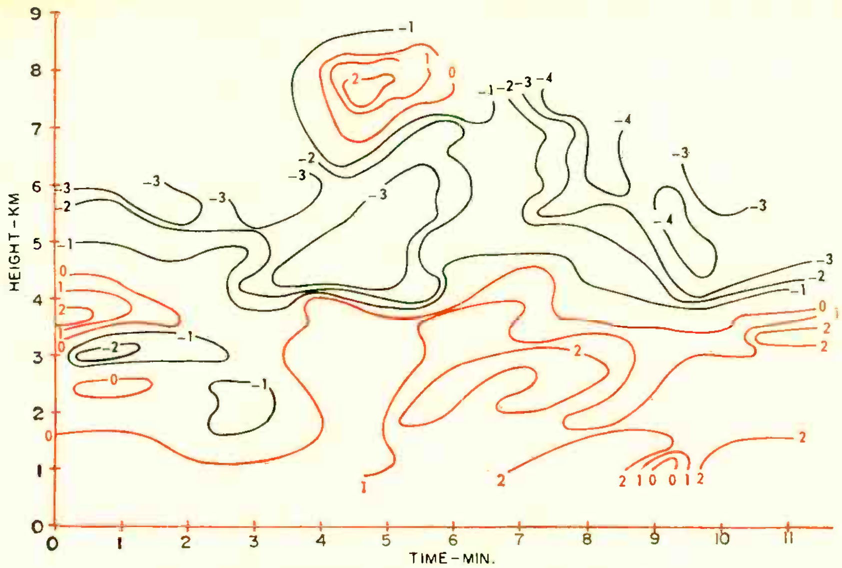


Fig. 1. Computed updraft structure of a typical storm. Values are in meters per second with negative indicating updrafts.

DOPPLER RADAR IN WEATHER RESEARCH

While ordinary radar will show the presence of rain, snow, or clouds, Doppler radar is capable of determining the characteristics of these weather components, thus aiding forecasting.

THE use of radar in observing the weather is now a common practice. Meteorologists first became interested in radar about 20 years ago when it was noticed that a kind of background clutter, or noise, was often present on radar screens whenever "weather" such as rain or snow was in the vicinity. Ships, planes, or other important radar targets would sometimes be obscured by this "weather" noise.

It was found that large collections of raindrops, snowflakes, or cloud droplets, collectively called *hydrometeors* backscatter enough of the radar energy incident on them so as to constitute detectable radar targets. For most radar wavelengths, the energy returned by a single hydrometeor is proportional to the square of its volume. Thus, a raindrop twice the size of another will return 64 times as much energy. Although the energy returned by a single hydrometeor is extremely small, in the high concentrations frequently present in rain and clouds, they become radar-visible.

The pattern observed on a radar set then takes on the look of the hydrometeor distribution—a kind of weather map. The patterns are generally different for rain or snow and, to some extent, their characteristics depend on the large-scale weather features such as cold fronts and wind structure. The use of radar in locating and mapping the progress of these weather systems is a well-established practice, and is being used not only by ground stations but also by commercial passenger aircraft in flight so as to avoid air turbulence associated with some frontal systems. However, conventional pulse radar only indicates the *presence* of these hydrometeor clusters and the relative size of the area they cover.

Probably the most significant of the latest weather-radar investigations are those using coherent Doppler radar. Research of this type was first undertaken in 1955 at the *Cornell Aeronautical Labs.*, and a continuous program of such weather investigation is still going on there.

The valuable property of Doppler radar that makes it so distinct from conventional pulse radar is its ability to measure the velocity components of targets in a direction towards or away from the transmitter. (Some readers may be acquainted with this system as used in police speed radar.) The familiar Doppler effect operates in such a way that the radar signal returned from a target moving towards the radar has a slightly higher frequency than the transmitted signal. Conversely, the signal from a receding target has a lower frequency than that transmitted. The difference between the transmitted and received frequencies is called the Doppler shift, the value of which is proportional to the radial velocity of the target.

Since weather targets are in fact large collections of small targets, moving with a wide distribution of velocities, the return signal consists of many different Doppler-shifted frequencies. Snowflakes, for example, fall at a slower rate than raindrops, therefore they will produce a different frequency shift. This makes it possible to use a Doppler radar to determine at what altitude snow turns to rain. This would be of great help in weather prognostication. It would also make possible determination of the exact configuration of updrafts and downdrafts so that frontal systems could be determined.

A typical Doppler pattern showing the transition from snow to rain is shown in Fig. 2. This plot of Doppler spectrum *vs* altitude shows a melting layer at about 3.5 km. where there is an abrupt increase in the mean falling speed from the relatively slow fall of snow at about 1.5 meters per second, to the much faster fall of rain at about 6 meters per second.

The most important dynamic characteristic of the atmosphere in determining the formation and growth of clouds is the structure of updrafts. The very presence of a cumulus cloud implies the existence of an updraft.

Fig. 2. Transition from snow to rain (3.5 km.) shows up as change in Doppler shift.

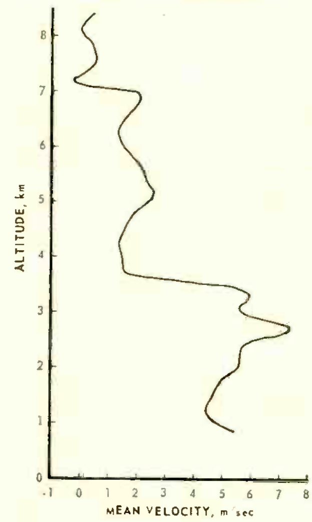


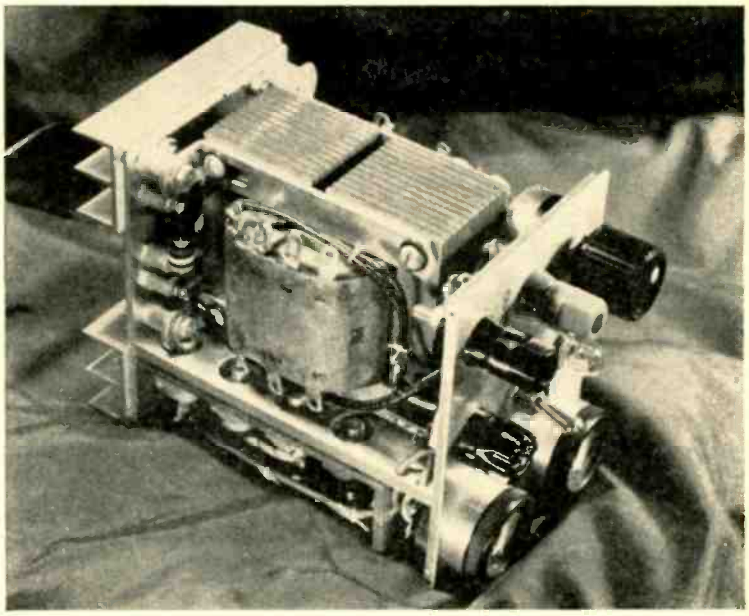
Fig. 1 shows how an updraft structure looks to a Doppler radar. In this case, the Doppler radar was pointed vertically, and the storm moved past the radar beam. Note that the region between 3 and 4 km. appears to be a transition zone between updrafts above and downdrafts below. This was also the region above which the air was colder than freezing and below which the air was warmer. In this case, the hydrometeors above the level were apparently raindrops, not snowflakes.

Future plans for Doppler radar weather research include research into wind structure in showers and thunderstorms. Attempts will be made to relate radar observations to large-scale weather characteristics and thereby understand the dynamics of storms.

This article is based on data supplied by *Cornell Aeronautical Labs.* ▲

DESIGNING A TRANSISTOR POWER SUPPLY

By THOMAS J. BARMORE



By using miniature components, including meters, it becomes possible to make a relatively small package of the power supply. Heat sink forming the rear wall mounts transistor Q1.

Step-by-step process shows how to design a compact, regulated power supply which may be adjusted between 7 and 40 volts output at load current up to 2 amperes.

DESIGNERS and experimenters who find themselves associated with transistorized circuitry often need a source of nearly pure d.c. power. Batteries are the first thought, but any source that supplies a fixed voltage (or a selection of fixed voltages) will be necessarily limiting, since voltage is the one parameter that must be made continuously variable when experimenting with transistor circuits.

Variable, regulated, transistor power supplies are readily available on the commercial market, but their cost is often quite high.

The power supply to be described utilizes inexpensive components and will easily fit into the smallest workspace since it measures 3 by 4 by 6 inches. The output voltage may be adjusted to any value between 7 and 40 volts d.c. at load currents up to 2 amperes. As shown in Fig. 1, regulation and ripple are directly proportional to the output voltage and current, and output voltage is essentially constant, at full load, even with line variations on the order of ±25 volts.

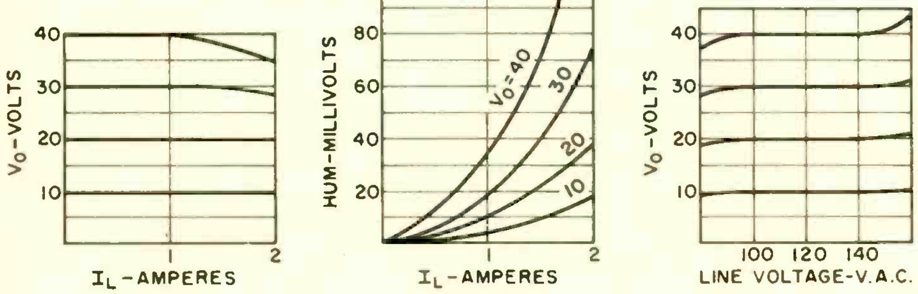
Normally, the output voltage from a power supply consisting of a transformer and full-wave bridge rectifier with adequate filtering will vary for one or all of three reasons: *IR* voltage drop in wiring and transformer windings proportional to load current; core-loss voltage drop due to load current; and variations in the line voltage.

To maintain adequate regulation in each case, the change must be sensed, amplified, and used to reduce or eliminate any tendency the output voltage might show toward changing.

Circuit Design

Ordinarily, either one of two basic circuit designs may be used to achieve regulation. One, known as shunt regulation, is current limiting, but cannot easily provide a variable output voltage. The other design, series regulation, while not current limiting in the same sense, is versatile because its output voltage may be changed quite readily. In its simplest form, the circuit uses a series transistor to absorb voltage changes and a zener diode to clamp the output level. This is the circuit shown in Fig. 2.

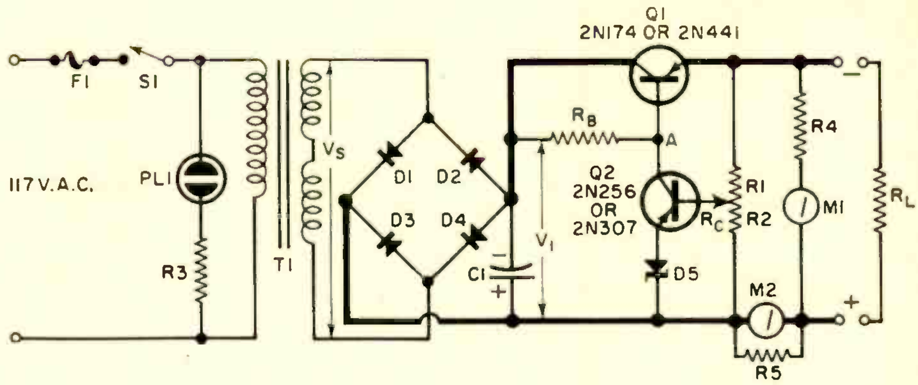
Fig. 1. Comparison of output voltage vs current (left), hum level (middle), and output vs power-line fluctuation (right).



Since output voltage is dependent on the value of the clamping voltage, the addition of a sensing amplifier, consisting of transistor Q2 and resistor R_E, will provide gain resulting in an increased degree of regulation.

The action of the regulator may be explained by assuming that a higher output voltage is desired. An increase in the quantity $R1 / R2$ (moving the slider down in the diagram), will decrease the negative potential at the base of $Q2$, decrease its base current, and cause a corresponding reduction of its collector current. This, in turn, results in a lowered voltage drop across resistor R_B, which is essentially the load resistor for $Q2$.

This causes point "A" to be more negative than previously, increasing the base current of transistor $Q1$. An increase in base current must cause an increase in emitter current. Therefore, it follows that output voltage will *increase* since the load R_L is constant. To provide a decrease in output voltage, or to compensate for output voltage fluctuations due to load changes, and/or line-voltage variations, the same line of reasoning may be applied.



R_B—390 ohm, 1 w. res.
R_C—(R1,R2)—1000 ohm, 2 w. pot.
R3—100,000 ohm, ½ w. res.
R4—20,000 ohm, ½ w. res.
R5—.0231 ohm, 2 turns #36 copper wire on 10 ohm (or greater), ½ w. res.
C1—1500 μf., 50 v., elect. cap.
D1,D2,D3,D4—1N250 diode
D5—6.8 v. zener diode, 1 w. (Motorola 1N3829A, 1N3016B or equiv.)
M1,M2—Miniature 2 ma. meter, with approx. 23 ohms internal res.
T1—Power trans. 12 to 29.6 v. @ 2 amps.
PL1—NE-2 neon bulb
F1—Line fuse, ½ amp.
S1—S.p.s.t. switch
Q1—2N174 or 2N441 transistor
Q2—2N256 or 2N307 transistor

Fig. 2. Schematic diagram and parts list for the regulated power supply.

The power supply may be constructed in accordance with Fig. 2, or the design changed to suit particular needs. If this latter course is chosen, the following design procedure can be used to obtain the desired output.

Choose the maximum output voltage ($V_{o\ max.}$) and minimum output voltage ($V_{o\ min.}$) desired.

Select the maximum load current ($I_{L\ max.}$).

Pick the power transformer based on $I_{L\ max.}$, d.c. input voltage to the regulator ($V_{1\ max.}$), and the output voltage (V_s). Then, $V_s = 1.11\ V_{1\ max.}$.

Filter capacitance should be chosen on the basis of the load impedance. $C\mu f. = 22{,}500\ (I_{L\ max.}/V_{o\ max.})$.

The rectifiers should meet the following specifications: I_{peak} (per rectifier) $= 4.75\ I_{L\ max.}$; $P_{dis.}$ (per rectifier) $= .5\ I_{L\ max.}$; and *p.i.v.* (per rectifier) $= 1.414\ V_{s\ max.}$.

Breadboard the basic d.c. supply (*i.e.*, transformer, full-wave bridge, and filter capacitor), and determine the values of V_s, $V_{1\ max.}$, $V_{1\ min.}$, and $I_{L\ max.}$ (R_s). R_s = total series resistance. $V_{1\ max.}$ equals no-load output voltage, while $V_{1\ min.}$ may be measured after the supply is loaded to $I_{L\ max.}$. Therefore, $I_{L\ max.}\ (R_s)$ is equal to the difference between the two voltages.

Transistor selection may be somewhat more difficult, owing to the fact that particular care must be taken to insure that none of the breakdown voltages is exceeded, and that the transistors will dissipate their power when provided with an adequate heat sink. For transistor $Q1$; $P_d = (V_{1\ min.} - V_{o\ min.})\ I_{L\ max.}$; $I_{c\ max.} = I_{L\ max.}$; and $BV_{ces} = V_{1\ max.} - V_{o\ min.}$. In addition to the preceding specifications, a power transistor should be chosen that has as high a d.c. gain (h_{FE}) as possible.

Select a voltage value for the reference source based on the desired minimum output voltage: $V_z = V_{o\ min.} - .4$. The value chosen for V_z should not be too small since the quality of the zener regulation is directly proportional to the zener voltage.

Both the maximum zener current and the value of resistor R_B must be calculated by approximation, using the following two equations:

$$\text{(A)}\quad R_B = [I_{L\ max.}(R_s) + V_{ce}\ Q1] / [(I_{L\ max.}/h_{FE}\ Q1) + I_{z\ min.}]$$

$$\text{(B)}\quad I_{z\ max.} = (V_{1\ min.} - V_z) / (R_B + R_z)$$

Solve equation (A) for R_B by eliminating the term $I_{z\ min.}$, then solve equation (B) for $I_{z\ max.}$ by eliminating the term R_z. Then by allowing $I_{z\ min.}$ to equal .1 of $I_{z\ max.}$, re-solve equation (A) for the final value of R_B. Choose a zener diode based on V_z and $I_{z\ max.}$.

From the characteristic sheet for the particular zener chosen, use the value given for R_z and $I_{z\ max.}$ and rework equation (B) verifying that the new value for $I_{z\ max.}$ is within the maximum limits of the selected diode.

Select transistor $Q2$ by: $P_{dis.} = I_{z\ max.}(V_{o\ max.} - V_z)$; $BV_{ces} = V_{o\ max.} - V_z$; and $I_{c\ max.} = I_{z\ max.}$.

By choosing a transistor for $Q2$ which has a high wattage rating, no heat sink will be required.

Resistor R_C should be selected such that it will not load the base-emitter circuit of $Q2$, *i.e.*, the base current for $Q2$ should not cause an appreciable voltage drop in leg $R1$. In most cases, the value for R_C will lie somewhere between 500 and 1500 ohms.

Care must be taken in wiring the circuit, using at least #12 or #14 gauge wire in the current paths indicated by the heavy lines in Fig. 2. Even small amounts of wiring resistance will adversely affect regulation. It is possible to obtain either positive or negative feedback in the circuit by selectively allowing changes in the wiring resistance (see Fig. 3.).

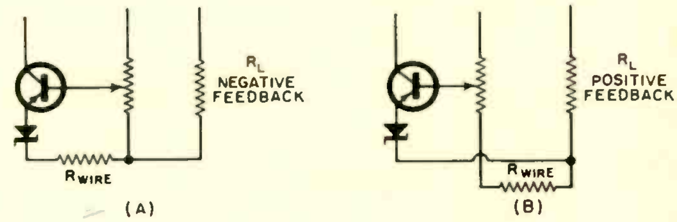
Negative feedback will produce an output voltage characteristic which will be constant or slightly decreasing with increasing load. Positive feedback may cause an increasing voltage under the same conditions. The degree depends on the value of the resistance R_{wire}.

Construction

Packaging is straightforward with all controls and metering on the front panel. Transistor $Q1$, mounted on a modified heat sink, serves as the rear panel. Both front and rear panels are held together with a single piece of aluminum in a layer configuration, so as to allow a flush fit of the outer covers of the unit.

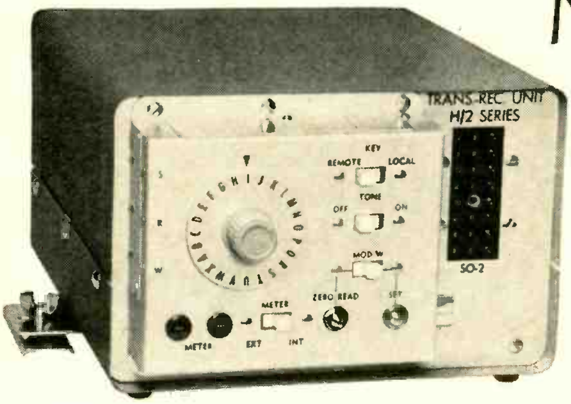
The diodes and transistor $Q1$, do not require heat sinks and together with the regulating circuitry (with the exception of R_B) are mounted on an L-shaped printed circuit board fastened to the internal cross member. ▲

Fig. 3. Positive or negative feedback can be introduced by selectively allowing changes in internal wiring resistance.



NEW CITIZENS BAND CIRCUITS

By LEN BUCKWALTER



A

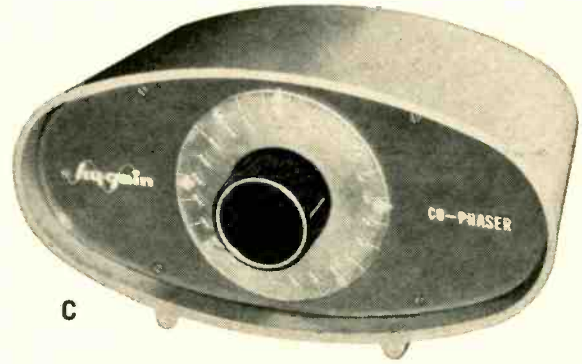
Description of:

Self-testing transceiver

Simplified frequency-synthesis circuit

"Co-Phaser" for CB antennas

B



C

NARROWING down a defective stage in *International Crystal's* new transceivers is greatly facilitated by built-in test circuits. A special selector switch and numerous internal refinements permit quick sampling of two dozen key values spotted in all major stages. The second circuit to be described is an interesting modification of frequency synthesis. *Regency* has transferred the idea from its 23-channel "Range Gain" unit to a more moderately priced 8-channel set. It enables a CB operator to change channels with a single crystal instead of the usual two. Our last circuit is found in *Hy-Gain's* "Co-Phaser." This accessory device couples two standard vertical antennas, permitting them to function as a beam without a mechanical rotator.

International Crystal's Built-in Test Circuits

The concept of adding test circuits inside equipment is brought to a high degree of development in *International Crystal's* Model 750 transceivers. The approach goes beyond similar methods found in much military and commercial two-way gear. The popular technique has been to bring key test points to a chassis-mount socket. The technician may then plug in a special "test set" to read important circuit values. The test set generally contains a meter, selector switch, and suitable multiplying resistors. In the Model 750 transceivers, however, these elements are self-contained.

By rotating a 24-position selector switch mounted on the rear of the unit (Photo A), the technician can check performance of every stage within the transceiver. The readings are viewed on the set's "S" meter. (Optional meter jacks are supplied if the technician wishes to substitute his own 100-μa. meter during bench tests.) Thus, most field and bench testing can be performed rapidly with facilities contained within the transceiver. The only major instruments not provided are a calibrated signal generator for receiver alignment, and a frequency meter for checking accuracy of channel frequencies. These, however, are not normally used to localize trouble; the basic function of the built-in test circuit.

A novel provision in the system enables the technically unskilled user to detect trouble in advance of a complete failure. With each transceiver the company supplies a "Factory Final Test Sheet"—a chart listing all test switch positions. Prior to leaving the factory, each transceiver is operated and meter readings taken on each test position. These values are recorded on the chart for reference. Any future variation from these readings tells the operator that the unit requires servicing. For the technician they help pinpoint the troublesome stage or section.

Certain switch positions aid the technician in other ways. There are three, for example, which enable him to adjust his primary power source—117 volts a.c. or the two battery voltages, 7.1 and 13.6—to exactly match that of the factory's when readings were first taken. One switch position permits proper adjustment of the set's internal microphone gain control. A tone switch next to the selector provides a steady audio source. One condition external to the transceiver can also be measured: reflected power from the antenna.

But most switch positions are tied into successive stages in both transmitter and receiver. Beginning at position "A" the technician may quickly sample major receiver stages, starting at the cathode of the r.f. amplifier and ending at position "K," the audio output amplifier cathode. In some instances, screen and grid readings are sampled. Most of the remaining positions occur in transmitter stages, including power output, filament voltage, and percentage modulation.

The test switch is shown in Fig. 1, with a listing of functions beside it. To reveal typical switch action, the receiver front-end circuit is also shown. It is seen that the switch is divided into two halves, forming a double-pole, 24-position unit. The meter connects between the two common poles, or wipers, lettered "F" and "R." In most positions, the "F" section simply grounds one side of the meter. The other wiper, "R," ties the "hot" meter terminal to the various stages under test. Since the switch is now shown in the "D" position, let's consider this connection: it provides a relative reading for the 2nd Receiver Oscillator.

In the "2nd Rec. Osc." stage, found near the bottom right of the schematic, there is a lead marked "DF" from the tube's control grid. This letter coding indicates that the lead ultimately connects to the left side of the meter, to the Test Switch through "F" common, then on to the "D" position.

At the same time, the right side of the meter is grounded by the other switch section. This inserts the meter into the voltage divider formed by resistors *R*1 and *R*2 in the grid circuit. It provides a meter reading which may be compared to the factory chart.

Numerous other samplings are taken in similar fashion. There is, for example, an "AR" lead from the cathode of the "R.F. Amp." This couples a small current flow through multiplying resistor *R*3 to the "A" position, located in the "R" section of the switch. Another appropriate resistor is used in the "1st Converter" screen for the "BR" lead running to the test switch. High sensitivity of the meter and bypassing in the test leads enables samplings to be taken with negligible effect on the operating circuits.

For copy of manufacturer's brochure, circle No. 53 on coupon (page 15).

Regency One-Crystal Operation

In the conventional transceiver, crystal-controlled operation is achieved by inserting two crystals: one for controlling the transmit oscillator, as prescribed by law; the other to lock the receiver local oscillator on frequency. These crystals, of necessity, are of different frequencies for a given channel. The transmit unit provides an operating frequency on 27 mc. The receive crystal, however, is offset from the operating frequency. This enables the local oscillator to mix with the incoming frequency and produce the desired i.f. difference signal.

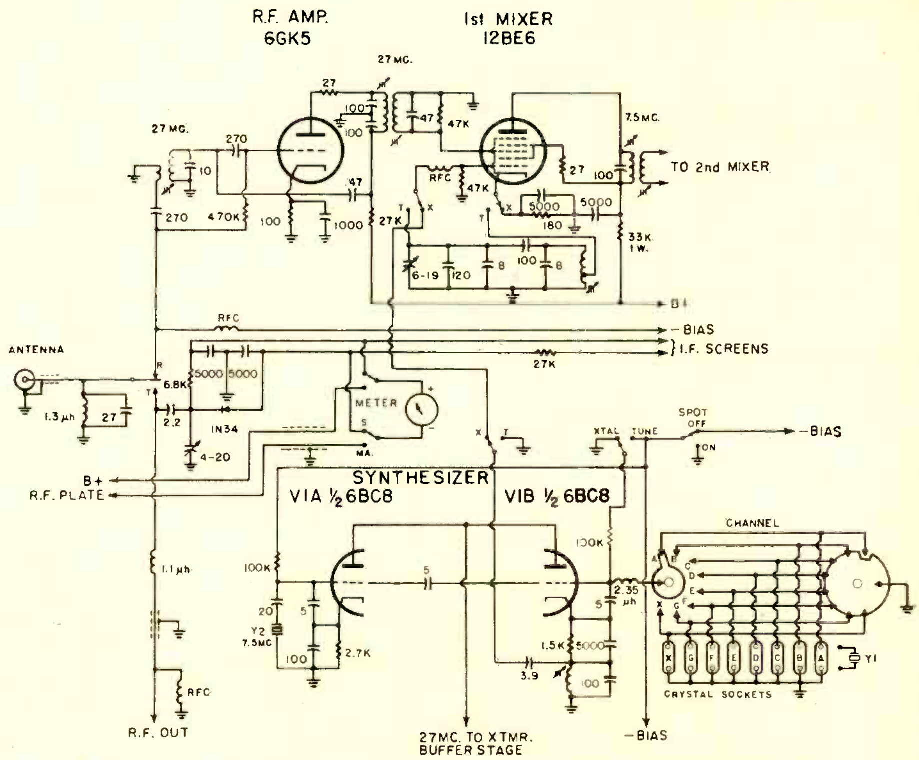


Fig. 2. The Regency simplified frequency-synthesis arrangement is shown here.

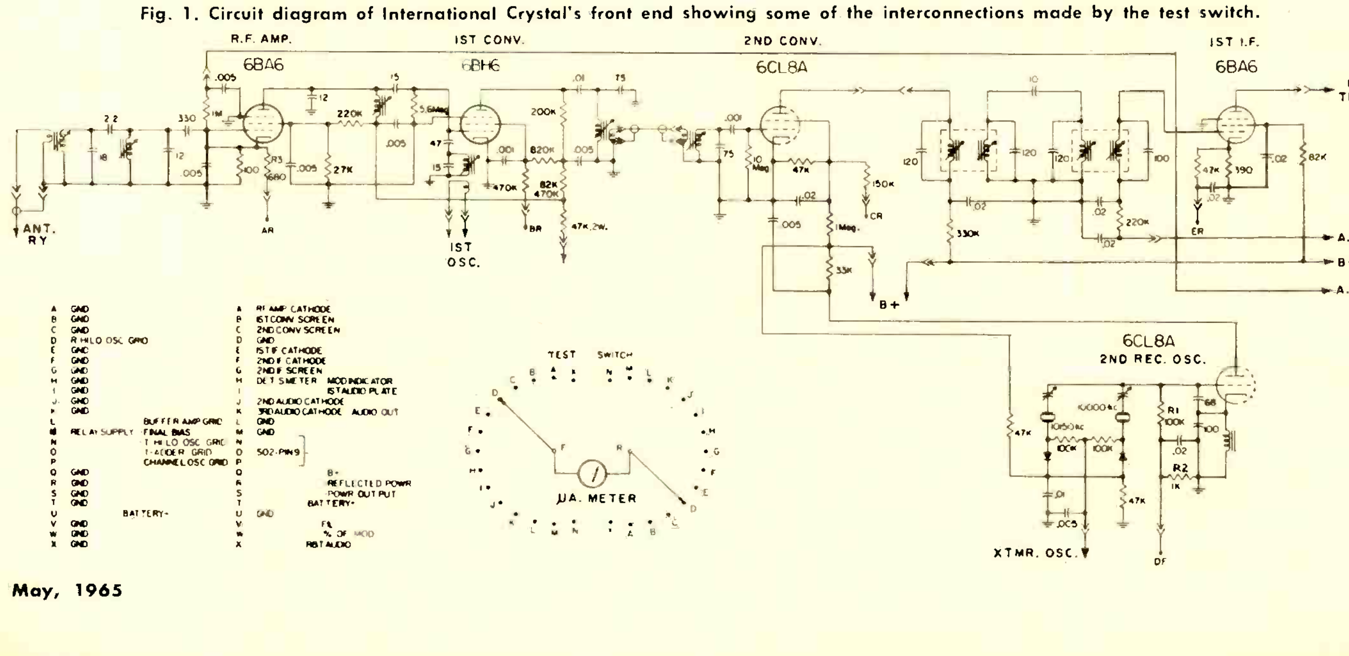
In the *Regency* "Romper" (Photo B), a circuit arrangement enables one crystal to serve the needs of both transmit and receive oscillators. It provides the operator with the added convenience of setting up for any channel quickly by inserting one crystal in a front-panel socket. (Seven other crystals are mounted internally and are switch-selected.) The one-crystal performance of the transceiver is based on a frequency-synthesis circuit.

The heart of the system is in the partial schematic of Fig. 2. It is the synthesizer formed by stages *V*1*A* and *V*1*B*. To discover what occurs during receive, note the position of the front-panel crystal, seen as "Y1" at the lower right of the diagram. The crystal is approximately 19.5 mc. (exact frequency depends on the particular channel). Tube *V*1*B* is set into oscillation. The 19.5-mc. signal is tapped from the tube cathode and coupled to the grid of the "1st Mixer." Here the 19.5-mc. signal is mixed with an incoming channel on 27 mc. The mixer produces the difference—7.5 mc.—and the correct i.f. is obtained.

Now to observe how the same crystal operates during transmit, again crystal Y1 establishes a 19.5-mc. signal in stage *V*1*B*. At this time, too, the other section of the synthesizer *V*1*A*, will oscillate and produce a signal. Crystal Y2 in its grid circuit, however, produces a signal fixed at 7.5 mc. Oscillator signals mix in the paralleled *V*1 plate circuits, and an additive mixing occurs. In this fashion, 7.5 and 19.5 produce 27 mc., the desired transmit frequency. This is applied to the transmitter buffer amplifier and subsequently to the final amplifier for transmission. Changing the transmit channel, as in the case of receive, may be achieved solely through changing crystal *Y*1.

The "Romper" receiver can be continuously tuned over the 23-channel band. In this case, the operator switches from "Xtal" (*X*) to "Tune" (*T*). This disables the *V*1*B* section of

Fig. 1. Circuit diagram of International Crystal's front end showing some of the interconnections made by the test switch.



the synthesizer circuit. The "1st Mixer" now operates as a self-excited oscillator and will produce a range of local-oscillator frequencies in the 19.5-mc. region, formerly supplied by crystal Y1. Like the crystal, it establishes the required i.f. mixture on 7.5 mc.

For copy of manufacturer's brochure, circle No. 54 on coupon (page 15).

Hy-Gain "Co-Phaser"

Non-directional antennas predominate at CB base stations since it is often impossible to predict the road location of mobile units. The directional beam, however, has gained some favor. The ability to greatly multiply signal power apparently outweighs the restriction of a uni-directional pattern and need for a mechanical rotator. Another approach to gain and directionality is the phased antenna. Instead of movable elements, the antenna remains mechanically fixed. Radiation patterns are shifted in direction by varying the phase of signals entering the active elements. Fields of radiated radio-frequency energy interact—adding and cancelling in different directions.

Before signals can be applied to the antenna they must be processed in two ways: sent through suitable matching devices and adjusted for correct relative phase. These functions are performed in the "Co-Phaser" (see Photo C), a circuit produced by *Hy-Gain* for phasing two standard vertical CB antennas. The operator may switch-select three possible radiation patterns; two cardioids to cover, say East or West; and a bi-directional pattern for simultaneously covering North and South.

The internal components of the "Co-Phaser" consists of three lengths of coaxial cable and a switching arrangement. The simplified schematic of Fig. 3A shows how the first major pattern is achieved; the bi-directional. Here, two coax lengths are switched into the line from the CB transceiver. Their function is primarily that of impedance matching; solving the problem of feeding r.f. from a 50-ohm source (the transceiver) to 50-ohm loads in parallel (the two vertical antennas). Antenna impedances in parallel would otherwise fall to 25 ohms and present a serious mismatch to the transceiver. The coax cables are each cut to a quarter-wave on 27 mc. (6 feet) and act as impedance transformers. In creating standing waves, each cable presents 100 ohms at the transceiver end. The net effect of this arrangement is a perfect match throughout.

Actual phasing of signals for the bi-directional pattern occurs between antenna elements. Note that they are physically spaced 9 feet apart or a quarter-wave in free space. (Only 6 feet are required in the coax cable quarter-wavelengths due to velocity factor. The cable slows down wave velocity.) There are now equal signals in both antennas. Since both signals have undergone identical processing, they are identical in phase the instant they radiate from the elements. Assume that both signals are positive in polarity. As they span the distance between elements, each encounters the opposite antenna. Since time elapses during this trip, a positive wave from one side encounters a signal of differing phase in the opposite antenna. This is easiest to visualize if the two elements are exactly a half-wave apart (18 feet). A positive wave consumes just enough travel time to permit the opposite element to go from positive to negative, or 180 degrees. This out-of-phase condition causes cancellation of energy along a line between the two antennas, as shown. But along a line perpendicular to the first, the original waves are traveling outward. They overlap and reinforce each other. The total effect then is a "figure-8" pattern of bi-directional characteristics.

In the "Co-Phaser" system, however, physical antenna spacing is reduced to a 9-foot quarter-wave. Cancellation is not as complete and the resulting bi-directional pattern is broadened out, as shown in Fig. 3A. Coverage of the two lobes is more extensive than if the usual half-wave spacing were used.

The "Co-Phaser's" internal circuits participate in phasing signals for the two uni-directional patterns. Shown in Fig. 3B is the circuit as switched by the operator. We see again the two coax lengths which produce the correct impedance match. Note, however, that a third coax section is introduced into one leg of the circuit. This upset in symmetry causes the transmitter signal traveling through the additional length to reduce velocity as compared with the other section. The effect is to drive the right antenna with a signal that lags the left antenna by 90 degrees. If the right antenna receives a signal from the lagging left antenna, the net effect is reinforcement; a second 90-degree lag has occurred as left signal crosses the gap to reach the right antenna. Another way of viewing it: Assume that the left antenna is plus. The right antenna is now 0 polarity since the "Co-Phaser" has delayed the signal by 90 degrees. The plus signal from the left antenna travels to the right antenna arriving 90 degrees later—just as the right antenna is going positive. The two positive signals add, propagating a strong lobe in the direction of the right antenna, as shown.

Cancellation in the opposite direction to the left, occurs at the same time. Assume that the right antenna is positive. Since it lags the left antenna by 90 degrees, the left antenna at this instant is 0 polarity. In crossing the distance between elements, the positive signal from the right takes just enough time for the left antenna to advance from 0 to negative. The net effect is a 180-degree out-of-phase condition at the left antenna. Signal cancellation, therefore, produces a null in the area shown. This pattern can be instantly reversed if the operator switches the extra length of coax in the "Co-Phaser" to the opposite leg.

Compared with the gain of a conventional co-linear antenna, the "Co-Phaser' is said to provide an additional 3.86 db in the bi-directional pattern; 4.5 db gain for each of the two uni-directional patterns. ▲

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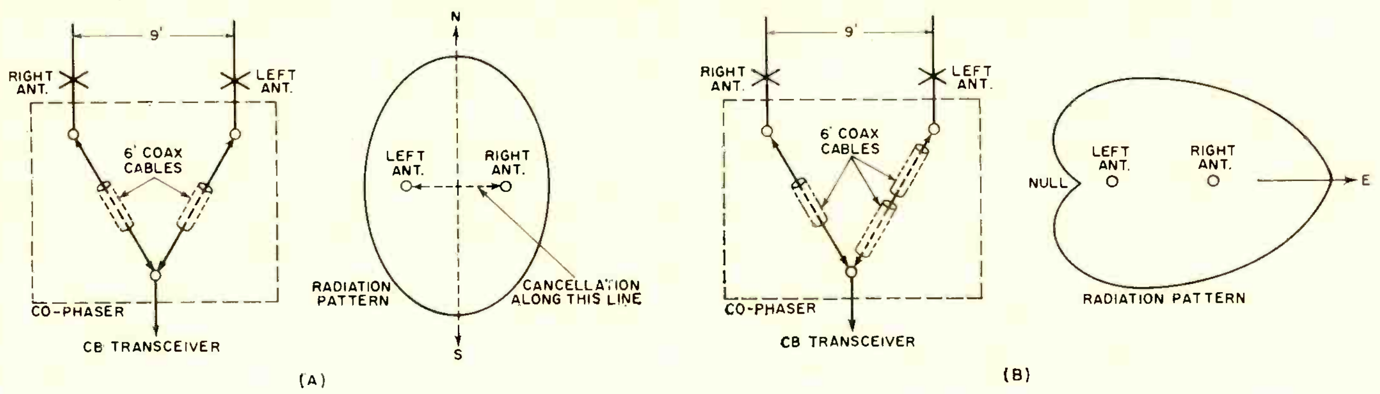
Fig. 3. Internal connections of the Hy-Gain "Co-Phaser" are changed to produce a bi-directional or two uni-directional patterns.



SPECTRUM ANALYZERS

By JIM KYLE

Operating principles and important applications of instruments that produce CRT display of input signal strength vs frequency. Uses include communications band monitoring, checkout of radar and other pulse modulated equipment, and general transmitter testing.

ONCE virtually unknown outside the most advanced electronics laboratories, spectrum analyzers are today found in many fields. Many instrumentation experts consider the spectrum analyzer to be the most versatile and the most informative tool available to the designer, production test engineer, quality-control specialist, or maintenance technician.

The device's function, as well as its basic operating principle, is deceptively simple. The spectrum analyzer is simply an instrument which presents a display (usually on the face of a cathode-ray tube) of input signal strength *versus* frequency. Analyzers are available to cover any portion of the frequency range from subsonic out to 100 gc. and beyond.

The resulting display is almost identical to the spectrum graphs shown in engineering textbooks, facilitating interpretation of the signal under test. See Fig. 1.

Early Analyzers

Although the present usage of spectrum analyzers is primarily in the area of instrumentation, including microwave checkout and telemetry analysis, the instruments are also valuable accessories in communications systems. In fact, the device was originally invented for communications use and its value for general measurement purposes went almost unnoticed for more than a decade.

The first known spectrum analyzer was built in 1932 by Dr. Marcel Wallace, a chemist and ham radio operator, who five years earlier had co-invented the tricycle landing gear for aircraft. He called this first device a "Panoramic Receiver" and its purpose was to present a visual image of the entire ham band to spot vacant frequencies and to locate answers to his calls.

Six years later, Dr. Wallace formed *Panoramic Radio Corporation* to produce Panoramic receivers and other similar instruments.

Before the Panoramic receiver won widespread acceptance, however, World War II had broken out. Thousands of such receivers, as well as "Panadaptors" for existing receivers, were used by the Allies during this conflict, both in military communications where the ability to see an off-frequency signal often meant the difference between life and death, and in monitoring of enemy transmissions.

Meanwhile, at MIT, the Radiation Laboratory was working on radar techniques and had to produce not only working radar sets but also all test equipment necessary to maintain them. It was here that the Panoramic receiver was renamed, more scientifically, the *spectrum analyzer,* and was developed into an essential item of microwave test equipment.

With the cessation of hostilities in 1945, dozens of firms the world over began producing spectrum analyzers. *Panoramic,* now a part of the *Metrics Division* of *The Singer Company* (more noted for sewing machines than for electronic instruments in older days) is still one of the leaders. Others include *Hewlett-Packard, Polarad,* and *Probescope.* These firms produce wide and varied lines of spectrum analyzers; professional catalogue directories list several dozen smaller firms making more specialized lines.

Although the basic operating principle of an r.f. spectrum

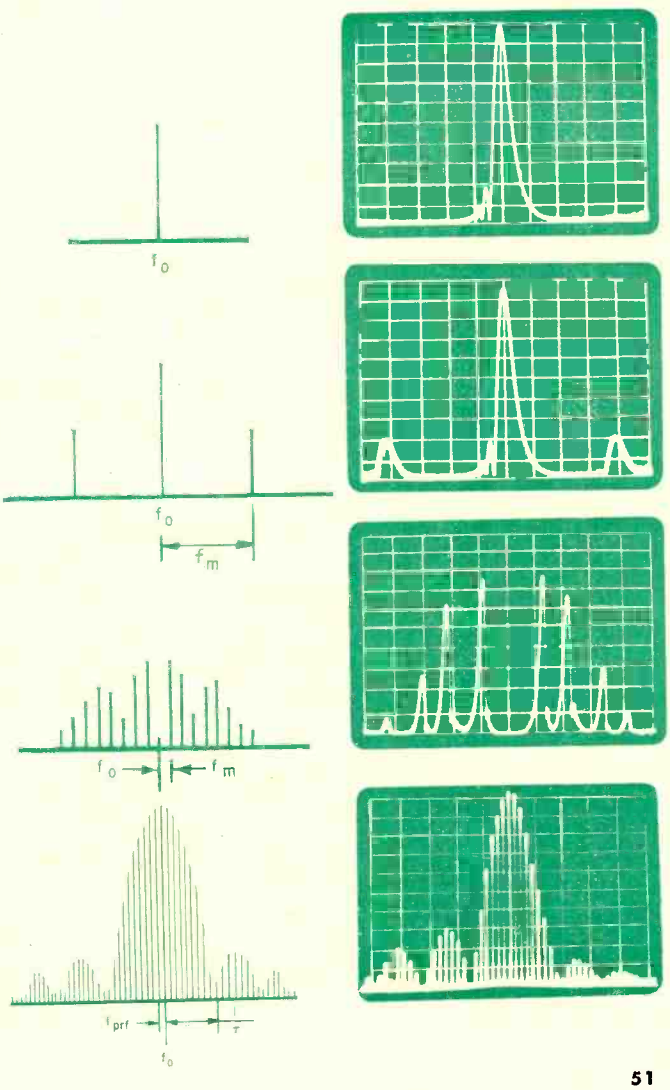
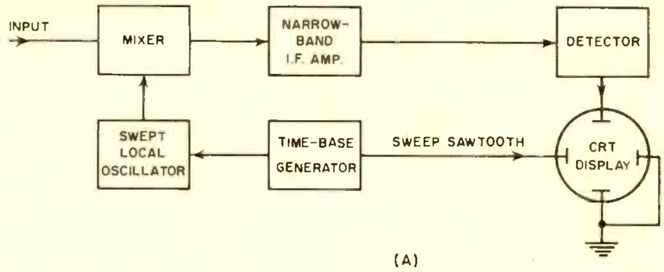
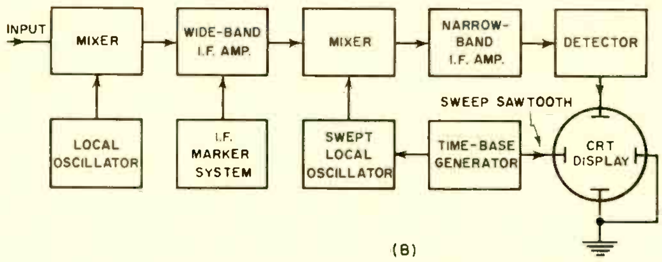


Fig. 1. Various spectra as they appear on a spectrum analyzer (right) and as shown in standard texts. The upper patterns are for an unmodulated c.w. signal; second is an AM signal; third is an FM signal; and fourth is a pulsed signal. Symbols on the drawings are f_0 for carrier frequency, f_m for modulating frequency, f_{prf} for pulse repetition rate, τ for pulse width.



(A)



(B)

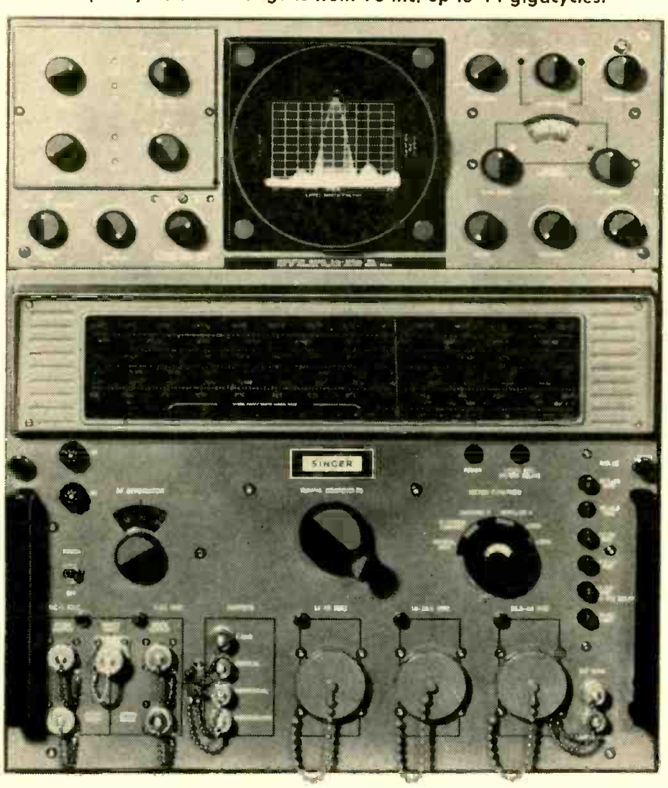
Fig. 2. (A) Block diagram of the basic circuit arrangement. (B) Circuit arrangement that is used in swept-i.f. system.

analyzer is simple, the devices themselves are usually quite elaborate and cost can run into the thousands of dollars. This comes about because of two major factors; most stock instruments for r.f. use cover frequency ranges extending well into the microwave region, and microwave equipment is usually costly. In addition, despite the simplicity of the basic approach, the practical application of this approach requires a certain minimum complexity—and most instruments have added features for maximum versatility and flexibility.

Basic Principles

In essence, the spectrum analyzer is nothing more than a high-quality radio receiver, with two important differences. One is that the receiver is sweep-tuned, covering a band of selected widths many times every second; the other is that

Pulse-spectrum display is visible on screen of "Panoramic" Model SPA-4a from Singer Metrics. This instrument is widely used in industry, and features high sensitivity and selectivity, together with push-button selection of the operating frequency band. Its range is from 10 mc. up to 44 gigacycles.



output, instead of going to a loudspeaker or headphones, is applied to a cathode-ray tube to produce a visual display.

Fig. 2A is a block diagram of the simple basic circuit, stripped of all frills. Note that a single sweep-frequency time-base generator controls both the receiver local oscillator frequency and the CRT horizontal deflection. Because of this, the CRT horizontal trace can be calibrated directly in terms of frequency.

The detected output from the i.f. amplifier is applied to the vertical deflection plates. In the absence of signals within the sweep band, no vertical deflection occurs and the display is a single straight horizontal line. With one signal present in the band, an output will be obtained from the detector every time the receiver sweeps across that signal, and will cause a vertical deflection of the trace. Thus the picture on the CRT face consists of a vertical pip for every signal present in the sweep band. Strength of the signal determines height of the pip.

Sweep bandwidth is controlled by varying the amount of sweep voltage applied to the receiver oscillator (sweep voltage to the CRT is fixed to provide a constant-width display). The greater the sweep voltage applied, the wider the band of frequencies swept. Most spectrum analyzers allow sweep widths up to several megacycles and down to 15 kc. (some can sweep up to 2000 mc.). Some instruments allow sweep width (more often known as "dispersion") to be reduced to zero, which converts the analyzer into a visual-readout r.f. v.t.v.m.

For microwave and laboratory use, some modifications of this basic system are necessary. The i.f. amplifier must have sharp selectivity since the spectrum analyzer cannot separate two signals which are in the i.f. passband simultaneously. This, in turn, usually requires double-conversion techniques since a low i.f. is needed for selectivity yet a high i.f. is necessary to reduce image problems.

In today's commercial usage, two systems are commonly employed for obtaining a spectrum analysis. They are usually described in terms of the stage at which the sweeping occurs, and are known as swept-i.f. and swept-front-end systems.

Swept I.F. and Front-End Units

Fig. 2B is the basic diagram of a swept-i.f. system. A stable local oscillator is used to convert or "transfer" the input signal down to a lower frequency. The converter signal is then applied to a second mixer where it combines with the swept local oscillator and the difference frequency goes through the narrow-band i.f. amplifier.

The swept-front-end system block diagram is identical to the basic analyzer circuit shown in Fig. 2A. The only differences are in the types of components used. When microwave frequencies are involved, the swept local oscillator is usually a backward-wave device or a voltage-tunable magnetron.

Each of these approaches has its own set of advantages and disadvantages. The swept-front-end system provides greater dispersion (sweep-bandwidth) capability, usually up to a full octave. However, cost of components is usually high, increasing the cost of the instrument, and difficulties are encountered in making such a system stable enough for high-resolution measurements.

The swept i.f. system, on the other hand, is limited in dispersion capability to approximately 100 mc., due to the bandwidth of the first i.f. amplifier. Offsetting this limitation is the extreme resolution capability and the ease of band-switching to obtain wide coverage. Through the use of phase-locking, oscillator stability in the tens of cycles can be obtained even at input frequencies as high as the gigacycle range and with such stability that 1-kc. resolution is no problem.

Because of these advantages, most general-purpose spectrum analyzers are of the swept-i.f. variety, with the swept-front-end system being used only where very wide dispersion is required (in microwave work) and where minimum expense is necessary (as for amateur and commercial communications band monitoring applications).

Important Characteristics

Like most equipment, the spectrum analyzer has a specialized vocabulary to describe its characteristics. "Dispersion" and "resolution" have already been encountered. More specific definitions of these terms and of terms not yet mentioned will be helpful to anyone having occasion to deal with analyzers.

"Dispersion" is usually defined as that section of the frequency spectrum viewable on the display for one full sweep.

"Resolution" is defined as the bandwidth of the sharp i.f. amplifier at its −3 db points. However, this is a definition *only*, and actual usable resolution may vary widely from this figure. An important feature of modern spectrum analyzers is the ability to vary the resolution, and thus obtain optimum response from the instrument for various applications.

"Sensitivity" of spectrum analyzers, like sensitivity of any other receivers, has a number of definitions. Three are in common use. There are "minimum discernible signal (MDS)," "signal plus noise equal to twice noise," and "input voltage for 'full-scale' deflection." MDS ratings tend to give sensitivity figures from 5 to 8 db greater than do "$S + N = 2N$" ratings; both are usually expressed in dbm (decibels below one milliwatt). In any event, actual usable sensitivity varies with resolution, sweep speed, and dispersion, and so will vary somewhat from application to application even with the same instrument.

"Dynamic range" is an important term in the spectrum analyzer vocabulary. It may be specified in either of two ways. One is the "display dynamic range" which gives the maximum input amplitude visible on the screen. This is usually variable, and is typically 10 db power, 20 db linear, and 36 to 40 db logarithmic. The other specification is the actual signal overload point, and is the ratio between minimum discernible signal and the overload point itself.

Both ratings are important. The first indicates the range which may be viewed on the screen, while the second indicates the maximum signal which may be applied to the instrument. Like all receivers, the spectrum anaylzer will, when overloaded, generate spurious signals within itself, which cannot be distinguished on the screen from true input signals. Thus the instrument must always be operated below the overload point for indications to be valid.

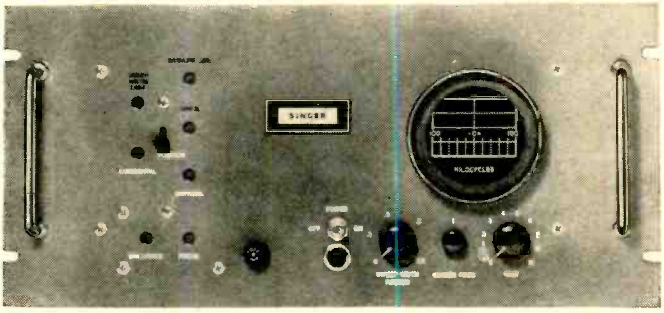
Applications of the spectrum analyzer are limited only by the imagination and ingenuity of the user, since its display is of such a generalized nature. Here are a few of the more common applications of spectrum analyzers.

Communications-Band Monitoring

This was the original purpose of the instrument, and a whole class of simplified spectrum analyzers is still in production for this purpose alone. Basically, the analyzer is connected to a standard communications receiver in such a manner as to view the spectrum existing at the output of the mixer stage, and analyzer center frequency is adjusted so that the receiver i.f. is in the center of the screen.

Under these conditions, the signal audible through the receiver will appear as a pip at the center of the screen and all other signals within the dispersion range chosen on either side will appear as pips to the right and left.

Ham operators use the instrument in this manner to locate vacant spots in the band, to spot replies to their "CQ" calls, and to monitor v.h.f. bands to detect band openings. Commercial operators use them to spot off-channel calls, which would not be heard through the normal receiver but which appear instantly on the analyzer screen. CB operators can use them in the same manner during emergency operating conditions, to detect calls on channels other than the one to which the net-control station is listening.



Typical adapter for attachment to communications receiver for professional use is Singer Metrics Model SA-3. This unit samples output of first mixer in receiver and displays all signals present within 200-kc. region centered at received frequency.

Fig. 3A shows the typical hookup. Simplified units, designed for this purpose alone and having all the more elaborate features omitted, are available at prices up to $300. There is even a kit available on the market (the *Heathkit* "Ham-Scan") intended mainly for amateur use at about $80.

Pulse-Modulated Transmitters

The spectrum analyzer may be used virtually alone to check out pulse-modulated transmitters, because a spectrum analysis of the output signal will reveal errors in pulse duration, pulse repetition frequency, power output, excessive frequency modulation during the pulse, and unwanted amplitude modulation.

This application, like many others, depends upon the almost exact correspondence between the analyzer display and the textbook graphs. The analyzer is tuned to the desired frequency, the pulse spectrum display centered, and the dispersion width and i.f. gain controls are adjusted until the screen is filled by the main lobe and two additional lobes on each side. The sweep control is then adjusted for best definition of the pulse envelope.

Fig. 4A shows the display from a perfect 1-microsecond rectangular pulse, while Fig. 4B shows the display from a similar triangular pulse. If frequency modulation is present, the lobe nulls will fail to fall to zero, as shown in Fig. 4C, while combined frequency and amplitude modulation during the pulse will produce a non-symmetrical and distorted display such as Fig 4D.

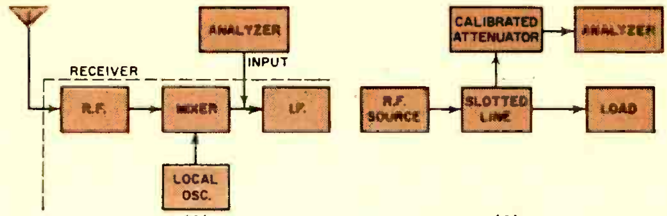
Pulse width may be measured by use of a frequency marker (usually built into the analyzer). Using the marker, the distance in megacycles between the first nulls on either side of the main lobe is measured. Rectangular pulse width in microseconds is equal to $2/f$, where f equals the distance in megacycles between first nulls. See Fig. 4A.

Power levels are measured by noting vertical deflection. Gain controls are adjusted to give a display of convenient heights and a c.w. signal (the power of which can be readily measured by other means) is then applied without disturbing any adjustments of the analyzer. Power of the c.w. signal is varied until the same height pip is obtained. Peak power of the two signals is then equal. By use of an accurately calibrated attenuator in the line to the pulse transmitter, a high-power pulse may be measured with only a low-power reference c.w. signal.

Radar set performance checks: Radar transmitters may be checked as just described for pulse-modulated transmitters of any sort. Receivers are checked in a similar manner.

Untuned Laboratory Receiver

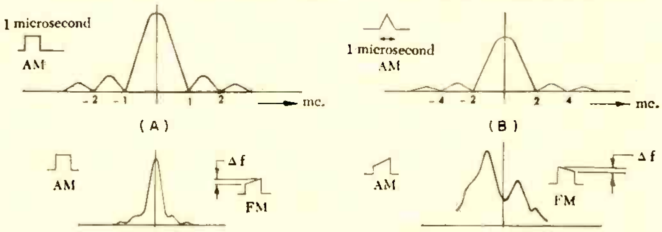
Another application of the spectrum analyzer is as a sensitive detector in bench test work. Since it is far more sensitive than the crystal diode or bolometer detector generally used in microwave measurements, the analyzer can be used to measure a far wider range of power. This makes it particularly well suited to s.w.r. measurements by the slotted-line



(A) (B)

Fig. 3. (A) A Receiver hookup. (B) The measurement of s.w.r.

Fig. 4. Pulse-spectrum envelopes for (A) perfect rectangular and (B) perfect triangular 1-μsec. pulses. If the pulse has some frequency distortion or modulation, spectrum is as shown in (C). (D) shows spectrum for pulse with both frequency distortion or modulation and amplitude distortion or modulation.



method, especially if high s.w.r. is involved. Fig. 3B shows the arrangement for this use. By adjusting the calibrated r.f. attenuator to give a constant pip height on the analyzer screen, the s.w.r. may be determined by the difference between settings of the attenuator.

An additional laboratory application of the analyzer is as a calibrating comparator. Fig. 5A shows a hookup for calibrating attenuators by comparison with a standard attenuator. Fig. 5B shows use of the analyzer to calibrate a wavemeter.

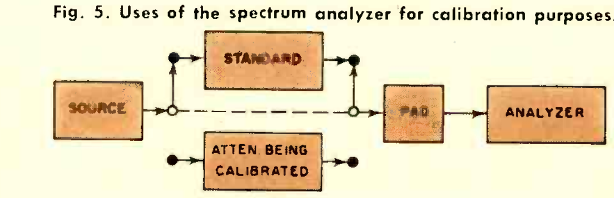
Checking for Spurious Output Modulation

The sensitivity and panoramic presentation of the spectrum analyzer make it ideal for the detection and measurement of harmonic, parasitic, and other spurious output signals from oscillators and transmitters. The hookup is simple; the transmitter or oscillator is merely connected to a dummy load, and the spectrum analyzer input coupled to the load so as to sample the r.f. output.

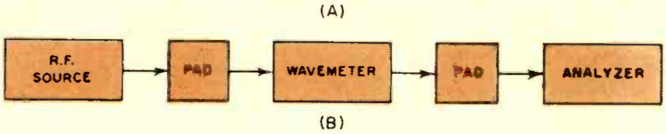
Frequencies at which the transmitter or oscillator may be working are then searched with the analyzer. When a spurious radiation is detected, its frequency is noted from the display and its amplitude (relative to the desired output) measured in db, using either the log or linear vertical presentation.

Not all signals displayed on the screen, however, will be true spurious outputs of the transmitter. Since the analyzer is basically a superheterodyne receiver and has little or no preselection due to its wide bandpass requirement, some spurious responses will be generated in the analyzer itself. No analyzer is completely free of these, but they are no handicap when their existence is known. The location of the spurious analyzer responses can easily be determined with the aid of a few key instrument specifications.

Fig. 5. Uses of the spectrum analyzer for calibration purposes.



(A)



(B)

Spurious responses of the analyzer fall into three general types. These are image responses, high-order modulation in the mixer, and i.f. break-through. They may be identified as follows.

Image response may be distinguished from a true signal by the fact that it appears on the opposite side of the analyzer's local oscillator frequency from the true signal. If the input signal frequency is varied slightly, an image pip will move the wrong way on the screen, allowing instant identification of images whenever the input frequency can be varied. If input frequency is fixed, a bit of calculation is necessary. Take the apparent frequency of the response pip, add to it twice the analyzer i.f. and also, in a separate calculation, subtract from it twice the analyzer i.f. If either of the answers coincides with the frequency of the true signal, the response on the screen is an image.

High-order modulation in the mixer is a bit more difficult to detect. This type of spurious response results from the fact that harmonics of both the local-oscillator frequency and the input-signal frequency are unavoidably generated in the mixer circuit and may combine to produce sum or difference signals at the intermediate frequency.

When the analyzer local oscillator tracks *above* the signal input frequency, spurious responses from this cause may appear at all dial settings which result from solving the term $(n/m)(f-f_i[m\pm1]/n)$, where f is the true signal frequency, f_i is the analyzer intermediate frequency, m is an integer indicating the order of the harmonic of the local oscillator frequency, and n is an integer indicating the order of the harmonic of the signal frequency.

Thus an analyzer having a high-side local oscillator, an i.f. of 160 mc., and viewing a true signal of 3000 mc., may have spurious responses from this cause at apparent frequencies of 786.6 and 893.3 mc. due to the third harmonic of the local oscillator and the signal-frequency fundamental; at 1260 and 1420 mc. from the second local-oscillator harmonic and the signal fundamental; at 1786.6 and 1893.3 mc. from the third local-oscillator harmonic and the second harmonic of the signal; at 2760 mc. from the second harmonics of both local oscillator and signal; at 2786.6 and 2893.3 mc. from the third harmonics of both oscillator and signal; at 2920 mc. from the second harmonics of both again; and at 4260 and 4420 mc. from the second harmonic of the local oscillator and the third harmonic of the signal.

Intensity of this type of spurious response falls off rapidly as input signal level decreases, and a first check to determine if such a response is present is simply to decrease analyzer gain (or preferably decrease the input signal). In addition, this type of spurious response is usually much weaker than true input signals. Many of those listed, although mathematically possible, may well be invisible on the display.

Should the analyzer local oscillator be below signal-input frequency, the term remains the same except that the minus signal before f_i changes to a plus.

The third type of spurious analyzer response, i.f. breakthrough, is easy to distinguish. It is caused by a strong signal at the analyzer intermediate frequency getting through and results in a stationary display on the screen which does not move as the analyzer is tuned across a band.

Spurious transmitter outputs such as harmonics and c.w. parasitics will show up on the screen as c.w. signals. "Squegging" and intermittent parasitics are, in essence, pulse-modulated signals, and will present the typical pulse-modulated display rather than a c.w. pip. Incidental frequency modulation will appear as a pip moving back and forth if the analyzer's resolution is set for a wide enough bandpass to accept all the FM sidebands. Otherwise, it will present the typical FM spectrum. AM will appear as a pip of varying height if resolution is broad enough to accept all the sidebands, and as a typical AM display otherwise.

The spectrum analyzer makes possible an instantaneous

Some plain talk from Kodak about tape:

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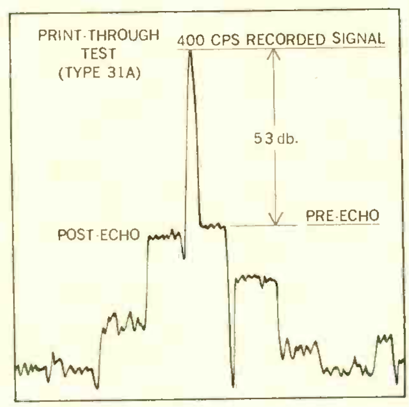
Put a magnet near a piece of iron and the iron will in turn become magnetized. That's print-through. With sound recording tape, it's simply the transfer of magnetism radiating from the recorded signal to adjacent layers on the wound roll. Print-through shows up on playback as a series of pre- and post-echoes.

All agreed. Print-through is a problem. There are some steps you can take to minimize it. You can control the environment in which you keep your tapes, for example. Store them at moderate temperatures and at no more than 50% relative humidity. Also store them "tails out" and periodically take them out for "exercising" by winding and rewinding them. What fun! If worse comes to worse, you can even interleave the layers with a non-magnetic material such as paper. Any volunteers? A better way, however, is to start with a tape that doesn't print much to begin with . . . which leads to low output problems *if* you don't make the oxide coating substantially more efficient.

And this is Kodak's solution. It's not simple, but it works, and it works well! It starts with the selection of the iron oxide. In order to achieve low print-through, the oxide needles must have the proper crystalline structure. Kodak's oxide needles have that structure . . . offering the highest potential of any oxide currently available. But oxide alone doesn't make a low-print tape.

Milling the oxide ingredients, for example, is very critical. If you mill for too long a time, the needles will be broken up and print-through will be drastically increased. Too short, and the dispersion will be lumpy. But other factors in the milling process are equally important. Like the speed at which the ball mill turns. It can't be rotated too fast, otherwise the needles will be broken up, and broken needles, you know, exhibit horrible print-through behavior. If you rotate the mill too slowly, the oxide and other ingredients will not be blended uniformly. Other factors such as temperature and the composition and viscosity of the ingredients must also be critically controlled. One more thing. You've got to make sure all the needles end up the same size (.1 x .8 microns) if print-through is to be kept down.



A very important contributor to low print-through is the binder that holds the oxide particles in suspension. The *chemical composition* of a binder contributes nothing magnetically to the print-through ratio. What a binder *should* do is completely coat each individual oxide needle, thus preventing the particles from making electrical contact. And that is just what our "R-type" binder does. The final step is to take this superb brew and coat it on the base. The coating mustn't be too thick, for print-through increases . . . or too thin, for then output suffers. For best results, extreme uniformity is the word. Here's where our film-making experience really pays off.

Print-through tests are a million laughs. We record a series of tone bursts . . . saturation, of course. We then cook the tape for 4 hours at 65°C. and then measure the amplitude of the loudest pre- or post-echo. The spread between the basic signal and the print-through is called the signal-to-print-through ratio. The higher the number, the better the results. Most of the general-purpose tapes you'll find have a ratio of 46-50 db. Low-print tapes average about 52 db. You can see from the graph that our general-purpose tape tests out at 53 db., so it functions as both a general-purpose tape and a low-print tape —and at no extra cost. High-output tapes with their thicker coatings have pretty awful print-through ratios—generally below 46 db. Kodak's high-output tape (Type 34A) has something special here, too. A ratio of 49 db—equal to most general-purpose tapes.

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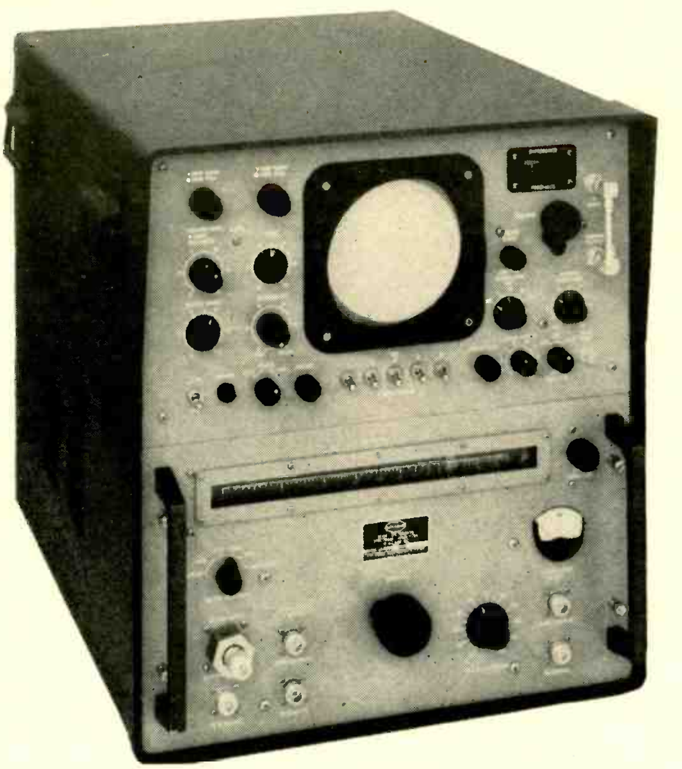


This extended-range microwave spectrum analyzer is Polarad's Model SA-84WA. It covers the region from 10 mc. to just over 63 gigacycles in 10 bands with a single tuning unit. Variable frequency marker is built in, as is 0.01 % crystal marker.

check of transmitter modulation, regardless of the type of modulation technique employed or the nature of the modulating signal.

The basic technique is similar to that described for the previous application in that the transmitter's modulated output is sampled and applied to the analyzer. For a rapid check of over-all modulation quality, white noise covering the modulation-frequency range of specific interest is applied to the modulator.

Settings of the analyzer will be determined by the type of modulation being tested, and the accuracy of the results desired. With sharpest usable resolution and white-noise modulation, the analyzer will display a plot of modulation capability *versus* sideband frequency for AM, FM, video, and SSB.

Fig. 6A shows a trace resulting from such a test on an SSB transmitter, without carrier suppression. Approximately 30 db suppression of the undesired sideband is evident, using the log scale of the screen for the measurement.

Similar testing of an AM transmitter would result in both sidebands being displayed but if modulation frequency range were still limited to the 300 cps–3 kc. region as in the SSB unit, the display would be otherwise unchanged.

For an FM unit, the display would appear similar but the sidebands would extend to the frequencies corresponding to maximum deviation, rather than to those corresponding to the highest modulating frequencies present. Video would again be similar, but with wider range of frequencies.

More accurate measurements may be made by substituting a single pure sine wave for the white-noise modulation input and measuring the resulting output spectrum with the analyzer. Fig. 6B shows such a spectrum for an SSB transmitter with a 1000-cps tone input. The small pip at the center is the carrier, down some 37 db from the sideband frequency at the right. The unwanted sideband is below the dynamic range of the analyzer and so does not appear. No measurable distortion is present in this view. Fig. 6C shows the same set of test conditions, except that the 1000-cps tone was increased until the SSB modulator was overdriven. The second harmonic sideband is only 25 db below the desired sideband while carrier suppression has been degraded to only 31 db and a third-harmonic sideband some 32 db down also appears.

Fig. 6D shows the spectrum of NBFM with a modulation index of 0.4, while Fig. 6E is the same spectrum except that modulation index has been increased to 8.65 (third carrier null). Both are with a single tone input. Combined AM and FM with a single tone input are shown in Fig. 6F. Modulation deviation for the FM was set to produce a null of the lower sideband; in general, the display of combined AM and FM will result in non-symmetrical sidebands, but existence of a complete null will be purely by accident.

In general, making the most accurate measurements with this technique involves measuring the spectrum components then applying the classical methods of sideband analysis in reverse to establish the actual operating conditions of the modulator. Such measurements are used by a good many broadcast stations to satisfy FCC requirements.

The applications listed here are but a few of the many to which the spectrum analyzer is suited. As many such applications exist at audio frequencies (notably telemetry analysis and ultrasonic investigations) as at r.f. Manufacturers of these instruments have a number of application notes and reference manuals available to professional analyzer users. Copies may be obtained by writing on company letterhead to the following firms:

The Singer Company, Metrics Division, 915 Pembroke Street, Bridgeport, Conn. 06608.

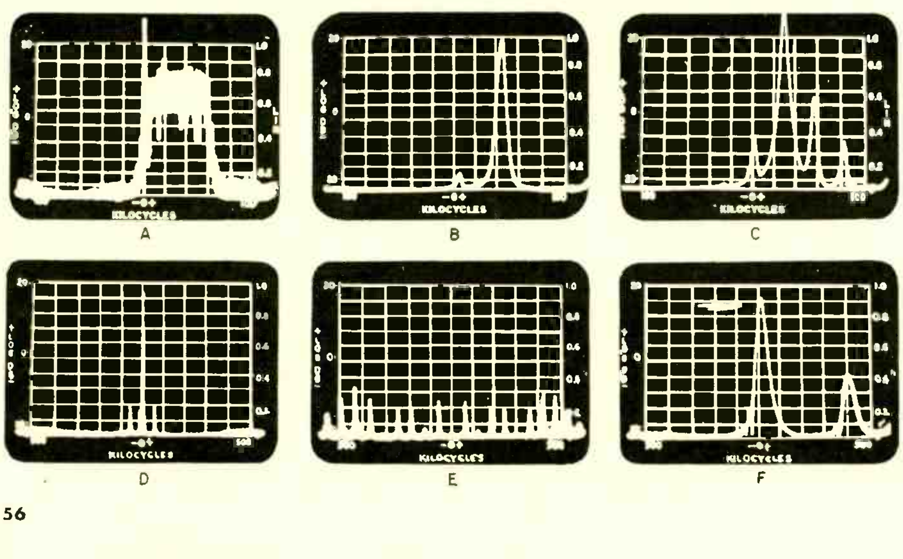
Polarad Electronic Instruments, Division of *Polarad Electronics Corporation*, 34-02 Queens Blvd., Long Island City, N.Y. 11101.

Probescope Co., Inc., 211 Robbins Lane, Syosset, Long Island, New York 11791.

Hewlett-Packard Co., 1505 Page Mill Road, Palo Alto, California.

The author would like to express his gratitude to Mr. Edward F. Feldman of *Singer Metrics* and to Mr. Hal Reinish of *Polarad*, who furnished much detail concerning specific applications and who provided source material for most of the illustrations accompanying this article. ▲

Fig. 6. (A) Spectrum of noise-modulated SSB transmitter, without carrier suppression. (B) Single-tone (1000 cps) modulated SSB transmitter with good carrier suppression. (C) Degraded performance of transmitter whose spectrum is shown at (B) when modulating tone overdrives the SSB modulator. (D) Spectrum of narrow-band FM transmitter with modulation index of 0.4. (E) Wide-band FM transmitter with modulation index of 8.65. (F) A combination of AM and FM with a single-tone input is illustrated here.



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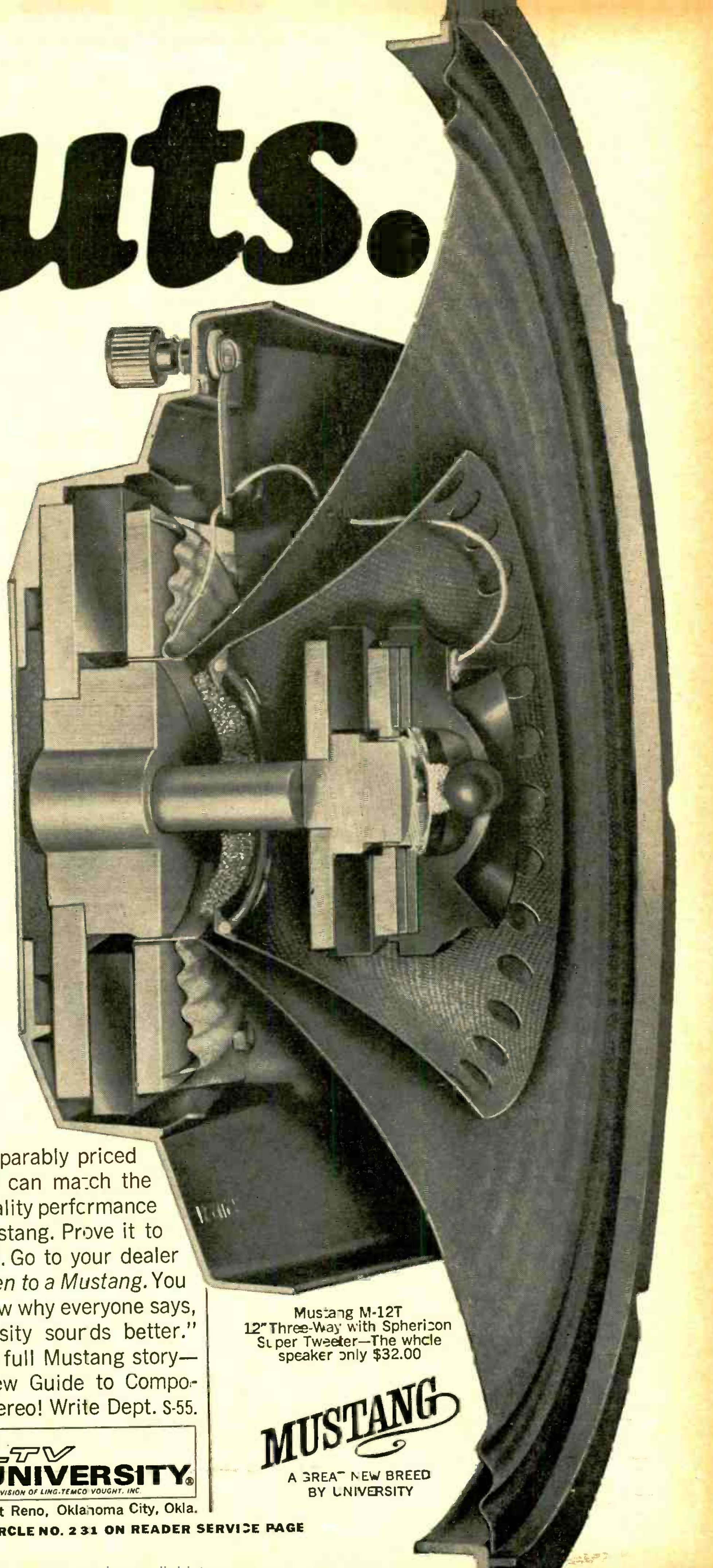

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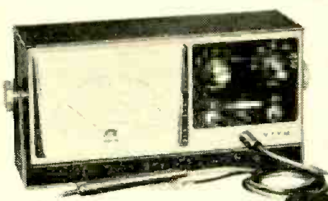
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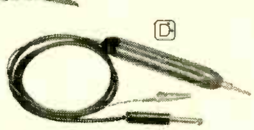
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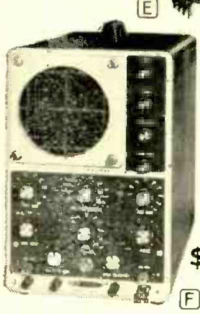
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H

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[N] Kit **$47.50**
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[L] **"Solid-State" Regulated DC Power Supply, Kit IP-20...$72.95, Assembled IPW-20...$114.95** 50 MA, 150 MA, 500 MA & 1.5 A current ranges; 5, 15, 50 v. DC voltage ranges; filtered output for less than 150 uv ripple; adjustable current limiter, 30 to 100% on each range. 16 lbs.

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JOHN FRYE

Design of service facilities for transistor devices only, and description of new automatic weather station.

TRANSISTOR BENCH & CATV WEATHER STATION

"MEN simply can't see dirt!" Matilda, office girl at Mac's Service Shop, believed this devoutly; so every so often she invaded the service department and did a thorough job of whisking away dust, shining instrument faces, digging bits of wire and blobs of solder out of corners of the service bench, and performing a host of other housekeeping chores described loosely as "tidying up."

That's what she was doing this sun-drenched May morning. Mac, temporarily pre-empted from his favorite spot at the service bench, was installing a light over a new smaller bench in one corner while Matilda, humming gaily, worked with her dustcloth, window cleaner, and furniture polish.

"Wonder why Barney, your number one assistant, is late this morning," she said.

"Probably out late last night," Mac guessed. "After all, he's young, and it's spring."

"That figures. By the way, what are you doing? Are you building *another* bench for me to keep clean?"

"I'm fixing up a bench exclusively for servicing transistorized equipment," Mac answered. "This kind of service has quickly outgrown its original sideline status. With more and more transistorized radios, tape recorders, and amplifiers coming in every day, the tail is beginning to wag the dog."

"Is there so much difference in working on tube or transistor equipment?"

"Enough that the two kinds of service don't mix well on the same bench. One big difference is size. It's mighty easy to roll a heavy TV chassis over on top of an unnoticed transistorized pocket radio lying on the bench. Transistorized chassis and components are so much smaller that seeing what you need to see is a big problem. That's why I'm installing this combination circular fluorescent light and magnifying lens mounted on a flexible arm to the side of the bench so that the 5" lens with a 13" focal length can be swung into position over a chassis lying on the bench. This will be backed up with our jeweler's loupe and magnifying glasses for still greater magnification when it's needed."

"What's that other little lamp?"

"That's a miniature high-intensity lamp that provides a spot of brilliant white light for still better viewing. It will also be very handy for looking *through* printed circuit boards. With the light shining on the far side of a translucent circuit board, it's easy to see just what lead connects to what component terminal. Sometimes, with a little gentle board flexing, this method will even reveal a tiny crack in a printed circuit lead."

"That's a pretty imposing array of instruments at the back of the bench. Are they all designed especially for transistor service?"

"Not all. The signal generator and signal tracer are conventional. However, the v.o.m., transistor tester, and bench power supply are different. Transistors use much lower voltages than tubes, and some of these voltages are quite critical. In many cases a difference of only .1 volt on an emitter can point toward a source of trouble. That's why the v.o.m. selected has a lowest full-scale range of only .3 volt at 200,000 ohms per volt.

"The adjustable power supply provides 0-30 d.c. volts at currents up to 300 ma. with a maximum of .005% ripple. A dual-range voltmeter permits setting the output voltage exactly, and I have added this dual-range milliammeter bypassed with a normally closed push-button switch in one lead so that I may know precisely how much current is being drawn by the device connected to the power supply."

"Why the push-button switch?"

"Most transistor sets have a large electrolytic capacitor that is connected directly across the battery when the set is turned on. The inrush of current to this capacitor might damage the milliammeter if it were not protected against this short-duration current surge. Actually, this power supply is a valuable service instrument. Comparing the current drawn by a transistor radio with its rated current at the rated voltage is the first step in diagnosing trouble and should be a routine test in all cases.

"This test is especially dictated when short battery life is the complaint. Measuring the current will often reveal that the capacitor I mentioned is leaky, causing wasted excess current. Dropping the voltage will sometimes expose a defect, causing oscillation to stop when the supply voltage is reduced only slightly from the fresh-battery value. As a rule of thumb, I expect any transistor radio to perform with only slightly reduced volume and sensitivity when the supply voltage is dropped 20% from the fresh-battery figure. If it doesn't, batteries will have to be replaced with unnecessary and expensive frequency."

"Is that an expensive transistor tester?"

"It's not in the laboratory class. All I expect it to do is reveal clear-cut defects in transistors that prevent their performing satisfactorily in ordinary receiver, recorder, or amplifier circuits. It will not reveal all parameters of all transistors, and it's not infallible in marginal cases, just as our tube tester is not infallible under similar conditions. But we can still fall back on direct substitution of transistors we know to be good. One use for the tester will be to permit us to match transistors for use in push-pull stages."

"I see the bench even has its own tools."

"Right. Most of the tools are simply smaller than those on the big bench. That goes for the diagonal cutters, the needle-nose pliers, the little end wrenches, the jeweler's screwdrivers, the soldering aids, and the pencil-type solder guns. Notice we have special tips for the latter that permit unsoldering the several leads of various different components simultaneously. And there is also this: a solder pencil with a sucking attachment that lets melted solder be drawn up into a little reservoir when this squeezed bulb is released. It frees a lead from solder *before* the lead is removed from a hole in the circuit board and keeps melted solder from running all over the board. These hemostats are used as clip-on heat sinks in soldering transistor or diode leads.

"Finally, in addition to our stock of replacement transistors and batteries, we have in these plastic boxes a good stock of low-voltage capacitors, ¼-watt resistors, subminiature i.f. transformers, and other components used in transistor circuitry. It's essential they be kept separate from similar components used in tube circuits. Those are transistor-radio service manuals at the top. Actually—"

He was interrupted by the slamming of the front screen.

"Good morning," Mac greeted Barney sarcastically as the youth came bustling in. "I trust you slept well."

"Now don't go making waves about my being a little late," Barney protested. "I didn't sleep in. Just as I was starting to work, Paul, chief technician for the local CATV system, came by and asked if I wouldn't like to go with him to the tower site and see the new automatic weather station they put into service on channel 10 back in February. I've been itching to see how this works—several of our customers have asked me about it—so I took him up."

"Well, how *does* it work?"

"Imagine a semicircular table about six feet wide along the straight side. A panel about a foot and a half high runs all along the curving edge. At each end of this panel is a small display screen, and at equal intervals between the two screens are mounted seven round instruments or meter faces.

"Right in the center of the straight edge of the table is mounted a TV camera housed in a round case about a foot long and five inches in diameter. This camera continually scans back and forth across the semicircular panel with a movement like that of an oscillating fan. It takes about forty-five seconds to scan from one end of the panel to the other. Baby spotlights on either side of the camera move with it and illuminate the point where it's 'looking.'

"The display screen on the left is for announcement cards or other hand-prepared material. Next to it is a clock, then a relative-humidity indicator, then a temperature indicator, a barometer, a wind-velocity dial, a wind-direction indicator, a rainfall gauge, and finally the ground-glass screen of a commercial rear-projector. This projector handles up to 80 slides and changes them automatically so that a different one is shown each time the camera points toward it. A switch permits the camera oscillation to be stopped while the camera is pointing at either display screen. If desired, the display card on the left can be removed so the camera will show the head and shoulders of an announcer sitting behind the screen.

"The output of the TV camera is fed into a *Jerrold* 'TM Modulator' that's actually a miniature TV transmitter. A microphone can be connected into this unit for sound modulation. The channel-10 output is fed into the cable along with the other signals. Any time a cable customer wishes to know anything about the weather, all he has to do is switch to channel 10 for a few seconds. He immediately learns the local conditions, and the display card will give him the latest forecast. The slide projector may remind him of important TV shows he will not want to miss.

"The arrangement has important emergency possibilities. For example, the display card could give advance warning of a possible tornado in our community. Urgently needed special-type blood could be solicited for an emergency operation. Pictures of missing persons could be shown on the slide projector. In a city-wide emergency, public officials could reassure the people and give them detailed visual instructions in front of the TV camera."

"Okay, Matilda and I take back the disparaging thoughts we had about your tardiness," Mac said amiably. "But now if you can wrestle that dust cloth out of the hands of Miss Susan Spotless and shoo her out into her own bailiwick, you and I had better get to work on some of these sets." ▲

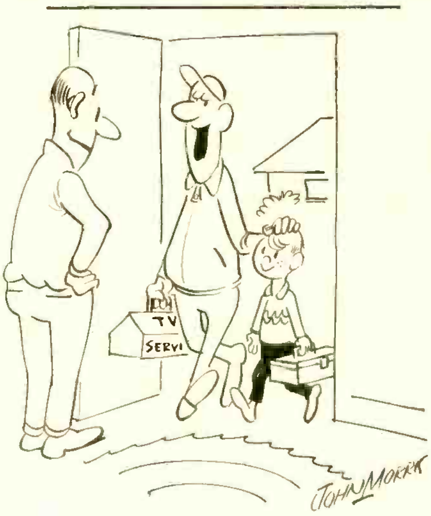
FRESNO HAMFEST

THE Fresno Amateur Radio Club is sponsoring its 23rd Annual Hamfest on Saturday, May 15th at the Towne & Country Lodge in Fresno, California.

The activities are scheduled to begin at 9:00 a.m. Saturday morning and will continue through group breakfasts on Sunday morning.

There will be swap tables, technical talks, a ladies' luncheon with entertainment, mobile judging, transmitter hunts, free time for swimming and sightseeing, etc. At 6:30 p.m. on Saturday the group will gather for a smorgasbord dinner and grand award banquet.

Tickets are $7.50 each and include the banquet. Reservations should be made with the Fresno Amateur Radio Club Inc., P.O. Box 783, Fresno, California. Pre-registration closes at midnight, Sunday May 9th. ▲



"This is my tube caddy."

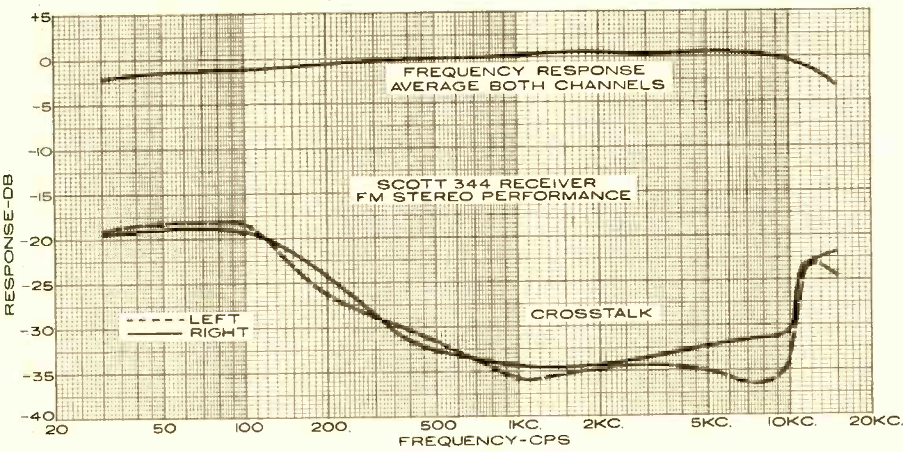
EW Lab Tested

(Continued from page 22)

ference in our area. It has no apparent effect on any normal FM stereo program.

The tuner was easy and non-critical to tune, and the stereo indicator light (unlike most such devices) would light only on a stereo broadcast and did not flicker on interstation noise. In all respects, the operation of the receiver was flawless, free from switching transients and other undesirable effects. Its sound was smooth and free from strain or irritation. It unquestionably ranks with the best stereo receivers we have used, in listening quality. The effectiveness of the nuvistor front-end in preventing cross-modulation was illustrated by the fact that we were able to inject 200,000 μv. of 100% modulated signal into the antenna terminals without causing any intermodulation spurious signals to appear.

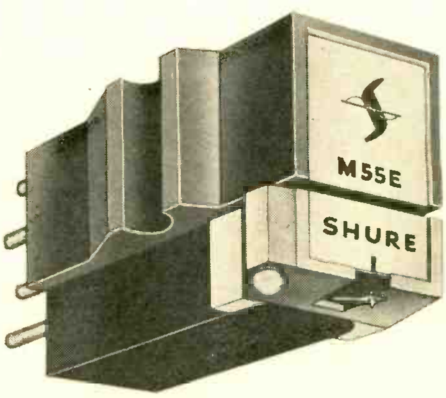
The *Scott* 344 receiver is priced at $429.95. ▲



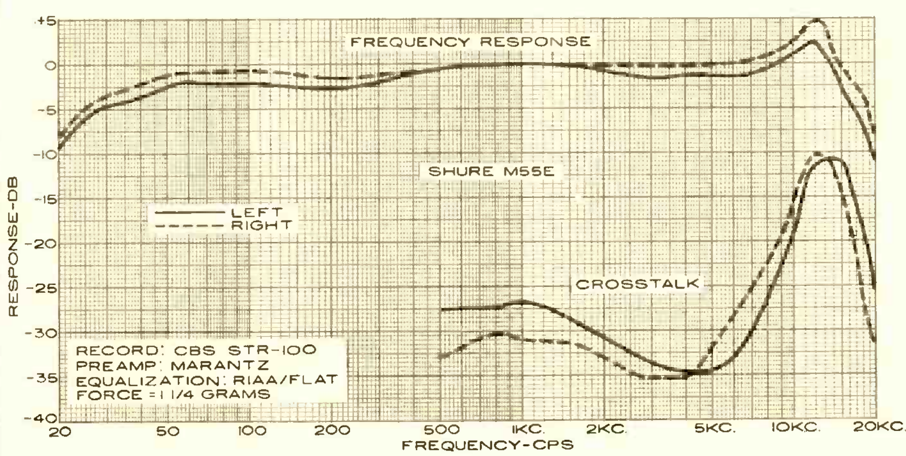
Shure M55E Stereo Phono Cartridge

For copy of manufacturer's brochure, circle No. 52 on coupon (page 15).

THE *Shure* M55E "Stereo Dynetic" phono cartridge is a moving magnet design, featuring an elliptical diamond stylus. The conventional spherical stylus imposes certain limitations in record playing. If it has a tip radius of 0.7 mil (the usual compromise dimension for playing both stereo and mono records), it has difficulty in following very-high-frequency groove modulation, especially in the inner grooves of a record. The recorded wavelength becomes comparable to the tip dimensions, giving rise to distortion. The "pinch effect" causes the stylus to rise and fall at a second harmonic rate when tracing lateral modulation. Since stereo cartridges respond to vertical stylus motion, their output contains second harmonic distortion from this source.



The stylus tip radius may be made



smaller, in some cases as small as 0.3 mil. This reduces pinch-effect distortion and improves high-frequency tracing, but the stylus tends to "rattle around" in the bottom of the groove on some records. This is especially likely to happen with older mono LP's, and causes a highly objectionable form of distortion. Styli with these small tip radii are, therefore, not recommended for playing mono records.

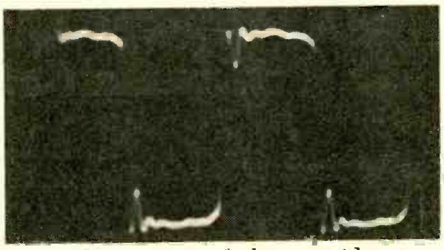
A properly designed elliptical stylus offers a workable solution to this problem. The stylus of the *Shure* M55E has a radius of 0.2 mil on the sides which contact the record groove walls. This gives superior high-frequency tracing ability and minimizes pinch-effect distortion on all types of records. Across the groove width the radius is 0.7 mil. The stylus cannot "bottom" in the groove and is capable of playing mono recordings with exceptional quality.

The cartridge is designed for an effective vertical stylus angle of 15 degrees. This is the angle between the moving magnet system of the cartridge and the record surface. Most modern records are cut with an effective 15-degree vertical angle. The correspondence between the recording and playback vertical angles reduces another source of playback distortion to a minimum. Although the distortion from this source is not serious in most cases, any reduction in distortion is obviously desirable.

The cartridge has a rated compliance of 25×10^{-6} cm./dyne in both vertical and lateral planes. It is designed to track at forces from ¾ gram to 1½ grams, depending somewhat on the characteristics of the arm in which it is installed. The removable stylus assembly has a small, soft plastic button on its bottom surface. If excessive vertical force is applied, the stylus retracts until the button rests on the record surface, preventing damage to stylus or record.

The M55E was tested in an automatic turntable arm of good quality. The tracking force was adjusted until the cartridge would play the high-velocity 32-cps bands of the *Cook* Series 60 record without groove jumping or excessive distortion. This required a 1-gram force. The 20 cm./sec., 1000-cps bands of the *Fairchild* 101 record were tracked with minimum distortion at 1¼ grams, which force was used for all other measurements. Both records contain much higher recorded velocities than are found on ordinary music recordings, and most such records can be tracked perfectly at ¾ to 1 gram.

The measured vertical stylus angle, using the *CBS* STR160 record, appeared to be about 20 degrees, probably due to the slight downward tilt of the arm when playing a single record. The vertical angle should be quite close to 15 degrees with the arm parallel to the record sur-



face. The output of the cartridge was about 7 millivolts with 3.54 cm./sec. velocity at 1000 cps. Its sensitivity to magnetically induced hum was very low.

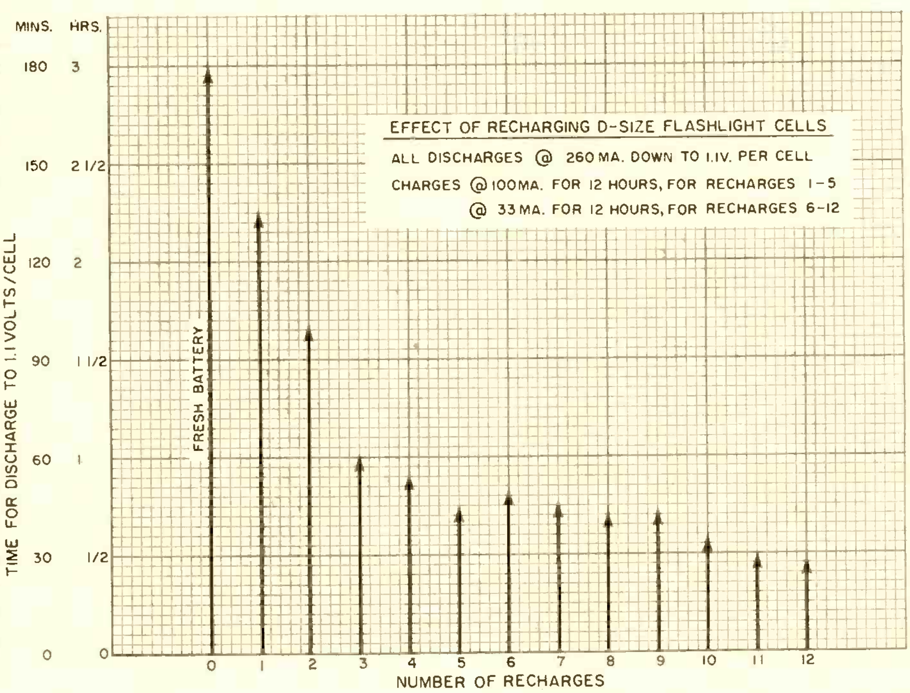
The frequency response was quite flat up to about 10,000 cps, with a moderate peak at 12,000 cps. It fell off to −10 db at 20,000 cps. The stereo channel separation was very good, averaging 30 to 35 db between 500 and 6000 cps, and about 10 to 15 db between 10,000 cps and 20,000 cps. Its response to recorded square waves at 1000 cps was good, with a few cycles of ringing at 12,000 cps superimposed on the square wave (see waveform photo).

The cartridge produced a clean, effortless, and well-defined sound, with a trace of sparkle due to the high-frequency peak. Its needle-talk was very low. The low distortion and excellent separation of this cartridge were evident when playing modern stereo records. However, the most striking audible benefit of the elliptical stylus was realized when playing some older, well-worn mono LP discs. Some of these had been damaged by playing with worn or insufficiently compliant styli, and sounded unpleasantly distorted when played with the best stereo pickups. The cartridge effectively restored these records to usefulness. In most cases it completely eliminated the harsh, rattling distortion which occurred with other pickups.

Not only is the M55E one of the best stereo cartridges on the market, but it is unquestionably a superior cartridge for playing mono LP's. The older they are, the more dramatic is the sound improvement when played with this cartridge.

The *Shure* M55E sells for $35.50. ▲

The graph below shows the results we obtained recently in recharging conventional D-size zinc-carbon flashlight cells. These cells were first discharged through a 5-ohm resistor until their voltage fell to 1.1 volts, a 30 percent reduction from their no-load voltage. Initial discharge current was 300 ma., tapering off to 220 ma. The time required for a number of fresh cells to reach this value was 3 hours. Then the cells were recharged from a d.c. source at a rate of 100 ma. for 12 hours. Using the same load as before, the time required for the voltage to fall to 1.1 volts per cell was 2¼ hours. We repeated the charge-discharge cycle for twelve times with the results shown. After the fifth cycle, the charging current was reduced to 30 ma. for 12 hours to avoid overcharging. Since an ordinary leak-proof flashlight cell has no vent for the release of gases produced during an overcharge, cells may burst open under such conditions. It would probably be a good idea to use the lower charging current starting with the second or third cycle because even here the recharge ampere-hours far exceeds the discharge ampere-hours, resulting in overcharging. A simple charging circuit may be constructed using a 10-watt lamp and a silicon diode connected in series with the batteries to be charged, the entire circuit being connected across the a.c. line. A safer circuit would use a filament transformer for isolation, diodes for rectification, and a series resistor to limit charging current to about 30 ma. One circuit we have used employs a 6.3-volt filament transformer, a full-wave bridge rectifier using four diodes, and a 100-ohm series resistor. The circuit will readily charge one to four 1½-volt dry cells.



COLOR-TV FOR EUROPE

THE U.S. Commerce Department is working with the EIA to inform the nations of the world of the advantages of the NTSC color-TV system, prior to the decision that will be made to determine the color system to be used in Europe.

The EIA has also petitioned the White House Office of Science and Technology for support in its effort to get the U.S. color system accepted as the standard in other countries. It was noted that U.S. industry has been making such effort without government aid while the British, French, and German broadcasting systems have had full support of their governments. The EIA also has been instrumental in pushing for adoption of the U.S. standard through sponsorship of an *ad hoc* group of U.S. receiver manufacturers formed to promote the NTSC system and rebut claims made in behalf of the French (SECAM) and German (PAL) color-TV systems. The group has asked EIA members to furnish NTSC information to their affiliated overseas companies.

The Commerce Department threw its weight and resources behind the NTSC system on Feb. 5, with a letter drafted by Donald S. Parris, director of the Business and Defense Service Administration's Office of Scientific and Technical Equipment and forwarded by the State Department to U.S. embassies in nearly 100 world capitals for dissemination.

"Although the system selected gives the sponsoring country some economic advantages," the letter said, "it will be to the advantage of all countries, both from a standpoint of program exchange and cost of TV receivers, if a single system can be adopted for all nations. Since administrations in Africa, Asia, and Latin America are also actively considering the adoption of a color system, and may be expected to follow Europe's example, it becomes doubly important to insure that appropriate authorities are aware of the proved advantages of the U.S. system over the proposed experimental systems of Germany and France."

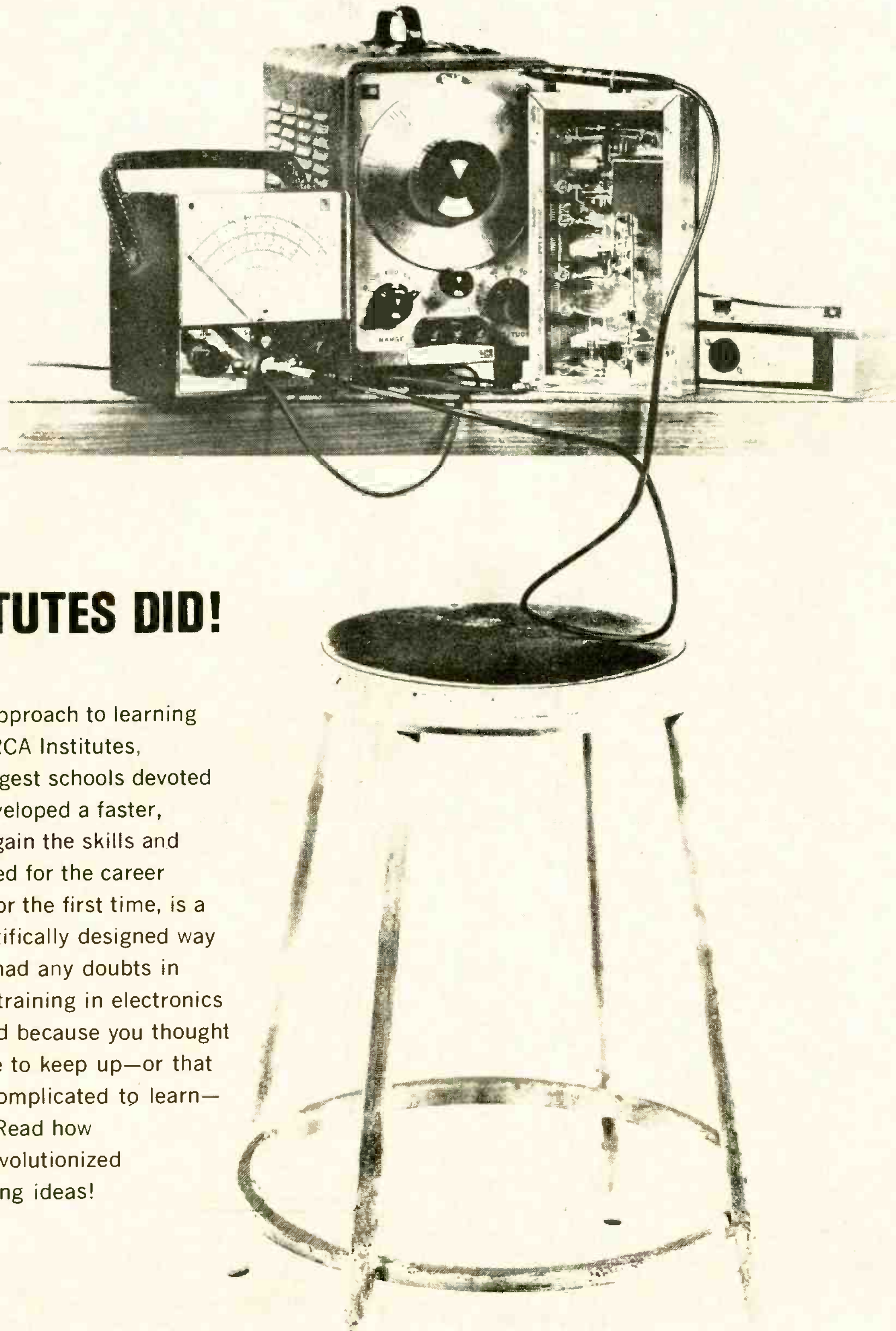
The letter also noted that Japan has already adopted the NTSC system.

West Germany reportedly has announced that the PAL system will be put into effect in that country in 1967, and the French are expected to adopt the SECAM system, regardless of the system recommended by the CCIR.

RCA has sent a mobile color-TV studio on a 10-country tour of Europe to demonstrate the NTSC system in the hope of winning converts. The studio will be in Vienna during the CCIR meeting to decide the color system. ▲

CIRCLE NO. 237 ON READER SERVICE PAGE→

SOMEONE SHOULD DEVELOP AN EASY WAY TO LEARN ELECTRONICS AT HOME



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ADDITIONAL NOTES ON SCR AUTO IGNITION SYSTEM

By WILLIAM STURGEON / Staff Engr., Physics Dept. UCLA

Modifications of previously published circuit to adapt it for use on 12-volt positive-ground cars.

THIS version of the circuit described by Brice Ward in the November, 1964 issue of this magazine, will function in a car with positive-ground battery. Insulated breaker points are *not* required, so the original points and coil may be used. The modifications of the circuit may be divided into (1) inverter modifications, and (2) trigger modifications.

The inverter is essentially the same as the original circuit, except that the center-tap of the transformer is grounded and the inverter transistors are insulated from the heat sink with mica washers. The "– 12-volt" lead is brought to the collectors. This is a straightforward change in ground point. The inverter transistors function well with mica insulators and their temperature is just warm to the touch. I used 2N174 transistors in the inverter rather than 2N-456A's originally called for because they were available. They work well but I found it necessary to lower the values of the base resistors, R3 and R4, to 18 ohms from the 39 ohms originally specified. (EDITOR'S NOTE: *The proper value for these resistors is 3.9 ohms rather than 39. Also, some readers have found that the inverter operation is improved if R1 and R2 are reduced to 150 ohms.)*

The trigger changes are a bit more complex. The thing to remember is that

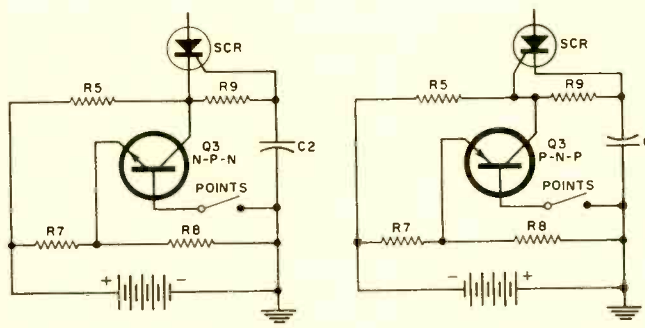
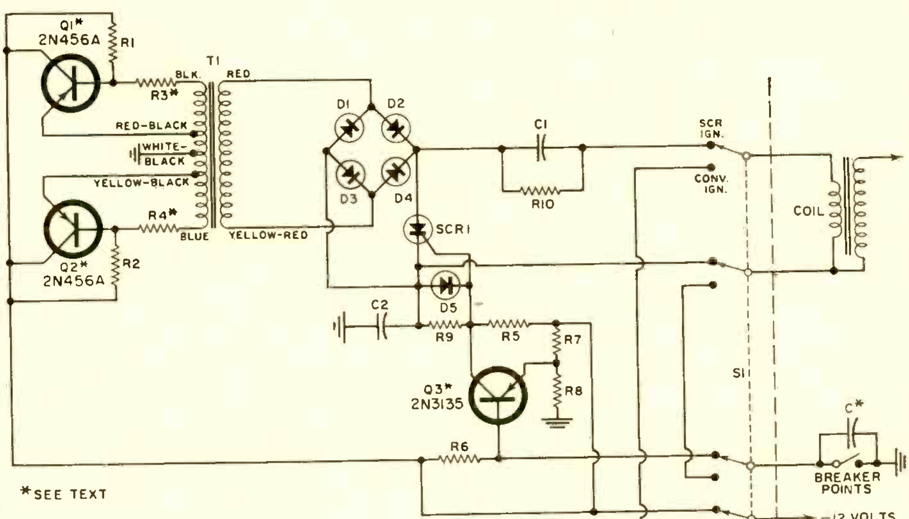


Fig. 1. Simplified schematic diagrams showing SCR triggering in (A) negative-ground and (B) positive-ground systems.

Fig. 2. Complete diagram of the revised SCR ignition system for positive-ground cars.



R1,R2—220 ohm, 1 w. res.
R3,R4—3.9 ohm, 1 w. res.
R5,R6—1000 ohm, ½ w. res.
R7—470 ohm, ½ w. res.
R8—100 ohm, ½ w. res.
R9—330 ohm, ½ w. res.
R10—330,000 ohm, ½ w. res.
C1—1 μf., 400 v. capacitor
C2—0.47 μf., 100 v. capacitor
D1,D2,D3,D4,D5—750 ma., 400 v. silicon diode (Sarkes Tarzian Type F-4)
SCR1—Sarkes Tarzian 5TCRH
T1—Special inverter transformer
S1—4-pole, d.t. toggle or rotary switch
Q1,Q2—2N456A transistor
Q3—2N3135 transistor

the trigger of the SCR requires a positive-going signal referred to the cathode. The trigger circuit is, essentially, two resistors ($R5$ and $R9$), a capacitor ($C2$), and the car battery connected in series. See the simplified schematics of Fig. 1. The voltage drop across one of the resistors, $R9$, is used as the trigger signal. Transistor $Q3$ is used as a switch to (essentially) ground the junction of $R5$ and $R9$ when the points open. The charge on $C2$ holds the other end of $R9$ at battery voltage.

With a positive-ground system the pulses appearing across $R9$ will be negative-going instead of positive-going. It is, therefore, only necessary to reverse the connections made by the trigger and cathode of the SCR across the triggering resistor, $R9$, and use a *p-n-p* transistor for $Q3$, instead of the *n-p-n* used for the negative-ground system. A 2N404 transistor works well in the circuit, but if you live where it gets hot in the summer it would be well to use a silicon transistor for $Q3$. I used a 2N3135 (silicon *p-n-p*) which works well and is reasonably priced.

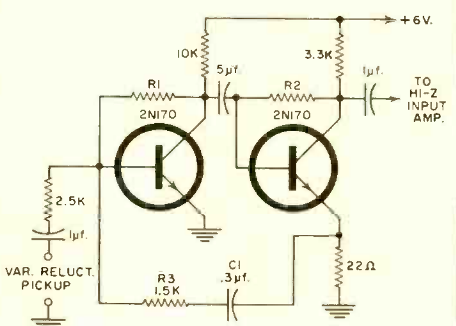
I also used a 4-pole, double-throw switch in my ignition system, as shown in the schematic of Fig. 2. This allows the car's original circuit to be put into operation if something should malfunction in the SCR system. Thus far, I have not had to use this switch but I feel more secure with it in the circuit. The capacitor across the points (C^*) need not be removed when using the SCR system, and if you wish to add the 4-pole, double-throw switch, this capacitor must be left in place in order for the original circuit to function. ▲

VARIABLE RELUCTANCE PREAMPLIFIER

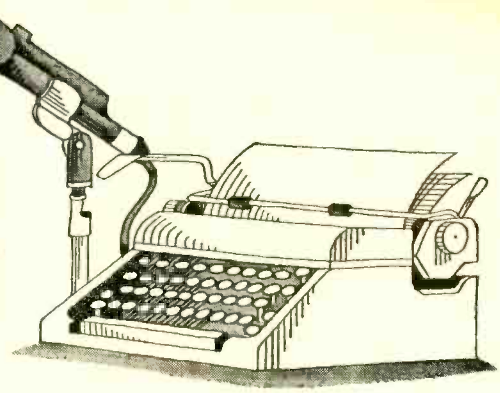
RECOMMENDED by G-E, the two-transistor variable reluctance cartridge preamplifier shown in the diagram will provide a high-impedance output to supply a power amplifier.

The value of resistors R1 and R2 should be between 100,000 and 500,000 ohms and be chosen to make the collector voltage between 2.5 and 3.5 volts.

Changing the values of C1 and R3 will vary the compensation curve. The values shown will give approximate compensation for the RIAA recording characteristics. ▲



RADIO & TV NEWS



We tend to associate digital computers with mathematical calculations at high speed, or prodigious feats of memory. However, there is another side to this sophisticated electronic tool that has not been publicized—this is the area of electronic-biology.

Dr. Blaine R. Butler of Purdue University has successfully used a digital computer to study the causes and possible cures of human stuttering. He explains that speech is a biological closed-loop automatic control system, and that stuttering is a failure of that system resulting from too high level of feedback or from overloads of pressure whose effect is to raise the feedback level. Hearing is the feedback that closes the loop in the speech system. We listen to ourselves and we correct our speech depending on what we hear. The normal person does not have to listen to himself too closely and is relaxed and doesn't stutter. In engineering terms, the loop gain is not too high and the system works without disabling instability and without blocking.

The stutterer, on the other hand, listens to himself too closely and overloads the feedback segment of the loop, producing an unstable state in which he repeats a single sound, or a blocked state in which he may be able to make only one sound once, if he can make any at all.

Dr. Butler set up a model of the human speech system on a digital computer, and by altering the various elements of the system, he found that measures that increase or decrease human stuttering produced comparable behavior within the computer. Purdue University spokesmen hope that Dr. Butler's computer model of one human fault will be followed by others to devise means of preventing or treating other human dysfunctions.

Cheater Stopper

One of the petty annoyances of telephone companies is on the way out, according to engineers of the *Zero Manufacturing Co.* It seems that inventive college students have been recording telephone signals and playing them back to the operator instead of depositing money for long-distance calls. This scientific attack is now countered by science.

This company has now come up with a pay phone that sends an electrical tone rather than bell signals down the line, and this tone also opens the line so that the caller hears nothing at all.

Besides the electronic approach, the new phone is expected to outwit the "brute-force" cheaters as it is constructed of heat-treated metals in a smooth case having no projections or holes. This will deny vandals any handholds or toolholds besides concealing the actual location of the coin-storage safe. The handset is connected to the box via a hardened flexible metal cable that will resist vandalism.

Lead-Pencil Computer

The glamorous world of electronic data processing, with its exciting complex of high-speed computers, punch-card transmitters, and other sophisticated business machines has a new look —the common lead pencil.

A *Western Union* data-card transmitter, developed for the Louisiana State Highway Dept., "reads" the pencil marks on specially printed data cards that include programmed, or variable, hand-marked data.

These data cards are printed with conductive ink. Since pencil lead is a conductor of electricity, a simple, firm stroke of an ordinary soft lead pencil on the data card marks the variable information to be transmitted and completes the electrical path from the control stylus to the electronic circuits.

Besides its use in payroll, costs, inventory control, and other functions, the new computer can be used by field personnel merely by marking the appropriate places on a card with an ordinary soft lead pencil.

Power To Spare

With the advent of semiconductor rectifiers, especially silicon units, many high-current power supplies came into being. Current ranges have gone up until many hundreds, and in some cases, many thousands of amperes are made available to the user.

Now, however, *Toshiba* (Japan) has come out with a silicon rectifier system for use by a Japanese chemical firm that can deliver 70,000 amperes at 120-volts d.c. from a 120-v.a.c. power source. ▲

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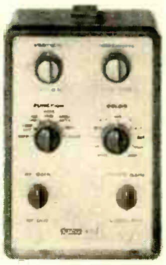

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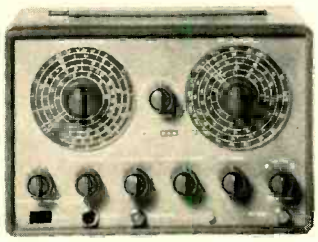

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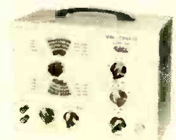

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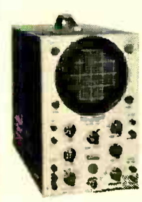

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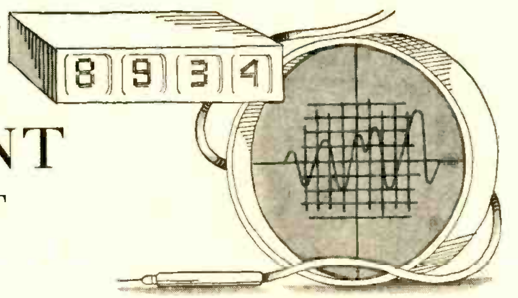
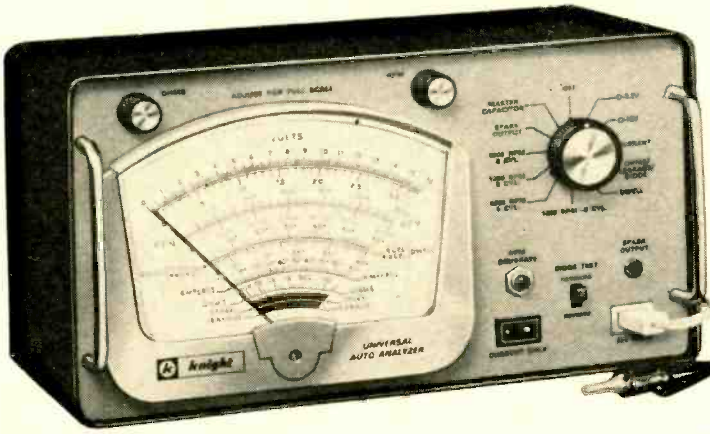


"Knight-Kit" KG-375 Auto Analyzer

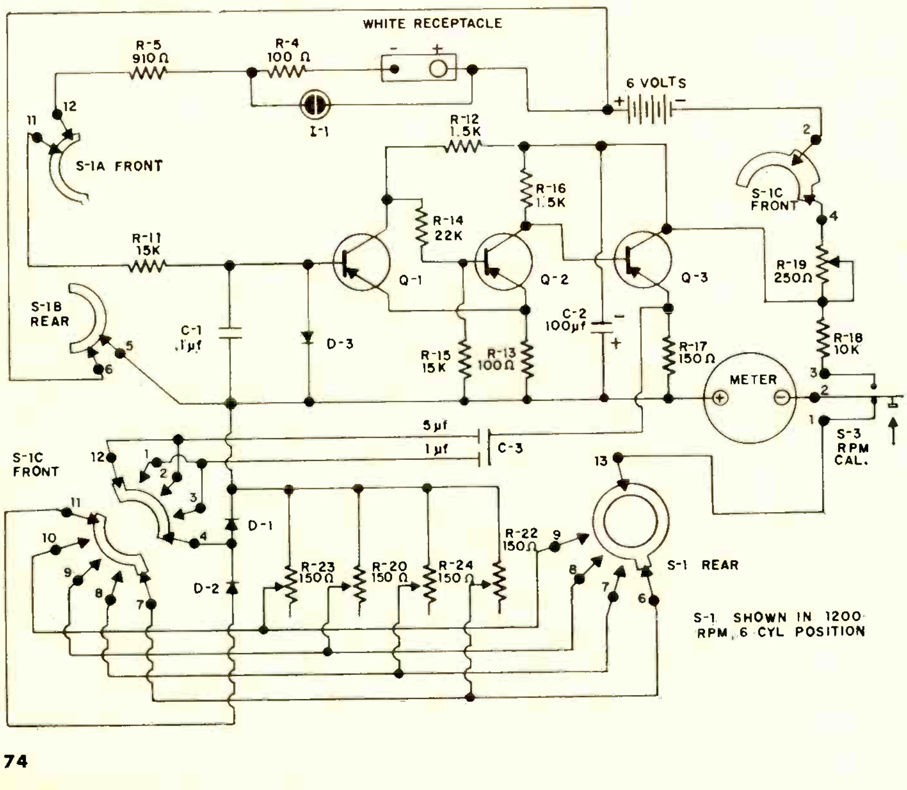
For a copy of manufacturer's brochure, circle No. 56 *on coupon (page* 15).



FROM the large amount of reader interest in electronic items for automobiles, it would appear that any piece of test equipment that measures just about everything electrical on a car would be eagerly awaited. The "Knight-Kit" KG-375 auto analyzer is such a unit. An examination of the multi-scaled seven-inch meter and the function switch will give some idea of the versatility of the instrument.

First, the analyzer has two voltage ranges: 0-16 and 0-3.2 volts. The former is useful in adjusting the car's voltage regulator and checking its battery and generator output. The latter can be used to check small voltage drops in wiring. A high-current ammeter (0-90 a.) can be used to test charging current with the aid of a separate low-resistance current shunt. Then, there is an ohmmeter range for locating high-resistance leakage and shorts. So far, except for the high-current range, the instrument seems like a fairly conventional v.o.m. However, it has many more features.

The analyzer has a built-in two-range (1200 and 6000 rpm) tachometer for both six- and eight-cylinder cars. This is a standard pulse-counting circuit (see diagram) consisting of a Schmitt trigger square-wave generator (*Q*1 and *Q*2) and a constant-amplitude pulse amplifier (*Q*3). The output pulses are rectified by *D*1 and *D*2 and are then applied to the meter which is directly calibrated in rpm.



In addition, a dwell-meter function is built in. This is actually the ohmmeter with a diode in series with a calibrating resistor. The diode is biased such that the car's battery voltage has no effect on the dwell readings shown on the meter. Full-scale readings are 60 degrees dwell for six-cylinder cars and 45 degrees dwell for four-or-eight cylinder cars.

The instrument has a special "leakage scale" on the meter for indicating forward and back resistance of diodes used with auto alternators. It also provides a relative output indication of the spark voltage output of the ignition system. The high-voltage pulses charge a built-in capacitor which discharges through the meter movement between pulses, resulting in an indication on a special "spark" scale. A neon lamp on the front panel of the instrument flashes in step with the spark pulse. Finally, a 0.22-μf. capacitor in the unit can be used as a substitute for the car's distributor capacitor if it is suspected of being defective.

The analyzer operates from four D-size flashlight cells. It is available in kit form from *Allied Radio* at a price of $49.95. ▲

Kay Electric Model 159-B Sweep Oscillator

For a copy of manufacturer's brochure, circle No. 57 *on coupon (page* 86).

THE *Kay Electric* Model 159-B "Multi-Sweep" is a wide-range sweeping oscillator, with a versatile system of frequency markers. It is designed for laboratory or production-line use. This unit, utilizing electronic frequency-modulating techniques, provides a full 300 mc. of swept r.f. output. The output voltage is held constant by a fast-acting a.g.c. circuit, and the frequency linearity is accurately maintained.

The 159-B may be swept at repetition rates above 20 kc. or driven by an external varying d.c. signal to act as a voltage-controlled oscillator. A direct-reading, digital frequency dial provides smooth vernier control of the center frequency, and it adapts this wide sweep for excellent use as an i.f. to v.h.f. oscillator with continuously variable center frequency and sweep width. Eight fixed markers, at customer-specified frequencies, and circuits for externally controlled variable markers are provided. The use of all solid-state circuitry in this unit produces both stability and compactness.

A sweep-generating circuit (see diagram) develops a saw-tooth signal which may be locked at line frequency or, by changing circuit constants and removing the line-frequency sync signal, varied between 5 and 60 cps. When the internal sweep generator is disabled, an external signal generator may be used to supply a sweep signal for the r.f. oscillators. A pulse is taken from the sweep generator and amplified to form a blanking signal. This blanking signal is applied to the r.f. oscillators, turning them off during the retrace time of the saw-tooth signal. The saw-tooth signal is passed through the sweep-linearity network, which shapes the saw-tooth to compensate for non-linearity in the r.f. oscillator voltage/frequency curves. This shaped saw-tooth is impressed across voltage-variable capacitors in the r.f. oscillators, changing their frequency with respect to time.

The output of the two r.f. oscillators is mixed and only the difference frequencies are accepted by a filter. The frequency range of the r.f. oscillators is in the u.h.f. region, and the output of the mixer will range between 0 and 300 mc. The swept r.f. is then passed through a high-frequency wide-band amplifier. Samples of the swept r.f. signal passing through this amplifier are taken for the a.g.c. and marker circuits. The r.f. sampled by the a.g.c. diodes generates an error voltage which is amplified by the a.g.c. amplifier. This signal is used to control the r.f. output into the mixer.

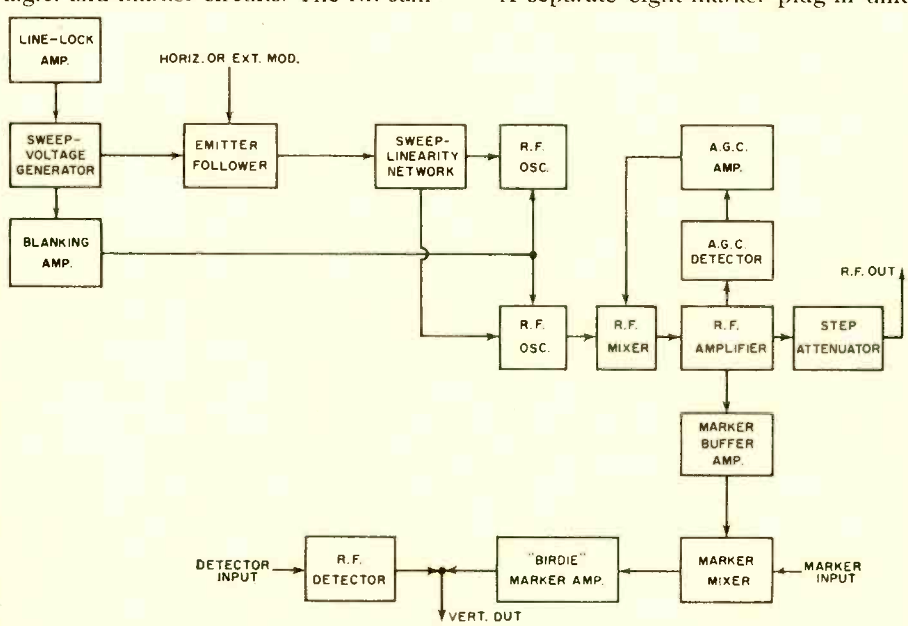
"Birdie" markers are developed when a c.w. signal is fed into the marker input jack. A sample of the swept r.f. signal is mixed with the incoming c.w. signal and the beat note is amplified by the "birdie" marker amplifier.

Six additive, switchable attenuators rated at 20, 20, 20, 10, 6, and 3 db, and an r.f. level control with a range of 6 db give a wide degree of r.f. amplitude control. The r.f. output (maximum 0.5 v.r.m.s., loaded) is monitored by a calibrated panel meter.

The sweep rate can be varied or locked to the line. To assure an accurate zero-voltage reference line on the scope, r.f. output is blanked during retrace. A saw-tooth sweep is generated, is separately available, and needs no phasing adjustments.

A front-panel control provides for manual tracing of the frequency response display. It operates over the same range as the electronically swept mode of operation and permits tracing of the response with point-by-point control. It can be used with v.t.v.m. or frequency counter without changing the swept alignment set-up.

A separate eight-marker plug-in unit

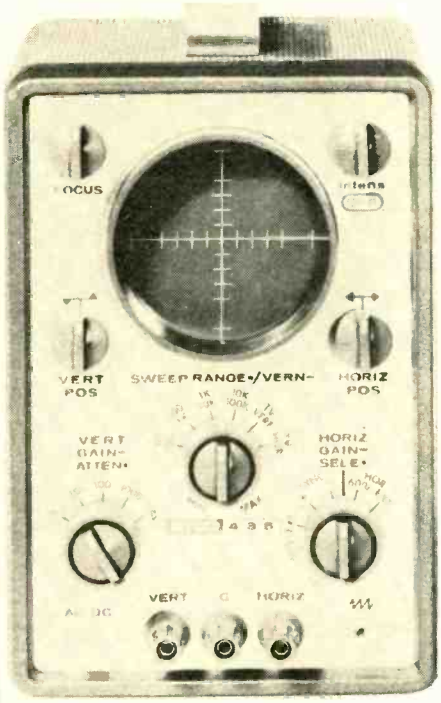


makes it possible to select a variety of markers. Sharp pulse-type crystal filter markers are available at frequencies below 100 mc., and crystal-oscillator "birdie" pip markers are available over the entire range. All of these are individually controlled and may be used in any combination.

The price of the Model 159-B is $795 without the marker unit. ▲

Eico Model 435 Oscilloscope

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



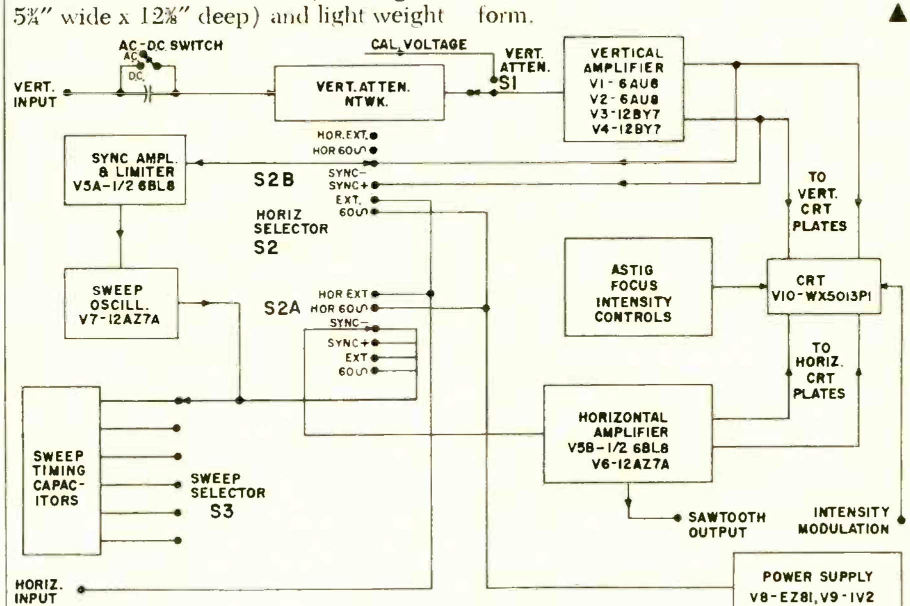
ALMOST two years ago, *Eico* introduced a compact three-inch scope (Model 430) that is suitable for general-purpose applications. Recently, the company has come out with a little more expensive scope that looks like a twin to the Model 430 except that this new instrument is a wide-band scope, with response from d.c. out to 4.5 mc. The new unit, the Model 435, is suitable for laboratory use or on a service test bench. Because of its small size (8½" high x 5¾" wide x 12⅝" deep) and light weight (15 pounds), the scope can be carried into the home for on-the-spot color-TV servicing.

In addition to its wide frequency response and high sensitivity (18 mv. r.m.s. per cm.), the scope has several other interesting features. It employs a zener-diode-controlled voltage-calibration source with an output-voltage pot. The circuit provides a precise 200-mv. p-p square-wave calibration voltage that is useful for making accurate peak-to-peak measurements of waveforms. Automatic sync limiting and amplification (see diagram) eliminate the need for sync-voltage adjustment. Retrace blanking is employed to prevent the flyback portion of the sweep from appearing on the screen. An edge-lit calibration grid on the filter screen, with controllable illumination level, is provided.

The trace on the scope is very bright and sharp and is free of "blooming." The high-voltage accelerating potential is 1600 volts. External fields have no effect on the scope trace because of the use of a Mumetal neck shield around the cathode-ray tube.

The vertical-input decade attenuator has four positions with full frequency compensation. Either direct or capacitive input coupling can be employed. There are four overlapping sweep ranges from 10 cps to 100 kc. with two additional pre-set sweep rates of 30 cps and 7875 cps for TV vertical and horizontal signals.

The instrument is priced at $99.95 in kit form and $149.95 in factory-wired form. ▲



Fiber Optics

(Continued from page 28)

diameter of a human hair.) The bundles usually have an *NA* of about 0.50 and are limited to the visible and near infrared wavelengths. Transmission is a function of length and in the six-foot length, for example, will drop off to about 25 percent. See Fig. 4.

The traditional concept of long cylindrical fibers arranged in an oriented fashion can be varied in two interesting ways. The first is to purposely interweave the loose portions of an assembly of strands so that the entering image is scrambled as it passes through the bundle, yet emerges in its original form at the other end. Then, if the bundle is cut in two, each part is capable of coding an image that can be decoded only by joining it to the other half, or one identical to it. Countless "codes" are possible with bundles having thousands of fibers available for scrambling. But no practical method has been found to reproduce any given pattern.

The other variation is the tapering of fibers and bundles, which is done during the drawing process. This month's cover shows tapered "roots." Such tapered bundles can change light intensity or image size. The magnification is directly proportional to the ratio of exit diameter to entrance diameter and intensity is inversely proportional to the ratio of exit area to entrance area. The relationship of entrance and exit angles is shown in Fig. 5 and is: $d_1 \sin \theta_1 = d_2 \sin \theta_2$.

Light entering the smaller end and emerging from the larger end will be more collimated. (Note the angle θ_2 is smaller than θ_1). The reverse also holds true. The maximum angle at which light may enter the larger end and be transmitted is limited. Therefore, a more collimated source is employed whenever intensification is required.

Fiber-Optic Plates

The one form of fiber optics that is perhaps of most interest to electronics engineers is the fused plate. Unlike bundles, plates are generally made to order for a specific use, such as special electron tubes. They can be square, round, or rectangular and either vacuum-tight or not. The largest size believed ever to have been specified is 12 inches in diameter. The thickness, and therefore the fiber length, is usually a specification meeting mechanical strength requirements. For simple geometries, an opening size-to-thickness ratio of 16-to-1 is generally used.

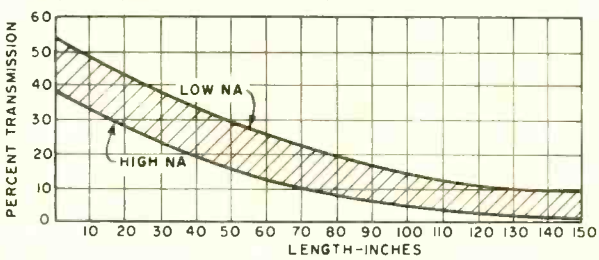
Plates are made by longitudinally stacking previously drawn fibers and then fusing the cladding. The billet thus formed is then sliced in cross-section to desired thicknesses and the pieces are ground and polished by standard optical finishing techniques.

Principal cost factors in this manufacturing process are: 1. individual fiber size, 2. cubic volume of the piece, 3. absorbing media used, 4. special core glasses, 5. vacuum tightness, and 6. allowable blemishes.

The first four factors substantially affect the time necessary to draw, or attenuate, the initial glass blanks to obtain a sufficient number of fibers of required diameter.

Core glasses must have good optical quality, that is, be free of stones and bubbles. Refractive indices up to 1.75

Fig. 4. Light transmission vs length. (Data: Bausch & Lomb)



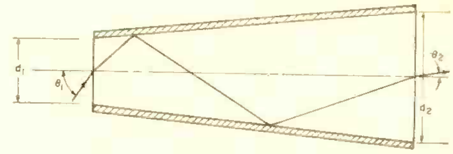


Fig. 5. Path of a light ray that is transmitted in tapered fiber.

are available in commercial glasses, which in combination with proper cladding provide an *NA* sufficient for many applications. Higher index glasses, however, require more complex formulations and process control, and often contain much more costly raw materials.

Unless the plate is mounted inside an electron tube envelope, it usually serves as one end of a structure and must therefore be vacuum-tight. Fiber-optic plates can pick up enough moisture from handling or from the atmosphere to seal any voids.

Blemishes or spots are usually caused by fiber surface contamination and adsorbed gas bubbles. Spots less than .002 inch are difficult to avoid. Care must be exercised in specifying freedom from blemishes, or the price will become prohibitive.

Making vacuum-tight, blemish-free plates is not simple. In a typical plate of one square inch, there may be 20 million fibers, each composed of two different glasses, and each ideally sealed to its neighbor without impairing the critical interface between core and cladding.

In most electronic applications, the plate is sealed to a glass envelope or perhaps a metal flange.

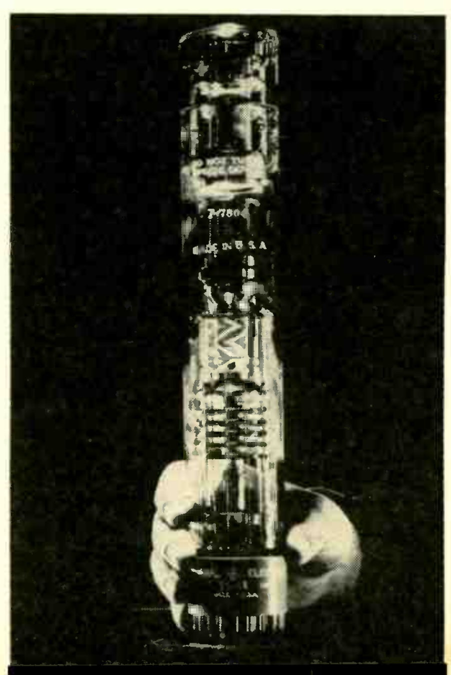
These operations require a carefully controlled process, so the fiber-optic manufacturer should always be consulted about every phase of the seal design, the frit and glass combination, and the subsequent heat cycles.

Because of their mosaic structures, fiber-optic plates have a lower dielectric breakdown strength than solid glass of equal thickness. Breakdown usually occurs along one of the fiber interfaces, at voltages above 10-12 kilovolts. This can be a limiting factor in some applications, and improvements are being sought by fiber-optic manufacturers.

The Future

Fiber optics will be less expensive in the very near future. As volume applications are developed, competition will reduce prices and improve quality. Another outlook for fiber optics is a greater variety of glasses to perform in the ultraviolet and infrared regions. Certainly, new uses will be seen in medicine, instrumentation, office duplicating equipment, photography, and in various types of optical communications systems.

Fiber optics, in short, can so efficiently transmit light and image information that the technology will surely have a future wherever this particular capability is needed in any device. ▲



A new electrostatic image orthicon that is available with a fiber-optic faceplate.

SUBSCRIPTION TV TEST RESULTS

NOW in its third year of operation over WHTC (channel 18), in Hartford, Conn., *Zenith Radio Corporation's* subscription TV system has made available some of the results of this test period.

Of the 5000 subscribers, 40.8% had average incomes between $4-7000 annually, 43.3% from $7-10,000, and 14.4% had incomes over $10,000 annually.

During the first two years of operation, average spending per week was somewhat higher in the $4-7000 bracket and lowest for subscribers with incomes over $10,000. As the number of subscribers increased, the proportion of those in the $4-7000 income group consistently increased.

Subscription TV viewing represented slightly more than 5% of the 38 hours the public now devotes every week to TV viewing.

The results also showed the viewer response to the 599 different features telecast during the first three years. These programs came from over 50 different sources with current and other U. S. motion pictures providing 83% with an average audience of 20.7% per picture. Championship boxing drew 63.3% per fight while other major sports included professional basketball (6.6%), and ice hockey (5.3%).

Productions from Broadway, concert halls, night clubs, etc., represented 5.5% of the total offerings and had an average viewership, for all showings, of 8.7%.

Special post-graduate medical educational features for doctors only drew an average of 18.7% of the physician-subscribers, for all showings.

Charges for the programs ranged from 25¢ for some educational features, to $3 for a world championship boxing match. Most programs were priced between 75¢ and $1.25. Average charge for movies was about $1; opera and ballet $1.50; and sports events $1.37.

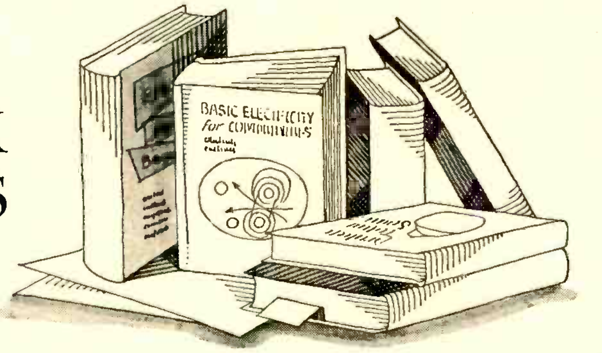
Hartford subscribers purchased approximately one program a week (about 2 hours) at an average of $1.20 making an average annual program expenditure of $62.40, in addition to the decoder rental of 75¢ per week.

Projections based on these results (which *Zenith* calls "conservative") show that over-the-air subscription TV can begin to operate profitably with 20,000 subscribers. *Zenith* also points out that in its opinion, subscription TV has a great potential for the development of u.h.f. broadcasting. It could make possible many new stations, now authorized but not on the air because of the lack of local advertising revenue and programming. ▲

"**COMMUNICATIONS, ELECTRONICS TERMINOLOGY HANDBOOK**" compiled and published by *Public Affairs Press*, Washington 3, D.C. 547 pages. Price $7.00.

This is a manual of definitions, abbreviations, acronyms, and designations useful to those involved in communications-electronics. Most of the definitions included in the volume are based on standards set up by American Standards Association, IRE (IEEE), and the American Institute of Electrical Engineers (IEEE).

BOOK REVIEWS



The contents were prepared by the Communications-Electronic Doctrinal Office, Research Studies Institute, Air University, Maxwell Air Force Base, and are, therefore, official although the publication is not.

The definitions are limited to statements of meaning rather than circuit analysis or detailed descriptions. The selection of expressions for inclusion was governed mainly by usage in the communications-electronics fields. Usage was determined by the language found in texts and magazines as well as by glossaries and other publications of Department of Defense agencies.

All entries are in simple alphabetical order of the entire expression as if it were one word. Definitions, where applicable, are given with the spelled-out expression rather than with the abbreviation or acronym. Extensive cross-referencing is employed, but the definition is given with the primary expression.

° ° °

"**BASIC THEORY AND APPLICATION OF TRANSISTORS**" prepared by the U.S. Department of the Army. Published by *Dover Publications, Inc.*, New York. 251 pages. Price $1.25. Soft cover.

This is one of the Government's comprehensive basic texts, originally prepared for the Army but now made available to the general public.

This book which can be used as an introductory textbook, as a course supplement, for self-study, or by the electronics technician, covers every aspect of the subject with only an elementary knowledge of physics and the theory of electron tubes as prerequisites.

Included are such topics as the history of crystal semiconductors, function of transistors, their applications and construction, definitions of terms and concepts, elementary physics, the structure of matter, *p-n* junctions, transistor amplifier fundamentals, parameters, equivalent circuits, characteristic curves, bias stabilization, audio amplifiers, tuned amplifiers, wide-band amplifiers, and pulse and switching circuits.

Carefully prepared background is given for each topic discussed with new information introduced logically for easy assimilation. There are outline summaries at the end of each chapter and nearly 250 schematic diagrams, photographs, and wiring diagrams that show correct procedures and results for every important point covered in the text.

There is also a glossary of technical terms and an appendix listing the letter symbols used.

° ° °

"**BASIC ELECTRONICS**" prepared by Bureau of Naval Personnel. Published by *Dover Publications, Inc.*, New York. 449 pages. Price $2.75. Soft cover.

Those with a background in basic electricity and elementary mathematics can use this volume as a self-contained course of study in the basic principles and important aspects of applied electronics.

The volume starts with the basic operating principles of the electronic tube and an introduction to transistors. The book continues with power circuits, tuned circuits, electron-tube and audio-tube amplifiers, oscillators, transistor circuits, modulation and demodulation, transmitters, antennas, elementary communications receivers, radar, electronic test equipment, and special circuitry.

This is the tried-and-true text developed by the Navy for training hundreds of its personnel in the fundamentals of electronics. Those who took the course will recall how thorough and complete the treatment is—with definitions of the technical terms, mathematical derivations, schematic diagrams, and other pertinent addenda.

This volume, as well as the previous one reviewed, are among the best "buys" in basic electronics texts available today.

° ° °

"**DIODE SELECT-A-SPEC**" edited and published by *TechPress Publications*, Brownsburg, Indiana 46112. 137 pages. Price $2.95. Soft cover.

This is another of this publisher's compact and concise listings of specifications, along with suitable substitutions—this one covering diodes.

There are over 25,000 computer-selected substitutes for the signal and power diodes of over 50 manufacturers—both American and foreign. Substitutions are listed directly alongside the type number and specifications of each diode, with the *most accurate* listed first, etc.

The book includes power-supply diodes, a.f.c. and a.v.c. diodes, diodes used as mixers and demodulators, and as switches in computers. Specifications listed include: maximum working volts, p.r.v., maximum forward current, forward voltage drop (*IR* drop), maximum reverse current, type, and use.

° ° °

"**PRINCIPLES & APPLICATIONS OF BOOLEAN ALGEBRA**" by S. A. Adelfio & C. F. Nolan. Published by *Hayden Book Company, Inc.*, New York. 319 pages. Price $8.00.

In this volume the authors concentrate on explaining the basic concepts of Boolean algebra and its basic electronic applications without bringing in the applications of Boolean algebra to computers and related areas. By thus operating within fixed limits, the text gains clarity and the student is more likely to grasp the material easily.

The first six chapters are devoted primarily to Boolean algebra, chapters 7 and 8 review electronic principles and serve as background for the final three chapters which cover various logic and counter circuits.

The material in this book is based on courses given by the authors at *RCA Institutes* and represents a practical presentation of this material for hundreds of students. As a textbook, there is lavish use of diagrams, tables, and examples, as well as problems for assignment or self-checking.

° ° °

"**TV RECEIVER TUBE USAGE GUIDE**" compiled by Sams Staff. Published by *Howard W. Sams & Co., Inc.*, Indianapolis. 96 pages. Price $1.95. Soft cover.

This is a listing of tubes and semiconductors used in 1963-64 television receivers made by most U.S. set manufacturers. This pocket-sized booklet is intended to permit the technician to come equipped for a service job with the correct tubes, fuses, and semiconductors in his caddy.

Another valuable section is a tube usage chart which serves as a handy guide to the popularity of a given tube type. This information can be used in stocking the shop and in loading the tube caddy.

An index lists the manufacturer or brand name with their 1963-64 model numbers. The page on which detailed

SPECIAL ANNOUNCEMENT FROM THE PUBLISHER

During the past few months, we have completely converted our subscription service department from 434 South Wabash Avenue in Chicago, to an ultra-modern Univac-III computer operation at Portland Place in Boulder, Colorado.

You may have already noticed the change in your address tape, which is now being run at the rate of 135,000 names and addresses per hour. The first letter in the code line indicates the magazine. The next four digits indicate the month and year that your subscription expires. For example, 0567 means your last copy will be the May, 1967 issue; or 1166 means your last copy will be the November, 1966 issue. All of the other numbers in the code line are meaningless, except to the computer.

This important change for all Ziff-Davis publications was necessary to enable us to give our constantly growing subscription lists the most efficient and reliable type of subscription fulfillment possible. However, as much as we have tried for absolute perfection, we are sure you will appreciate that in any conversion of this magnitude, some errors will occur, but every precaution has been taken to hold them to a minimum. Should you experience any problem with your subscription service, please do not hesitate to advise us at once. The proper address is: ELECTRONICS WORLD, Portland Place, Boulder, Colo. 80301.

P.T. Heffernan

tube, fuse, and semiconductor information is provided is then listed for each model, along with the circuit function of that particular component.

* * *

"ELECTRICAL ENGINEERING" by Julius I. Franklin. Published by *The Macmillan Company*, New York. 382 pages. Price $9.00.

This is another volume in this publisher's series subtitled "Studying to Pass the Professional Engineers' Licensing Examination." The author has drawn on his years of experience in giving "brush-up" courses for those taking state licensing exams for professional engineering certification. The book covers fundamental concepts, serves as a refresher and reference for engineering graduates, and helps to sharpen the candidate's problem-solving ability.

Sample problems from examinations of the past comprise fully half of the book while the solutions, their explanation, and pertinent reference material take up the balance of the 382 pages. The author provides reasonably full answers to the problems and goes into some detail explaining why the answer is correct, but without an engineering background, the student will founder on page 2.

Used for the purpose for which this book was designed, candidates will find this a valuable tool in preparing for their licensing exams.

* * *

"AN INTRODUCTION TO PATENTS FOR INVENTORS AND ENGINEERS" by C. D. Tuska. Published by *Dover Publications, Inc.*, New York. 171 pages. Price $1.50. Soft cover.

This is an unabridged re-publication of the seventh edition of the author's "Patent Notes for Engineers" (*McGraw-Hill Book Company*, 1956). It is a basic and thorough guide for anyone engaged in technological research or experimentation on how to obtain a patent for his invention. The author, who was formerly director of *RCA*'s patent department, has cut through a lot of excess legal verbiage and provides practical step-by-step procedures which should be followed to protect a discovery—whether or not one wants to take financial advantage of the invention.

Since the book is directed to engineers, inventors, businessmen, and undergraduates and graduates who are about to join scientific, engineering, research, and development organizations, there is no attempt to make a patent attorney of the reader. The author does emphasize the very basic steps the inventor must take from the very first in order to claim priority because if such information is incomplete or lacking, even the best patent attorney can't win the case if the patent is challenged at some later date. ▲

Component Reliability

(*Continued from page* 41)

more than their lower-quality counterparts.

Probably the easiest and cheapest way to improve reliability is to *derate* components. The more a part is *stressed*, the sooner it will fail. Stresses can be many different things, such as shock, vibration, heat, voltage, or power dissipation. These factors all combine to cause part failure. A good rule of thumb is to derate all components by at least 50% and use them in as cool an environment as possible (but not so cold as to cause failures from low temperature effects).

One manufacturer has run extensive tests on tantalum capacitors with the following result: there is an improvement of at least 300 times in failure rate when the capacitor is operated at 100°F and 50% rated voltage rather than 175°F and 100% rated voltage.

Heat sinks on transistors and thermal shields on vacuum tubes tend to prolong part life by reducing stress levels. A cooling fan can also assist in upgrading reliability. Where possible, adequate ventilation and spacing should be maintained between parts which have a significant temperature rise.

Derating can be carried to an extreme which may cause a lowering of MTBF. A relay rated for 10 amperes may exhibit a high contact resistance at 10 ma., causing a failure. Or a resistor that is barely warm may permit corrosion to occur in a humid atmosphere, whereas a hot resistor would not permit this. But a 50% derating is not going to get us in trouble and usually won't increase costs.

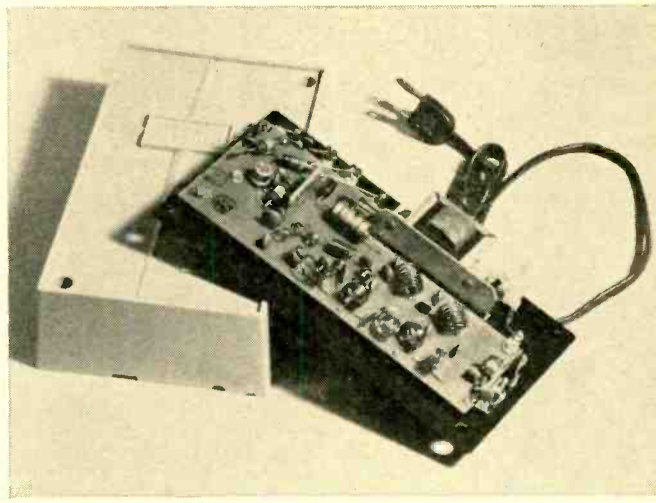
More About Failure Rates

The failure rates shown in Table 2 are considered "typical" and are drawn from several sources. So-called high-reliability parts may exhibit failure rates of better than 0.0001% per thousand hours at 90% confidence level. To qualify a part to this level requires in excess of *one billion* unit hours of testing with no more than one failure. One can readily see why a part meeting this reliability level is bound to be more expensive.

In more detailed analyses, failure-rate data is presented in a manner which allows the user to make closer estimates. *Stress* factors are used which adjust failure-rate figures to reflect how the part is used. A space environment for example may make the failure rates 80 to 100 times worse because of mechanical shock, vibration, and temperature extremes. As more tests are conducted on existing parts, reliability estimates tend to be closer to measured values. Research in the technology and science of manufacturing components will also pay off in more reliable electronic systems. ▲

BOOSTER FOR FM STEREO

By LON CANTOR
Jerrold Electronics Corp.



With the booster unit removed from its plastic case, the coils and capacitors forming the various filter networks can be seen. The single transistor and diode used are at the left while the step-down power transformer is mounted on a bracket at the rear.

Designed to improve stereo reception, the Jerrold Model SRX r.f. preamp provides 15-db gain over the entire band.

FM-stereo is a decided step forward in realistic music reproduction. But stereo broadcasts are a lot weaker than their mono counterparts. In fact, you can get mono reception at almost twice the distance from which you receive good FM-stereo signals.

The FCC does not permit any increase in effective radiated power of FM stations, therefore the only possibility for improvement is at the receiving end.

Typical of the units designed to improve FM-stereo reception is the new *Jerrold* Model SRX FM Stereo Range Extender. The SRX provides more than 15-db gain over the entire FM band. Since it is mounted indoors and most good FM tuners today have excellent noise figures, the SRX provides little, if any, improvement in signal-to-noise ratio. However, the effect of the r.f. preamplification is to drive the receiver into limiter action, as illustrated in Fig. 1.

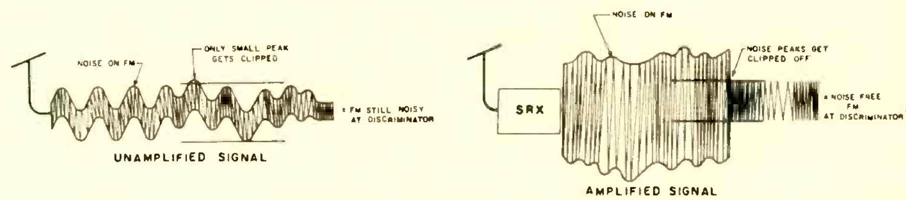


Fig. 1. While the FM preamp does not improve signal-to-noise ratio of high-gain, low-noise tuners, it increases the amplitude of the signal enough to activate the receiver limiter circuits. As a result, more of the noise peaks are clipped.

A block diagram of the booster is shown in Fig. 2 and the schematic in Fig. 3. This single-transistor unit includes an input filter which splits FM from the TV signals, permitting the use of a single antenna for both TV and FM. Except for channel 6, no TV signals are attenuated by more than 1.5 db. Because channel 6 is adjacent to the FM band, it is attenuated severely.

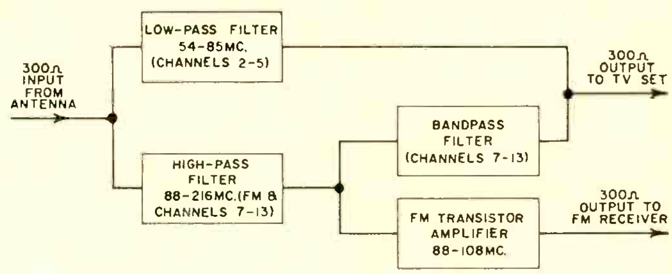
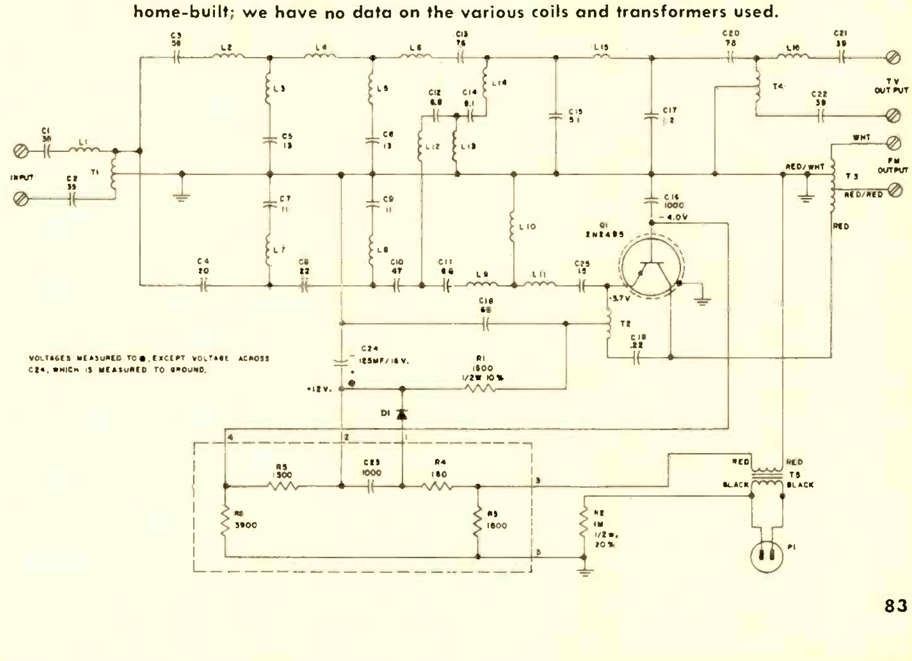


Fig. 2. Block diagram showing the use of filter networks.

Input signals are first separated into low-band (54-85 mc.) and high-band (88-216 mc.) signals. The high-band signals are then further divided into the high-band television (174-216 mc.) and the FM (88-108 mc.) segments.

Fig. 3. Circuit diagram of the booster. This unit is not designed to be home-built; we have no data on the various coils and transformers used.



Circuit Description

The input circuit consists of capacitors $C1$ and $C2$, coil $L1$, and transformer $T1$. This circuit matches the 300-ohm impedance of the antenna to the 75-ohm impedance of the TV and FM filters.

The low-band TV filter is a two-section M-derived low-pass filter. Cut-off frequency is about 85 mc., which means that the channel-6 sound carrier (87.75 mc.) is attenuated sharply. Capacitor $C3$, coil $L2$, trap $L3$ and $C5$, coil $L4$, trap $L5$ and $C6$, and $L6$ with $C13$ are the elements of this filter.

Capacitor $C4$ is the first element of the high-pass filter, which includes trap $L7$ and $C7$, capacitor $C8$, trap $L8$ and $C9$, and capacitor $C10$. This circuit passes all frequencies from 88 to 216 mc., trapping out all lower frequencies.

The TV portion of the high-pass filter output is fed into a double-tuned band-pass high-band filter. This filter comprises $L12$, $C12$, $L13$, $C14$, and $L14$.

Output of the high-band TV filter is combined with the output of the low-pass filter into an artificial line. This artificial 75-ohm line (printed inductance $L15$ with capacitors $C15$ and $C17$) is then transformed to a 300-ohm TV output by matching network $C20$, $T4$, $L16$, $C21$, and $C22$.

FM Filter and Amplifier

FM signals are amplified by a 2N2495 transistor. The neutralized, common-base configuration is designed to produce maximum overload capability and stability, with a good noise figure. The double-tuned input circuit of the transistor amplifier comprises $C11$, $L9$, $L10$, $L11$, and $C15$.

Capacitors $C18$ and $C19$, plus $T2$ provide neutralization. $C16$ is the base bypass for the transistor and resistor $R1$ serves as the emitter resistor. The base bleeder network, $R5$ and $R6$, is contained in the printed-circuit network enclosed within the dashed box. A special bifilar transformer matches the FM amplifier output to 300 ohms.

The low-voltage d.c. required to operate the transistor is obtained from step-down transformer $T5$ and rectifier diode $D1$. Conventional RC filtering is employed.

While the unit produces best results with a good outdoor antenna, the amplifier can also make a considerable improvement in the reception provided by any indoor FM antenna. ▲

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83	Jerrold Electronics Corp.

Solid-State Power Controls

(*Continued from page 36*)

making continuous adjustment of such a control rather difficult.

Most kitchen and shop outlets, however, are at counter height so this is not a problem when the control is used with appliances.

The conventional tool control consists of a control box equipped with a long, heavy-duty line cord. This type is intended for the home workshop and is usually equipped with 3-prong plugs and outlets for safety grounding. They may also include fuses or circuit breakers for control protection. This type of control is not suitable for use on table lamps because it is far from decorative and often the required 3-prong outlets are not available in such locations.

The industrial version of this home tool control is extremely rugged and specifically designed to operate a single motor or tool. The torque and speed may be controlled independently while internal feedback circuits automatically adjust for changing load and line-voltage variations.

Also available is a special double dimmer intended for photoflood control. The adjustment gives precise shadow control and balance on black-and-white photography and control of color temperatures for color work. A very important feature of this control is that it can substantially extend the life of normal six-hour photofloods. Photofloods almost always fail on the turn-on current surge. By starting in an "off" position and bringing the bulb voltage up to full brilliance slowly, the bulb life can be greatly prolonged.

There is also a built-in control integrated into the trigger of an electric drill. As more pressure is exerted on the trigger, the speed of the drill increases steadily. The circuit is built right into the tool itself during original manufacture.

Other built-in controls are included in an ordinary desk or end-table lamp during initial manufacture. The advantage of these latter two controls is their integral, built-in circuitry. The low additional cost of these controls means that ultimately many lamps and power tools will incorporate them. As these see more and more use, other types of controls will be displaced—with integral control spotlighted in the marketing of many appliances.

Next month, we will investigate the specific control circuitry common to all these types of units, considering what power semiconductors are used, how they are controlled, and how the special circuits that use fluorescents, feedback, or external inputs for control operate. Parts values will be included wherever possible.

(Concluded Next Month)

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 15, 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 15 for "GENERAL USE" Coupon

Mail to: ELECTRONICS WORLD P. O. BOX 7842, PHILADELPHIA 1, PA.

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(VOID AFTER JUNE 30, 1965) 5

NEW PRODUCTS & LITERATURE

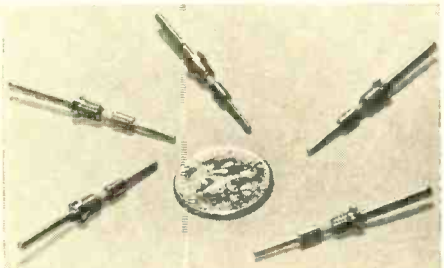
Additional information on the items covered in this section is available from the manufacturers. Each item is identified by a code number. To obtain further details, fill in coupons appearing on pages 15 and 86.

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

SUBMINIATURE FUSES

1 **Littelfuse, Inc.** is now marketing a series of special-purpose subminiature fuses which the firm has designated "Picofuses."

The new line is designed for multi-purpose applications in single- and multi-pin connectors, rack and panel connectors, printed-circuit connectors, terminal strips, and terminal boards.



They are especially suited to applications where conventional fuse posts or holders cannot be used because of space limitations.

The component is available in a wide range of ampere ratings from 1/8 through 5 amps at 125 volts. All models have short-circuit interrupting capacity of 300 amps at 130 volts d.c. The ceramic body fuse combines low resistance with high-speed action and provides extreme accuracy in blowing time at a minimum of 300% of rating.

SOLAR BATTERIES

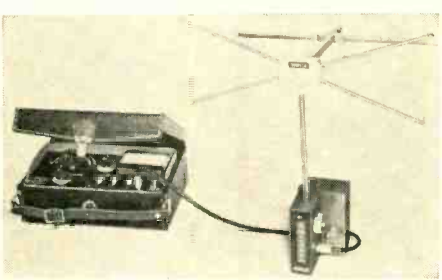
2 **Hoffman Electronics Corporation's** Semiconductor Division is now marketing a practical solar battery for operating personal transistor radio receivers.

The 2 1/8" x 3 1/4" x 1/4" thick solar shingles come in three types designed to power 4.5-, 6-, and 9-volt receivers. No wiring changes are necessary for the use of the solar batteries. They may be used as a total replacement for the conventional dry-cell batteries or as an alternate source of power. A plastic socket comes with the solar battery to facilitate orienting it to the light source—which may be the sun or an ordinary household incandescent light bulb.

FIELD-STRENGTH METER ADAPTER

3 **Sadelco Inc.** is now offering a u.h.f. accessory which is designed to adapt any v.h.f. TV field-strength meter for versatile u.h.f. performance. A universal mounting bracket allows the UA-1 adapter to become an integral part of any present v.h.f. meter Its compact size, battery power, and 18-ounce weight will not burden the meter. It can be snapped on or off the mounting bracket.

The built-in battery supply permits the unit to be operated at a distance from the field-strength meter and can thus be used as a hand-held v.h.f. signal probe. A plug-in antenna is supplied for this purpose.



3-AMP AXIAL-LEAD RECTIFIER

4 **Motorola Semiconductor Products Inc.** is now in production on a new 3-ampere axial-lead rectifier which occupies less than half the space required by conventional stud-mounted rectifiers.

The MR1030 rectifier series is well suited for circuit-board applications where stud packages and heat sinks are not practical. The device handles surges of up to 300 amperes. It is available in a welded, hermetically sealed case and has readily solderable flexible leads.

IN-CIRCUIT TRANSISTOR TESTER

5 **Transition Inc.** is now manufacturing and marketing a transistor tester, developed by IIT Research Institute, designed for accurate in-circuit measurement of leakage current.

Lightweight, the basic unit is portable and

accurately measures collector-to-base leakage currents as low as 1 μa. with a collector load resistance down to 100 ohms.

The device is designed to be operated with one hand. Simplicity of operation and rapid setup time allow the unit to be used by non-skilled personnel for both manufacturing and maintenance testing. A 0-25 μa. meter with a taut-band movement is used to read leakage currents and to indicate transistor shorts and opens with complete safety for all components. Maximum ranges on the three-range scale are 25, 250, and 2500 μa.

The instrument is powered externally from any 120-volt, 60-cycle a.c. source.

RC GARAGE-DOOR CONTROL

6 **Eico Electronic Instrument Co., Inc.** has introduced the 4000 "Dormatic" garage-door opener system which consists of a door-opener mechanism, a radio-control receiver, a manual push-button wall switch, mounting hardware, and a small, compact transistorized portable radio-control transmitter.

The garage door may be opened or closed from inside the garage by operating the wall-mounted push-button. The garage door may also be opened or closed from outside the garage or inside a nearby vehicle by activating the battery-operated RC transmitter.

The door control mechanism stops instantly when the door meets any resistance in its path. This automatically prevents injury to anyone or anything that might be under the door. Whenever the mechanism starts to open the garage door, a lamp is lighted within the garage to provide illumination.

The transmitter is transistorized and operates from a self-contained battery. It is crystal-controlled and modulated by an audio tone. Inadvertent operation of the door by CB, amateur, or other radio transmitters is prevented by tone coding.

Full details on the 4000 and its accessories are available from the manufacturer.

175-AMPERE SCR

7 **Westinghouse Semiconductor Division** has announced the availability of a 175-ampere silicon controlled rectifier with forward blocking voltage and peak reverse voltage to 1000 volts.

The new Type 220 SCR offers designers 17% greater half-wave and r.m.s. current capability and 33% greater surge current capability (4000 amperes) than the 150-amp SCR currently used in many designs.

Additional features include a unique, internal, compression-bonded construction that eliminates thermal fatigue by eliminating solder joints. Low thermal impedance, glazed ceramic headers, and hermetically weld-sealed cases insure dependable operation under severe application conditions, according to the company.

CURVE TRACER ATTACHMENT

8 **Rameco Corporation** has added the Model CTA-1 transistor curve tracer to its line of test instruments. This instrument was developed to provide an inexpensive means of adding this capability to any general-purpose d.c. oscilloscope. It features a peak voltage range of up to 240 volts in four steps and automatically

traces five steps per family in the common-emitter configuration.

Base currents of from 20 μa. to 1 ma. are provided. Both "p-n-p" and "n-p-n" transistors may be tested with the instrument. The collector sweep circuits may be used alone to check breakdown voltages of transistors as well as diodes and zener regulators. A collector load selector provides twelve resistance values from 10 to 100,000 ohms.

U.H.F./V.H.F. COUPLER-SPLITTER

9 **Gavin Instruments, Inc.** has combined a u.h.f./v.h.f. coupler and splitter into one easy-to-install package. The Model C-201/2 requires only a single down lead. The u.h.f. an-

tenna is mounted to the existing v.h.f. mast. Both antennas are connected to the coupler and a single down lead is run to the splitter at the TV set where the output is split to the v.h.f. and u.h.f. terminals.

KIT FOR ENGINEERS

10 **Esterbrook Pen Co.** is now marketing a new "Professional Kit" which includes three of the company's "Wonderiters": three cartridge six-packs of black, blue, and red inks and two extra "Flo-Tips." The inks in the pens won't bleed through paper and will write on any surface. They are especially useful for audio-visual work because the inks project well and can be washed off acetate easily.

They can also be used for charts, lettering of diagrams, color coding, and in making engineering layouts.

INVERTER RUNS TV SET

11 **Dynamic Instrument Corp.** is now marketing "Video Mate" which permits standard TV receivers to be operated from any 12-volt car or boat battery.

This lightweight, completely transistorized inverter can be used with any TV set requiring 175 watts of power or less. It converts 12-volt d.c. into regulated 110-volt a.c. with a waveform

closely duplicating that of household current for a sharp, clear picture. The unit connects to the battery by means of a shielded cable with two spring clips. The TV set is plugged into a receptacle on the face of the unit.

The inverter measures 4½" x 3½" x 4" and weighs approximately 3½ pounds. It is designed to operate in marine environments and meets military specs for salt-spray and fungus resistance.

ARCING & CORONA PROTECTION

12 **Chemtronics, Inc.** has developed an insulating spray for protecting high voltage components such as flyback transformers and yokes against arcing and corona shorts as well as providing a tough and durable coating of insulation against humidity and weather.

Manufactured to exceed MIL-C-12599, "No Arc" comes in a handy aerosol spray can which assures accuracy of application.

RFI SHIELDING GASKET

13 **Instrument Specialties Company, Inc.** has developed a new electronic gasket which is expected to permit design simplification of structures to be shielded. Three of the mechanical problems in the assembly and maintenance of finger strip gaskets are solved by the new design: soldering is completely eliminated, prefabricated 90° corners are available for rectangular openings, and a new spring fastener permits easy assembly or disassembly in the field.

The new spring fastener has a head thickness of only .004 inch, permitting solid compression of the new gaskets to improve attenuation. The fasteners and gaskets are installed with a pencil butt, and are removable without damage with a knife blade.

The company will supply copies of a special test report on the RFI shielding properties of the new gasket.

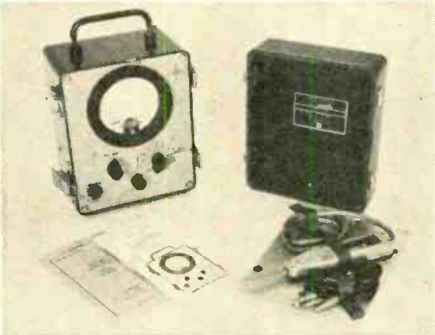
INDUSTRIAL MARKER

14 **Markal Company** has developed a heavy-duty felt tip marker especially for industrial applications. The "Dura" ink marker is available in eight brilliant colors. The marks are water-

proof, dry instantly, and remain permanent. The heavy-duty extruded seamless aluminum case is designed to withstand extreme abuse and neglect. The felt tip writes fine, medium, and broad and keeps its shape for sharp writing.

PORTABLE SEMICONDUCTOR TESTER

15 **American Electronic Laboratories, Inc.** has announced the development of a portable, militarized in-circuit semiconductor tester designed for quantitative troubleshooting and repair of semiconductor circuits on PC boards.



The Model 245-MA is said to be completely safe and foolproof for all semiconductors, in-circuit and out-of-circuit. The instrument will measure beta of a transistor, resistance appearing at the electrodes of a transistor or diode, reverse leakage of a transistor or diode, a shorted or open condition of a diode, and condition of its internal batteries to indicate replacement when required. Power output of the tester is limited to 0.25 microwatt.

A special feature of the tester is the specially designed, one-hand-operated tri-contact testing probe which makes positive point contact on printed-circuit boards. The three probe tips are easily adjustable by thumb wheels to any desired contact pattern.

The unit is powered by replaceable standard Type C flashlight batteries.

COAX FOR COLOR-TV

16 **Jerrold Electronics Corporation** in emphasizing the theme "Coax is a Must for Color" has developed a new series of products to encourage coaxial TV and FM installations.

These products are being marketed as the "Coloraxial" line and include three coaxial antennas, two coaxial preamps, indoor and outdoor matching transformers, a matching transformer kit, pre-packaged lengths of coaxial cable with factory attached fittings, and a complete kit which contains a coaxial antenna, cable, indoor matching transformer, tri-mount, and hardware.

PORTABLE POWER SUPPLY

17 **Terado Corporation** is now marketing a portable power supply that has a self-contained storage battery and inverter. The "Trav-Electric" provides 117 volts, 60 cycles to operate lights, soldering irons, electric drills, tape recorders, 11" portable TV sets, radios, hedge clippers, record players, and electrical devices.

Frequency is maintained by the use of a tuning fork and is kept accurate within ½ cycle irrespective of the changing load. The device weighs 29 pounds, complete with storage battery, charger, and inverter housed in a copper-clad steel case with handle. The battery can be recharged from a regular a.c. receptacle or from a car cigarette lighter.

SOLID TANTALUM CAPACITOR LINE

18 **Union Carbide Corporation's Kemet Department** is in production on a series of solid tantalum capacitors with the highest ratings ever made available to the electronics industry.

The new A-series super-capacitance units are available at 1000 μf., 6 volts d.c.; 680 μf., 10 volts d.c.; and 39 μf., 60 volts d.c. A wide range of ratings at working voltages of 6, 10, and 60 volts is available in standard can sizes and with standard tolerances.

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The capacitors are designed to operate from −55°C to +85°C with no voltage derating and can be operated at 125°C when derated to ⅔ of the nameplate voltage. Capacitance ratings are available in ± 20 or 10% tolerances. A ± 5% tolerance is available on special order.

INTRUSION ALARM

19 **Radar Devices Manufacturing Corp.** is now marketing the "Radar Sentry Alarm," an intrusion alarm that operates on the Doppler principle. A single unit can monitor an area of up to 5000 square feet. Without movement the microwave signal remains stable; any human movement causes a change of 2 to 4 cps which is detected, amplified, and then triggers a police-type siren that is audible up to a half mile away.

The system can be enlarged by means of accessory remote detectors, special fire detectors, or transmitter/receivers for central station or police station interconnection, via leased phone lines. Also available is a relay for activating house lights and a battery-operated siren or bell which warns of any power line failure or equipment tampering.

SUBMINIATURE LEVER SWITCH

20 **Oak Manufacturing Co.** has developed a subminiature lever switch, Type 184, engineered for applications requiring precision two- or three-position switching.

Featuring a switching section only 1-inch in diameter, the new unit has been developed to provide the original equipment manufacturer flexibility and reliability in a compact lever switch. Using a newly developed coil spring and

"star wheel" cam mechanism to assure positive indexing, the new switch can be fabricated so that the lever will either index to both sides or provide a momentary spring return to the "off" or neutral position.

The switch, which measures only 1-15/16 inches high and ½ inch wide, has a 30-degree throw and sections are available with up to 22 clips. Switch sections can be made with glass silicone stator and "Kel-F" rotor or molded diallylphthalate stator and phenolic rotor.

SILICON ZENER DIODES

21 **General Instrument Corporation** has developed a new series of one-watt silicon zener diodes housed in a miniature hermetically sealed glass case.

A further expansion of the firm's "Glass-Amp" diode-rectifier line, the new zeners are being produced in 32 registered EIA types (1N4162 through 1N4193) in a range from 10 through 200 volts. A and B sub-types are available for tolerances of ± 10% (A) or ± 5% (B).

The zeners are packaged in the "Glass-Amp" case, only .360" long and .150" in diameter. The company has been assigned JEDEC outline number DO-29 for this configuration. Operating temperatures are over the range of −65°C to +175°C and storage temperatures are from −65°C to +200°C.

Electrical characteristic charts and interchangeability guides will be supplied by the company on request.

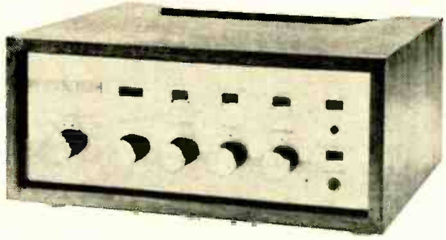
HI-FI AUDIO PRODUCTS

INTEGRATED STEREO PREAMP/AMP

22 **KLH Research and Development Corp.** has designed an all-transistor stereo preamplifier-amplifier combination especially for those who want an instrument capable of driving virtually any loudspeaker system.

The moderately priced Model Sixteen is rated at 70 watts r.m.s. +0 db, −1 db from 25 to 20,000 cps with both channels driven simultaneously into 8-ohm loads. At 1000 cps, with both channels operating, it will deliver 43 watts minimum per channel at less than 1%. IHF music power rating is well over 100 watts.

The semiconductor complement includes 24



transistors and 8 diodes. The 8 output transistors are of the drift-field germanium type which permit broader bandpass at higher levels of power than was previously possible with germanium types.

There are five rotary switches (program selector, volume, balance, treble, and bass) and six slide switches (three-position loudness, stereo/mono, tape monitor, h.f. filter, "on-off," and speakers "on" or "off."

The Model Sixteen is equipped with a special protective electrical circuit in its output stages to protect the unit should the speaker outputs be shorted. It is housed in a black anodized aluminum chassis with a satin-finished aluminum front panel and knobs. It measures 10½" x 11¾" x 4¼". An accessory case of oiled-walnut veneer is available.

FM-MULTIPLEX SIGNAL GENERATOR

23 **Eico Electronic Instrument Co., Inc.** has come out with a new instrument for servicing, testing, and demonstrating FM-multiplex stereo tuners and receivers.

The Model 342 FM-multiplex signal generator provides a controlled amplitude composite audio signal for direct injection beyond the detector into the multiplex section of the tuner or receiver, plus a 100% modulated (±75 kc.) FM radio carrier, modulated by the same composite audio signal, which can be fed to the antenna terminals of the tuner or receiver. Frequency of the r.f. carrier is adjustable but is ordinarily set at about 100 mc.

This 8½" high x 5¾" wide x 12¼" deep,

ten-pound instrument owes its convenient size to the use of compactron tubes in its circuit. Full specifications and features of the Model 342 are available from the manufacturer.

SOLID-STATE INTEGRATED STEREO AMP

24 **Harman-Kardon, Inc.** has added the Model SA-2000 integrated stereo amplifier to its line of solid-state hi-fi components. The new all-

transistor unit provides 36 watts (IHF music power) output (18 watts per channel).

Since the amplifier is output transformerless, it is able to reproduce all frequencies from 8 to 25,000 cps with a flat response within ±1 db at normal listening levels (1 watt). At full rated power, the unit reproduces 10 to 23,000 cps flat within ±1 db. Damping factor is 25:1.

Controls include volume/power switch, balance, ganged bass and treble controls, contour switch, low-cut switch, high-cut switch, tape monitor switch, and speaker-defeat switch. There is a front panel earphone receptacle, two convenience outlets, a phono input, tape amplifier input, and two auxiliary inputs. Over-all measurements are 13¼" wide x 4⅜" high x 8¾" deep. The weight is 9 pounds.

SPEAKER-BALANCING RECORD

25 **KSC Systems, Inc.** has introduced a new 7" 45 rpm record which explains how to balance high-fidelity stereo or mono speaker systems to achieve maximum performance in an actual listening environment.

All speaker controls can be adjusted by ear, with no instruments of any kind required. The record demonstrates how the size of the room, its furnishings, and speaker placement can affect performance. It also explains how to adjust or align the mid-range and treble speaker components for highest efficiency.

VOICE-ACTUATED SWITCH

26 **Kinematix, Inc.** has developed a unique accessory switch for low-cost conversion of any tape recorder to voice-actuated operation. Known as the "Voice-matic," the switch can be installed

in only a few seconds without the use of tools. With the unit installed, the tape recorder automatically starts at the sound of a voice and stops when the signal stops. The self-contained microphone has adjustable sensitivity to compensate for different noise-level conditions. In addition, a pause adjustment permits setting of the time required for the unit to respond to silence.

A full line of accessories, including a.c. accessory cord, audio adapter, contact pickup, magnetic phone pickup, phone-actuated switch, remote start-stop cable, and high-current relay, is available for use with the switch.

A colorful brochure detailing features and specifications is available.

CB-HAM-COMMUNICATIONS

MECHANICAL FILTER FOR CB

27 Collins Radio Company has recently introduced a low-cost mechanical filter for use with CB radio equipment. Priced competitively, the filter offers a needed improvement in signal-to-noise ratio and permits better communications on the overcrowded CB frequencies, according to the company.

The filter offers 6 kc. at 3 db. and 20 kc. at 60 db with electrical and mechanical stability. Complete specifications and prices will be supplied by the company on request.

MARINE RADIOTELEPHONE

28 The Bendix Corporation has added a new radiotelephone for commercial and pleasure boats to its line of marine communications equipment.

The new transmitter/receiver, designated Model 73, provides 84 watts of power on six channels. The transistorized set features an up-front speaker and incorporates new circuit designs which the company claims increases sensitivity and provides greater transmitting efficiency.

MORSE CODE TYPEWRITER

29 Computronics Engineering is now marketing the Model 400 "Codetyper," a subminiature code generator which has only 21 transistors and is self-powered by an internal "NiCad" battery supply.

For teaching code, the monitor and speaker produce 1000-cycle tone bursts. For transmitter keying, a relay contact output is provided. The speed of the unit is continuously adjustable from 5 to 55 wpm. The key action is momentary snap-action with electrical lockout during character-plus-space duration.

The keyboard's 12-bit word can be quickly reprogrammed to ASCII, CCIT, or three BCD.

PORTABLE V.H.F. AM RADIO SET

30 Aircraft Radio Corporation is marketing the "Bantam," a portable v.h.f. AM two-way radio in the 118-136 mc. frequency range.

The transistorized circuit can be operated either by standard dry cells or long-life nickel-cadmium batteries. A separate, fully automatic battery charger is available for use with the nickel-cadmium storage battery.

The radio has five controls: "off-on," volume, squelch, channel switch, and press-to-talk button on the microphone. The circuit features noise-controlled squelch. Receiver sensitivity is 0.8 μv. for 10 db signal-to-noise ratio while audio output is 250 mw. at less than 10% distortion. The transmitter r.f. output is AM, up to 1 watt. Modulation is 90% maximum. Up to 3 crystal-controlled channels are available, with channel spacing of 50 kc.

The entire unit measures 8⅝" high x 5½" wide x 2-1/16" deep and weighs approximately 4 pounds. In the carrying case the weight is 4 pounds, 10 ounces.

MANUFACTURERS' LITERATURE

TWO-WAY RADIO TRAINING

31 **Motorola Training Institute** is now making available complete information on enrollment and home study for its two-way mobile radio course.

Thirty-eight lessons are offered, including transistors, receivers, transmitters, power supplies, antennas, and servicing basic and special equipment. Nine reference textbooks are provided covering basic application of transistors, pulse techniques, test methods and practice, and vacuum-tube circuitry and operation. More than twenty technical articles are also supplied.

TOOL SETS

32 **Moody Machine Products Co., Inc.** is now offering a booklet giving complete information on their entire line of miniature tool sets. Featured is a tiny screwdriver that is ideal for use on the hinge screws of eyeglass frames.

DISTRIBUTION AMPLIFIER

33 **Entron, Inc.** is now offering a 2-page information bulletin (F-64) containing specifications and technical data on the company's Model LHD 404R high-low v.h.f. and FM distribution amplifier.

AVALANCHE RECTIFIERS

34 **Sarkes Tarzian Inc., Semiconductor Division,** has released an application bulletin (64-AB-11) explaining the operation and advantages of an avalanche rectifier. Also described is the difference between a standard rectifier and an avalanche type.

SEMICONDUCTOR CATALOGUE

35 **Hoffman Electronics Corporation** is now distributing a new 28-page illustrated catalogue covering 57 families of semiconductor products. The catalogue highlights a host of new products, including a new family of micro-miniature regulators, JEDEC-registered tunnel diodes, four families of fast-switching rectifiers, SCR's, and a family of high-reliability micro-circuits.

Each family of semiconductor products shown has between 3 and 50 members, and complete electrical specifications and ratings are provided for all devices listed.

COMPUTER NUMBERING

36 **Honeywell Inc., Electronic Data Processing Division,** has issued a 32-page programmed-instruction textbook on computer numbering systems intended to provide self-instruction in binary arithmetic, as well as introduce basic concepts of computer numbering systems for those new to computer technology.

Included with the textbook is a convenient plastic mat containing binary representation of 6-bit alphabetic characters, decimal digits, and a listing of special characters.

TV EQUIPMENT

37 **General Electric Company** is now making available information on how to obtain its completely new "Television Equipment Manual," Vol. I, a streamlined publication in loose-leaf form containing over 450 pages describing the firm's complete line of broadcast products.

Including transmitters, cameras, audio equipment, and antennas, the illustrated manual is intended for TV station managers and chief engineers. It supersedes the company's previously published "Broadcast Equipment Data Book."

NICKEL-IRON BATTERIES

38 **Exide Industrial Marketing Division** is currently offering a 27-page manual entitled "The Nickel-Iron Industrial Storage Battery," a comprehensive digest explaining the fundamental principles, operation, and care of this type of battery.

Illustrated with graphs, charts, and photographs and printed in two colors, the manual describes in detail such factors as physical construction, voltage, discharge and charging characteristics, and charging equipment and controls.

WIRE & CABLE CATALOGUE

39 **Continental Wire Corporation** is now supplying copies of a new 33-page, fully illustrated catalogue covering a wide range of power, apparatus, and control cables.

Arranged in tabular form, the booklet provides information on wire and cable for a variety of applications, including mining, soaking pits, boiler rooms, heaters, motion-picture machines, and traffic signals.

Two special sections contain background information on wire gauges and dimensions and National Electrical Code tables.

RESISTOR CATALOGUE

40 **Ward Leonard Electric Co.** is now offering a 12-page, fully illustrated catalogue (D-130) covering the company's complete line of "Vitrohm" resistors. These vitreous enamel wire-wound power resistors are available in eight basic stock types in a wide variety of sizes and resistance values.

Stock types include miniature resistors with axial leads, fixed and adjustable resistors, strip- and disc-shaped resistors, and non-inductive types.

SWITCH CATALOGUE

41 **Carling Electric, Inc.,** is currently distributing a new 28-page catalogue describing the company's complete line of toggle switches, slide and push switches, rotary switches, trigger switches, snap-in devices, and accessories. Featured is a full selection of "Tippette" (on-off) switches.

Complete with illustrations giving device dimensions, the booklet also provides electrical specifications for all units shown.

CONNECTOR WALL CHART

42 **The Thomas & Betts Company** has issued a comprehensive illustrated wall chart, T91, which shows a full line of compression connectors for use with shielded and coaxial conductors to terminate or ground the shielding.

The chart, which is printed in color, displays catalogue and ordering information on connectors covering cable diameters from .034" to .185", those designated from RG-U/6A to RG-U/316 according to MIL-C-17B. Instructions on how to install connectors and descriptions of the tools available for such work are also covered on this 18" x 23" chart.

COMPREHENSIVE WIRE CATALOGUE

43 **Columbia Wire and Supply Company** has recently released the most comprehensive catalogue ever published by the company, covering complete information and specifications on the firm's line of wire, cables, and cords. Included in this 44-page catalogue are TV wire and cables, coax, intercom and audio cables, TV service aids, rotator cables, hook-up wire, power cords and cable cord sets, and antenna wire and kits. The publication is completely indexed and cross-indexed.

SOLDER AND FLUX R&D KIT

44 **Alpha Metals, Inc.** has brought out a two-color flyer, Bulletin A-105, which gives details on the firm's new solder and flux R&D kit developed for presoldering research and development and for solving pre- and post-soldering production problems.

The kit, which contains 36 solder-chemical materials, a flux-finder guide and solder selector chart, a solder alloy chart, and special soft solder alloy diagrams, is described and fully illustrated in the bulletin.

CAPACITOR CATALOGUE

45 **JFD Electronics Corporation's Components Division** has released a new 8-page catalogue describing the company's full line of more than 165 types of "High Q" and "High K" microminiature fixed ceramic capacitors.

The "High Q" line, which mets MIL Spec MIL-C-11272B, offers 160 models covering a wide range of capacitance values from 0.5 to 10,000 pf. The "High K" line, providing the highest capacitance values per unit volume commercially available, meets MIL Spec MIL-C-11015C and is similar in construction to the "High Q" line.

Also included in the catalogue (UNM-64-2) are performance curves and a complete listing of electrical characteristics for each type of capacitor discussed.

DECIMAL EQUIVALENTS

46 **John Hassall, Inc.,** maker of cold-headed fasteners and threaded parts, has available a new edition of its product information and decimal equivalent wall chart.

The chart, which measures 16" x 23", is a quick, easy-to-read reference for engineers and designers.

MICROPHONE CATALOGUE

47 **The Turner Microphone Company** has just issued its 1965 complete-line microphone catalogue, a 16-page, 4-color publication. Included are all of the firm's microphones for every field: CB, broadcasting, amateur, professional, home recording, etc.

SWITCH/DISPLAY MATRIX

48 **Micro Switch, a division of Honeywell,** has published two brochures covering its "KB" switch/display matrix. This new modular unit permits bench assembly of an entire matrix of lighted and unlighted push-button switches, pushbars, indicators, mechanical interlock "add-on" devices, and necessary hardware for mounting and wiring. Data entry, control, and indicating elements can now be placed in the best positions and arrays without tooling or costly custom engineering since all components can be bench assembled, wired, and tested.

Form 84-711 includes comprehensive performance and application data while Form 84-737 lists products in the line along with abbreviated specs and features.

COMPONENT SELECTOR

49 **Cornell-Dubilier Electronics** has recently introduced a new concept in marketing, based on standardization of electronic components. The new program is designed to reduce to 7784 the 40,000 items now catalogued by the company, permit 90% of orders to be filled off-the-shelf, and minimize special-order runs.

In connection with this changeover, the company has just issued a new component selector, a 128-page, fully illustrated catalogue covering all of the items immediately available from stock.

NEW KIT CATALOGUE

50 **Heath Company** has published Catalogue Supplement 800/53, a 48-page booklet crammed with information on the firm's extensive line of electronic kits. The line includes CB radio gear, general products, automotive equipment, marine gear, stereo/hi-fi, ham radio, educational kits, and test instruments.

SEMICONDUCTOR REPLACEMENT

General Electric Company's Electronic Components Sales Operation has recently published the fifth edition of its popular 10-page, illustrated, 2-color "Entertainment Semiconductors Replacement Guide and Catalog."

Covering the firm's complete line of transistors, rectifiers, dual diodes, crystal diodes, and color-TV rectifiers, the guide also provides a handy 5-page fold-out chart listing JEDEC type of part numbers and their corresponding G-E replacements.

Copies of the booklet (Pub. No. ETR-2982D) are available only through the company's local electronic-components distributors. ▲

ELECTRONICS MARKET PLACE

COMMERCIAL RATE: For firms or individuals offering commercial products or services. 60¢ per word (including name and address). Minimum order $6.00. Payment must accompany copy except when ads are placed by accredited advertising agencies. Frequency discount: 5% for 6 months; 10% for 12 months paid in advance.
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DIAGRAMS for repairing Radios $1.00. Television $2.50. Give make model. Diagram Service, Box 1151 E, Manchester, Connecticut 06042.

INVESTIGATORS, free brochure, latest subminiature electronic surveillance equipment. Ace Electronics, 11500-J NW 7th Ave., Miami 50, Fla.

CANADIANS—Giant Surplus Bargain Packed Catalogs. Electronics. Hi-Fi, Shortwave, Amateur, Citizens Radio. Rush $1.00 (Refunded). ETCO. Dept. Z, 464 McGill, Montreal, Canada.

RESISTORS precision carbon-deposit. Guaranteed 1% accuracy, ½ watt 8¢. 1 watt 12¢. 2 watt 15¢. Rock Distributing Co., 902 Corwin Road, Rochester 10, N.Y.

INVESTIGATORS—Electronic surveillance devices. Price breakthrough on ultra miniature professional devices. Free details. Trol Electronics-EW, 342 Madison Avenue, New York, N.Y.

KOMTRON introduces a complete selection of digital circuits, starting with a $3.87 10,000 pps reset-set flip-flop. Send for detailed specifications on all circuits. Box 275, Little Falls, New Jersey 07424.

NEW supersensitive transistor locators detect buried gold, silver, coins. Kits, assembled models. $19.95 up. Underwater models available. Free catalog. Relco-A22, Box 10563, Houston 18, Texas.

JAPAN & Hong Kong Electronics Directory. Products, components, supplies. 50 firms—just $1.00. Ippano Kaisha Ltd., Box 6266, Spokane, Washington 99207.

TV CAMERAS, transmitters, converters, etc. Lowest factory prices. Catalog 10¢. Vanguard, 190-48 99th Ave.. Hollis, N.Y. 11423.

WEBBER Labs. Transistorized converter kit $5.00. Two models using car radio 30-50Mc or 100-200Mc, one Mc spread. Easily constructed. Webber, 40 Morris, Lynn, Mass.

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BUILD TV Camera Cheaper Than Ever! Send 10¢ for details. ATV Research, Box 396, South Sioux City, Nebr. 68776.

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TRANSISTORS—Miniature Electronic Parts. Send for Free Catalog. Electronic Control Design Company, P. O. Box 1432M, Plainfield, N.J.

TRANSISTOR Ignition Coils 400:1 Special $3.95. Two Delco Transistor Cascade Amplifier (15 Amp) in Anodized aluminum Heatsink. Below Parts Cost at $5.95. 4/10-6/10 80 Watt Ballast Resistors, 69 Cents, 6-10 Volt 20 Amp load Relay with fuse, 99 cents. Complete Kit for 6-12 Volt Negative Ground, $9.95 postpaid. Orders under $5.00 Add 50 cents postage. Closeout, all new merchandise, supply limited. Electronic Liquidators, Box 1946, Grand Junction, Colorado.

DETECTIVES! Free Brochures! Electronic intelligence devices for your needs and budget. **SILMAR ELECTRONICS,** 3476 N.W. 7th Street, Miami, Fla. 33125.

AUTO Reverberation Units Wholesale. Signal Systems, 31160 Eight Mile, Farmington, Mich. 48024.

RESISTORS. Newest type Metal-Film, Copper Circuit Board, Capacitors, Terminal Blocks, Free Catalog. Farnsworth Electronic Components, 88 Berkeley, Rochester, New York 14607.

FREE catalog: Wholesale electronic parts and equipment. Royal, Box 2591, El Cajon, Calif.

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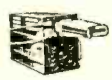
LORAN R-65/APN-9 RECEIVER & INDICATOR



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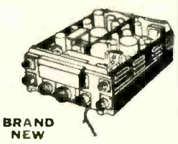

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350	2.30	3.05	—	—	—
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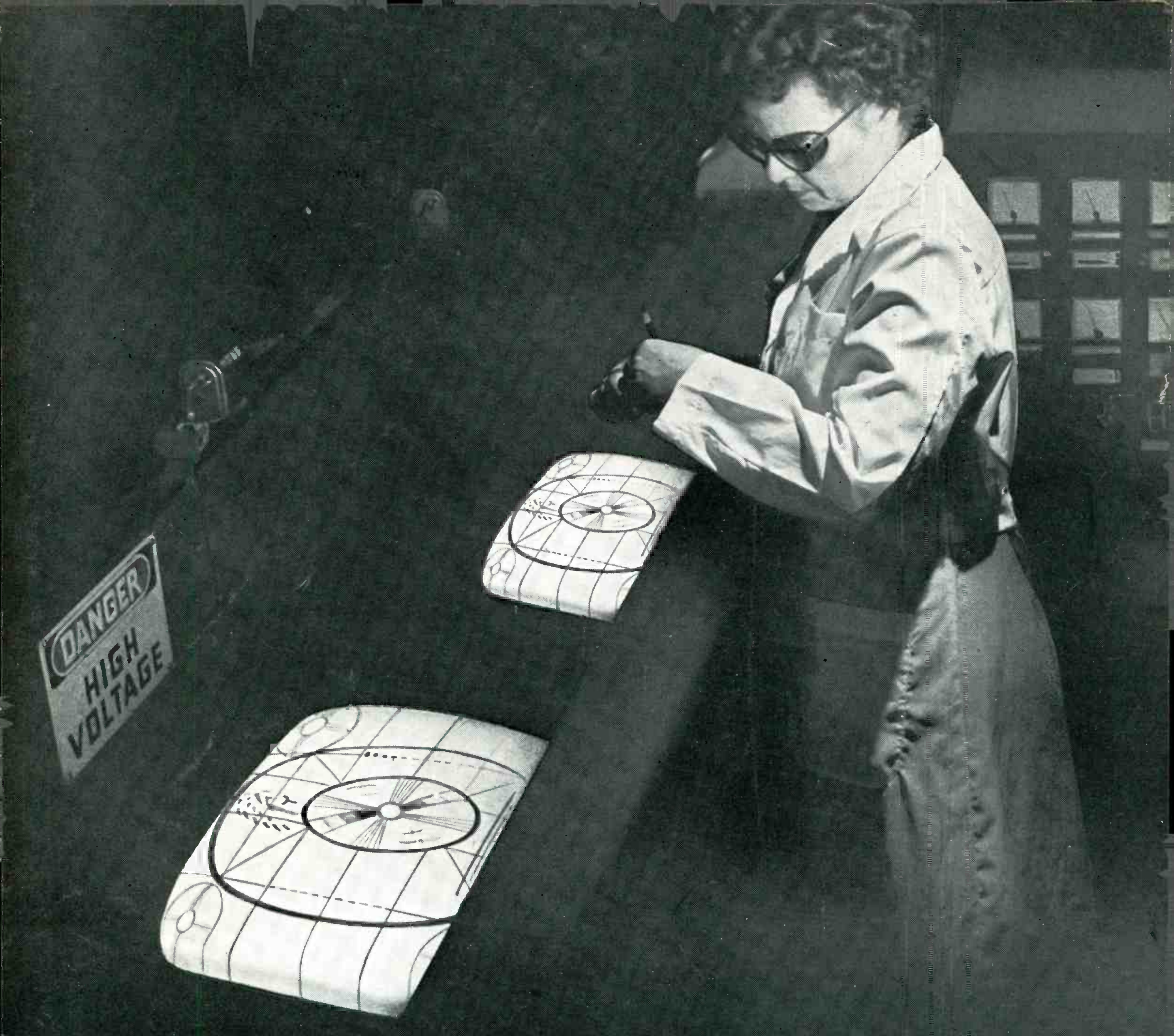

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