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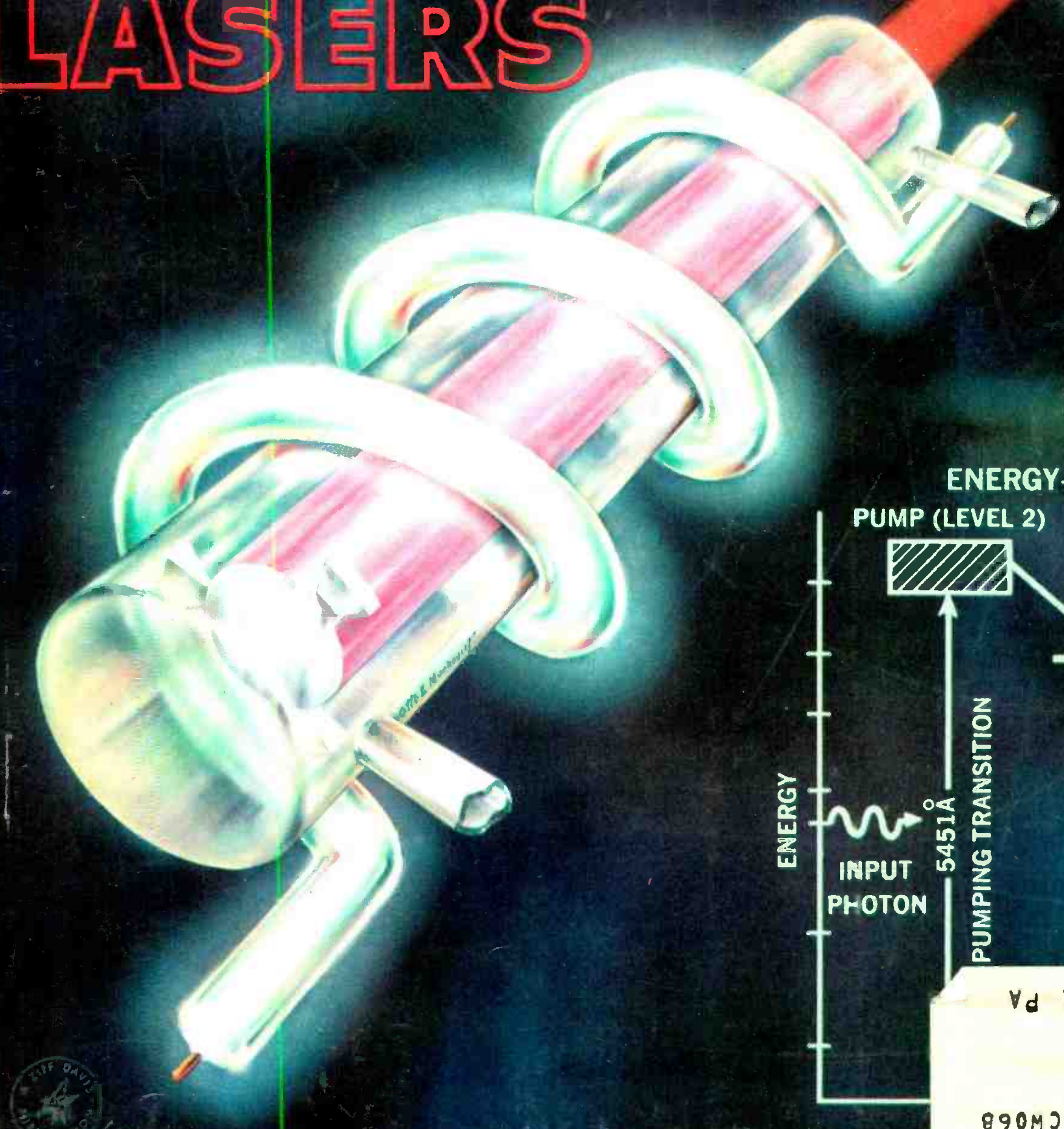

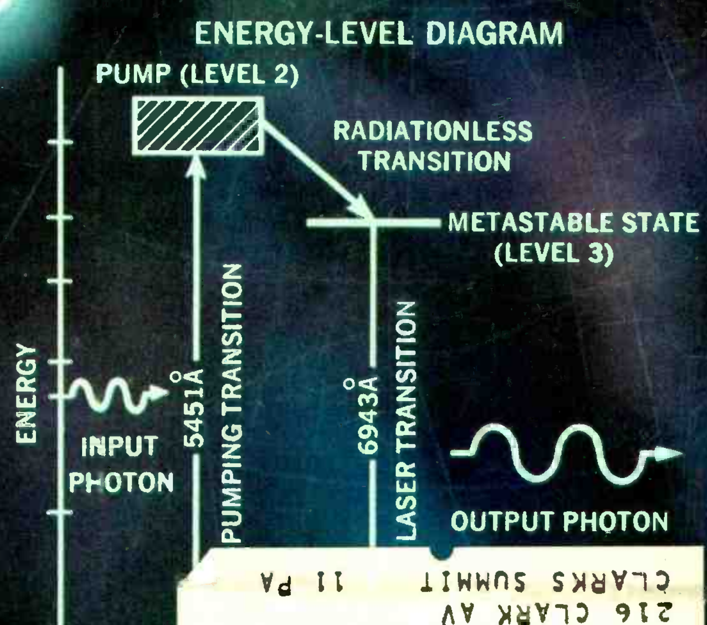

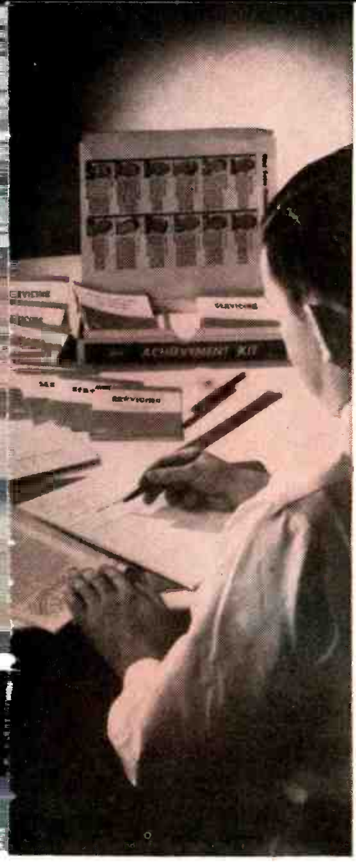

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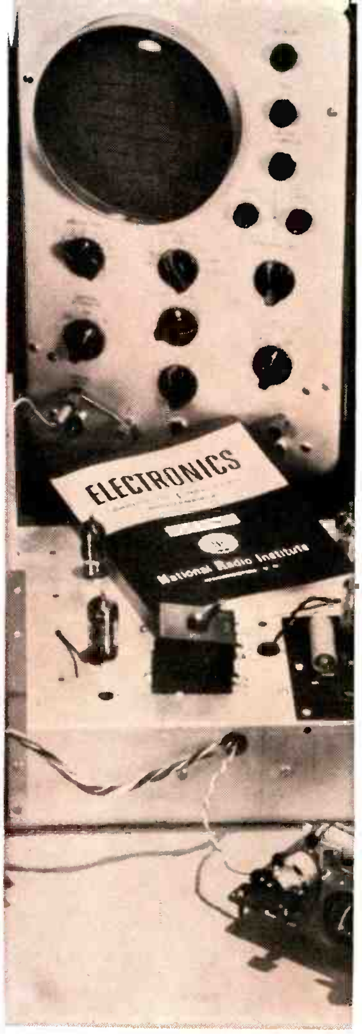

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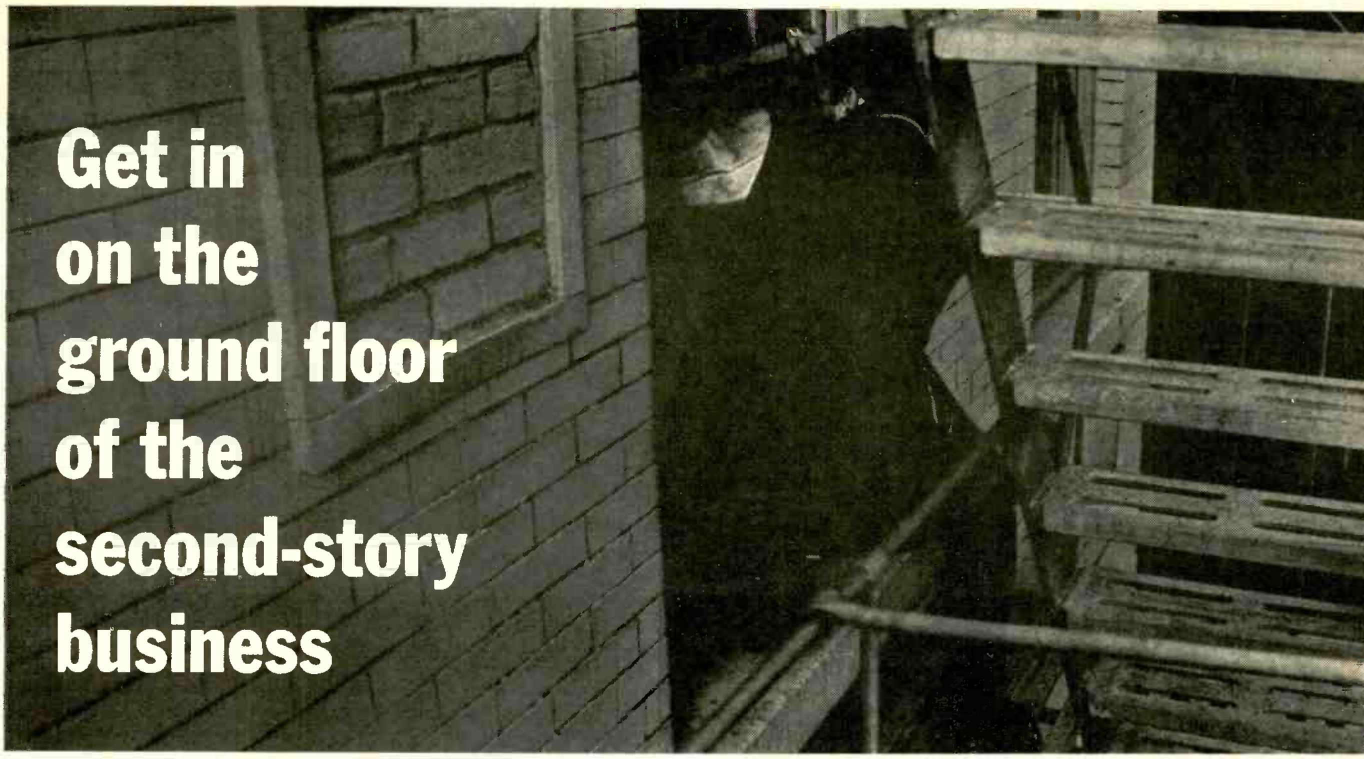

Every 40 seconds a burglary takes place in the United States.

TECHNICAL INFORMATION

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

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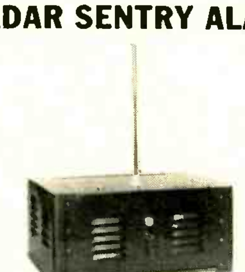

Mail to: RADAR DEVICES MANUFACTURING CORP.
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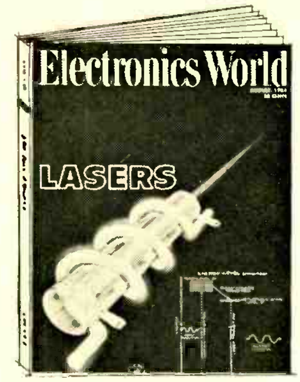
Electronics World

AUGUST 1965
VOL. 74, No. 2

CONTENTS

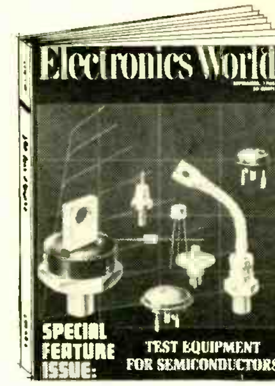
MONTHLY FEATURES



OUR COVER is a somewhat simplified representation of a ruby laser along with its energy-level diagram. The ruby rod is surrounded by a chamber through which coolant flows. Surrounding the entire assembly is a flash tube that supplies the high-intensity pumping light required for laser operation. An intense beam of coherent light emerges from the partially silvered end of the ruby rod. For details on the operating principles of this and other laser types, refer to our story on page 31. This is the first of a three-part group of articles on lasers... (Illustration: Otto Markevics.)

COMING NEXT MONTH

SPECIAL FEATURE ISSUE



TEST EQUIPMENT FOR SEMICONDUCTORS—This issue will carry five articles of vital interest to all those who work with semiconductors. Not only will there be a comprehensive directory of companies making specialized test equipment but also a valuable glossary of the important semiconductor parameters and what each means. In addition, Ralph Show of Tektronix will explain how the curve tracer can be used to obtain characteristic curves, determine parameters and breakdown voltages, etc. for semiconductors, with emphasis on practical aspects of making measurements. Carl David Todd discusses Testing Semiconductors with V.O.M. or V.T.V.M. A. H. Seidman presents a survey of circuits found in commercial units in his article Testers for Semiconductor Devices. A variety of such instruments is covered along with an analysis of operation, accuracy, and special features.

MAGNETIC REED SWITCHES & RELAYS

The unique properties of these fairly new components make them ideal for a wide variety of electronic applications. Gary A. Lehmann outlines their application in such devices as tach pickups, proximity switches, d.c. choppers.

THE OPTICAL LINK

A light source, coupled to a photosensitive device in an opaque enclosure becomes an "optical link". This useful device is commercially available with frequency response from d.c. to 10 mc. and power control capabilities from a few milliwatts to 100 watts. Donald Lancaster explains the operation and applications.

IMPROVED SWITCHING OF INDUCTIVE LOADS

Switching element life and reliability can be greatly increased by protecting relay contacts and semiconductor drivers from high-frequency transients produced by inductive loads.

LASER PRACTICE & APPLICATIONS

An explanation of injection laser operation, pumping power-supply circuits, and the modulation and demodulation of the laser beam. Various applications are covered.

*All these and many more interesting and informative articles will be yours in the SEPTEMBER issue of ELECTRONICS WORLD . . . **on sale August 21st.***

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For the record

WM. A. STOCKLIN, EDITOR

LASER PRECAUTIONS

IN view of our present cover and feature story on the subject of lasers, it seems appropriate to point out a few important facts at this time. (1) There is no such thing as a low-powered, harmless laser and (2) it is very easy for a human or animal to be permanently blinded, painlessly, within a fraction of a second.

Since the advent of the laser many engineers and technicians have been projecting laser beams around the countryside in an attempt to cover distances for various research purposes. We have seen demonstrations of the power of the laser to burn holes in metal objects. At the same time, a few publications have carried do-it-yourself laser construction articles directed to students for their science-fair projects.

Although knowledgeable people take the proper precautions when operating these dangerous beams, they are however, in the hands of the inexperienced, as hazardous as a loaded, cocked rifle in the hands of a novice.

According to C. H. Swope and Dr. C. J. Koester of the *American Optical Company*, the very property of a laser which makes it so useful as a surgical tool for the eye also makes it a hazard to vision. Laser radiation impinging on the retina—the light-sensitive membrane at the back of the eye—can either heal or impair eyesight by precisely the same process: coagulation of the retina.

The great virtue of laser retinal coagulation as a surgical technique is that it occurs so quickly the patient feels absolutely no pain. As there is no essential difference between a medical laser and the types used in various electronic experiments, the same instantaneous effect can accidentally occur, possibly causing damage before the victim becomes aware of the danger.

If all the energy in a ruby laser with an output of one joule in a ½-degree beamspread entered the eye, it would produce an energy density over 10,000 times that needed to produce coagulation. If this laser pulse lasted only half a *millisecond*, it would produce 47,000 times the energy on the retina that the sun would produce in the same time interval.

It is not even necessary to look at the laser to produce permanent eye damage. Like other forms of light, the intense beam can be reflected from many types of surfaces with sufficient intensity to produce the unfelt eye damage. This is the problem in carelessly using the laser to burn holes in razor blades . . . or in unthinkingly beaming lasers over considerable distances.

Like an intensely focused beam of sunlight, a high-power laser can produce a burn on the skin. (The relatively low-power c.w. laser does not have this capability at the moment, but its output power is being increased steadily.) The result is much like a sunburn with no apparent serious permanent effects but medical researchers are still not sure of the long-range effects. There is the possibility, although not yet proven, that even a low-power laser beam may, after a period of time, cause some damage to the skin, internal organs, or even bone marrow.

We are all aware that the automobile kills more people in a day than the buggy did in years. Yet this does not discourage continued development of higher powered vehicles. Similarly, the above warning is not meant to discourage continued development work and experimentation on lasers, nor for that matter restrict the sale of laser devices or equipment.

To educators, teachers, scientists, and engineers who have the responsibility of directing science programs or laboratory experimental work in laser techniques—make sure all of your students, your co-workers, and you are aware of the potential dangers and take the proper precautions.

A few cardinal rules that should be followed are:

1. Never look into a laser beam, either direct or reflected.
2. Wear special laser eye protective glasses or goggles.
3. Contain the laser beam as much as possible by using a light trap.
4. Avoid the use of reflecting surfaces.
5. Be examined periodically by an ophthalmologist trained in photocoagulation.

Remember: Laser blindness is *permanent*. ▲

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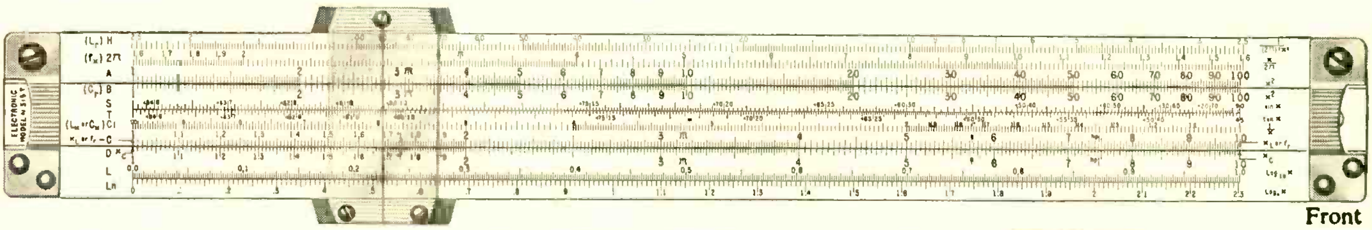
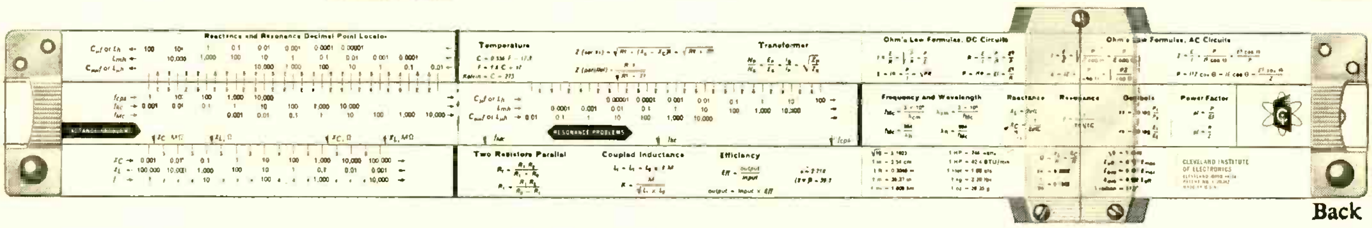


Front



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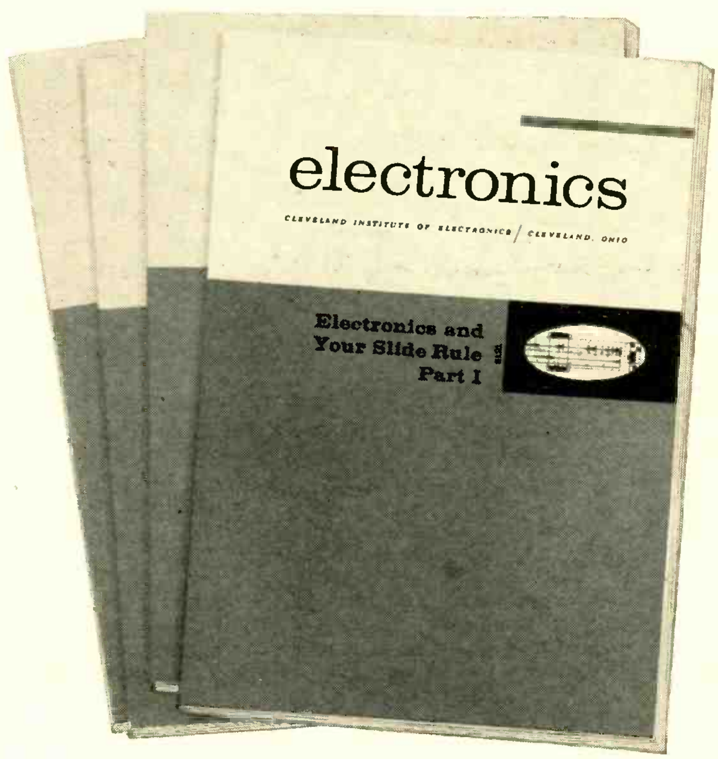

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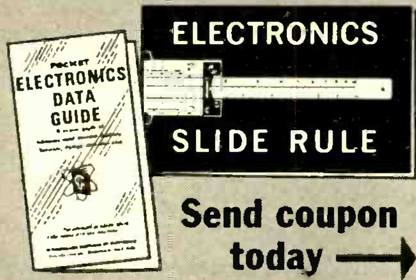

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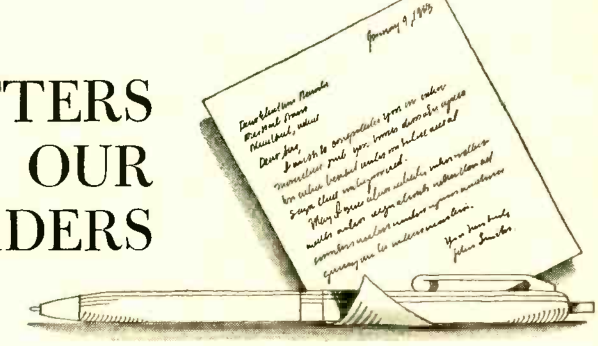

LIFE OF VIDEO TAPE

To the Editors:

I have been asked to respond to your readers' questions about the longevity or permanence of video recording. This is a question which is obviously asked quite often by many of our customers and potential customers.

As far as we can tell, a video recording is as permanent as an audio recording, provided that the tape is not subjected to any extremes of heat or unusual environments. We have in our files video tapes which have been stored for six or seven years and have not been handled in any special way. In other words, they have been through temperature cycling common for this part of the world and we have yet to detect any change in the replay characteristics of these tapes whenever we take them out for review. These tapes include such memorable events as early television shows done on tape, as well as the Nixon-Khrushchev debate made in Moscow and programs obtained in other parts of the world. The networks themselves are storing tens of thousands of hours of programming on video tape, and I occasionally see re-runs of programs which I know to be on tapes that were originally recorded four of five years ago. This is especially true around the holiday season.

From time to time, *Ampex* participates in international trade fairs to which we send pre-recorded American programs which we have obtained from *NBC* or *CBS*, and these tapes run for weeks on end in places like Brazil or Yugoslavia under poor climatic conditions. These tapes have been returned to us after much usage, and other than the wear caused by multiple passage through the machine and the subsequent degradation of signal-to-noise ratio caused on the tape surface, there appears to be no other defect, certainly nothing that we would attribute to aging.

Video-tape recording has only been around for some eight years, which means that our viewpoint on longevity is an extrapolation of a limited amount of experience. However, audio recording has been around since 1946, and I am told by people who handle our tapes that the backing material is a greater problem than the retentivity of signal on the oxide. Apparently acetate will age, become brittle, and break easily. Since, to the best of my knowledge, our video tapes use Mylar as a backing, this is a reasonably impervious material. There should be no problem retaining a magnetically recorded program for an indefinite period of time.

JOSEPH ROIZEN
Ampex Corp.
Redwood City, Calif.

* * *

ELECTRONIC INTRUSION ALARMS

To the Editors:

In reply to the many letters I have received on my article "Electronic Intrusion Alarms" (June issue), listed below are the addresses of the firms mentioned in the article.

Bay State-Intrudalarm
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Albertson, N.Y.

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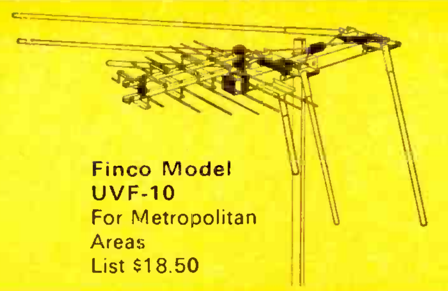
* * *

SCR IGNITION SYSTEM

To the Editors:

After some use, I have experienced some difficulty with my SCR ignition system modification for positive-ground autos as seen on p. 70 of the May issue, as well as with the original circuit (November, 1964 issue).

I found that the systems would work for anywhere from 15 minutes to several hours of driving time, whereupon the car would miss for a minute or two and then quit altogether. The cause of this failure was always found to be a triggering transistor with a shorted base-emitter



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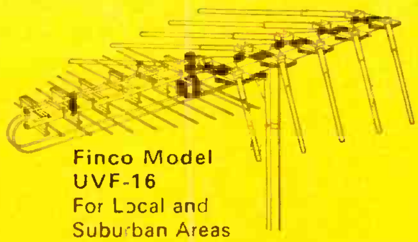

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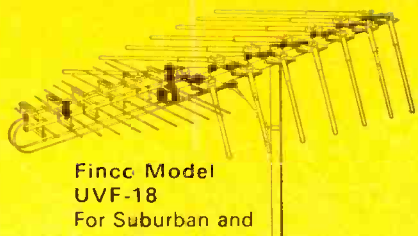

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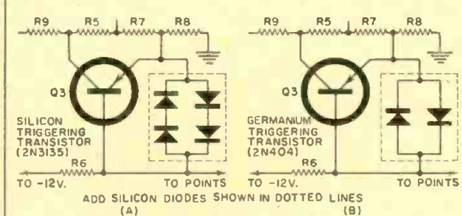
junction. I discovered that pulses of very short duration and very high voltage appeared between the base and emitter of this transistor. I believe that these spikes were capacitively or inductively picked up between the wires from the SCR system to the points and the ignition coil. (These wires are cabled together and are about four feet long.)

To prevent this effect, insert silicon diodes between the base and the emitter of the triggering transistor. If a silicon transistor is used, four diodes are needed, while only two diodes are required for a germanium transistor (see diagrams).



The diodes may be any small silicon units. There is very little power to be dissipated by them, and they serve to keep the peak voltage between the transistor base and emitter limited to the forward drop of the diodes in either direction (about 1 volt). Any silicon diode will work; if you have none handy, 1N1692 diodes may be used.

William Sturgeon, Staff Engr.
Physics Dept., UCLA
Beverly Hills, Calif.

* * *

SINAD?

To the Editors:

The article "Transistors vs Tubes for Two-Way Radio" in one of your issues did an excellent job in comparing the two types of equipment. However, in the table of receiver specifications in the story, the word or abbreviation "SINAD" appeared next to the sensitivity figure. What is it? It sounds as though it came out of the "Arabian Nights."

Walt Steiner
Poughkeepsie, N.Y.

SINAD is an Electronics Industries Association standard method of measuring receiver sensitivity and it is widely used for two-way radio equipment. In taking this measurement, a 1000-cps input signal adjusted for ⅔ the maximum deviation is applied to the receiver input. The ratio between this SIgnal plus Noise And Distortion divided by the noise and distortion alone is adjusted to 12 db (4:1 voltage ratio). This signal must produce fifty percent of the rated output of the receiver being tested. If it does not, the signal is increased until the fifty percent output level is reached. The number of microvolts applied under these conditions is referred to as the "usable sensitivity," the "12-db SINAD sensitivity," or the "EIA-SINAD sensitivity."—Editors. ▲

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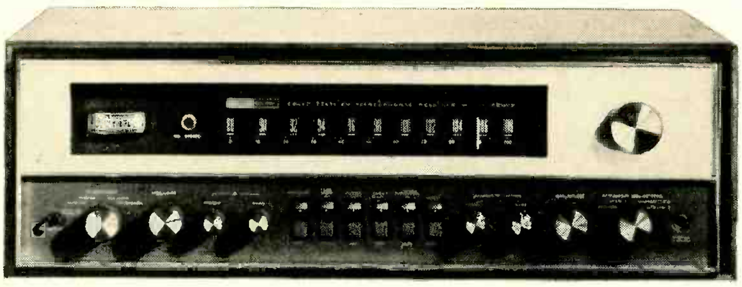
KLH Model 17 Speaker System

Harman-Kardon "Strataphonic" Stereo Receivers

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



THE new *Harman-Kardon* "Strataphonic" series of stereo receivers are fully solid-state instruments, spanning a broad price range. They have many features in common, the more expensive models naturally being more sensitive, more powerful, and having various circuit and operating refinements.

The three receivers in this series are the SR300, SR600, and the SR900 (shown in photo). Each has a grounded-base tuned r.f. amplifier, but the SR900 has two tuned circuits ahead of the amplifier stage. This gives it an improvement of about 30 db in image rejection, as well as a reduction of out-of-band spurious responses and less tendency to cross-modulation from strong local stations.

The mixer of the SR300 is a self-oscillating ("autodyne") type. The other receivers have separate oscillator and mixer stages. All these have zener-diode-regulated power supplies for the oscillator to eliminate drift with line voltage variation.

The receivers have identical i.f. sections, with four stages of amplification and four double-tuned i.f. transformers for a high degree of selectivity. All three have a diode detector driven from one of the i.f. amplifiers to operate the tuning meter. Ratio detectors are used in all three models.

The multiplex demodulators of all the "Strataphonic" receivers are essentially identical. The 19-kc. pilot carrier is filtered from the composite detected signal, amplified, and doubled to generate the 38-kc. demodulating carrier. The 38-kc. signal is stepped up in voltage by a high-"*Q*" tuned circuit to light a neon indicator lamp when receiving stereo broadcasts.

The four-diode balanced modulator is gated by the 38-kc. signal to generate left- and right-channel outputs. When a mono FM signal is received, it is passed through the modulator without modification. The de-emphasis networks in the SR300 incorporate parallel-T filters to reduce any 38-kc. signal in the outputs, preventing beats with the bias oscillator in a tape recorder when recording off the air. The SR600 and SR900 use the feedback circuits of the phono preamplifiers for de-emphasis, with *LC* filters built into these circuits for trapping out 38-kc. components. All three receivers have SCA filters, to remove higher frequency subcarriers which might interfere with FM-stereo reception.

The audio sections of the three receivers are basically similar. A two-stage feedback-equalized preamplifier for magnetic phono cartridge (and tape head in the case of the SR600 and SR900) is followed by a feedback tone-control stage, a voltage amplifier, and a driver which is transformer-coupled to the single-ended push-pull output stage.

The SR600 and SR900 have separate bass and treble tone controls for the two channels. A switch on the panel completely bypasses the tone-control circuits, for flattest response and minimum phase shift. This is a feature which was first offered in the deluxe *Harman-Kardon* "Citation" series of components. The SR300 has ganged tone controls for the two channels which are always in the circuit. All the tone controls have similar electrical characteristics, with a boost of up to 9 or 10 db at 50 cps and 10 kc., and a cut of 7 to 9 db at the same frequencies.

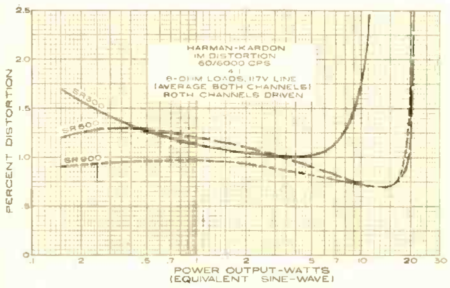
All three receivers have ganged volume controls and a separate balance control. The tracking between the sections of the volume controls was good over their entire usable range. They have individually switched high- and low-cut filters which cut the output by 6 db at 10 kc. and 10 db at 50 cps. The switchable loudness compensation boosts the low frequencies at low volume-control settings. Tape monitoring provisions are included in the SR600 and SR900. The SR300 has tape output jacks, but no means of monitoring from the tape while making a recording. The SR600 and SR900 also have an equalized high-level phono input for ceramic cartridges, while the SR300 accepts only magnetic phono cartridges.

The output transistors are directly coupled to the speakers, through protective fuses. Loads of 4 to 16 ohms may be used, with rated power being developed into 4-ohm loads.

The output transistors of the SR600 and SR900 are identical and are rated for higher power than those used in the SR300. The SR900 has diode stabilization of the output transistor operating points, allowing more power to be developed without damage to the transistors. On the SR600 and SR900, the output transistors are mounted on the outside of the rear of the chassis for improved heat dissipation.

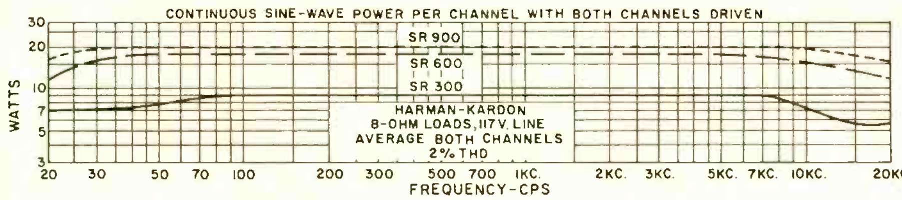
All three receivers have silicon diode power-supply rectifiers, supplying seven different operating voltages to the various stages. An illuminated push-button power switch is used on the SR600 and SR900, while the SR300 has a conventional switch operated by the volume-control knob.

In addition to the differences just noted, the SR900 has a switchable mut-



ings. To the extent that the amplifiers are constant-voltage sources, one would expect them to deliver twice as much power into 4 ohms as into 8 ohms, and the music power might be 20% or more greater than continuous-power output.

At 2% IM distortion, the SR300 delivered about 11 watts per channel, and the SR600 and SR900 delivered about 20 to 21 watts. At 2% harmonic distortion (1000 cps), the SR300 delivered 9 watts, the SR600 18 watts, and the SR900 20 watts per channel. All three delivered nearly constant power over the entire 20 to 20,000-cps range.



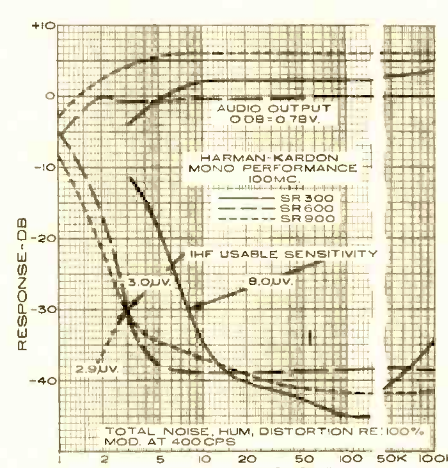
ing circuit which senses the rectified voltage used to operate the tuning meter and grounds the detector output electronically until the signal level is above the selected threshold. It also has a selectable stereo threshold which can be set to prevent the automatic mono/stereo selecting circuits from operating on weak stereo signals which cannot produce satisfactory listening quality. The SR600 and SR900 have front-panel switching for operating either or both of two pairs of stereo speakers, plus a front-panel stereo headphone jack. The SR300 has only one pair of speaker outputs and no headphone jack.

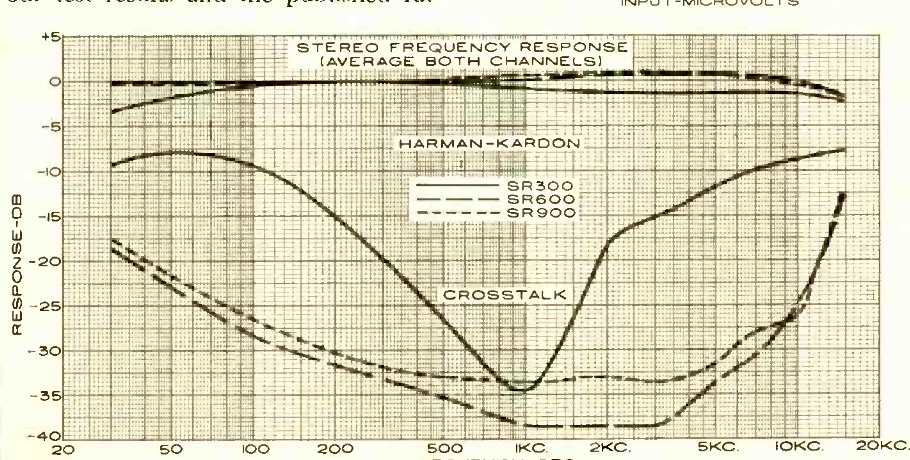
In styling the SR600 and SR900 are almost identical. They are handsomely finished, with a brushed aluminum dial bezel, a brown panel, and brown and gold knobs. The only other visible difference between them is in the use of slide switches on the SR600 and rocker-type switches in the SR900. The SR300 is smaller and plainer, having a flat panel instead of a contoured bezel. In other respects it is unmistakably a member of the same family.

Our measurements of power output were made on a continuous basis, with both channels driven into 8-ohm loads. Since the receivers are rated in terms of music-power output into 4-ohm loads, there is no simple correlation between our test results and the published ratings.

The hum levels of these receivers are low, in fact, inaudible. On "Aux" inputs the hum and noise was from 73 to 77 db below 10 watts, while on "Phono" inputs they were about −46 db in the case of the SR600 and SR900 and −62 db for the SR300. These outputs were predominantly hiss. The filters and tone controls had the stated characteristics. Frequency response was almost perfectly flat on the SR600 and SR900, and

(*Continued on page* 66)





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SPECIAL ENDORSEMENT: SHIP RADAR ENDORSEMENT - SEPTEMBER 11, 1963 - BUFFALO, NEW YORK

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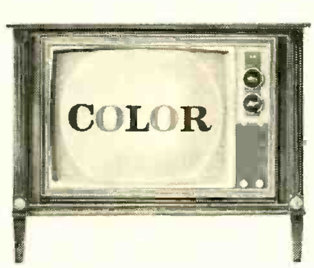

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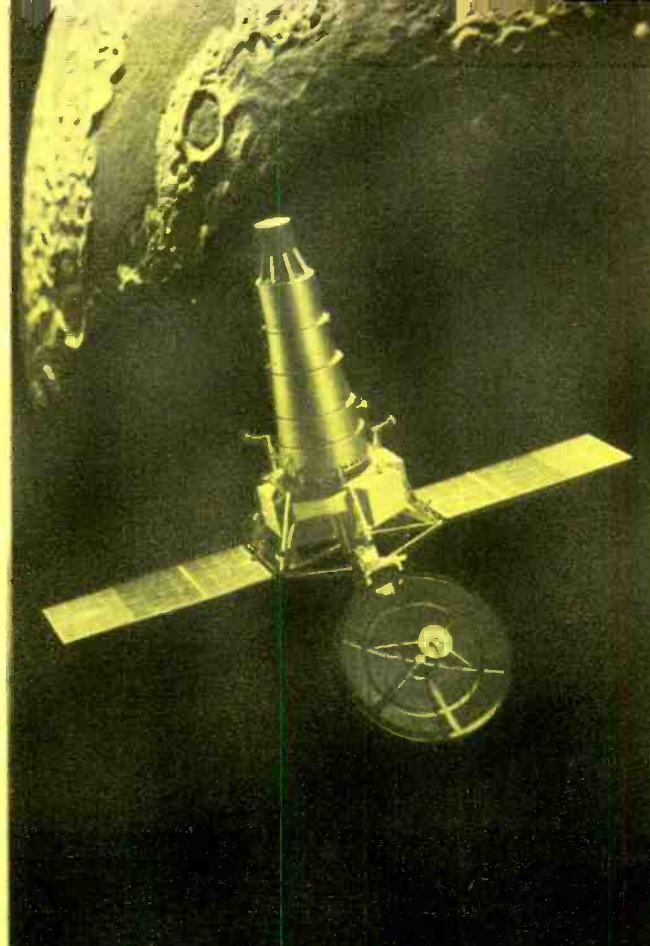
Three Ranger spacecraft, each using six television cameras operating in the slow-scan mode, have successfully taken the first close-up pictures of the lunar surface. These shots will be followed by Lunar Orbiter, Surveyor, and then manned landing by two astronauts from the Project Apollo spacecraft.



TELEVISION IN SPACE

By LESLIE SOLOMON
Associate Editor

Of the 35 TV cameras sent into space, some use slow-scan, some use digital techniques, and one uses a unique line-by-line scan from processed photographs. The Mariner Mars, Ranger, Lunar Orbiter, and Apollo spacecraft are covered.

THE first use of a TV camera in space took place on April 1, 1960 aboard the Tiros I weather satellite. This spacecraft carried two TV cameras into a 400 mile high orbit to photograph weather conditions around the world. Since then, thirty-three more TV cameras have been successfully launched into space on eight more Tiros vehicles, Nimbus I, the Ranger lunar spacecraft, and the Mariner Mars, now approaching the red planet.

There are many variations in the type of TV system used in these spacecraft, and this article will cover the digital system in the Mariner Mars, the slow scan in the Ranger program, and the one-line scan in the Lunar Orbiter. Some of the other programs will be briefly covered.

Mariner Mars

At 5:10 p.m. PST on July 14, 1965, after a flight of some 350 million miles taking about 7½ months, the 575-pound Mariner Mars spacecraft (Fig. 1) will take about 20 photographs of the red planet and, after passing by at slightly above 11,000 mph relative to Mars, will radio those photos back to earth.

The spacecraft is designed to make eight scientific investigations. Six of these are intended to measure radiation, magnetic fields, and micrometeorites in interplanetary space and near Mars. The seventh is an occultation experiment designed to determine the characteristics of the Martian atmosphere. The eighth experiment, the taking and transmission of photographs of the Martian surface, will be covered here.

The resolution of the TV pictures of Mars and the area of the planet they will cover are difficult to predict because these factors will depend on the fly-by distance from the planet. However, if planned trajectories are achieved, these pictures should be comparable in detail to photographs of the moon taken by the best earth-based cameras.

If the desired accuracies are obtained, the spacecraft will pass within 5600 miles of the Martian surface; if it is on the desired trajectory, the spacecraft will pass Mars between the Martian equator and the South Pole on the trailing edge of the planet as viewed from earth. It will then pass behind Mars for approximately one hour and subsequently re-appear to earth trackers for completion of the program.

A high-gain antenna is attached to the spacecraft atop the main octagonal body. Its 4½-pound honeycomb dish reflector is an ellipse, 46 by 21 inches, parabolic in cross-section. This antenna is pointed towards the earth during planet encounter and post-encounter phases, and it is painted green to keep it at operating temperature during planet encounter but within its upper thermal limit earlier in the mission.

A low-gain omnidirectional antenna is mounted at the end of a circular aluminum tube 3.88 inches in diameter and extending 88 inches from the top of the octagonal structure. The tube acts as a waveguide for the low-gain antenna.

Primary power is from 28,224 solar cells mounted on four panels facing the sun. A rechargeable silver-zinc battery provides spacecraft power during launch, mid-course maneuver, and whenever the solar paddles are turned away from the sun. Nominal power from the panels is 640 watts near the earth, decreasing to about 310 watts during Mars post-encounter. Total power demands during the mission range from about 140 watts during post-encounter playback of the TV data to 255 watts for a mid-course maneuver. Primary power to the spacecraft TV system is 2400 cps, 50 v.r.m.s.

Two-way communication with the Mariner is by a dual 10-watt transmitter and a single receiver aboard the spacecraft. All communication is in digital form with the spacecraft capable of accepting 29 direct commands (from the earth-based 10-kw. transmitters) and one stored command.

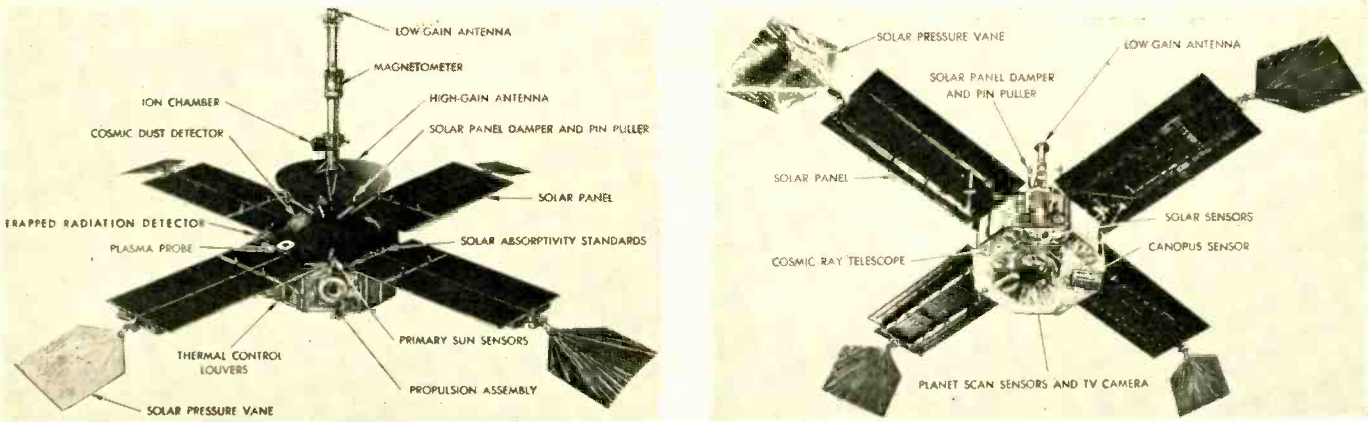


Fig. 1. Two views of the Mariner Mars spacecraft now headed past Mars and expected to take and transmit photographs.

The 100-channel telemetry subsystem is capable of sampling the 90 engineering and science measurements being made. All engineering and science data except the TV pictures will be transmitted in real time. The science data at Mars encounter will also be recorded, along with the tape-recorded pictures, for retransmission with the photos.

Television

The television system is divided into two portions: the slow-scan camera head and a small segment of the electronics mounted on a scan platform; and the remainder of the electronic equipment, including the tape recorder is placed in a compartment within the spacecraft frame. The basic TV system is shown in Fig. 2.

The heart of the camera is an electrostatic vidicon with a specially developed target surface having 200 scanned lines with 200 picture elements per line and capable of storing the image for 24 seconds.

A picture is formed on the vidicon target in ⅕ of a second every 48 seconds. The scanning, or readout, of the 200-line picture requires 24 seconds while image erasure and preparation for the next picture takes 24 seconds.

Working in conjunction with this vidicon is a solenoid-operated shutter disc containing four openings for alternating optical filters. Two filters will be orange-red with the other two blue-green. These filters will provide high contrast in the black-and-white photographs received on earth and will emphasize the difference in Martian coloration as seen from earth.

The optical system for the camera consists of an f:8 Cassegranian telescope system of 12-inch equivalent focal length. Its beryllium primary mirror has a diameter of 1.62 inches and an f ratio of 2.47, while a beryllium secondary mirror provides an amplification of 3.0.

The over-all camera system will be capable of resolving objects about three miles across at the fly-by altitude.

Approximately six hours before the fly-by, internal commands (or earth-based signals) will turn the camera system on. However, pictures will not be recorded until a narrow-angle planet-acquisition gate having a 1.5° field of view generates a signal indicating that Mars is within camera range. As a backstop, when the vidicon senses the increase in light due to solar reflection from the Martian surface, this gate also signals for tape-recorder start.

It is anticipated that the camera system will sweep through a large illumination range on Mars that will include the shadow line or terminator; therefore, the system is equipped to decrease or increase its internal amplification with either an increase or decrease in the amount of available light.

Some 20 resultant photographs will be taken during the fly-by. The signals for these images will be recorded and stored in digital form on magnetic tape until the earth station requests transmission after the spacecraft has appeared from behind Mars and is in view of the earth antennas. These photographs will be taken in groups of two with a small time gap between each pair. Depending on camera distance from the surface, each pair will cover overlapping areas of the Martian surface. The number of pictures recorded will be determined by the time required at encounter to synchronize the tape recorder and camera for the first picture and by the lighting conditions on the Martian surface. The tape recorder will be turned off after recording each picture and turned on again to record the next. The magnetic tape is a continuous loop 330 ft. long and the data will be recorded on two tracks.

Besides the sweep voltages, the electronics associated with the vidicon also includes a 110-kc. oscillator that modulates the vidicon beam, thus giving rise to an r.f. carrier signal output modulated by the target information between d.c. and 7 kc. This AM signal is processed to produce a six-bit digital word for each picture element some 200 times per scanned horizontal line, and it takes 24 seconds to read out each frame. The resulting 10,000-bits-per-second information is recorded on the magnetic tape.

Upon completion of a vidicon readout, a 12-second erase and prime mode is started, and the target is fully cleansed of the stored image and prepared for the next shot.

Once the spacecraft has passed by Mars (about 13 to 15 hours after the last picture is taken) and the spacecraft is in the clear for the earth stations, a tape-recorder transmit signal is sent. Because of the lengthy transmission path involved and the relatively low transmitter power available on the spacecraft, the electronic system reduces the 10,000-bits-per-second recorded video data to a slow 8.33-bits-per-second rate. With this slow transmission rate, it will take about 8⅓ hours to play back the quarter of a million bits comprising each picture. About 1½ hours of engineering data will be transmitted between each picture. All data from the other scientific instruments will be recorded with the pictures as a back-up for the real-time transmission of science data. Pictures are not erased after transmission.

If the communication distance has not been exceeded after one playback of all pictures, each frame will be transmitted again to provide a comparison for the detection of errors that may crop up during transmission.

Ranger

There has been a great deal of speculation about the texture of the surface of the moon but little scientific proof because astronomical observations are limited to details about one mile in size. With such restricted knowledge about the moon's surface, it is virtually impossible to design a manned spaceship to land on the moon. It is for this reason that the Ranger-type vehicle (lead photo) came into existence.

The picture-taking sequence begins at a minimum of 13 minutes and 40 seconds before impact at an altitude of about 1200 miles and continues uninterrupted until the vehicle

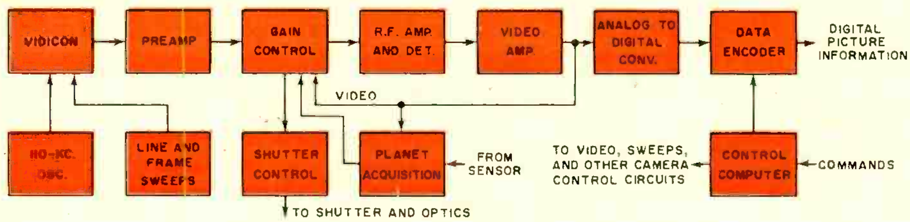


Fig. 2. Basic TV system as used in the Mariner Mars spacecraft. The analog video information is converted into digital form.

crashes into the moon at a speed of approximately 6000 mph.

The initial pictures from this altitude cover a wide area of the lunar surface at resolution comparable to that obtained by earth-based telescopes. As the Ranger falls toward the surface of the moon, area coverage is traded for increasing resolution, until resolutions of .5 meter or better per optical line pair are achieved in the final picture sequence just prior to impact.

The six TV cameras (Fig. 5) are designated F (for full scan) and P (for partial scan). One of the two F cameras has a 25-mm. (wide-angle) f:1 lens with a field of view of 25°, while the other has a 75-mm. (narrow-angle) f:2 lens with a field of 8.4°. Shutter speed of the F cameras is 1/200 second.

Cameras P1 and P2 have 75-mm., f:2 lenses with a 2.1° field of view, while P3 and P4 have 25-mm., f:1 lenses with a 6.3° field of view. Shutter speed for these cameras is 1/500 second. Video bandwidth is 200 kc. for each channel.

The basic timing signals for the cameras are provided by a camera-control assembly. Camera P1 is also provided with a "free-running" capability by the incorporation of secondary synchronization and sequencing circuits within the P1 camera electronics. These circuits enable independent operation of the P1 camera in the event that the P-channel sequencer fails.

In the P cameras, the central 282 resolution lines of the 1125-resolution-line camera raster are scanned for readout in .2 second. An additional .6 second is required for preparation of the camera for its next exposure. Thus, the exposure of the cameras in the P channel is sequenced at .8-second intervals to provide for the continuous transmission of video data.

The .2-second readout time of the P cameras enables the TV system to achieve extremely high resolution in the final sequence of four pictures taken from an altitude of less than 7000 feet above the moon's surface. These final pictures are exposed and transmitted to the earth in the last .8 second of flight prior to impact.

The cameras used in the F channel are essentially the same as those used in the P channel except that in the former cameras the entire 1125-resolution-line raster is scanned for readout in 2.5 seconds. As a result, the area covered by a picture from an 800-line camera is approximately 16 times that of a 200-line camera from an equivalent altitude. In this manner, the two F cameras provide the desired wide-area coverage.

Both types of cameras are used to provide area-coverage and high-resolution data during the final few minutes before impact. Both channels (F and P) are capable of independent or simultaneous operation. The power distribution network and signal paths for the two channels are completely independent, with the exception of the r.f. combining network.

Metallic focal-plane shutters are used on all camera lenses. This shutter is not cocked as in conventional cameras but is a solenoid-operated, sliding-aperture type that moves from one side of the lens to the other each time a picture is taken.

One reason for having several cameras with different lens apertures is that the lighting conditions on the moon cannot be precisely determined from the earth. The different lenses provide greater exposure latitude. The range of lunar lighting conditions covered by the lenses and the dynamic range of the vidicons is about 30 to 2600 footlamberts, corresponding roughly to about high noon till dusk of an average earth day.

The camera control sends three types of instructions to the cameras: (1) snap shutter, (2) read vidicon faceplate, and (3) erase faceplate and prepare for the next picture. The vidicon faceplates are erased by special lights built around the vidicons which are flashed to saturate the faceplate. The plate is then scanned twice by the electron beam to remove all traces of the previous image. The vidicon is then prepared to receive the next image.

The camera output signals are processed, amplified, and sent to a video combiner that enables sequential transmission of the cameras in each channel. The video combiner provides gating circuitry that blocks the erase-video signal from the vidicons while they are being prepared for their next picture.

The output of the video combiner is converted into an FM signal and sent to the two 60-watt transmitters where telemetry information is added as a subcarrier, and the resultant signal is transmitted to earth over the high-gain, four-foot parabolic antenna on the spacecraft.

Lunar Orbiter

The Lunar Orbiter (Fig. 3) is one of the three NASA programs for the unmanned exploration of the moon in advance of Project Apollo manned landing mission. The Ranger program has given us our first close views of the lunar surface, and it now remains for the Surveyor and Lunar Orbiter programs working as a team to provide specific types of information about selected areas of the moon's surface in order to make a safe manned lunar landing possible.

Surveyor will make a soft landing so that its instruments can measure important surface properties while eye-level TV cameras provide visual information.

It will be the job of the Lunar Orbiter to make the initial examination so that Surveyor data can be extrapolated over a full-sized landing site. Since protuberances only half a meter high are significant, and the area to be covered is over 8000 square kilometers per mission, heavy demands are made on the Lunar Orbiter's data-gathering capacity.

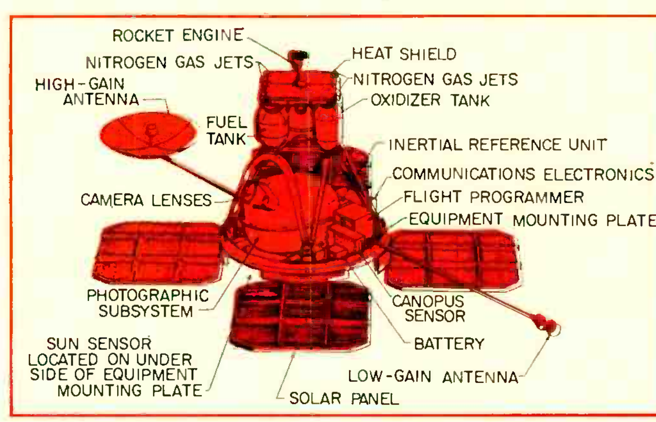
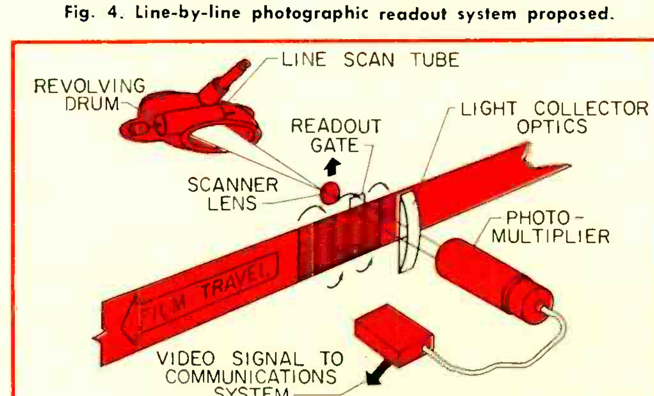


Fig. 3. Configuration of the proposed Lunar Orbiter vehicle.

Fig. 4. Line-by-line photographic readout system proposed.



The Lunar Orbiter differs from other video satellites in that it mounts two photographic cameras and a roll of 260 feet of 70-mm film. Once the vehicle has been placed in the desired lunar orbit, its cameras proceed to take the necessary pictures. Using the *Eastman Kodak* "Bimat" process, the films are fully developed within the spacecraft, and the negatives are stored pending electronic readout with the system shown in Fig. 4.

Television System

The high-resolution film negatives are placed in front of a special flying-spot CRT whose electron beam traces one scanning line only. At the beam intensities required, the phosphor would burn up if it did not keep moving. In this tube, the phosphor is coated on the outer surface of a continuously rotating metal drum. The scan period is 1250 microseconds and the scan line is about 2½ inches long at the phosphor. The emitted light is focused on the film negative through a scanning lens that reduces the line width to 1/10 of an inch. Mechanical motion of the scanning lens moves the now-tiny bright line across the film. It takes about 17,000 horizontal scans of the original electron beam to cover the 57-mm. width of the film negative. This process requires about 20 seconds. The film negative is then mechanically advanced 1/10 of an inch and the scanning lens then scans the next segment in the reverse direction. It takes 40 minutes to read out the 11.6 inches of film negative corresponding to a single exposure.

After the bright spot has passed through the film negative, it is modulated by the exposed density existing at each point. Collecting optics then pass this light to a photomultiplier. The video is then combined with the necessary sync pulses, telemetry signals, and a reference pilot tone; then the composite signal is conditioned for radio transmission to the earth.

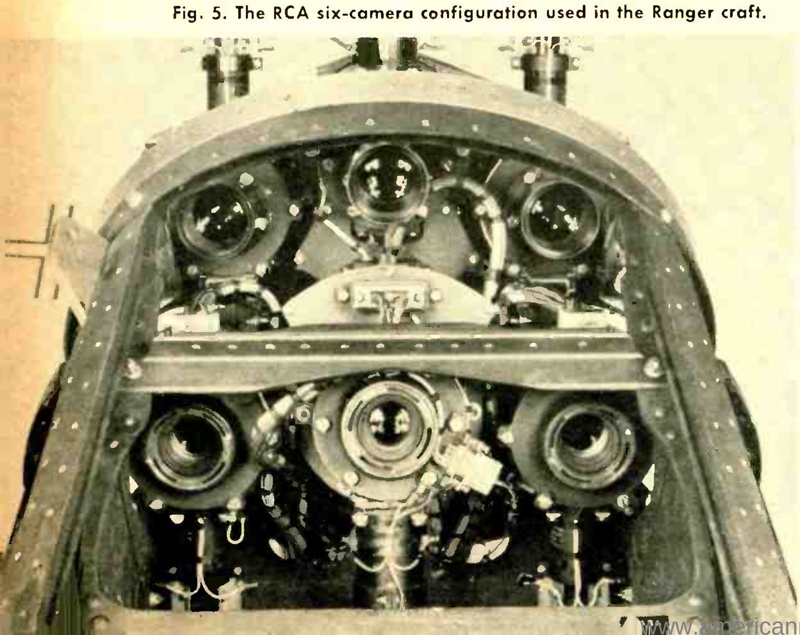
At the earth station, the r.f. carrier is demodulated and the telemetry signals diverted to equipment and stored on magnetic tape, while the picture information is passed on to the picture-reconstruction system for further processing and magnetic-tape storage. The video data is displayed line by line on a kinescope face with the image being recorded on a continuously moving 35-mm. film strip.

Project Apollo

Within the capsule of this first three-men-to-the-moon flight will be a hand-held TV camera head that will be used to provide real-time TV pictures of crew activities for public information (TV as required, newsreels, and newspaper use) and documentation.

The on-board camera has the unique capability of providing dynamic scenes of activities aboard and outside the spacecraft without the necessity of vehicle recovery. Secondary application such as monitoring propellant tanks, launch escape tower, recovery chute development, etc., are probable as the

Fig. 5. The RCA six-camera configuration used in the Ranger craft.



project progresses. These are secondary, however, and the TV camera has been optimized around the public-information requirement.

The 4½-pound camera has a bandwidth of 500 kc. with a frame rate of 10 per second with 320 lines per frame. Consuming 6¾ watts, the camera has a .1 footcandle highlight-illumination sensitivity minimum and a resolution of 227 lines. It uses a one-inch vidicon and is provided with a 9-mm., *f* 1:9 lens and a 20- to 80-mm., *f* 2:5 zoom lens.

The camera will be mounted in one of two positions within the spacecraft. One of these positions is near the bottom of the instrument panel and slightly to the right of the center astronaut so as to view the crew during the launch phase. After powered flight, the center astronaut will stow the center seat so as to make an aisle, and he will mount the camera in the second position where it can monitor activities of the crew in this center aisle.

Alternate applications of the TV camera are provided for portable operation. The camera may be hand held and moved throughout the control module as desired. A second zoom lens is available for external viewing through the module windows to obtain TV pictures of the earth or moon.

The Apollo TV camera feeds into a premodulator where it will be frequency multiplexed with both voice and telemetry data. The composite signal is fed to an S-band transponder, then power amplified and passed through either the S-band omni antenna for near-earth transmissions or the high-gain S-band antenna for transmission from deep space.

Once the Apollo command module has been placed in lunar orbit, one astronaut remains in the command module while the other two are soft landed on the moon by the Lunar Excursion Module (LEM). The same TV camera as used on the mission will accompany them. Pictures will then be transmitted directly between the LEM and the earth stations.

Tiros

Typical of the Tiros class of weather satellites is the Tiros I, now circling the earth in a polar orbit.

The two-camera TV system used in these observations has a ground resolution of about two miles at the picture center. The two cameras are mounted on the sides of the spacecraft so that they view the earth once every revolution (every six seconds). An on-board timer programs the cameras to take pictures only when they are looking directly at the earth.

The camera tube is a 500-scan-line vidicon with a persistence that permits a two-second scan with less than 20% degradation in picture quality. Each wide-angle camera, using 104-degree lenses, nominally takes 16 pictures per orbit at 128-second intervals, providing nearly full dawn-to-dusk coverage. Each picture will cover a 550,000 square mile area. The interval can be reduced to 64 or 32 seconds for overlap pictures if desired.

The video data is stored on one of two tape recorders for readout when the satellite passes within 1500 miles of a ground station.

Transmission time for a full orbit of pictures takes about three minutes from receipt of the ground radio command. Sufficient tape is provided in each of the two recorders for storing 48 picture frames at a speed of 50 ips. The tapes are erased immediately after playback and again just before recording. ▲

EDITOR'S NOTE: *According to the latest report we have received from NASA on Mariner Mars (Mariner 4), the spacecraft is still holding steady on its course and is continuing to transmit scientific and engineering data from interplanetary space. Although two of the radiation experiments have evidently failed, the other experiments are still operating. It is expected that up to 21 photographs of Mars will be taken when the craft gets as close as 5600 miles of the planet on July 14. On June 16, Mariner 4 was over 109 million miles from Earth traveling at a velocity of about 57,000 mph.*

AMPLIFIER GAIN NOMOGRAM

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

Power and voltage gain of amplifiers with equal input and output impedances are readily found.

To find the power gain of an amplifier, it is necessary to compute the ratio of its output to input power, take the log and multiply by 10. When the input and output resistances are equal, the voltage gain of the amplifier can be calculated by multiplying 20 times the log of the ratio of output to input voltages.

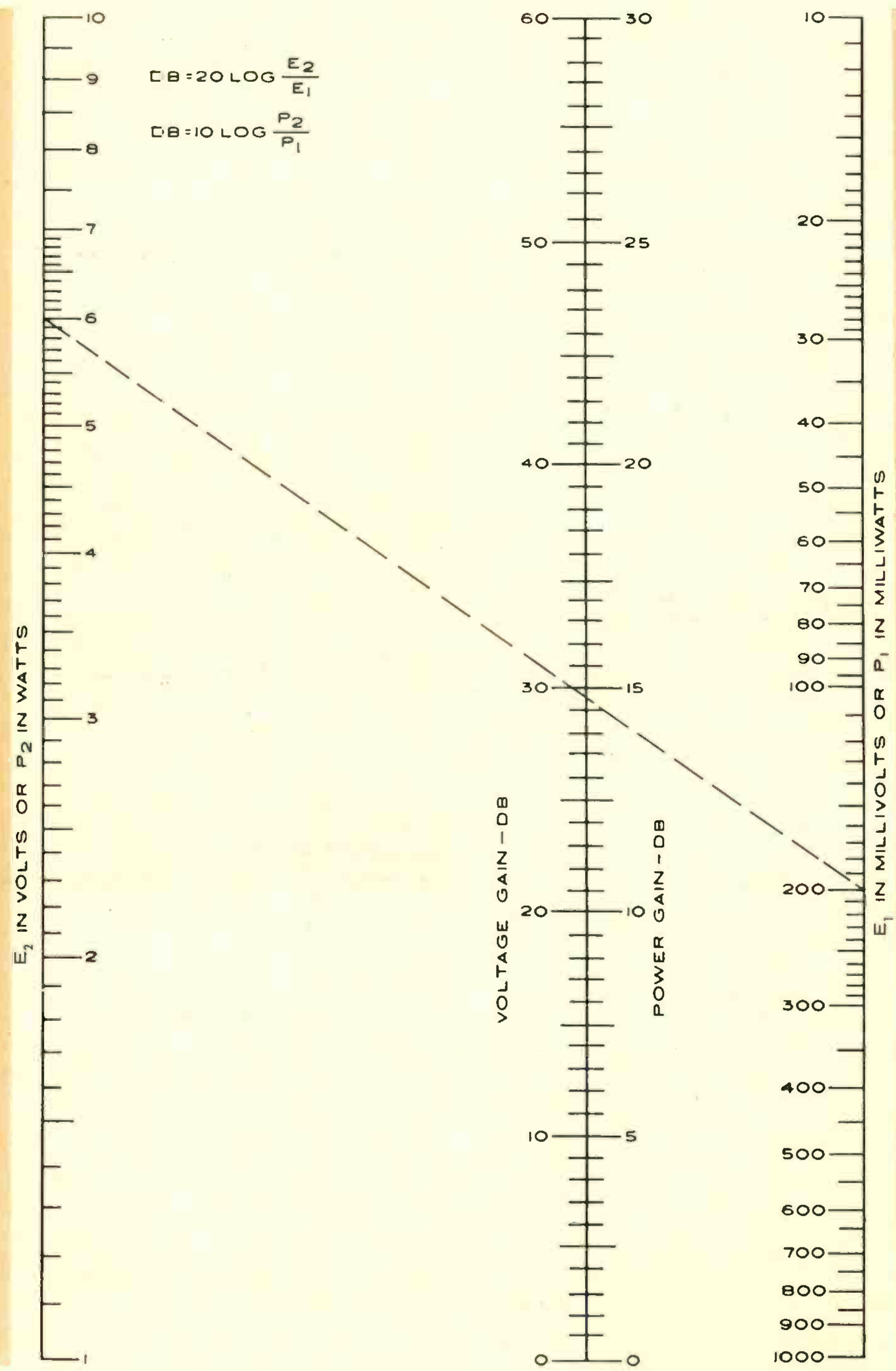
This nomogram eliminates the tedious calculations involved, and gain can be determined in a much simpler manner.

For values of 10^n or 10^{-n} times those on the E_1 scale, subtract or add, respectively, n times 20 db from or to the values on the voltage-gain scale. (n times 10 db from or to the power-gain scale when the P_1 scale is used.)

For values of 10^n or 10^{-n} times those on the E_2 or P_2 scales, add or subtract respectively n times 20 db to or from the values on the voltage-gain scale and n times 10 db to or from the values on the power-gain scale.

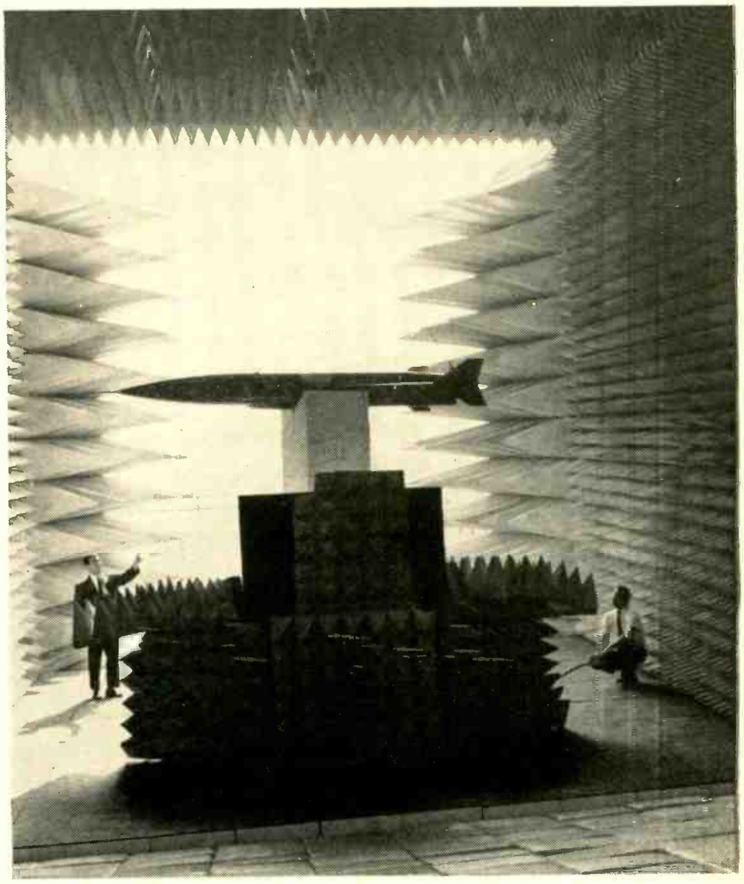
Example: Find the voltage gain of an amplifier whose input and output resistances are equal, when 6 volts output is measured for 200 mv. input.

Solution: Place one end of a straightedge over 6 on the left-hand scale and the other end over 200 on the right-hand scale. Find 29.6 at the point where the straightedge crosses the center scale. This is the voltage gain in db. ▲

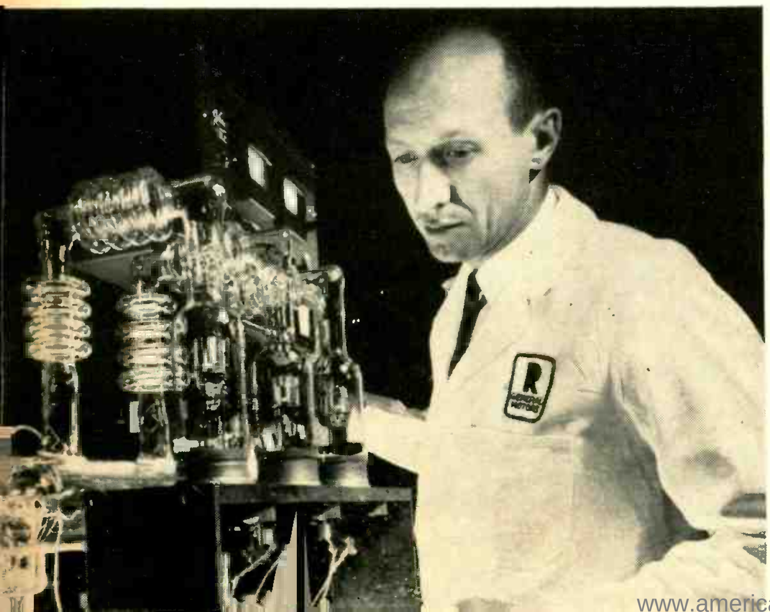


TV Pictures from a Record. (Left) A new system, called "Phonovid," plays still TV pictures as well as sound from a phonograph record. Up to 400 pictures and 40 minutes of sound can be recorded on both sides of a 12-inch long-playing record. Heart of the system is a slow-to-fast scan converter which takes the signals from the phono pickup and converts them into a TV display. An electronic storage tube stores the picture line by line and, when the picture is complete, reads it out to the receiver. Two such storage tubes are used. One is repeatedly reading out a picture while the other tube is constructing the next one from the video information in the grooves of the recording. The storage tubes alternately read out a picture every six seconds. Both the turntable and the television set are entirely standard. The equipment, in laboratory prototype form, was demonstrated recently by Westinghouse. The company foresees the system for classroom instruction, industrial and military training, vocational education, and sales presentations.

RECENT DEVELOPMENTS in ELECTRONICS



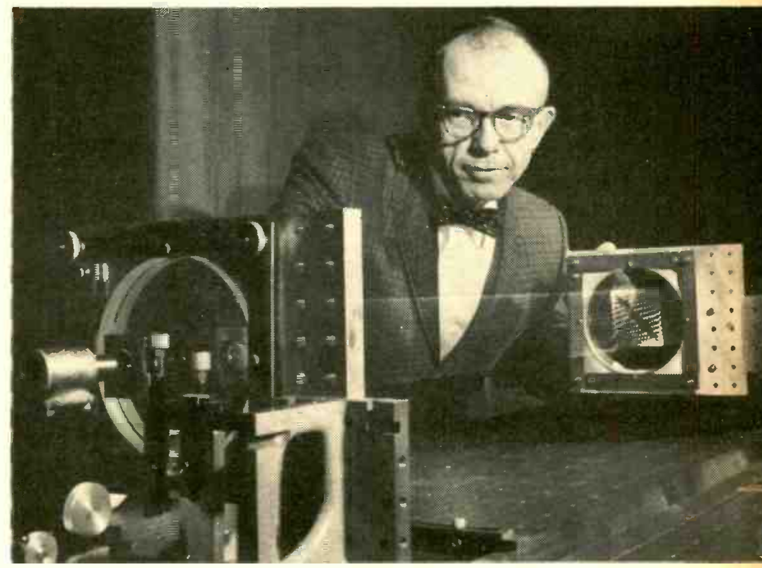
Microwave Anechoic Chamber. (Right) A doorway to space is seen from inside this microwave anechoic chamber, a room that allows engineers to test electronic equipment in an echo-free environment like that of outer space. Engineers at the Bunker-Ramo Corp. are shown using the chamber to test antenna system of a missile. The large chamber is lined with foam plastic pyramids, developed by B.F. Goodrich, to absorb the microwaves.

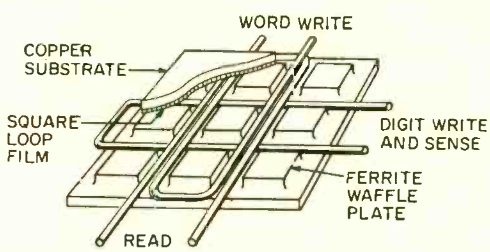


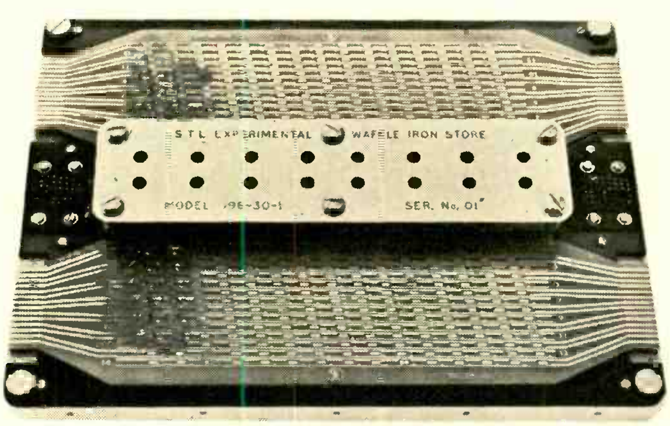
Nuclear Thermionic Converter. (Left) A unique approach for converting heat directly to electricity is the nuclear thermionic converter shown here. Such converters consist of a heated emitter of electrons, a collector, and a gas (that becomes a plasma when ionized) between these electrodes. The main problem with conventional converters is that the gas used is highly corrosive. Also, this gas tends to impede the passage of electrons, requiring the use of undesirably small emitter-collector spacings (a few mils). The General Motors Research Laboratories has been working toward a nuclear converter that eliminates these drawbacks. In this converter, uranium is used in the emitter. When bombarded by neutrons from a reactor, the uranium undergoes fission. As a result, the high-energy fragments heat the emitter—to a much lower temperature than in other converters—and, at the same time, produce the plasma by ionizing the gas. Electrons then flow readily from emitter to the collector of the unit.

Laser Progress. (Left) The laser's five-year progress is shown in this comparison of the original laser with one of the latest devices. The original is the little device nestled in the hand of its developer Dr. Theodore H. Maiman. The unit first "lased" on May 26, 1960 and had a power output of 10,000 watts. The new laser, made by the Korad Corp., of which Dr. Maiman is president, is partly shown at the right in the photo; it has a power output of up to 6,000,000,000 watts. Currently there are some 500 to 600 companies, institutions, and government agencies in the laser field. Current volume of laser business, including research and development, is estimated at $50 million, but this figure may reach $250 million by 1970. The government is now the biggest customer but the commercial market will increase.

Folded Laser Beam. (Right) A two-mile long laser beam has been folded into a 10-foot space by reflecting it over a thousand times between two mirrors. Because the points of reflection on the mirrors do not overlap, information can be modulated onto the light beam, stored and retrieved 10 microseconds later. This experiment, conducted at Bell Telephone Labs, opens the way for optical delay lines to be used as high-speed, sequential, computer memories. It also provides an excellent means of measuring very small losses in lenses and other optical materials. For this photo, the mirrors were closer together and the beam was reflected about 400 times.



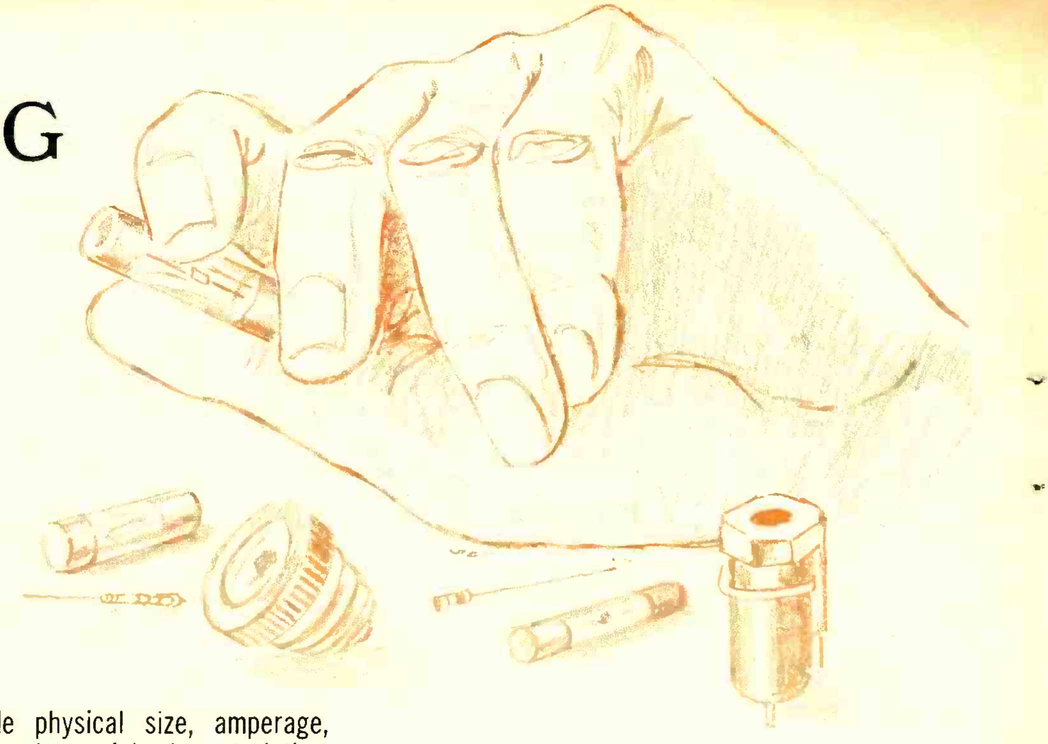




Waffle-Iron Computer Memory. (Left) An experimental computer memory has been constructed of ferrite in a waffle-iron configuration as shown. This memory unit, built by a British subsidiary of ITT, combines the advantages of conventional thin-film and ferrite-core systems. These include high packing density, simple construction, low driving current, good output voltage, and absence of creep. The flux is returned through the soft ferrite structure, while driving and sense conductors are laid in grooves in the ferrite plate. The plate is pressed into contact with the thin film (an iron-nickel alloy plated on a polished substrate), which has square-loop magnetization curve.

Largest-Capacity Computer Memory. (Right) The largest capacity computer memory ever built has been delivered by IBM to the NASA Manned Spacecraft Center in Houston, Tex. The unit shown is the first of five to be installed at the Center. They will process vast amounts of data generated during the Gemini and Apollo space missions. In each of the memory units, almost 20 million ferrite cores, tiny doughnut-shaped objects, each about the size of a pinhead, are strung in two-wire networks and packaged, with associated circuitry, into a cabinet. Some 35,000 silicon diodes are used in the memory unit. A built-in test system is provided in order to reduce maintenance time.

SELECTING THE PROPER FUSE



By ARTHUR J. STEELE
Staff Engineer, Littelfuse, Inc.

Important factors to consider include physical size, amperage, voltage, type, ambient temperature, and special characteristics. A number of important rules for proper fusing are included.

A FUSE is an intentionally weakened part of an electrical or electronic circuit. Its purpose is to protect the other elements of the circuit from a possibly damaging overload. If it is to perform its function of protection properly, it must be thoughtfully selected and installed or mounted. Fuses are used to protect many different types of circuits. In some instances we are trying to protect only the wiring and prevent a fire. In other instances, we may be protecting a very sensitive meter or an electronic component in a television set.

Fuses are generally a glass-bodied cartridge with nickel-plated brass caps. High-amperage fuses are made of a punched zinc alloy element. Low-amperage fuses are made with a filament wire of many materials from copper to platinum and many alloys to accomplish the desired result.

Rules of Fusing

The first question that must be answered is, "What am I trying to protect?" Is it the wiring of a house? the wiring of an electronic device in industry? the wiring of a very sensitive mechanism to be used in our space program? In each case, am I trying to protect against a fire hazard? or am I trying to protect a piece of equipment? a very sensitive metering device? an expensive component? or eliminate shock hazard to personnel? There is a definite series of questions that you should ask yourself when deciding on a fuse. Ask yourself the following questions:

1. What is the normal operating current?
2. What is the abnormal current at which the fuse is required to open the circuit?
3. What are the minimum and maximum times during which abnormal current is permitted?
4. What voltage is applied to the fuse?
5. What is the normal ambient temperature at the fuse location?
6. Are there pulse characteristics involved in the circuit?
7. What are the applicable commercial specifications?
8. Are there any applicable government specifications?
9. Are there other requirements special to this application (mechanical or electrical characteristics) beyond the normal requirements of a commercial fuse?
10. What is the physical size desired?

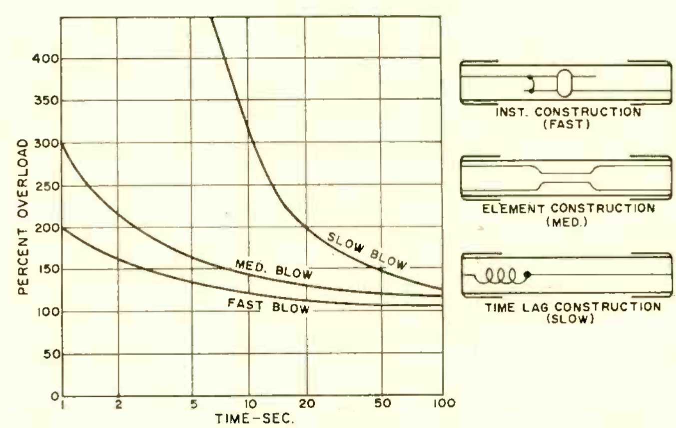
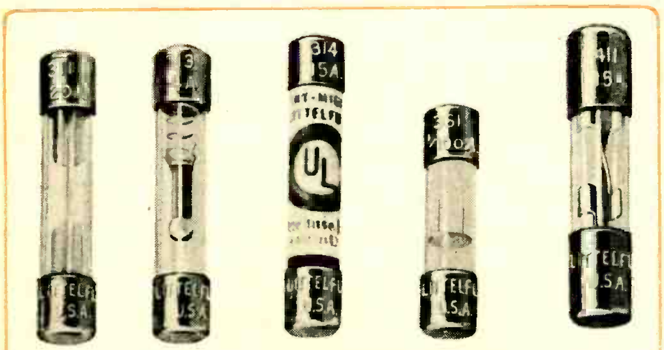


Fig. 1. Characteristics of fast-, medium-, and slow-blow fuses.

Glass and ceramic cartridge fuses. From left: 3AG medium-lag type; slow-blow fuse; 3AB ceramic anti-vibration fuse with arc-quenching filler; 8AG low-current instrument fuse; and 4AG low-voltage medium-lag fuse developed for aircraft use.



Types of Fuses Used

The number and types of fuses and fuse mountings required by the electronics industry have developed over the past 25 years in about the same proportion as those of resistors and capacitors. In the same way, too, the pressure from engineers has been to make fuses smaller and better. By far the greatest number of fuses used in electronic components and circuit

Standard Designation	Physical Size	Body Material	Amperage Range (a.)	Maximum Voltage Rating (v.)	Typical Applications
3AG	1¼"x¼" dia.	Glass	0-30	250 125 32	Commercial & Industrial Electronic Equipment
3AB	1¼"x¼" dia.	Ceramic	0-30	250 125	Appliance & Small Motor Protection
4AG	1¼"x9/32" dia.	Glass	0-40	250 125 32	Aircraft Electrical & Electronic Circuits
5AG	1½"x13/32" dia.	Glass	0-60	250 125 32	Aircraft Electrical & Electronic Circuits
8AG	1"x¼" dia.	Glass	0-5	250	Instrument & Meter Protection
"Microfuse"	.350"x¼" dia. Plug-in or Pigtail	Glass	0-5	125	Miniaturized Electronics (Space Program, etc.)
"Picofuse"	7/32"x.078" dia. Pigtail	Ceramic	0-5	125	Printed-Circuit Board Electronics
SFE	5/8"x¼" dia. ¾"x¼" dia. 7/8"x¼" dia. 7/8"x¼" dia. 1 1/16"x¼" dia. 1¼"x¼" dia. 1 7/16"x¼" dia.	Glass Glass Glass Glass Glass Glass Glass	4 6 7½ 9 14 20 30	32 32 32 32 32 32 32	Automotive Electrical Circuits

Table 1. Listing of fuses commonly used in electronic equipment.

protection are glass-enclosed, although ceramic is used for the higher current, 250-volt *Underwriters' Laboratory* listed fuses.

The common fuse families are listed in Table 1. The most popular fuses, their sizes, and maximum ratings are given, along with their standard industry type designation. Readers will be interested to note that there is no logical or rational relationship between the recognized "AG" designation and the physical size of the fuse. It has grown rather haphazardly over the past 40 years, starting with the automotive industry. 1AG was the first "automotive glass" fuse; 2AG was next (no longer used, dropped in an effort to standardize); 3AG was next, etc.

As the industry grew, additional sizes were necessary and they did not necessarily fall within the physical size order. In addition, the SAE (Society of Automotive Engineers) established a specification in an effort to try to prevent over-fusing by making the fuses non-interchangeable. As the amperage rating was increased, the physical length of the fuses was increased, thus preventing over-fusing. This approach, however, has not been too practical due to the limited number of amperage ratings available.

In general, then, the "AG" designations only classify the fuse as to the specific physical size of the envelope in which the fuse is placed.

The need for smaller and better fuses has led to the development of such fuses as the "Microfuse" and "Picofuse." The "Microfuse" is being used in the Gemini space program. It is small, accurate, and reliable, and is produced in either plug-in or pigtail versions. The "Picofuse" is a pigtail-type fuse with either radial or axial leads. This fuse is the smallest of protectors—accurate and fast-acting. It may be used where space and weight are at a premium and where mechanical and electrical requirements are high.

Fuse Characteristics

Fuses are the safety valves of electrical circuits, therefore it is important that they operate or "blow" before damage occurs in either the equipment or the wiring being protected.

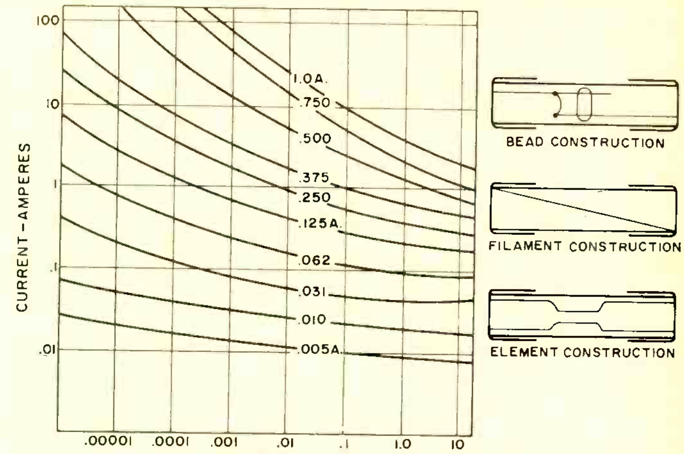


Fig. 2. Typical family of characteristic curves for 8AG high-speed instrument fuses of various current ratings. Most of these fuses are low-current devices with bead or filament construction.

Conversely, we do not want to have nuisance blowing. Thus, fuses must not blow too easily and cause open circuits when the equipment is operating normally.

It becomes obvious that time and current are the controlling factors in the function of a fuse. There is a time and current relationship at which the circuit will operate satisfactorily and cause no damage to equipment or wiring. There is also a time and current relationship at which the equipment will be damaged. In other words, the time-current characteristics of the fuse must conform to the time-damage characteristics of the equipment.

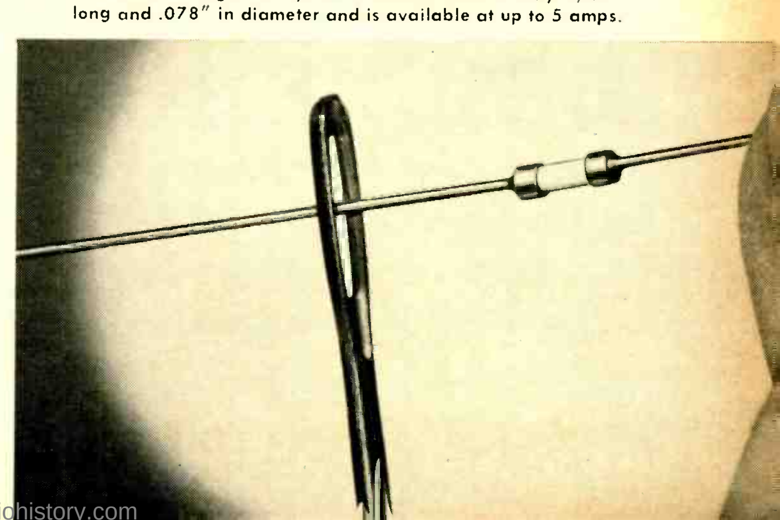
There are three basic types of fuse characteristics for different types of applications. Fast-blowing fuses are used for instrument protection where fast action is necessary in order to protect the equipment. Medium-blowing fuses are used for general applications. Slow-blowing fuses are used for applications where a time lag is desirable (see Fig. 1).

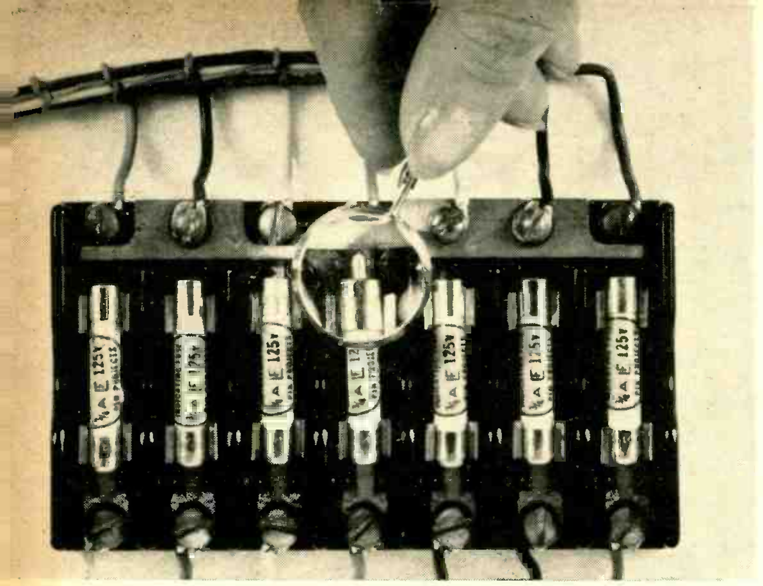
Fast-acting fuses are designed to carry 100% of current rating and blow rapidly at very slight percentages of overload. For example, they will open the circuit at a 200% overload within a maximum of 5 seconds. The greater the overload, the more rapidly the circuit opens. There is very little mass in the filament used, therefore the reaction can take place very quickly under short-circuit conditions. This filament is generally made of silver, platinum, or other precious metal alloys.

These fuses are manufactured with wire diameters as low as .000020". Obviously this filament will open the circuit under adverse conditions before any damage can be done in other parts of the circuit. Typical examples of the fast-acting fuses are the 8AG instrument fuses (see Fig. 2), "Microfuses," and "Picofuses."

There are three basic constructions of these fast-acting

This super-small, fast-acting ceramic cartridge fuse will almost fit through the eye of a needle. Fuse is only 7/32" long and .078" in diameter and is available at up to 5 amps.





A group of medium-lag indicating fuses is shown. When this fuse blows, the silver-plated indicating pin extends from the end of the fuse. This serves as a visual indicator. The pin can also be used to actuate an audible alarm circuit as well.

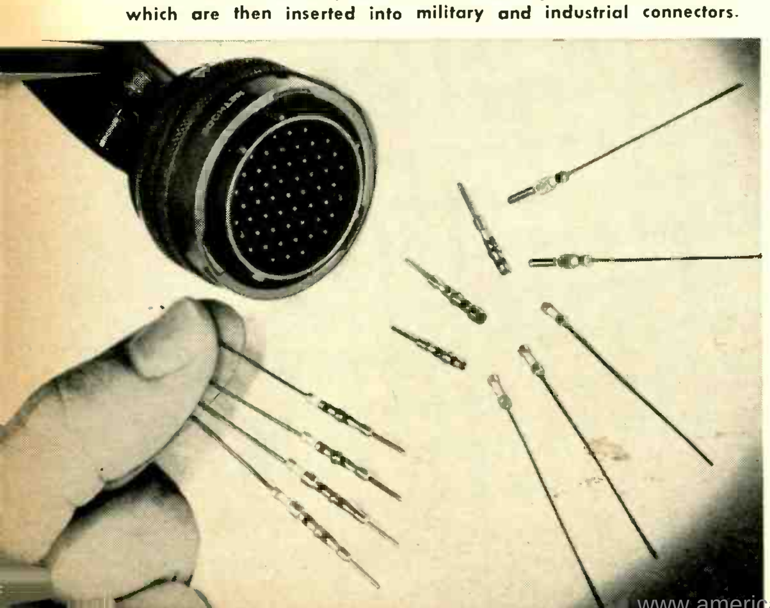
fuses. One, the bead-type construction, uses a small onyx bead holding two heavy wires, across which is placed a fine filament. The second is a filament-type construction employing a diagonal lineup to insure the constant blowing characteristics of the fuse; and third, the element construction for heavy amperage fuses in this design. By observing the characteristic curves, it will be noted that as the amperage rating increases there is an inherent lag, automatically built-in, due to the increase in mass of the fusible link.

Medium-Lag & Slow-Blow Fuses

Medium-lag fuses are by far the most widely used. They are used in automotive, commercial, and industrial electronic equipment, as well as in appliances. These fuses are designed to protect a non-critical device, wiring, or equipment at minimum cost. In general, they are designed to carry 110% of rated current for a minimum of four hours. Circuits will be protected if an overload of 135% of rating is placed on the fuse; it will open in less than one hour. If an overload of 200% of rating is placed on the circuit, the fuse will open the circuit in a maximum of 30 seconds. Notice that the action of these fuses is not as rapid as the fast-acting fuse. However, they are perfectly satisfactory in the majority of general applications for fuse protection. All SFE fuses fall into this category, as do many of the 3AG and 3AB fuses.

The slow-blow fuse is one that has a time-lag characteristic. Many circuits or pieces of equipment have a built-in pulse characteristic which is normal for the operation of this equipment. The starting of a motor, for example, produces the pulse characteristic referred to. Until the motor is up to speed, current far higher than the normal running current flows in the circuit. This is normal operation for this circuit, so we do not want the fuse or protector to open the circuit during these conditions. Therefore, a fuse must be designed with sufficient mass or time lag to prevent nuisance blowing. In some highly inductive or capacitive electronic circuits, this same characteristic is required.

Subminiature fuses may be assembled into cylindrical pin contacts which are then inserted into military and industrial connectors.



In the design of fast-acting fuses, we want to have a minimum amount of mass in order to cause the fuse to open the circuit as quickly as possible. For the slow-blow characteristic, the reverse is true. We want a period of delay, therefore additional mass of one type or another is added to the fusible link, thus causing a delay. This can be done by using a relatively large mass of low-melting point alloy placed near the heat-generating source. The fuse, being a thermal device, requires a certain amount of time for the current passing through a certain resistance to cause a reaction. It requires a certain amount of time for the current passing through the heat-generating source, or the resistance of the fuse, to bring the temperature of the low-melting point alloy to the point where it becomes liquid, triggering the mechanical action of a tensioning spring, and opening the circuit. The time that is required for this reaction is called the slow-blow or lag characteristic of the fuse.

The low-melting alloys are made up of tin, lead, bismuth, and small quantities of other materials to control the desired melting point. The heat-generating source takes many forms,

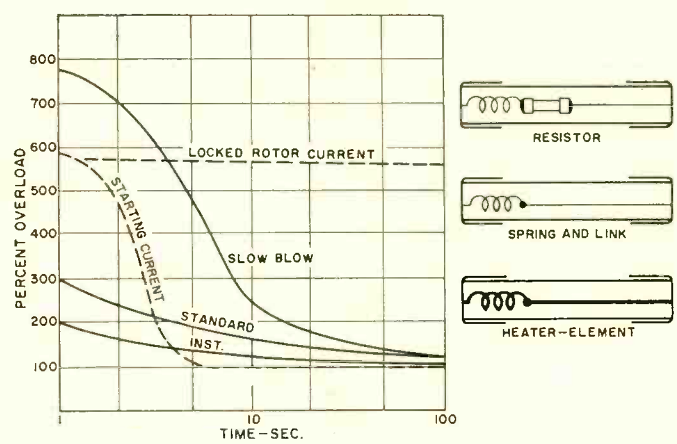


Fig. 3. Characteristics of slow-blow fuses for motor protection.

depending on the amperage rating of the fuse. In some instances a small carbon or wirewound resistor is added, or the resistance of a coil spring becomes the heat-generating source.

In most applications, the time-lag characteristic is desirable only in a limited range of operating currents. The current values in excess of this limited range require the fast action. Therefore, slow-blow fuses are designed to carry 110% of rating for a minimum of four hours and open the circuit at 135% of rating within one hour, have a minimum of 5-second delay at 200% of rating, and open the circuit within 2 minutes.

For overloads in excess of 700%, a fusible link is placed in series with the slow-blow fuse so that fast action is obtained in opening the circuit when an overload of this nature is encountered. Three types of characteristics are actually available in the slow-blow type fuse. First, a long life at the normal operating characteristic; second, a time delay to prevent nuisance blowing under slight overloads; and third, rapid action under short-circuit or high overload conditions. This type of fuse is used in TV horizontal sweep circuits, power supplies, motor circuits, etc. See Fig. 3.

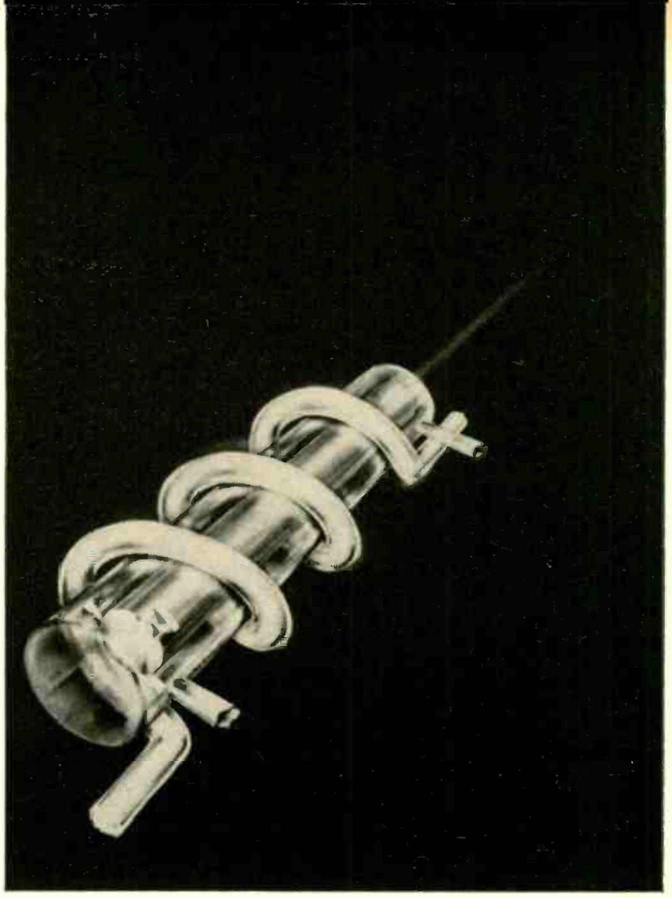
Fuse Mounting

There are many different ways of mounting fuses. The least expensive is the addition of a pigtail—or wire—to the ends of the fuse, which can then be (*Continued on page* 64)

LASERS

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

An authoritative explanation of the operation of solid and gaseous lasers. The significance of such effects as coherence, population inversion, photon amplification, and stimulated emission is made clear.



Editor's Note: This is the first in a group of three articles on lasers. Our objective is to provide the reader with a clear and accurate understanding of laser operation. Future issues will feature articles covering the modulation and demodulation of a laser beam, the injection laser, applications, and laser measurements.

THE first experimental production of electromagnetic waves by Hertz in 1888 ushered in the age of radio communication. The reader is surely familiar with the growth and importance of the communications industry. The milestones which mark its progress are numbered in consecutive orders of ascending frequency.

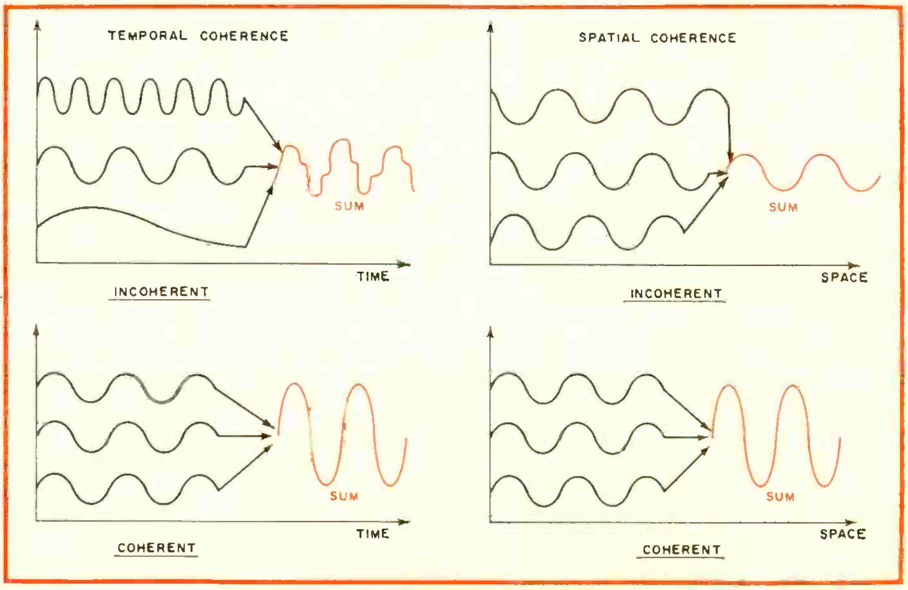
The reason for expanding the communications spectrum toward the higher rather than the lower end is that the rate of information (*e.g.*, video signals) which can be transmitted is directly proportional to the center frequency of the carrier wave. In addition, motivation has been furnished for the expansion of the electromagnetic spectrum by the greater atmospheric penetration of shorter wavelengths, by the increased directionality of transmitted power at higher frequency, and the needs of various interested parties.

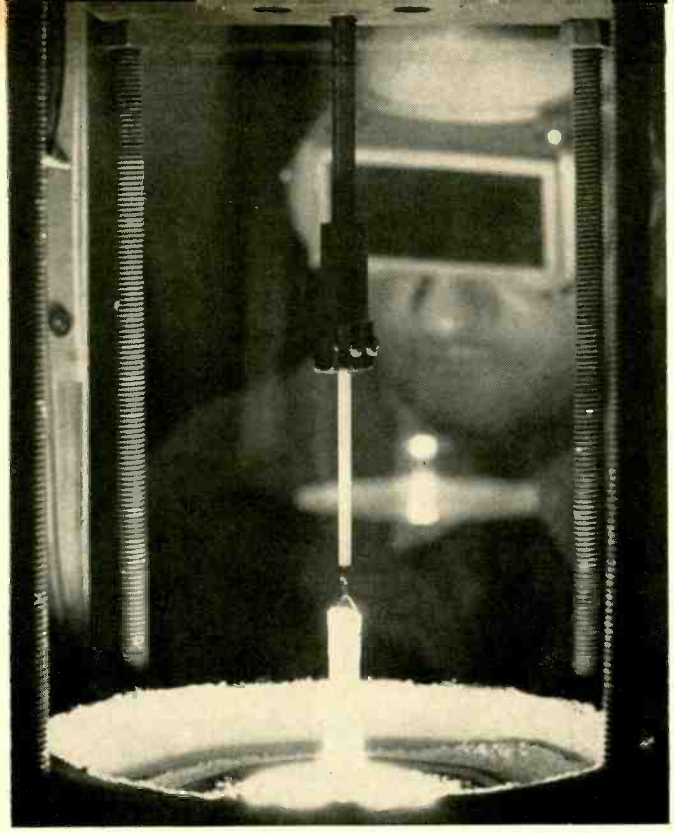
It is curious that ordinary light, recognized early in the game as electromagnetic waves of extremely high frequency ($\approx 10^{15}$ cps), was never exploited for communications purposes. To understand the reason for this neglect and appreciate the importance of the laser, it is necessary to consider what is required of a transmitter in a communications link. An effective transmitter is a generator of electromagnetic waves which radiates a significant amount of coherent power in a narrow band of frequencies, including the particular one of interest. But why is coherence desirable?

Need for Coherence

The need for coherence in an efficient generator is sometimes overlooked by the radio or microwave engineer. For example, the tacit assumption made when he designs or builds an antenna for a receiving system is that increasing the area

Fig. 1. The effects of temporal (in time) and spatial (in space) coherence on three waves.





A technician, eyes protected by dark goggles from the white-hot glare of light, monitors growth of a laser crystal boule. Painstaking eight-hour process starts with a crystal "seed" dipped into a crucible filled with molten raw laser crystal materials. Fixed to a slowly rotating rod, the seed is pulled up a half inch an hour. The molten metal adheres to the seed and cools and hardens as it is drawn from the crucible. The crystal looks like a small icicle before it is cut, machined, and then polished into a usable, commercial laser rod.

over which the signal power is collected will increase the signal-to-noise ratio at the detector. However, this is true only if the phase of the incoming signal is constant or varies in a predictable manner over all points of the antenna. If the phase of the incoming signal changes in a random way from point to point over the antenna, then the detector can sum only the absolute value of the incoming power. The sum of phase angles will be zero, in general, and all modulation will be lost. This correlation of phase in the signal is just what is meant by coherence. An instantaneous correlation of phase from point to point in space is called "spatial coherence" and a consistent correlation in phase at two neighboring points over a length of time is called "temporal coherence" (see Fig. 1).

The generators of radio, television, and radar signals exhibit both temporal and spatial coherence in the emitted signal. Until the advent of the laser, however, no sources of signal power operating in what is known as the optical spectrum were coherent in any but a statistical sense. This fact, more than any other, has precluded the highly desirable use of these frequencies for communications other than simple "on-off" switching.

The reason for the lack of coherence in optical sources other than the laser is related to the lack of correlation among the motions of the electrons, each electron behaving as a tiny oscillator which emits light. For familiar light sources, such as tungsten filaments and gas-discharge tubes, electrical energy is supplied to create conditions favorable to the emission of light, *e.g.*, by heating the filament or exciting the atoms in the gas. The actual emission process, however, is uncontrolled. Each oscillator radiates independently of its neighbors. Thus the emitted light, which is just the sum of all the individual radiations, lacks both spatial and temporal coherence. The idea of maintaining a constant phase relation over the oscillators by stimulating their emission with a wave of the frequency to be radiated was first proposed by C.H. Townes in 1958. Two years later, utilizing stimulated emission, Theodore Maiman achieved pulses of coherent optical radiation from a single ruby crystal.

Since that time the development of the laser, an acronym for *L*ight *A*mplification by *S*timulated *E*mission of *R*adiation, has proceeded at a phenomenal pace. The intensity, monochromaticity, and polarization of laser radiation has created potential applications in medicine, industry, and scientific measurement, in addition to the obvious application to communications. In conjunction with this spectacular growth, recognition of the importance of the laser, or *optical maser* as it is sometimes called, has become widespread. A billion-dollar laser market by 1970 has been predicted, and in 1964 Professor Townes was a co-recipient of the Nobel Prize for his pioneering work in this field.

The importance of the laser to the engineer and technician cannot be sufficiently stressed. Before learning the fundamentals of laser operation, some preparation is required. The laser is often referred to as a "quantum-electronic" device thus necessitating the introduction of some important concepts of modern or quantum physics.

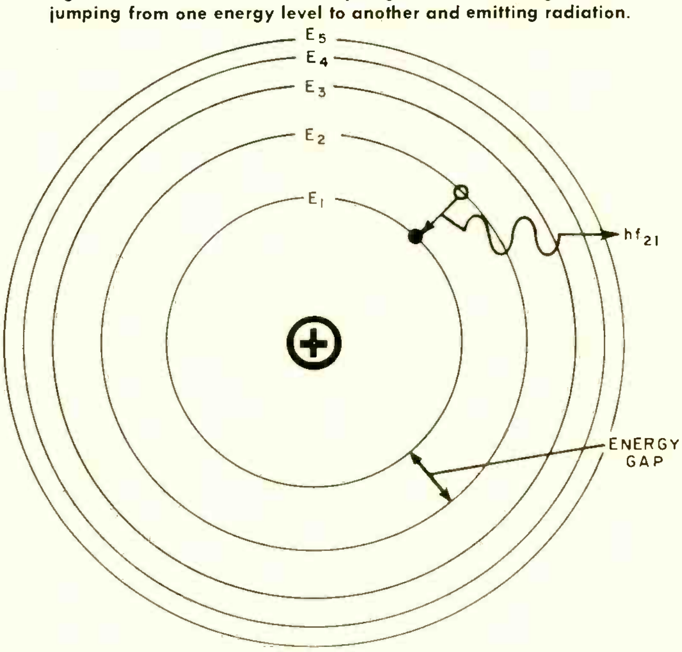
Some Ideas of Modern Physics

In 1900 Max Planck formulated an accurate description of the spectrum radiated from a black body. (A black body is a perfect radiator or absorber of energy.) Planck offered the revolutionary hypothesis that the energies of the electron oscillators responsible for the radiation are quantized, that is, restricted in certain integral multiples of a constant which now bears his name.

Although not too well understood at the time, Planck's "quantum" hypothesis was successfully employed by Albert Einstein in explaining, among other phenomena, the photoelectric effect. In explaining the photoelectric effect, Einstein extended the "quantum" concept to the radiation itself, by assuming that light interacts with electrons in a metal as if the light were itself composed of discrete bundles of energy whose energy E is given by $E = hf$ where h = Planck's constant and f = frequency of radiation. Consequently, a light beam can be thought of as a stream of massless particles called *photons* which travel at the speed of light. Each particle contains an energy of hf joules.

In 1913, Niels Bohr gave the quantum theory a big boost by proposing a quantized model for the hydrogen atom. In Bohr's model the hydrogen atom is pictured as a small, posi-

Fig. 2. The Bohr model of the hydrogen atom showing electron jumping from one energy level to another and emitting radiation.



tively charged nucleus orbited by an electron. Bohr postulated that the rotational energy of the orbiting electron can have only certain discrete values. These values define a set of stable electron orbits, that is, while an electron is rotating in a stable orbit it does not emit radiation. A region which separates allowed energy levels is called an *energy gap*. The electron could change energy only in a jump in which it either absorbed or emitted a photon. Thus, the conservation of energy for an electron jump may be written as $E_m - E_n = hf_{m,n}$ where E_m and E_n are two allowed energy states for the orbiting electron, and $f_{m,n}$ is the frequency of the emitted radiation. Fig. 2 shows this for energy levels corresponding to $m=2$ and $n=1$. Using Bohr's model, one could calculate the frequencies of the emitted radiation and it was found that these frequencies agreed almost perfectly with the observed characteristic spectrum of hydrogen.

In the years following the introduction of Bohr's model, quantum theory grew in significance and power. Many changes were made and even a brief sketch of this development would carry us too far afield for the task at hand. However, some of the features of the Bohr atom provide a useful introduction to the important concepts necessary to the description of laser operation.

A graphical picture of the Bohr model in terms of energy is

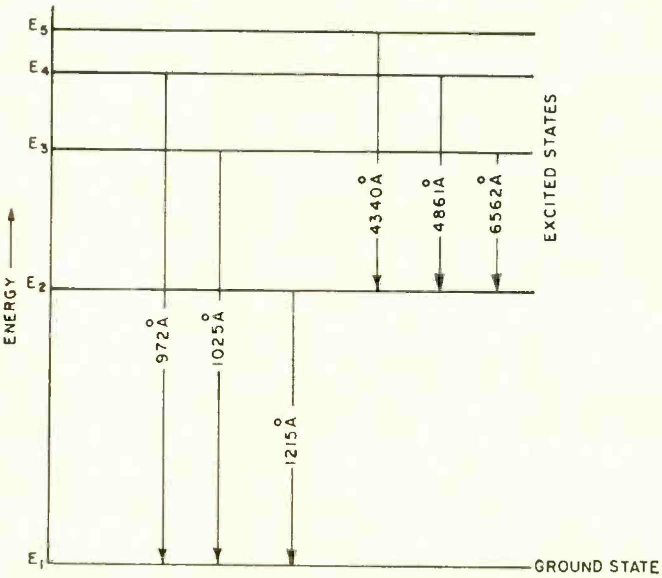


Fig. 3. Energy-level diagram for the Bohr model of hydrogen atom. When electrons make transitions from a higher energy level to a lower energy level, then radiation having a certain specific wavelength (in angstroms) and frequency is produced.

given in Fig. 3, where energy is plotted on the vertical scale. The horizontal lines are the allowed energy levels and the vertical connecting lines represent examples of electron jumps or "transitions" with the wavelength of the emitted radiation given along the transition lines in angstroms (1 ang. $= 10^{-10}$ meter). Energy level E_1 denotes the lowest energy level or *ground state* for the atom. The other levels (E_2, E_3 . . . .) represent *excited* states. Such a representation is called an *energy-level diagram*.

The usefulness of these diagrams in atomic physics may be appreciated when one realizes that the energy-level diagram for a given atom is peculiar to that type of atom. The energy-level diagram for an atom is to the atomic physicist what the schematic is to the electronics technician because such a diagram exhibits important information about atomic behavior.

Lifetime & Population of Levels

One feature of an atom's behavior not included in an energy diagram is the lifetime and population of levels. That is, if the atom at some given time is in an excited state (its electrons are at any level except the ground state), will it remain there for all time if undisturbed, or will it spontaneously jump to some other level and emit radiation? The answer to this question is that there is always a tendency for an atom to return to its lowest energy or ground state. Consequently it will *spontaneously* make transitions downward until the ground state is reached. For a gas of unexcited atoms almost all atoms will be in the ground state.

The situation, however, is complicated by the fact that the average time an atom remains in a state before decaying to some lower level depends on what state it is in to begin with. Therefore, in order to complete the picture, a set of numbers must be made available which represents the mean lifetimes of the electron in all its possible states before it decays spontaneously. In general, these lifetimes are quite short, $<10^{-8}$ second. However, there exist levels for which the lifetime is considerably longer and these are known as *metastable* states. It also must be remembered that each of the spontaneous transitions must conserve energy and therefore is accompanied by the emission of a photon. Photons emitted by spontaneous transitions are called *spontaneous emissions*. Because one atom does not know what another atom is emitting, there is lack of interaction among atoms, and the resulting emission that is produced is incoherent.

Stimulated Emission

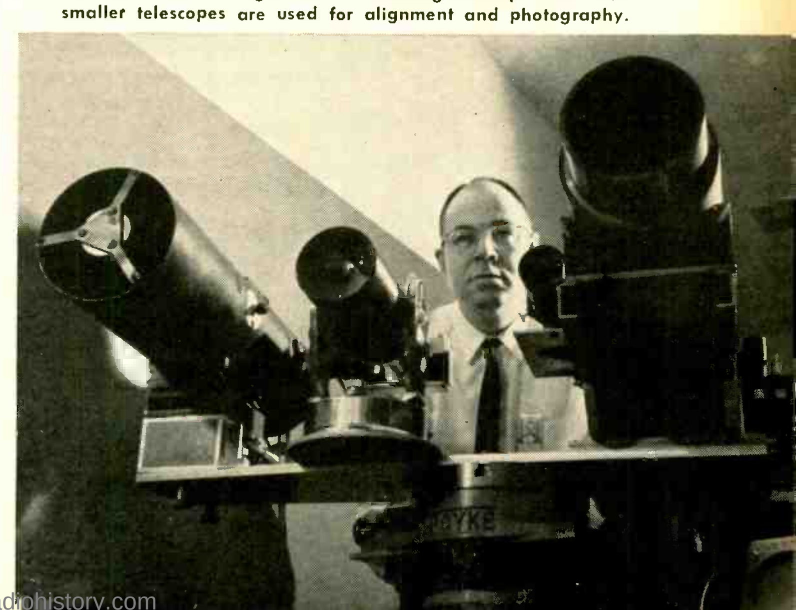
Recalling what was said earlier about ordinary light sources, it would appear that these sources rely on spontaneous emissions for their output. Spontaneous transitions are not the only means by which a particular atom may return to its ground state.

Consider the hypothetical case of a coherent light or photon beam traversing atoms of a gas.

When the frequency of such a source coincides with one of the frequencies of spontaneous emission, atoms are induced to make transitions between two particular energy levels whose difference is ΔE and satisfy the relation $\Delta E = hf$. An important result is that transitions from the upper to lower energy states are induced in addition to those in the opposite direction. In fact, the probability that the induced transition will be in one direction rather than the other depends only on which level the majority of atoms find themselves. When the transition is from a lower to an upper energy level (accompanied by the loss of one photon from the beam), it is called *absorption*, and when the transition is from upper to lower energy levels a photon is emitted and it is called induced or *stimulated* emission. Note that in this case the emission was induced by the *presence* of an energy source.

If equal numbers of atoms are in each of two levels, the beam intensity will remain constant in traversing the gas.

Experimental laser radar resembles a battery of rocket launchers as it is set up for a test. In operation, the laser beam flashes from the transmitting telescope (right) and bounces back off a distant target into the receiving telescope (left). Two smaller telescopes are used for alignment and photography.



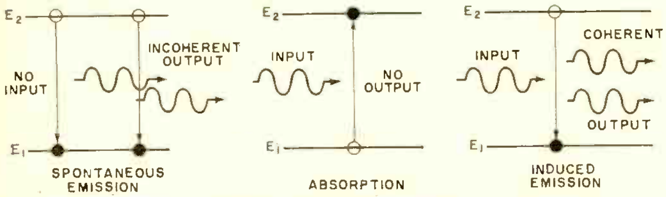


Fig. 4. Atomic transitions producing emission and absorption.

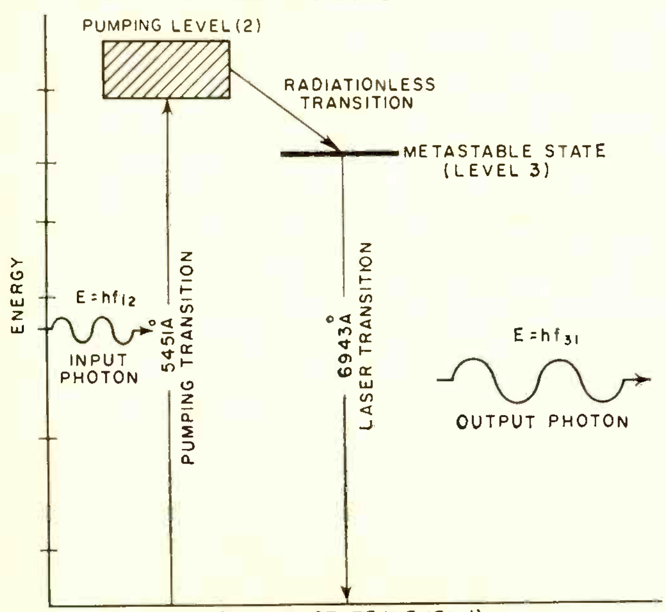
For more atoms in the upper than in the lower state the beam will see a net gain of photons or will be amplified by stimulated emissions in traversing the gas. Because photon emissions will be induced by interaction with the photons in the beam, which were assumed coherent, they will all be in phase, and the amplified beam will be coherent (see Fig. 4). In this way a single spontaneous emission may be amplified into an intense coherent beam. The remaining problem to solve is to obtain the higher concentration of atoms in the upper energy level necessary for amplification. This is known as *population inversion*, and this particular topic will be treated for the particular case of ruby in the next section.

The Ruby Laser

Obtaining population inversion involves the addition of energy to the gas. The process of populating an upper energy level at the expense of a lower one is called *pumping*. One possible method of pumping between two levels whose difference in energy is ΔE is by supplying electromagnetic energy of the frequency satisfying the relation $hf = \Delta E$ and thus raising the energy by absorption. This method is efficient only at the start, when the population of the lower level exceeds that of the upper. As equal population is obtained the number of upward transitions becomes equal to the number of downward transitions irrespective of the pumping energy. Thus, to obtain inversion, a more sophisticated technique is necessary, involving at least one intermediate energy level upon which the pumped atoms may be stored.

A simple example of the three-level system is in the chromium ions present in chromium-doped aluminum oxide, more familiarly known as ruby. Before continuing, it must be observed that since the essential property of a gas is that the constituents do not interact with one another, a lightly doped ($<<1\%$) crystal is essentially a gas of dopant atoms in a rather special container. However, their energy levels are somewhat modified by the presence of the host material. A simplified energy level diagram of the chromium ion in a ruby crystal is shown in Fig. 5. The intermediate level (3) is metastable with a lifetime of approximately 10^{-3} second. The operation is as follows:

Fig. 5. The three levels of the chromium ion in a ruby rod which is involved in pumping and in laser action.



A pumping light of frequency f_{12} causes transition between levels (1) and (2). The atoms in the excited (2) state may return to the ground state spontaneously either directly or by first stopping at the metastable state. Because the lifetime of the metastable state is 100,000 times longer than that of state (2), the atoms which fall there may be considered almost stationary. The rate at which atoms find themselves in state (3) is proportional to the rate at which they arrive in (2) which, in turn, is proportional to the pumping power and independent of the population. Thus, if sufficient pumping power is supplied, the population of the (3) state will grow at the expense of the (1) state without the limitation imposed on the two-level system, and population inversion is obtained.

As long as the population is inverted, the ruby can be an amplifier for radiation of frequency f_{31} and, as with any amplifier, adding a positive feedback loop can cause sustained oscillation. In this case what is meant by positive feedback is the return of some of the output light (f_{31} radiation) into the ruby. This may easily be accomplished with mirrors. In fact, by making use of the geometry of the mirrors so that the feedback is directional, a resonant cavity is formed. The amplified radiation, referred to as *photon amplification*, will build up in a standing-wave pattern familiar in microwave technology.

The resonant cavity is formed from the crystal itself by carefully grinding and polishing the ruby and silvering its ends. Because of the shortness of optical wavelengths, an essential difference exists between our crystal cavity and the more familiar microwave cavity. Calculating the wavelength from the energy-level diagram, the wavelength corresponding to f_{31} radiation is found to be 6943Å in vacuum. Thus a ruby ground to form a cavity 7.3 cm. long (a typical size), has 100,000 nodes in the standing wave and will be resonant for every frequency that satisfies the standing-wave condition: $(n/2)\lambda = L$ where λ is the wavelength and n an integer. For example, taking n as 10^5, the difference between resonant wavelengths $\Delta\lambda$ is given by: $(\Delta\lambda/\lambda) = (\Delta f/f) = 1/n = 10^{-5}$. The cavity is resonant for a large number of frequencies right around f_{31} instead of being resonant for only one particular frequency as in the microwave case.

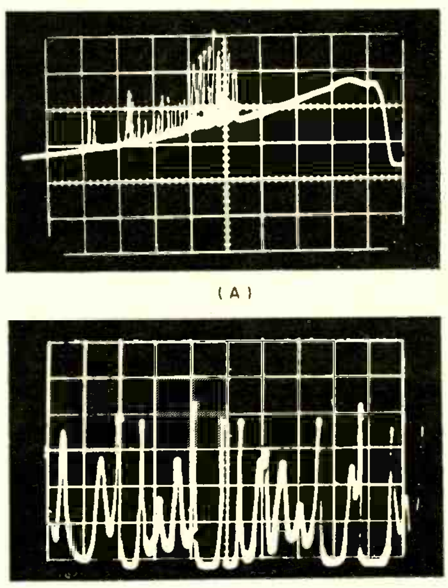


Fig. 6. (A) Output of ruby laser. Time scale is 0.1 millisec./div. The envelope is the pump-lamp flash. (B) Expanded portion of the trace with time scale of 1 μsec./div. Incidentally, in the scope traces shown time proceeds from right to left rather than left to right.

Practical Considerations

Before turning to a description of operation of the helium-neon gas laser, it is worth mentioning some practical considerations which arise in carrying out the scheme just described. First, the pumping power required to obtain population inversion for a reasonable size crystal is considerable, and may be accomplished only in brief bursts of light from a flash lamp. The operating time of the ruby laser is therefore limited to a couple of milliseconds. Second, while the ruby is lasing, the metastable state is being depopulated by stimulated emission, and quickly (in 10^{-6} second) outruns the pump, causing lasing action to stop until the pump can again create a population inversion. Hence, the output of a ruby laser consists, typically, of a series of irregularly spaced spikes about 10^{-6} second in duration in an envelope defined by the pump lamp duration. Fig. 6 shows an oscilloscope trace of the output of a photo detector receiving light energy from a ruby laser.

Finally, we may consider the over-all efficiency of the ruby laser by forming a percentage from the ratio of total output

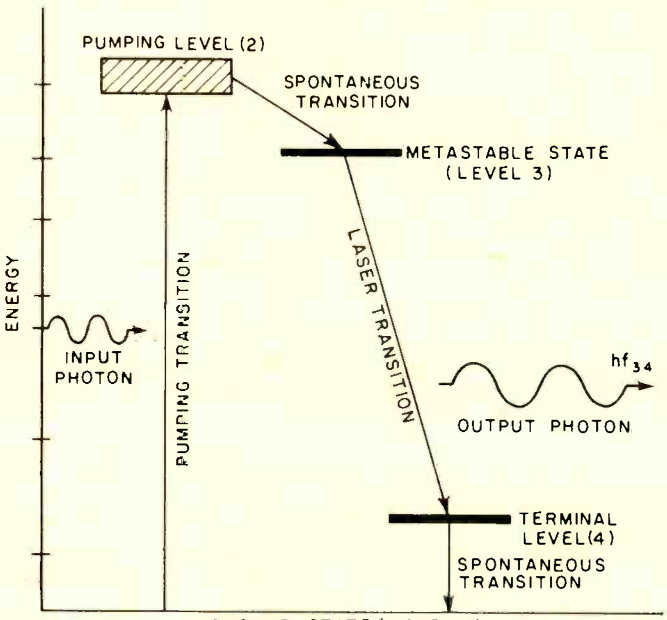


Fig. 7. Operation of four-level system as in gaseous laser.

of laser light energy to the electrical energy supplied to the pump. This efficiency is typically less than 1% with most of the lost energy heating the ruby. This makes cooling the crystal an important practical consideration.

The Gaseous Laser

To understand the operation of the helium-neon gas laser, a different means of obtaining population inversion as well as of pumping must be considered. The modification of the energy-level scheme is shown in Fig. 7. Note that a fourth or terminal level has been added above the ground state. The population inversion is now obtained between the (3) and (4) levels. The advantage of the four-level scheme is that the initial population of the terminal level is negligible compared to the ground state and therefore inversion is more easily obtained (*i.e.*, less atoms in the (3) state are necessary for its population to exceed that of the (4) state than that of the ground level). This reduces the pumping power required and opens up the possibility of pumping by a different method, called *electron-collision pumping*.

In quantum theory a striking analogy is found for an electron beam traversing atoms of gas and that of a photon beam. Only when the kinetic energy of the electrons coincides with the differences in energy between any two levels are atoms induced by collisions with the electrons to make transitions between these levels. As in the electromagnetic case, the most

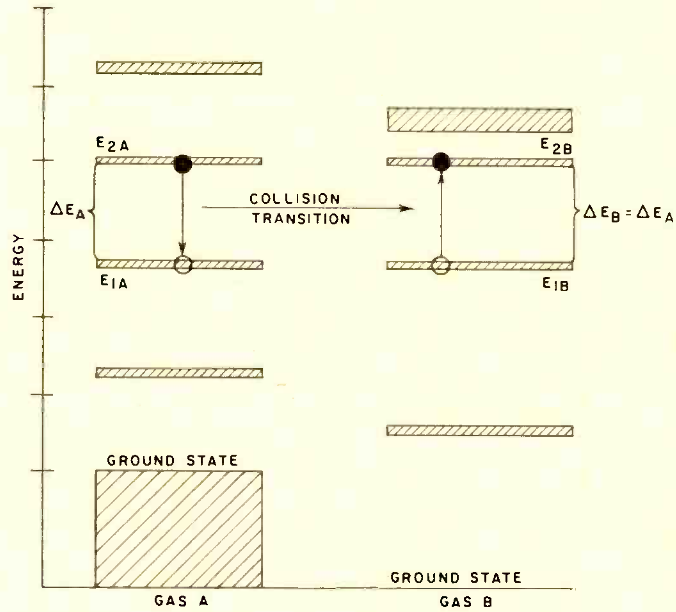


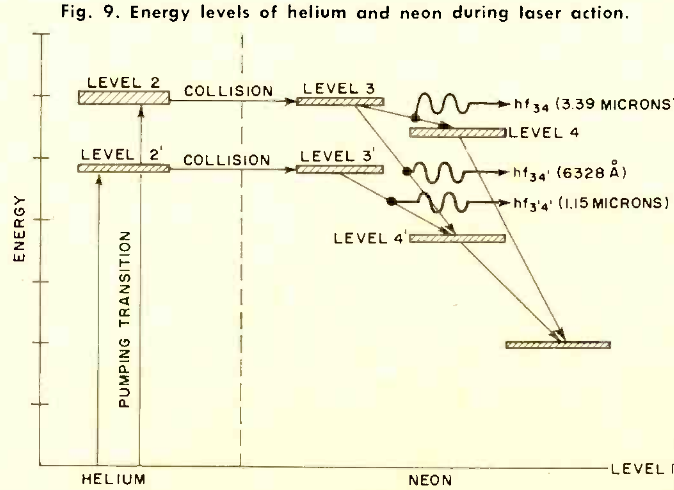
Fig. 8. Example of resonant transfer by collision of gas atoms.

probable direction of the transition depends only on the relative populations of the states. Hence, as an alternative, we may consider pumping atoms of gas with accelerated electrons in a discharge tube instead of by a light beam. These may be the result of a glow discharge when r.f. energy is applied to the discharge tube. The obvious advantage of this method is we can maintain this energy constant over extended periods of time and obtain a continuous laser output. This presupposes the availability of sufficient pump energy for inversion.

The first successful operation of a laser by collision pumping required the presence of two gases, such as helium and neon, in the discharge tube to realize the proper energy scheme. A slight digression is necessary to consider the transfer of energy between atoms of different gases. A sort of resonance phenomenon is encountered where energy transfer proceeds only when an energy gap is shared. That is, an atom of one type of gas (A) in a given energy level (2A) may transfer its energy to an atom of another type (B) in a stage (1B) *via* a collision if, and only if, there exist energy levels 1A and 2B such that $E_{2A}-E_{1A}=E_{1B}-E_{2B}$ (see Fig. 8). As before, the probability of the transition direction is determined by the population of the levels.

In this gas laser, the higher and lower energy levels are in different gases, and their population may be modified by changing the relative concentration of the different gases in the discharge tube. This additional control was fundamental in achieving the first observed laser action in a gaseous mixture of helium and neon. (*Continued on page* 63)

Fig. 9. Energy levels of helium and neon during laser action.



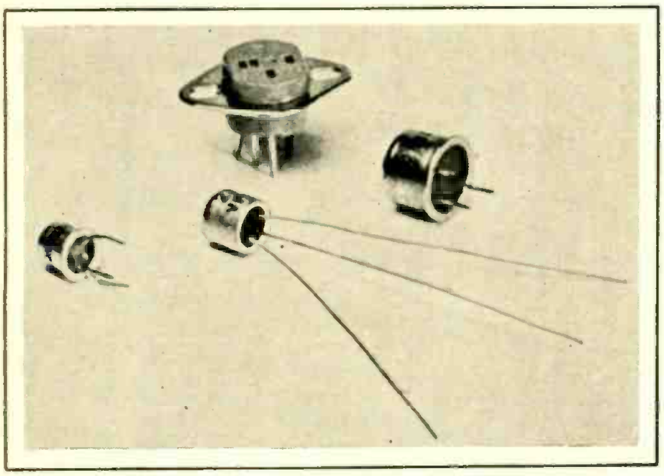


Fig. 1. An economy-line transistor is at the center. The case is about the same size as the TO-18 case at the left and is smaller than the regular TO-5 case shown at right.

ECONOMY-LINE TRANSISTORS

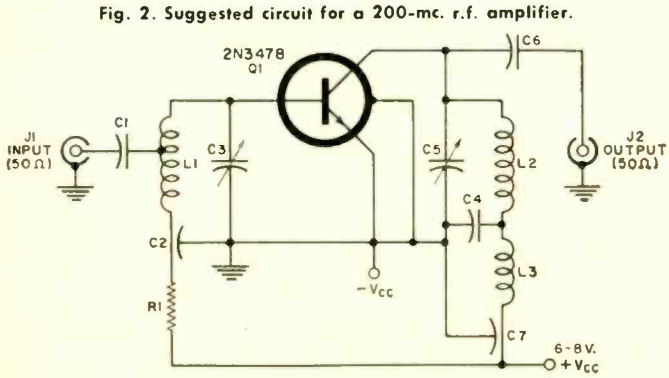
By ROBERT TELLEFSEN

Special lines of inexpensive "n-p-n" silicon transistors have been introduced to compete with the imported units.

RECENTLY several manufacturers have introduced special lines of low-cost transistors to compete with devices imported from Europe and Japan. These transistors are intended mainly for use by original electronic equipment manufacturers but there are also transistors of special interest to hams, experimenters, and CB'ers in the line. At least one type costs as little as 46 cents in single quantities. There are low-noise v.h.f. receiving r.f. amplifiers, r.f. power amplifiers for ham and CB transmitters, and general r.f. and audio transistors—all available at low cost.

The entries of one manufacturer, *RCA*, in this low-price field are unique in that they all have metal cases; other producers encase their devices completely in molded epoxy. The *RCA* case is smaller than a regular TO-5 case and similar in size to a TO-18 case (Fig. 1).

Fig. 2. Suggested circuit for a 200-mc. r.f. amplifier.



R1—About 2000 ohms, adjust for best gain or best noise figure (see text)
C1,C4—510 pf. capacitor
C2, C7—2300 pf. capacitor
C3,C5—2-25 pf. var. capacitor
C6—10 pf. capacitor
L1—2" #14 Formvar or enam. bent into hairpin loop and center tapped
L2—1½" #14 Formvar or enam. bent into hairpin loop
L3—1 μhy. r.f. choke
J1,J2—R.f. connector
Q1—2N3478 transistor (RCA)

Table 1 shows some applications, ratings, and approximate costs of the *RCA* line. The lines of the other manufacturers are, in general, similar. The devices are all *n-p-n* silicon types and are intended to replace germanium units. The replacement process is not difficult and has been discussed elsewhere ("Substituting Silicon for Germanium Transistors" by William O. Hamlin, ELECTRONICS WORLD, December 1964). Germanium is not a plentiful element but silicon is. In time, the cost of silicon transistors will go lower still and germanium will possibly be used for replacement-only devices.

Recommended Circuits

The low-noise v.h.f. r.f. amplifier mentioned earlier is the 2N3478. It has a typical noise figure of 5 db at 470 mc. and 2.5 db at 60 mc. The circuit of Fig. 2 is recommended for use with this transistor. The 2N3478 is capable of an unneutralized gain of 11.5 db at 200 mc., so it should work well in the 6- and 2-meter ham bands. The collector current should be kept between 1 and 2 ma. to utilize the low-noise capability. The case of the 2N3478 is identical to the one shown in Fig. 1, except that a fourth lead is connected directly to the case for grounding and shielding independently of the other three elements. With the high gain of the amplifier, thorough shielding between input and output is essential.

The economy line also includes three transistors in standard TO-5 cases intended for use in 5-watt CB rigs, but they work equally well at 29 mc. These transistors are designated by company house numbers 40080, 40081, and 40082; they have no equivalent 2N numbers. The 40080 is used as a crystal-controlled oscillator (100 mw. output); the 40081 is an r.f. driver (400 mw. output); and the 40082 is a power amplifier (3.5 watts output). The 40080 and 40081 will also work in the 6-meter ham band, but no information is available on the 50-mc. performance of the 40082.

A typical CB or 29-mc. ham transmitter r.f. section using these three transistors is shown in Fig. 3. It can provide an unmodulated r.f. output of up to 4.5 watts, well above the FCC limit for CB equipment. (*Continued on page* 72)

Table 1. Listing of economy-line transistors along with characteristics, applications, and single-unit prices.

TYPE	CASE	APPROX. COST
Audio and low r.f. amplifiers to 30 mc. (f_T=60 mc., P_T=2 w. max.)		
2N3241	Fig. 1	$ 0.73
2N3242 (higher β, lower noise)	Fig. 1	0.96
V.H.F. and low U.H.F. r.f. amplifier		
2N3478 NF @ 470 mc.=5 db, f_T=900 mc., P_T=200 mw. max.	Fig. 1	2.06
R.F. oscillator to 50 mc.		
40080 P_o @ 12 v.=100 mw., f_T=300 mc., P_T=0.5 w. max.	TO-5	1.40
R.F. driver to 50 mc.		
40081 P_o @ 12 v.=400 mw., f_T=300 mc., P_T=2 w. max.	TO-5	1.90
27-mc. r.f. power amplifier		
40082 P_o @ 12 v.=3.5w., P_T=5 w max.	TO-5	11.14
Very-low-noise, high-gain audio amplifiers (NF @ 10 kc.=2 to 2.8 db, f_T=60 mc., P_T= 1 w. max.)		
40231 (lower β)	Fig. 1	.54
40232 (higher β)	Fig. 1	.59
40233 (higher β, lowest noise, lowest leakage current	Fig. 1	.66
40234 (lower β, highest β spread)	Fig. 1	.46

MICROFILM and ELECTRONICS

MICROFILM and ELECTRONICS

By DANIEL M. COSTIGAN

Widely used for record keeping, storage of documents and drawings, microfilm equipment uses electronic techniques both for creating and retrieving the desired information.

MICROFILM has been quietly building itself a new reputation as one of the most versatile of industry's space-age tools, thanks in large part to electronics. Banks began using microfilm for record-keeping nearly forty years ago. Then, during World War II it won acclaim for its role in easing the overseas mail load. Meanwhile, libraries have used it increasingly over the years for the preservation of periodicals and rare books.

But the real boom has come within the past decade, with industry's mushrooming adoption of the medium to miniaturize paper records of all sorts. Electronics has helped immeasurably to insure the exacting standards that industry demands. Below are described some of the applications of electronics used in microfilm work.

Illumination Control

Reflectance characteristics tend to vary from one microfilmed item to another, making it necessary for the camera operator to perform frequent exposure adjustments. Production is speeded significantly by use of electronic illumination control.

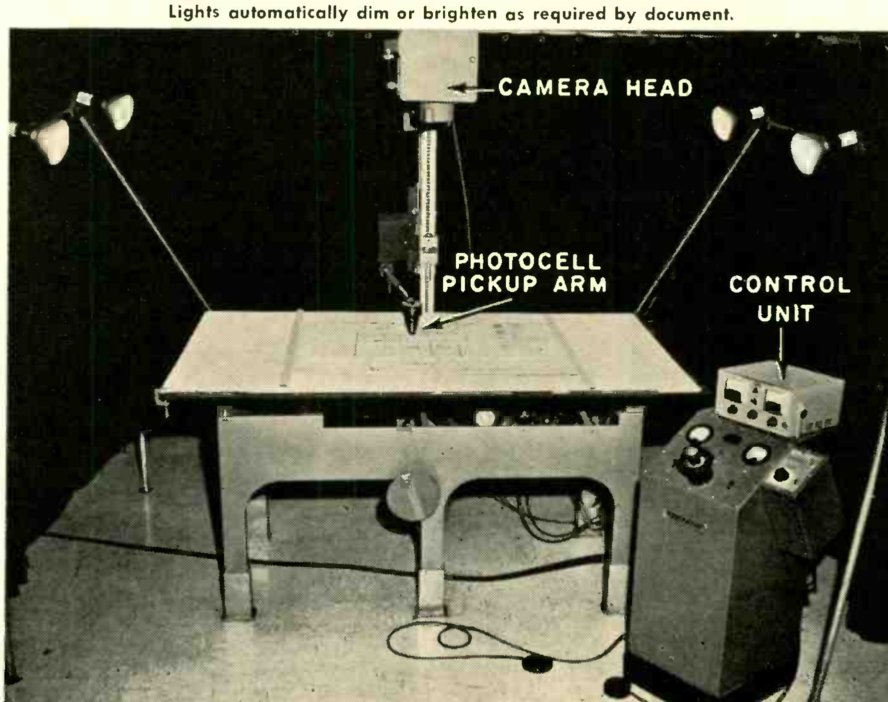
Unlike the electronic eye as used in a home-movie camera, in which the photocell output directly operates a delicate mechanical device that varies the size of an aperture (this method also is used on some microfilm cameras), the same feeble photocell output in an automatic illumination control acts to vary the voltage on a bank of high-wattage floodlamps.

Fig. 1 shows a commercial automatic light control mounted on a 35 mm. microfilm camera. Basically, this equipment consists of two components: a motorized photocell pickup arm, which "reads" the reflected light from the document or drawing being copied; and the control unit, which contains the electronic circuitry. The illuminating lamps are part of the camera.

When the item to be microfilmed is in place on the camera's copyboard, the operator presses a button to bring the motorized pickup arm out to sample a portion of the background area. The lamps automatically dim or brighten according to need to insure proper exposure.

The button is pressed a second time and two things happen: the pickup arm swings back out of the picture area, and the lamps "lock in" at whatever illumination level they have

Fig. 1. Microfilm camera with automatic illumination control. Lights automatically dim or brighten as required by document.



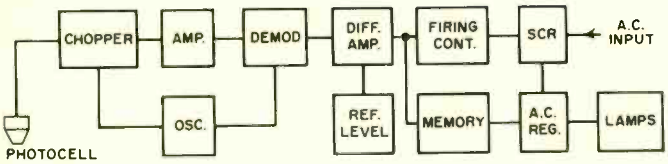


Fig. 2. Automatic illumination control uses reflected light from document to operate an SCR lamp brightness controller.

been adjusted to. A separate button snaps the shutter and automatically advances the film spool to next unexposed frame.

The block diagram in Fig. 2 illustrates the operating principle of this system.

The output of the photocell is first chopped to convert it to pulsating d.c.—varying in amplitude according to light intensity—and is then amplified through four transistor stages. The varying amplitude component is demodulated and compared with a pre-adjusted, zener diode-controlled reference signal. The difference voltage is amplified and fed to the firing control circuit, which uses a pair of silicon controlled rectifiers to adjust the voltage applied to the illuminating lamps. The lamps are dimmed or brightened depending upon which condition is necessary to produce an amplitude difference of zero between the amplified photocell output and the fixed reference signal.

The memory circuit, which uses a single vacuum tube and is the only exception to the unit's being fully transistorized, stabilizes lamp voltage at the compensated level long enough to allow taking several shots at the same illumination.

Densitometry

Among the methods used to spot-check processed microfilm for consistent quality is measurement of the density (opaqueness) of the dark, or background, portions of the negative images.

Measurements are made on a transmission densitometer, an electronic instrument in which the sample is introduced between a light source and a photocell or photomultiplier tube. The varying output of the light-sensing unit, depending on the density of the sample, is indicated by a meter calibrated in "density units." The higher the reading, the more dense or opaque is the sample being measured. Rigid standards are set to keep density within acceptable limits.

One typical transmission densitometer, such as shown in Fig. 3, uses a photomultiplier tube in a special feedback circuit designed to hold the anode current constant by automatically varying the voltage applied to the cathode and dynodes when a sample is being measured. Unlike the usual photomultiplier-tube circuits, in which the dynode voltage is held constant and the output current allowed to vary, this arrangement permits a more linear meter scale. It also provides greater stability and, with the aid of an "anti-fatigue" lamp to keep the photomultiplier cathode bathed in light between readings (thus reducing dynode voltage), it affords a substantial increase in tube life.

Fig. 3. Transmission densitometer measures image opaqueness.

The decrease in the amount of light striking the photomultiplier-tube cathode results in a corresponding decrease in the input signal from the anode to the first voltage amplifier stage. The amplified signal appears at the input of a power amplifier as a decrease in bias, thus increasing plate current. The result is a corresponding increase in the negative output of the high-voltage power supply due to the increased current flow through the dynode resistor chain. The gain of the photomultiplier tube is thus increased and the anode current restored to its original value.

A microammeter, from which density measurements are read, actually functions as a voltmeter, measuring the varying cathode-dynode voltage.

Because the feedback circuit alone cannot effect a perfectly linear relationship between cathode-dynode voltage and transmission density, a compensating circuit is provided to shunt the voltage appearing across the meter. Six factory-adjusted pots control the shape of the voltage-density curve at six critical points within the calibration range.

Electrostatic Reproduction

Xerography, an electrostatic copying process, may not belong strictly in the electronics category, but it rates at least a passing glance for its unique application of a photoelectric principle.

In one printer, designed to produce enlarged paper prints from microfilm, a photosensitive selenium-coated drum serves as intermediary between the microfilm input and paper output. The negative film image is projected onto the drum, which has been charged to a given static potential by a high-voltage source. Wherever light strikes the drum, the charge is reduced, thus forming an enlarged, latent electrical copy of the original image on the face of the drum.

Through differences in static potential, a heat-sensitive resin in the form of black powder is first made to cling to the neutralized portions of the drum and is then transferred to a sheet of paper. Application of heat completes the process by melting the black resin and fusing it to the paper, resulting in a permanent and convincing paper copy of the original document or drawing.

Other electrostatic copiers eliminate the photosensitive drum by the use of special paper onto which the image is projected directly. Still others utilize a combined chemical-electrical process in which the latent electrical image is made visible on the paper by chemical action.

Automatic Retrieval

Having applied electronics to the streamlining of microfilm production, the next logical step is to design equipment to expedite the "retrieval" of a specific microfilmed item from among the many thousands or millions in a given file.

One company offers an automatic microfilm retrieval system through which a specific micro-image is electronically selected from among several hundred by a photoelectric scanning technique. The system, known as MEDIA (*Magnavox* *E*lectronic *D*ata *I*mage *A*pparatus), utilizes a coded identifying track optically printed along the edge of the microfilm. Selection is made on a keyboard, and the capsuled film "chips" containing the micro-images zip past the photocell at the rate of ten per second until the selected image is found. The image is then either projected on a screen or reproduced electrostatically as an enlarged paper copy, after which the film chip is automatically returned to its proper place in the storage capsule until recalled at some future needed time.

A retrieval system developed by the *GPL Division* of *General Precision, Inc.* and the *Mosler Safe Company* goes a step farther by permitting the stored microfilm to be in one location and the selecting controls and viewing facilities in another. Selection is by keyboard and delivery by closed-circuit TV. The code for the desired item is keyed and the item is automatically retrieved from storage at the distant location and placed in position for camera pickup. A 21-inch monitor screen at the selecting station displays a 1000-line, 10X enlarged view of the selected micro-image. The retrieval unit holds 5000 *IBM*-sized cards, each of which can contain as many as 1000 tiny micro-images, giving the unit a total storage capacity of 5,000,000 separate documents.

New Concepts

For the most part, the devices we have looked at so far are merely aids in expediting the normal microfilm routine. Somewhat more impressive are certain imaginative new concepts aimed at broadening the scope of microfilm.

Recently one such concept to become a reality is the creation, by machine, of microfilm images from actually nonexistent documents and drawings. Basically, it works something like this: the raw data—statistical information, schematic symbols, etc.—is fed into a computer, which stores it in coded form on magnetic tape. The recorded data is then fed into another electronic device, at the output of which it is made visible in standard symbols on the face of a cathode-ray tube, from which it is recorded on raw microfilm.

A typical unit records data on microfilm at the rate of 17,500 characters per second. The end product may be a sequence of complex engineering drawings, schematic diagrams, texts, or graphs, each of which can be produced in less than a second, some in less than half a second. An example of such a computer-derived diagram is shown in Fig. 4.

The computer data is converted to visual form by a Charactron shaped-beam tube (Fig. 5). Voltages applied to the selection plates determine the matrix character through which the beam will pass *en route* to the tube face. The metal matrix can contain as many as 220 separate etched characters.

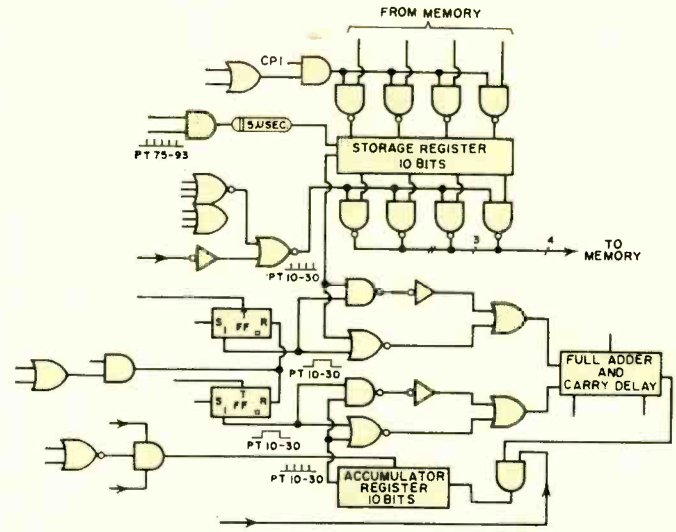


Fig. 4. This logic diagram was produced directly on microfilm by computer techniques in less than one second of time.

The convergence coil and reference plates set the shaped beam back on axis, and the signals applied to the deflection yoke determine the spot at which the beam strikes the tube face.

The Census Bureau of the U.S. Department of Commerce has developed a system which reverses the procedure just described. The system, known as FOSDIC (*F*ilm *O*ptical *S*ensing *D*evice for *I*nput to *C*omputers), transforms microfilm images into impulses on magnetic tape. A computer, using the tape as its storage medium, may then be queried, and the desired information is delivered in black-and-white *via* high-speed printers.

The marriage of microfilm to electronics is by no means complete. In the offing are systems through which the identifying number of a document or drawing can be "dialed" from any number of remote locations, and a copy of the desired item automatically retrieved from a central file of computer-produced microfilm and delivered by facsimile within seconds. ▲

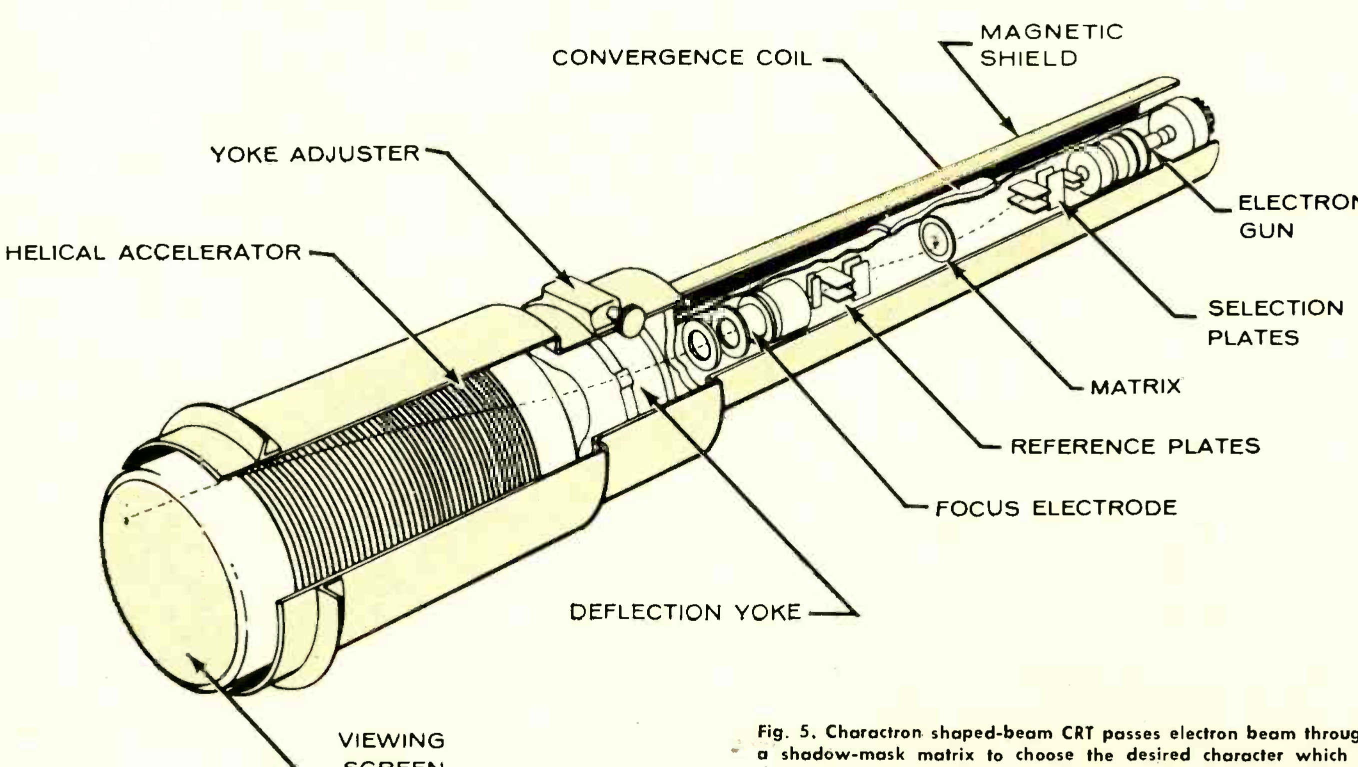


Fig. 5. Charactron shaped-beam CRT passes electron beam through a shadow-mask matrix to choose the desired character which is then positioned on the screen by beam deflection techniques.

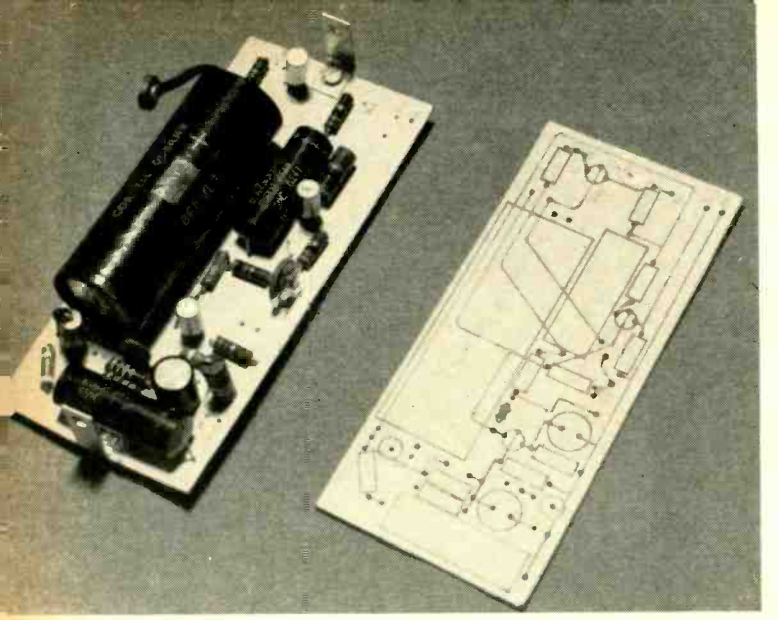


Fig. 1. A finished driver-amplifier using a board made by the "long-hand" wiring technique is at the left. The template at right was employed to produce the finished amplifier board.

"Long-hand" PRINTED CIRCUITS

IF you are like the author, you have probably found that the biggest stumbling block to building most projects is mechanical. How to mount the circuit components? Where to find a suitable chassis? How to transfer the schematic to a practical physical layout?

Most of us like to see a neat finished product. We also know how easy it is for our project to wind up looking like a mess of bailing wire. Printed circuits are neat, but they are also final. Even a slight change in circuitry can be extremely difficult.

The method of circuit building to be described can be the answer to the mechanical problems presented in building many projects. Although primarily devised for solid-state circuitry, this technique can be used for circuits employing nuvistors, relays, and small transformers and possibly even 7-and 9-pin miniature tubes.

This approach, called "long-hand" circuitry by the author, has been used in two ways: first, as a quick method for building a single item and, second, as the prototype of future printed-circuit designs. In the first case, the final product, while neat in appearance, can be changed later if some modification is desired. As a prototype, much fuss is eliminated as would be the case in making even a simple printed-circuit board, while modifications are easily made. Because a template is used in the initial phase of this approach, a printed-circuit board may be obtained easily and quickly at a later date. This is true even if the original intention was only to build a one-of-a-kind project.

A completed "long-hand" circuit is shown in Fig. 1, along with the original template board. This template was used to lay out the board of the final model. Probably the most unique feature of this circuit-building technique is the board material used—cardboard. Actually, many types of cardboard can and have been used by the author. Insulating "fish paper" was used on one occasion for a three-transistor square-wave generator. If you wish to make your finished circuit impervious to environmental conditions, you can encapsulate it. This can be done by using various expoxies or silicones.

Making the Template

The first step in building a "long-hand" circuit is to get a piece of cardboard which is a little larger than the anticipated final size. Start in the upper left-hand corner of the board. Make certain that the schematic from which you are working is clear and logical. This will provide the basis for a clean circuit-board layout.

Begin sketching the parts on the board, using the actual parts you will be using as a guide. Bend the leads of resistors and capacitors, etc. as you would insert them into the circuit board. Locate the holes for these parts by placing them against your board. You will be sketching the parts on the board as they will be viewed from the top of the board. Use a soft pencil to sketch the parts and the interconnections. As you draw the circuit remember: the lines of a schematic may cross but on a circuit board they may not. Even if you are careful you may find it necessary to redraw certain portions to achieve a more practical layout. With practice, you will find the layout process becoming easier.

Since the ½-watt resistor is the most common part, you will find it worthwhile to spend a few minutes making a template for this part. Obtain a piece of stiff plastic, such as is used in packaging. Cut out the rectangle of the resistor body with a razor blade or an "X-Acto" knife. Since the cut-out for the resistor body must be larger than the actual resistor body, to allow for the pencil lead, it would be difficult to locate the lead-hole pattern in the template. Use a ½" hole-to-hole spacing for the resistor leads. Space them equally off the ends of the resistor body. Because capacitors are of varying sizes and shapes, it would be difficult to make templates for each of them and no time would be saved by doing so.

Since transistors can either be wired directly into the circuit or be mounted by using transistor sockets, you should determine beforehand which approach you will use. If sockets are to be used, cut the appropriate opening in the circuit board with your blade. Remember, you will be using standard sockets for the "long-hand" circuit and printed-circuit types for any future printed-circuit boards.

A circle template is handy for drawing the transistors, stand-up electrolytics, and other round objects to be mounted on the board. Such templates are readily available.

Fig. 2. Method used to punch holes in "long-hand" circuit board.

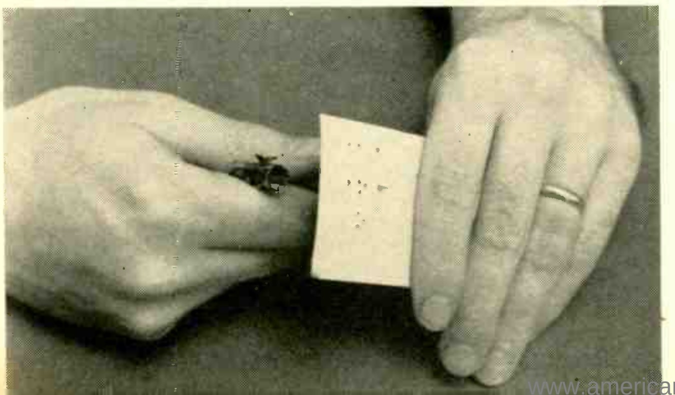
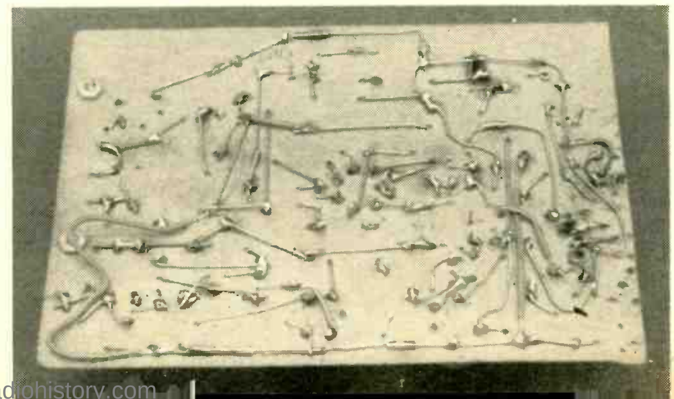


Fig. 3. The underside view of a fairly complicated circuit design.



Whether you are designing new circuits for future production or for a single prototype, this technique will speed your work. No chemicals, photo processes, or phenolic boards are used. Template permits simple changeover to more conventional printed circuitry.

By EDWARD M. LONG

After the complete circuit has been drawn on the board, check it out visually to make certain that all connections have been made and that none of the wiring crosses over itself. While the "long-hand" wiring technique lends itself to crossover wiring if insulated wire is used, it should be avoided if a printed circuit is desired later on.

Once you are certain the drawing is correct, the holes for the inserton of parts may be punched. Fig. 2 shows the method of hole punching. An ordinary compass is used. Actually Fig. 2 is intended to show the depth to which the compass point should be inserted.

A better way to punch the holes is to place the circuit board on a flat piece of polystyrene foam about one inch thick. The compass point is then pushed through the board to the desired depth. When all the holes have been punched, trim the board to the correct size. At this point you will have a master template and circuit-wiring guide from which you can make other circuit boards if these are required.

The Prototype

Place the template over a second board cut to the same size as the template. As a precaution, to prevent slipping, tape the template and the second board together at the edges with some short pieces of masking tape. Place them on the polystyrene pad and punch the holes in the second board by pushing the compass point through the holes in the template. When the hole pattern is completed, mounting of the parts on the second board can begin.

Since the circuit and parts have now been drawn on the template board, you can use this as a guide in building the actual circuit on the second board. Begin in the upper left-hand corner of the board. Insert the first few parts and, using the leads of the parts themselves, begin soldering the circuit together. Bend the leads down close to the board. It is best to do only a few parts at a time. If all the parts were inserted at once, the jungle of wires would be almost impossible to sort out and interconnect. This is true even if the circuit is relatively simple.

Fig. 3 shows the bottom of a fairly complicated circuit. You will notice that some crossovers are made with insulated wire. As noted before, these are permissible if a correction has to be made. This can be eliminated in two ways. The obvious way is to redraw the circuit to eliminate the crossover entirely. Sometimes this will prove almost impossible and you will have to use the second method. A jumper on the top of the board will allow a permanent crossover to be made. For the sake of neatness, jumpers should be eliminated by careful circuit layout.

You will also note the use of insulated wires for long runs and for wires which come near each other. These would be replaced by copper on a future printed-circuit board. There are also holes which are not used because of modifications in the final layout. If modifications are made as the circuit is being built or later during testing, corrections should be made on the template. This will assure that any future boards will be up-to-date. Holes in the template which will no longer be used should be marked, possibly with a red dot, so that you will not punch them into future boards.

Fig. 4 shows the top of the circuit board of Fig. 3, with all components mounted. Most circuits will be less complicated than this. Once you have built a few circuits using this technique you will find that it is easy.

In building simple circuits, there will be a temptation to build them directly without first making the template. The author has done this at times and regretted it later when the same circuit was needed again. The template stage may seem unnecessary at times, but in the long run it is well worth the time invested. The template can be used for both future "long-hand" circuits and for preparing the artwork that is needed for a printed circuit.

Printed Circuits

Fig. 5 shows the template of Fig. 1 and the printed-circuit artwork which was obtained from it. The method used to obtain this artwork will be explained. A piece of thin white paper is used to prepare the artwork. Lay the template on top of the paper. A pencil with soft lead is pushed through each hole in the template and a small dot is made on the paper. Make these dots very lightly. The template is removed and the circuit is drawn lightly on the paper using the circuit on the template as a guide. Draw a small circle around the holes so that they may be seen easily through the paper.

Now turn the paper over and lightly trace out the circuit with a pencil. Next, you may either ink in the circuit or make use of some of the printed-circuit dry transfer materials available.

The printed-circuit boards can now be made from this artwork using standard techniques. This artwork can also be blown up for re-touching and then reduced to the actual size that is required. ▲

Fig. 4. Top view of board in Fig. 3 with components mounted.

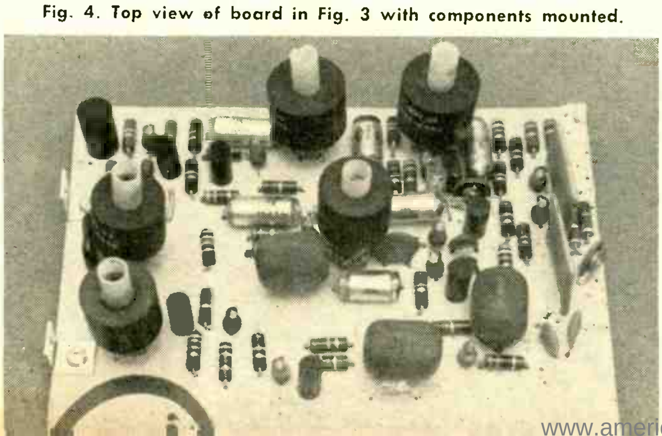
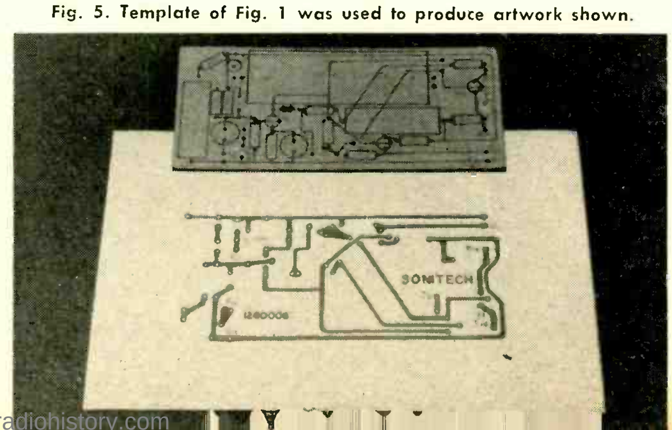


Fig. 5. Template of Fig. 1 was used to produce artwork shown.



RADAR IMAGERY

By J. L. NELSON
Military Electronics Division
Motorola Inc.

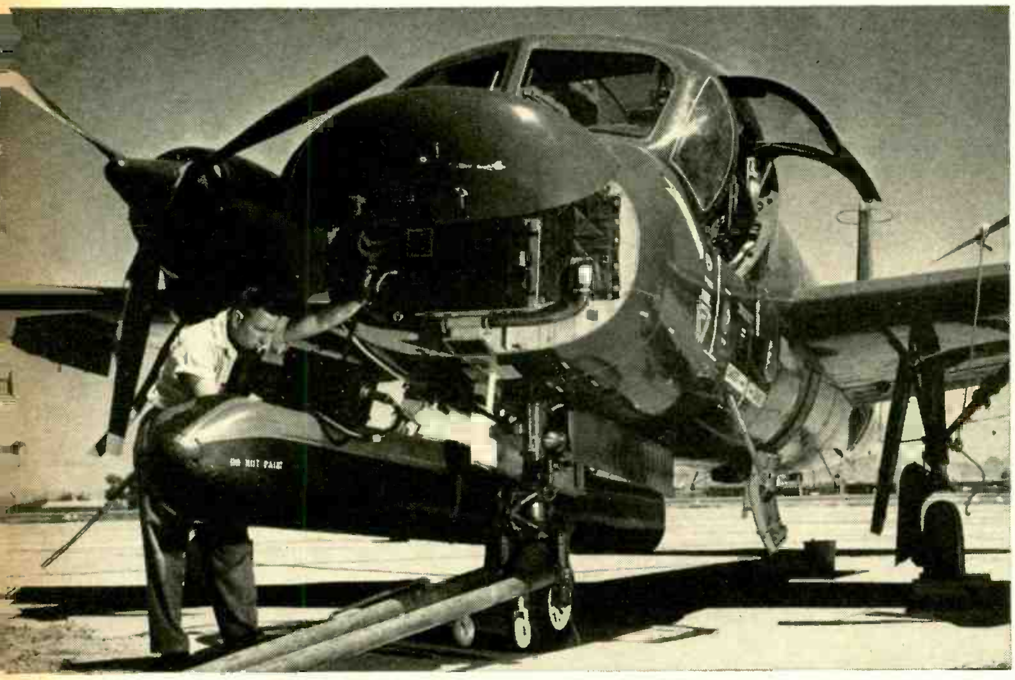


Fig. 1. Side-looking radar installation on an Army Mohawk aircraft. Notice the long cigar-shaped radar antenna housing mounted beneath the fuselage.

Side-looking radars mounted in our military reconnaissance planes provide near-photographic mapping coverage in clouds and darkness.

IMAGERY produced by electronic sensors, such as radar and infrared, is playing an increasingly greater role in the reconnaissance efforts of the military services. Such imagery not only supplements the aerial photograph, but in certain instances provides information that cannot be obtained by photographic techniques. For example, it has long been established that the ability of various types of electronic sensors to penetrate clouds and darkness as well as to map large areas is a most desirable characteristic.

Side-Looking Radar

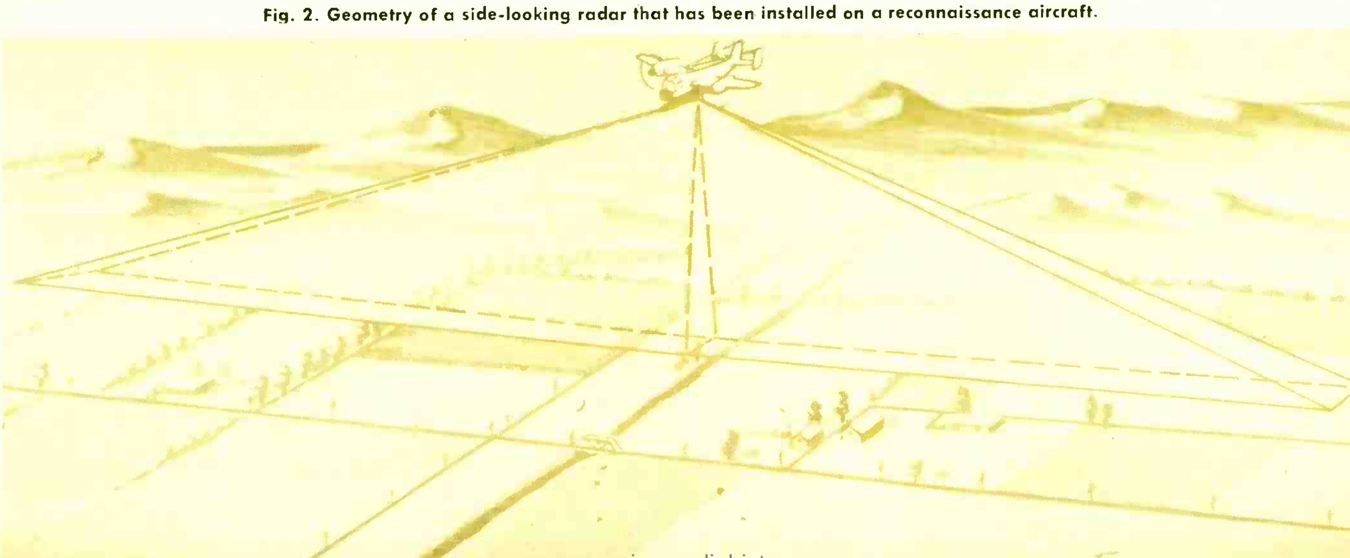
An example of an electronic sensor currently used for mapping purposes is the AN/UPD-2 Side-Looking Radar System produced by *Motorola's* Military Electronics Division for the U. S. Army. The name "side-looking" stems from the fact that this form of radar collects mapping information from the terrain to the sides of the aircraft. In contrast, infrared and photographic systems are generally used to record terrain beneath the aircraft. Radar as a sensor is a ranging device; its maximum range limit is approximately equal to the line-of-sight distance to the horizon.

For example, an aircraft flying at 3000 feet above the terrain is capable of mapping in excess of 50 miles to each side of the aircraft during a single run. It is not uncommon to map areas in excess of 30,000 square miles during the course of a single run, and this record may be contained on a strip of film less than 2 feet long. To better understand the structure of a radar image, the mechanics of the technique must be examined.

Fig. 1 illustrates a typical side-looking radar installation in the Army's Mohawk aircraft. The cigar-shaped structure beneath the aircraft is the radar antenna.

Fig. 2 shows the geometry peculiar to a side-looking radar. Note that the antenna pattern is a narrow fan-shaped beam extending from the aircraft outward to the horizon. In general, this beam is less than 1° thick; therefore, the radar illu-

Fig. 2. Geometry of a side-looking radar that has been installed on a reconnaissance aircraft.



minates and receives returns from only a narrow strip of terrain at any one time. As the aircraft moves forward, successive strips of terrain are viewed by the radar system.

As contrasted to a camera, a radar system does not examine the entire area contained in the strip at one time. It accomplishes its purpose by transmitting a high-energy pulse and recording the intensity of the return echo in synchronism with the time required for the pulse to reach a particular element of terrain and return to the aircraft.

Thus, the basic terrain information is contained in terms of "range *vs* time" as a video signal. This signal is converted to a film record by placing the video information on a cathode-ray tube as intensity modulation, sweeping the cathode-ray tube in synchronism with the radar return from each element of terrain, and photographing the resultant display. The film is caused to move at a rate proportional to the ground speed of the aircraft, thereby building up the map in synchronism with the illumination of successive strips of ground by the radar antenna. In general, the ground-scanning process may be likened to the scanning spot of a television raster.

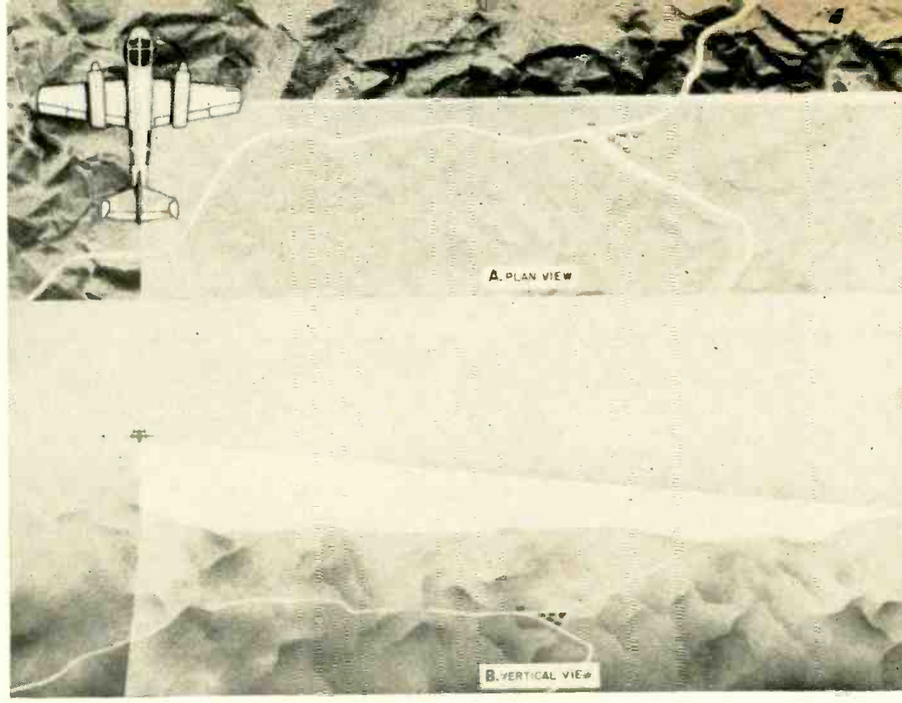


Fig. 3. Coverage patterns obtained with side-looking radar. (A) Pattern as viewed from above. (B) View from in front of plane.

The process, as viewed from a point directly above the surveillance aircraft, is illustrated in Fig. 3. The narrow light area perpendicular to the side of the aircraft represents the geometry of the radar beam; hence the strip of terrain under surveillance. The area immediately aft of this beam represents terrain already mapped by the sensor.

Examples of Imagery

A typical example of imagery produced by a side-looking radar is shown in Fig. 4. The horizontal dimension is related to radar slant range. The black central stripe represents the range to the ground directly beneath the aircraft. Features such as roads, cities, farms, and other landmarks are readily discernible. Another example of a radar map made in the area of Phoenix, Arizona is shown in Fig. 5.

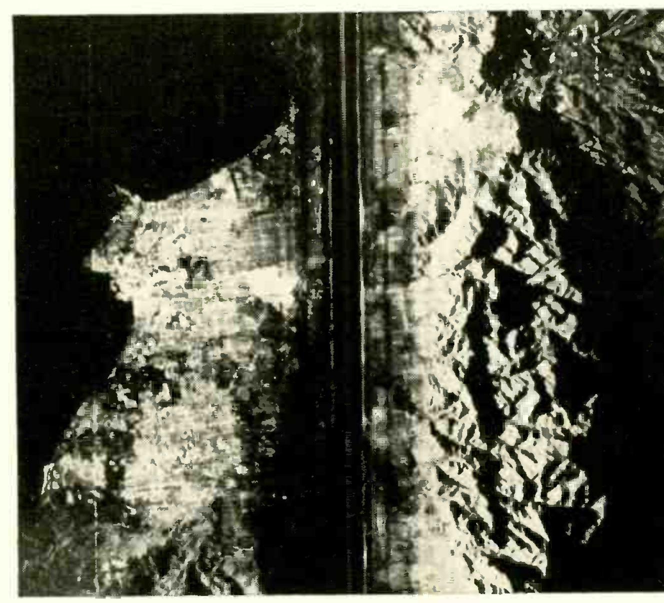
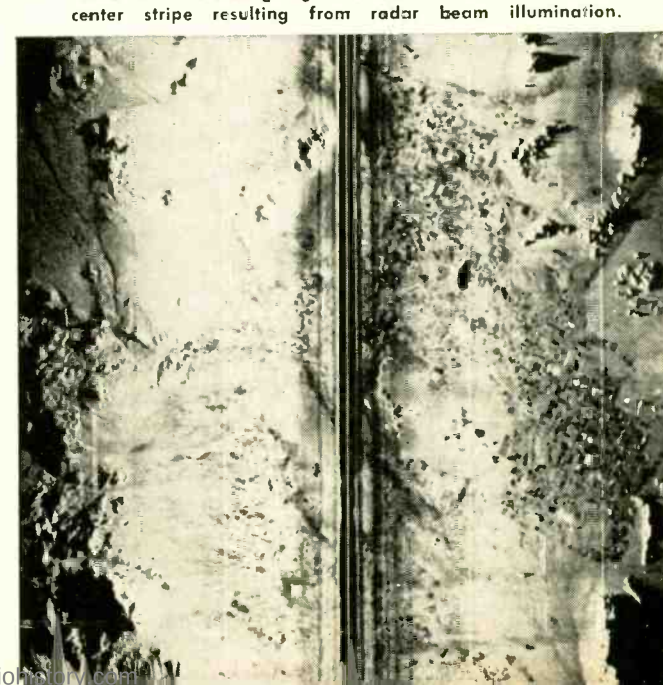


Fig. 4. Side-looking radar imagery of Los Angeles area. The black central stripe which resembles a roadway directly below the plane is the aircraft's line of flight.

Imagery such as that of Figs. 4 and 5 does not always lend itself to direct correlation with terrain maps or other systems of coordinates because of various types of distortion. Two prominent forms of imagery distortion often found in radar strip maps are: drift-angle distortion and ground-speed distortion.

Taking first the case of an aircraft encountering a side wind, it will be necessary for the pilot to intentionally "crab" or yaw the aircraft to maintain the desired ground track. If the antenna is rigidly affixed to the aircraft for aerodynamic reasons, the beam will no longer be perpendicular to the ground track but will be rotated by an angle equal to the drift angle of the aircraft. In general, side-looking radar systems compensate for this by rotating the intensity-modulated line scan on the cathode-ray tube a proportionate amount, thereby providing first-order correction.

Fig. 5. Side-look radar imagery of Phoenix, Arizona area. Notice the outward-going shadows on both sides of the center stripe resulting from radar beam illumination.


Distortion Effects

To avoid ground-speed distortion, it is necessary to synchronize the motion of the film across the image plane to that of the aircraft over the terrain. In the event such synchronization is not achieved, the scale factor lengthwise along the film record will not be in agreement with the scale factor laterally across the film record. Thus, it is necessary that two vital pieces of information be provided to render proper coordinates on the final imagery.

One device used for obtaining this basic information is a Doppler navigator. (*Continued on page* 80)

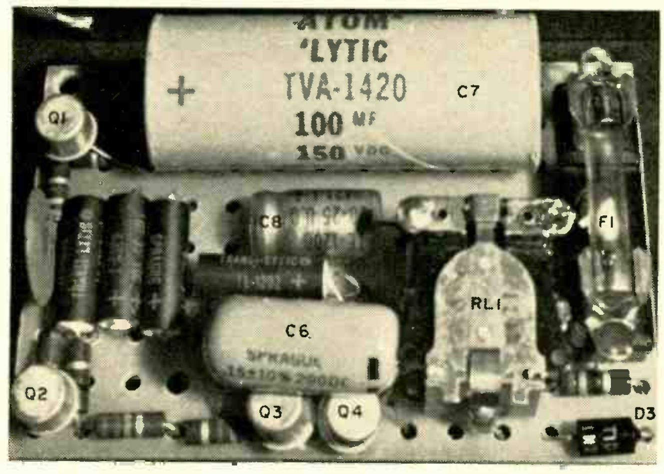
CAPACITANCE TOUCH-PLATE LIGHTING SWITCH

By R. WAYNE SIMISTER

Touching a single, small metal plate or several remotely located plates turns on and turns off lamp or appliance.

Circuit is built into a 4" x 2" x 2¾" metal box. Lamp or low-wattage appliance is plugged into convenience outlet while touch-plate(s) is connected via the phono plug.

Components are mounted on 2½" x 3⅝" piece of perforated circuit board that is mounted within the metal box.



THE purpose of this article is to describe a simple, inexpensive, and compact capacitance touch-plate lighting switch adaptable to home use. The power consumption is about 1 watt; the reliability is very high; and because it is transistorized, there will be very little maintenance.

One of the desired features in touch-control lighting is being able to use one touch plate for both turn-on and turn-off. With such an arrangement, switches in unlighted areas are easily located and turned on. Cost of such a system will be lower because fewer control lines are necessary.

In applications where hundreds of switching operations are performed daily, considerable time can be saved with touch-control switches. Several plates can be brushed by the fingers in patterns to achieve the desired combinations.

The switch becomes an immediate and fascinating conversation piece in the home. Constructed in a small box into which a table lamp can be plugged, the unit is inconspicuous. A control wire leading from (*Continued on page* 74)

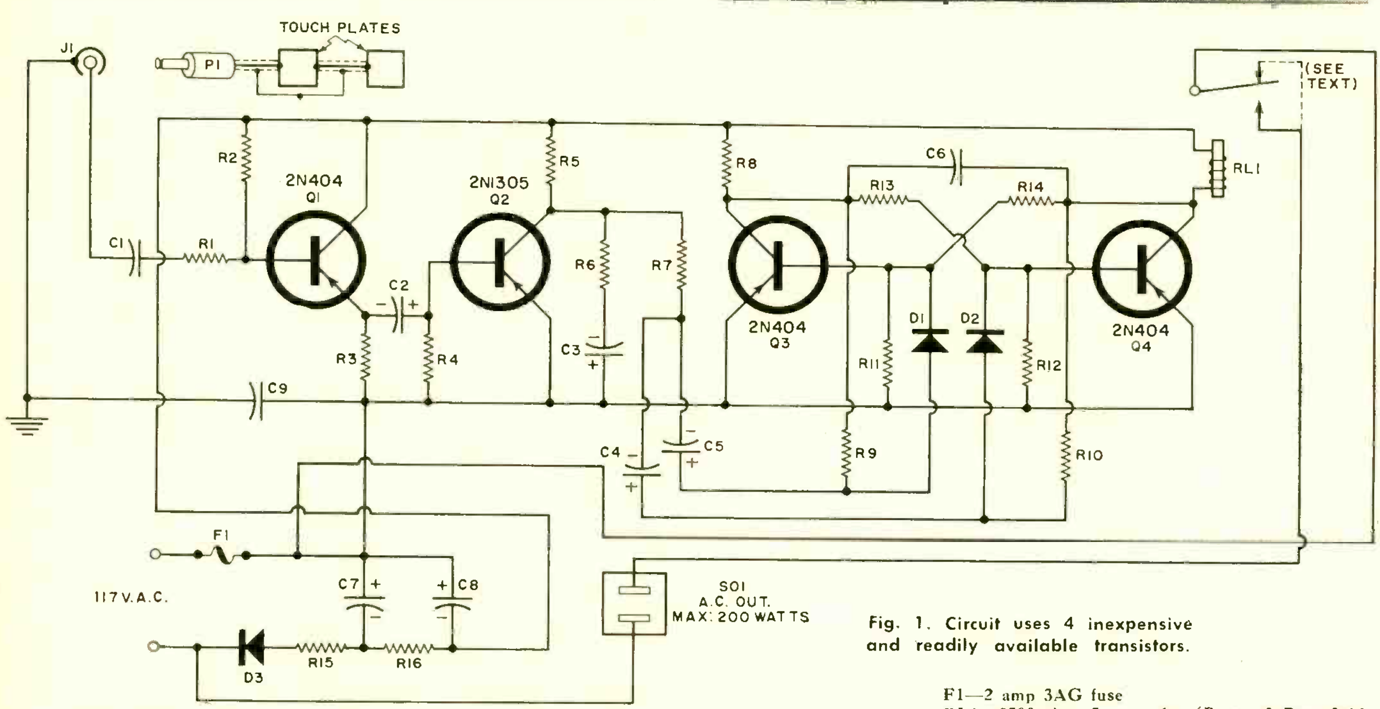
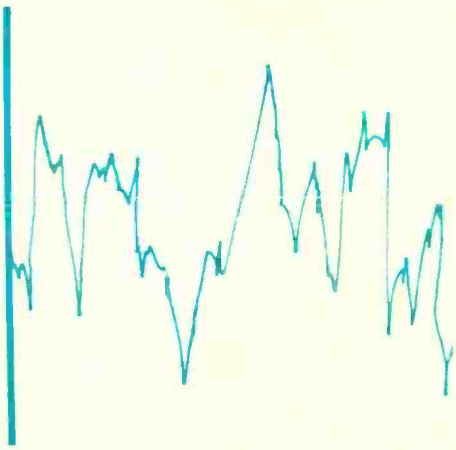


Fig. 1. Circuit uses 4 inexpensive and readily available transistors.

R1—6800 ohm ½ w. res.
R2—1 megohm, ½ w. res.
R3,R11,R12—10,000 ohm, ½ w. res.
R4,R7—4700 ohm, ½ w. res.
R5—22,000 ohm, ½ w. res.
R6—100 ohm, ½ w. res.
R8—2700 ohm, ½ w. res.
R9,R10—100,000 ohm, ½ w. res.
R13,R14—27,000 ohm, ½ w. res.
R15—27 ohm, ½ w. res.
R16—15,000 ohm, 2 w. res.
Note: All resistors ± 10%
C1—.003 μf., 100 v. disc ceramic capacitor
C2,C3,C4,C5—5 μf., 25 v. elec. capacitor
C6—0.15 μf. 200 v. Mylar capacitor
C7—100 μf., 150 v. elec. capacitor
C8—20 μf., 25 v. elec. capacitor
C9—0.05 μf., 400 v. Mylar capacitor
F1—2 amp 3AG fuse
RL1—2500 ohm, 5 ma. relay (Potter & Brumfield RS5D)
J1—Phono jack
P1—Phono plug
SO1—A.c. outlet
D1,D2—IN34 diode
D3—1N2069 silicon power diode (200 p.i.v. @ 750 ma.)
Q1,Q3,Q4—2N404 transistor
Q2—2N1305 transistor

Receiver Noise
FROM ANTENNA TO DETECTOR

By JOSEPH TARTAS



The sensitivity of a radio receiver is governed by the amount of internally generated noise. How this noise originates, how it is measured, and how it can be reduced are covered in this article.

THE most common byproduct of our civilized world is noise in one form or another. We rise in the morning to noise; we ride to and from work with noise; and we eat and relax with noise. In its most common form, noise is the effect of vibration upon our eardrums, and subsequently through the message centers of our nervous system, upon our brain.

In electronics, however, noise is a different matter. More than being just annoying, it is the limiting factor in the reception of intelligence through the medium we call communications.

The ultimate goal is the reception of intelligence and the reproduction of the originally transmitted material in its truest fidelity, whether the receiver be a simple table radio or an extremely complicated and sensitive piece of electronic laboratory equipment. The weak signal received at the antenna must be amplified, sorted out of the myriad of other signals and assorted electrical impulses, amplified to a greater degree than the undesired signals and noises, converted to a varying d.c. voltage by a detector, and then applied to functional circuits to actuate a speaker, CRT, relay, or any of a multitude of recording devices.

Kinds of Noise

The various types of noise can be broken down into two basic categories: natural and man-made. There are various methods of dealing with noise, but no matter what the source, there is a limit to the amount of reduction we can achieve.

Man-made noise includes both intentional and unintentional signals within the passband of the receiver; interference from sparking, such as automotive ignition, arcing of generator or electric motor brushes, and defective wiring; and a host of other causes, most of which result from an electric spark. Such a spark produces interference over an extremely wide frequency range and is impossible to filter out if it is near the level of the signal to be received.

Intentional signals might include those that are produced within the passband of the receiver, either due to drift of the transmitter or poor design of the receiver. Such a signal, if strong enough in intensity, will cause the first few stages of the receiver to draw grid current and hence block (in the case of tubes) or saturate (in the case of transistors). If automatic gain control (a.v.c. or a.g.c.) is used, the strong undesired signal will cause drastic reduction in the gain of the stage or stages, and the desired signal will then be amplified to such a small degree that it will be unintelligible or unusable. (Fig. 1.)

This effect is known as *cross-modulation*, and its effects are determined by the type of tube used in the r.f. or i.f. stages, the bandpass of the receiver, the shape factor of the selective circuits (relation of peak to skirt bandwidth), and the type of interference. If the interference has a different time relation or duration than the desired signal, it may have little or no effect on the intelligibility of the received signal. (Fig. 2.)

Another effect of undesirable signals within the passband is known as *intermodulation distortion*. Intermodulation distortion results when an interfering signal is applied to the mixer along with the desired signal. The non-linearity of the

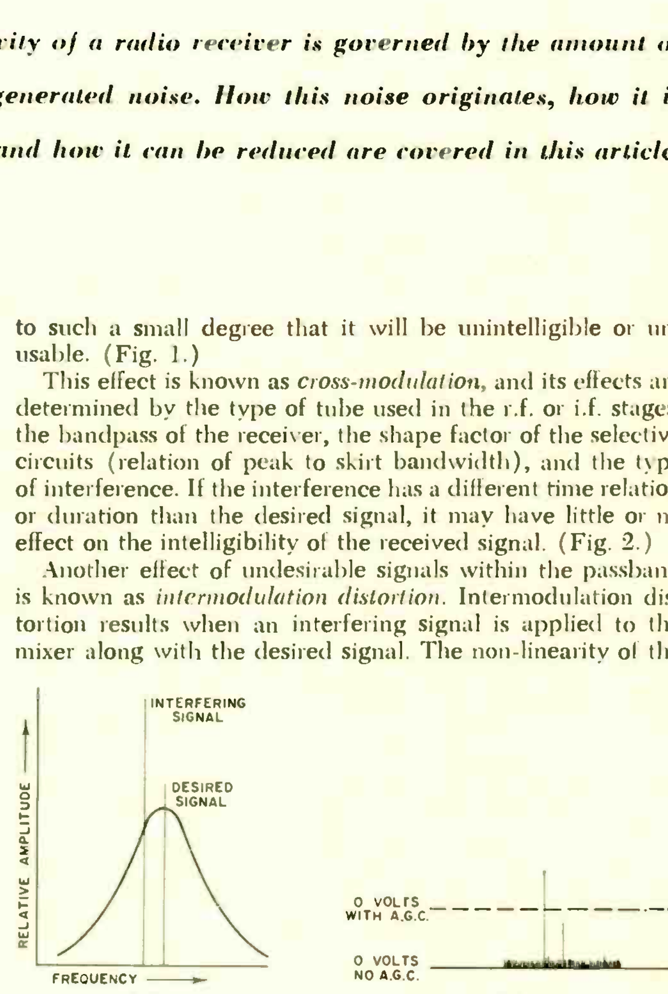


Fig. 1. (A) Passband of receiver showing both desired and interfering signal. (B) Detector output with and without a.g.c. Bias change due to a.g.c. can reduce or eliminate desired signal when the interfering signal is present.

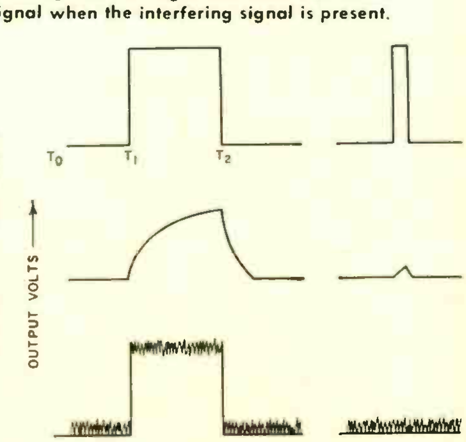


Fig. 2. If the interfering signals shown on the right occur between T1 and T2, their relatively short duration and low amplitude have no effect. If situation is reversed, receiver would then be blocked for that period of time.

mixer produces both sums and differences of the two, in addition to the modulation of one by the amplitude variations (modulation) of the other. In addition to this, if the interfering signal produces cross-modulation sufficient to bias the r.f. stage back to a non-linear point, then the r.f. stage itself will act like a mixer and produce its own sums and differences, which will then be passed on to the mixer stage to further produce sums and differences of those that get through the passband of the r.f.-output, mixer-input circuits.

Natural interference causes noise in a form we call *static*. Such interference results from lightning, aurora, whistlers, and, to some extent, so-called galactic noise. Lightning, or other static electricity, produces a spark during discharge, and hence yields the same result as man-made static. The only difference here is that the intensity of a lightning discharge is tremendous and in most cases completely blanks out the receiver, whether or not the signals coming through are desired or undesired. Aurora, on the other hand, produces a wide variety of effects, from sizzling static to rapid fade or flutter, not to mention the complete blanketing of electromagnetic circuits such as telephone lines. Whistlers are usually of short duration and, because of Doppler effect, change frequency to some degree as they progress. Depending upon the selectivity of the receiver, they may pass completely out of the passband before the a.g.c. can react. Galactic noises, except for u.h.f. and microwave receivers, and some v.l.f. equipment, with antennas designed specifically for the reception of these fixed noises, are not of any significance to the average reception medium, since the inverse-square law of r.f. signal strength *vs* distance shows them to be too minute. It is the natural law that makes the intentional reception of these stages difficult in radio astronomy. Galactic noises are so weak that other noises tend to obscure them, and the search for better reception methods is an unending one.

Receiver noise, other than that due to antenna or cable defects, is the most important factor to consider. Since the antenna itself is essentially a passive device, there is no significant noise contribution from it other than that received by it in the form of the electrical radio signals.

In most cases, the sensitivity of a receiver is set solely by

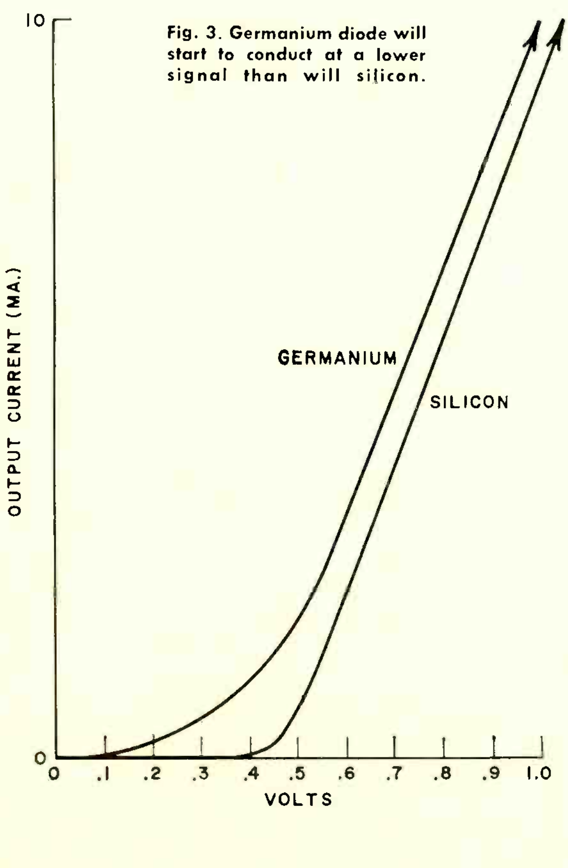


Fig. 3. Germanium diode will start to conduct at a lower signal than will silicon.

the front-end of that receiver itself; that is, between the antenna terminals and the first i.f. stage. Because the r.f. stage, mixer, or first i.f. stage can contribute to this sensitivity, they must be considered separately *and* together.

Defining Sensitivity

The relation among sensitivity, gain, detector levels, and selectivity seems to be a confusing one to many, yet each is a separate entity. Further confusion is often added by the concept of noise, signal-to-noise ratio, noise figure, and noise voltage. It is one aim of this article to clarify the meanings and relationship among these terms.

Sensitivity means just what it says. It is the degree to which a receiver is sensitive to a signal. In other words, a more sensitive receiver will be able to reproduce the same intelligence from a smaller amplitude signal, all other things being equal. A less sensitive receiver will require a larger signal, all other conditions being the same. However, the sensitivity at the input end will also depend upon the amount of gain, or amplification, that follows it and the level desired or obtained at the detector. By a detector, we mean the point at which r.f. is converted to d.c., AM, or any other type of intelligence. For practical purposes in this discussion, let us consider the receiver as being a high-frequency communications or radar receiver with a diode detector, the intelligence being in the form of positive square pulses. This is something that could be observed on an oscilloscope and thus serves well to aid in the explanation.

Because of the characteristics of the usual r.f.-type silicon or germanium diode detector, the last i.f. stage must have sufficient output to drive the detector well into the linear region. For most of these diodes, the output must be at least 0.5 volt to produce a minimum of distortion and good linearity of the modulation. (Fig. 3.)

If we put a pulsed signal into the receiver and increase its level until we can see a small output from the detector but no random noise, we have no way of knowing the actual sensitivity of the receiver. Additional amplification between the r.f. stage and the detector might show either of two things: the increase of output signal level resulting might also be accompanied by the appearance of noise such that any decrease in input signal would cause the output signal to disappear into the noise; and a decrease in input signal would still produce an output with no visible noise.

If additional gain produces noise at the output, no further gain would help and, for the given conditions, the maximum *sensitivity* of the receiver has been attained. This is also known as the *threshold sensitivity*.

If, however, no noise appears, the receiver still has inadequate gain between the r.f. stage and the detector, and the sensitivity can be further improved by additional stages of gain. This should be increased to the point where noise does begin to appear in the output, and we are then at the same point discussed previously. The point of adequate amplification has been reached when sufficient noise is seen at the detector output. This noise level should be about 0.5 volt or half the desired 1.0-volt signal.

Front-End

The selectivity of the front-end is the ability of the receiver to receive or reject certain signals close to each other, Thus selectivity means *to select*, to reduce or remove interference, and reduce cross-modulation and intermodulation interference. Traps and bandpass transformers eliminate specific signals that are sufficiently displaced from the desired signals and limit those that are not sufficiently out of the passband to be rejected completely.

The greatest amount of receiver noise is due to the action of electrons within the first tube or transistor. If the first stage is a converter rather than an r.f. stage, then the relative noise out of the receiver will be greater for a given input signal level. If a mixer (converter) stage follows an r.f. stage but the r.f. stage has little gain, then the relative noise level out of the receiver may be somewhere between the two levels. This will be explained subsequently.

Origin of Noise

Even in the most perfect component, some noise is always developed due to the random motion of free electrons within the material. Since the velocity of the electrons represents current flow, then a varying a.c.-voltage component is produced due to the natural resistance of the material. Because electron motion is always random, so is its velocity, and hence the frequency and amplitude of the noise voltages are continuously changing. The net result is called *white noise*, and its energy is evenly distributed throughout the entire radio spectrum.

Because the r.m.s. voltage taken over a relatively long period of time is measurable, we know that for a given bandwidth the voltage would be the same at 100 kc. as it would at 100 mc. because of this even distribution. This noise voltage, when due to the antenna and transmission line, is usually negligible compared to the tube or transistor noise and is further dependent upon the temperature, the resistance across which the noise voltage is developed, and the bandwidth of the component, circuit, or receiver.

Although the *average* noise voltage is zero, the a.c. component exists in cycles varying in a perfectly random manner and has a constant r.m.s. voltage. The mean-square noise voltage associated with the input circuit is found by: $e_n^2 = 4kTR\Delta f$, showing that the noise is dependent upon the temperature (T), bandwidth (Δf), and the equivalent input resistance (or noise resistance) for the first stage (R). k is a natural constant, a relation of energy-per-degree of temperture discovered by Boltzmann.

In a vacuum tube, random emission and random velocities of the electrons as they leave the cathode or arrive at the plate produce a random modulation of the d.c. plate current component known as "shot noise," If a tube is relatively noisy, then the *equivalent* resistance in the grid circuit is quite high. Hence, the merit of a tube in relation to its noise contribution is dependent upon how *low* an equivalent resistance can be assumed to be present in the grid circuit. This equivalent resistance for a triode is simply $2.5/Gm$, but for a pentode it is much higher because the electron stream is divided into two paths—plate and screen—and the random modulation of the d.c. plate component is considerably greater.

For any given tube type, there is a value of source resistance for which the best noise figure of that tube can be achieved. This information has been calculated for various types and is normally found in the manufacturer's data sheet for that tube. For transistors, the information is usually given as a typical noise figure at some test frequency, with a fixed-source impedance. In addition, curves are often shown that give the range of frequencies over which the transistor or tube is usable, and these show both the variation in noise figure with frequency and the difference in noise figure with different source impedances.

Except for the filaments, a transistor presents a similar problem in relation to noise. Since the flow of electrons (or holes) in both cases is from a lower to a higher energy level, the same sort of thermal agitation takes place, and the modulation of collector current produces a noise voltage. The transistor, however, because of its base-spreading resistance, methods of biasing, and impedances, has until recently resulted in a relatively high noise level. For the sake of discussion, however, the terms tube and transistor may be used interchangeably.

As the frequency is increased, there are further effects of transit-time loading with a reduction in gain that appears to increase the noise of the stage, and the equivalent input resistance seems to be as much as five times greater.

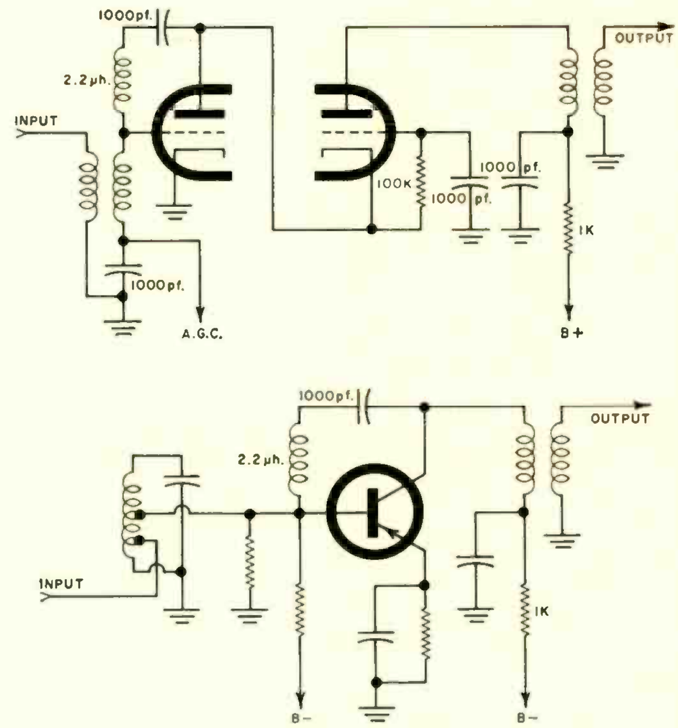


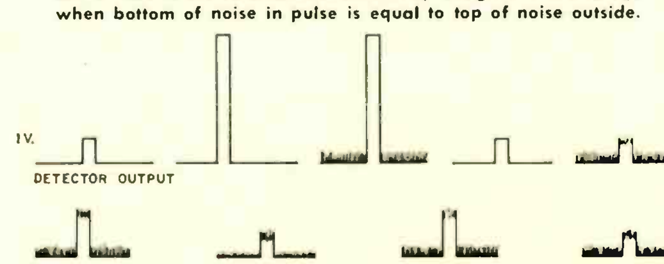
Fig. 4. Typical input circuits. (Top) Vacuum-tube cascode. (Bottom) Grounded (common) emitter circuit. Except for the bias and input circuits, r.f. circuit is similar in both.

If the signal and the noise in the first stage are amplified sufficiently, then all the noise added by the next stage will be hardly significant. For example, if the noise voltage at the input of the first stage is one microvolt, and the signal is two microvolts (representing a 2:1, or a 6 db signal/noise ratio), and the gain of the stage is 20 (or 26 dbv), then the noise voltage and signal voltage at the input of the next stage will be 20 and 40 microvolts respectively. If the next stage then adds one microvolt of noise to this, then it represents an increase of 1/20 or 5%. The third stage, if the second stage is similar to the first, will then add 1/400 or 0.25%.

The formula for this is usually given as: $NF_{total} = NF_1 + (NF_2/Gain_1)$ where NF represents the noise figure of that stage in db.

It is therefore essential that the first stage have the lowest possible noise contribution with the highest possible gain. Because the lowest noise figure in a tube is obtained with a triode, this is normally used as the input stage, or more often, two triodes in a *cascode* circuit are employed (Fig. 4). This circuit comprises a low-noise triode in a grounded-cathode stage with little or no gain, to eliminate Miller effect (change in tube capacitance with gain change from a.g.c.), followed by a grounded-grid stage with the gain of a pentode, to eliminate the grid-plate capacitance feedback problem. The

Fig. 5. Detector outputs. Top row, left to right: output, no visible noise; increased gain, still no noise; same condition, noise visible, shows adequate gain; signal reduced to original 1-volt level, noise disappears, signal good; noise level approaching that of signal. Bottom row, left to right: adequate gain and noise figure; gain not improved but noise reduced; same as last case but with additional gain after first stage, over-all signal still good; last condition shows maximum sensitivity (tangential sensitivity) when bottom of noise in pulse is equal to top of noise outside.



cathode impedance of the second stage, usually a few hundred ohms, serves as a low-impedance output load for the first stage, thus making this section extremely stable.

Transistors, until recently, were notorious for their noise and could not be used as input stages where good sensitivity was desired. As a result, hybrid receivers were constructed, with input stages using low-noise vacuum-tube circuits (usually the cascode) followed by transistor circuits for the mixer and i.f. amplifiers.

Recent improvements in semiconductor materials have resulted in germanium transistors with noise figures of 2 db up to several hundred megacycles and silicon transistors with noise figures near 3 db for the same frequency ranges. The nearest devices until then were the low-noise triode tubes, such as the *W-E* 417B, and the more recent *RCA* nuvistors and *G-E* ceramic subminiature triodes, but these required considerably more power for the active elements.

Noisy Converters

At reasonably low frequencies (up to 500 mc.), there is a definite advantage to the use of one or more r.f. stages to give adequate amplification with minimum noise contribution. Because the conversion gain of a triode used as a mixer (again the less noisy tube) is less than its gain as an amplifier, noise contribution can be minimized if the gain of the preceding stage or stages is adequate.

The input equivalent resistance as a mixer is $4/Gm$, instead of the $2.5/Gm$ as an amplifier, and the conversion noise figure is higher than that of the amplifier noise figure.

At some high frequency, known as the *transition frequency*, the use of an r.f. amplifier ahead of the mixer becomes impractical because of the transit-time loading effect, excessive feedback, insufficient gain, and other problems.

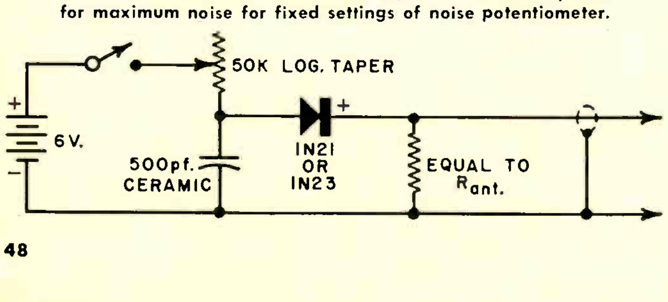
In this case, the signals are fed directly to a converter or mixer. This may consist of a special tube circuit or, at the higher frequencies where the reactances within the tubes or transistors cannot be tuned out, the use of mixer crystals or diodes is preferred. These are usually preceded by tuned circuits or cavities to provide the necessary selectivity to eliminate images or other interfering signals within the passband of the following circuits.

Because there is no amplification in this type of converter, and even a loss in signal during the conversion process, the first i.f. stage then becomes an important factor in the over-all noise of the receiver. In this case, the total noise figure becomes: $NF_{total} + L\ (NF_{i.f.} + t - 1)$ where L is the diode conversion loss and t is the diode noise temperature. The total noise then obviously rests heavily upon the noise contribution of the i.f. amplifier. Just as in the case of the r.f. stages, the first i.f. stage must have highest gain and lowest noise in order to have a minimum noise contribution from the i.f. stages as a whole when this system is operating.

Matching Considerations

Of equal importance in the consideration of low-noise circuitry is the matching of impedances between antenna and input stage, or input stage and mixer. Aside from the consideration of maximum power transfer, it is essential to provide the match from the source to the correct input *noise impedance*. It is only under these conditions that the minimum noise conditions can be achieved. In transistor circuits, some designers intentionally load down the input circuits with excessive damping resistance in order to make the stage more stable. This is often done at the sacrifice of gain, since this additional power is dissipated uselessly in the loading resistor. If such excessive loading is attempted, it should not only provide the correct noise-match impedance, but it should also be done by using the low input impedance of the transistor itself. In this way the excess power is not dissipated in a resistor but instead is dissipated as useful power within the active elements of the transistor, providing a stable amplifier but with more gain (and hence better sensitivity for the same noise voltage). This is the ideal solution.

Fig. 6. A simple noise generator. The output is fed to receiver antenna terminals while the input circuits are adjusted for maximum noise for fixed settings of noise potentiometer.



Measuring Noise

We have discussed the requirements of receivers with respect to noise, and in order to obtain the best possible noise figure for a receiver, it is necessary to make some adjustments. A *noise generator* as an outside noise source is quite often used in laboratories, but a calibrated signal generator may also be used.

A noise generator uses a *temperature-limited diode*, also known as a *noise diode*, with a variable anode current source. Because the noise output has a wide spectrum and its amplitude is directly related to the anode current, the generator can be calibrated directly in *noise figure*. It is connected through suitable d.c. isolation to the receiver input. The input is shunted by a resistive termination equal to the antenna impedance, and the noise power at the receiver output is measured. The anode current of the noise generator is then increased until the noise power out of the receiver has been doubled. The noise figure (usually in decibels) is then read directly off the generator. Theoretically, this represents the number of db of noise greater than a perfect receiver where *all* of the noise was due to the antenna. This perfect receiver would then have a noise figure of zero db.

The indicator for output power may be an oscilloscope, a peak-reading v.t.v.m., or a thermocouple indicator. When reading voltage, the power is doubled when the voltage is increased by 1.414 times the original value.

The noise factor is then $F = 20 I_b R_{ant}$, where I_b is the anode current of the noise diode and R_{ant} is the equivalent antenna, or receiver input impedance.

When trying to optimize the performance of a given receiver for best noise figure, it is not necessary to have an actual noise figure. A noise generator may be made from a high-frequency diode, and the receiver circuit is then adjusted for minimum *relative noise*. Such a generator is shown in Fig. 6.

The signal-generator method depends largely upon the bandwidth of the receiver and the linearity of the detector. If the detector level is adequate, as discussed earlier, the measurement may be considered quite reliable.

The standard of receiver measurement is that of the *e*quivalent-*n*oise-*s*ideband-*i*nput, or *ensi*. In this method, the unmodulated carrier is applied to the input of the receiver (always through its proper antenna impedance) and the noise power is read on an r.m.s.-reading instrument. This level should be three to ten times as great as the expected noise voltage, or about 2 to 5 volts. The carrier, still at the same level, should now be modulated at 400 cps and 30%. The signal-power output is then measured through a filter that will pass only 400 cycles (this eliminates the problem of different bandwidths in the receivers). The *ensi* is then equal to 0.3 $E_s \sqrt{P_s/P_n}$ where E_s is the unmodulated carrier level, and P_n and P_s are unmodulated and modulated output power, respectively.

Initially, it is necessary to select a tube or transistor with a good noise figure. This information, along with the best noise-match impedance, is usually provided in the manufacturer's data sheet. Sometimes it is necessary to use some other impedance, or because of (*Continued on page* 72)

DETERMINING METER RESISTANCE

By JOHN T. BAILEY / Vitro Engineering Co.

Using just two meter readings and very little pencil work, the exact value of a meter's resistance can be determined.

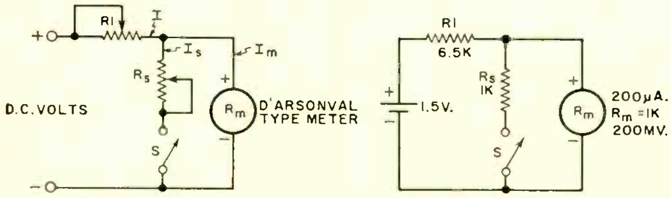
PROBABLY anyone who needs to be concerned with the internal resistance of a meter will recall the often-published and safe procedure of connecting the meter in series with a d.c. source (Fig. 1A) and, with switch S open, adjusting $R1$ for full-scale deflection. Then S is closed and R_S is reduced from its full resistance until the meter reads exactly half scale. The measured value of R_S will then be equal to the internal resistance of the meter, assuming that the meter scale is accurate.

This circuit is basically sound only if it is a constant-current circuit. In other words, the current flowing through $R1$ must not change when S is closed. A simple calculation will show how an erroneous measurement can be produced. Assume the conditions of Fig. 1B where a 200-μa. meter having a resistance of 1000 ohms is connected to a 1.5-volt battery through a 6500-ohm resistor. When S is open, the total resistance in the circuit is 7500 ohms. According to Ohm's Law, the current flow will be 200 μa. and this will produce full-scale deflection of the meter. When S is closed, the parallel resistance of the meter and the shunt will be 500 ohms. Therefore, the total resistance in the circuit with S closed is 7000 ohms, hence, the current flow will increase because of the reduced total resistance. The current now is 1.5/7000 or 214.3 μa. This will split equally between the meter and the shunt so that a little more than 107 μa. will pass through the meter. Half-scale on the meter is 100 μa. Therefore, an error of 7% is produced because the current increased when S was closed.

The obvious remedy for this situation is to use a much higher battery voltage and a correspondingly higher dropping resistor, $R1$. The voltage should be high enough so that the dropping resistor will be many times higher than the change in resistance when the meter is shunted, say 1000 times higher. The change in resistance for this example when the meter is shunted is 500 ohms so that the dropping resistor should be 500,000 ohms and the source should be 100 volts. This arrangement would produce an error of only 0.1%, which is much better but which involves a high d.c. source.

Another problem associated with this basic scheme is that the value of the shunt has to be measured after the meter reading has been reduced to half scale. Unless a bridge is obtainable, an ohmmeter will probably be the only instrument available to measure the shunt, and ohmmeter accuracies are not exactly precise, plus or minus 10% being a typical value.

Fig. 1. (A) Circuit to be used to make the test. (B) Although looking like (A), text shows how this circuit produces errors.



One way of getting around the problem of not being able to accurately measure the value of the shunt is to determine the shunt value as measured by an ohmmeter, select a 1% precision resistor of approximately the ohmmeter-measured value, and substitute it for the ohmmeter-measured shunt.

The meter scale, with S closed, will now be different from half-scale by an amount depending on how much different the precision resistor is from the original shunt. Note this new reading and enter it into equation (6) derived as follows.

Referring to Fig. 1A, with S closed, the voltage drop across R_S is the same as that across the meter, or

(1) $R_S I_S = R_M I_{M\ S\ closed}$

With a high d.c. source (equivalent to a constant-current circuit), meter current when S is closed is equal to meter current when S is open minus the shunt current, or

(2) $I_{M\ S\ closed} = I_{M\ S\ open} - I_S$

Substituting in equation (1):

(3) $R_S I_S = R_M I_{M\ S\ open} - I_S$, or

(4) $R_M = R_S I_S / (I_{M\ S\ open} - I_S)$

From equation (2)

(5) $I_S = I_{M\ S\ open} - I_{M\ S\ closed}$

Substituting in equation (4)

(6) $R_M = R_S\ (I_{M\ S\ open} - I_{M\ S\ closed})\ /\ I_{M\ S\ closed}$

The meter resistance R_M then equals the value of the precision resistor R_S multiplied by the difference between the full-scale reading and the part-scale reading (not necessarily the half-scale reading), all divided by part-scale reading. The calculations are valid if $I_{M\ S\ open}$ is less than full scale, but it is desirable to have it near full scale because meter accuracies are stated as percent full scale.

However, there is another approach that eliminates the need for a high d.c. source and constant-current circuit. Assume that the d.c. source is low and that the current flowing through it will increase when the switch is closed. Only two 1% resistors are needed, one for $R1$ and the other for R_S. The value of the d.c. source need not be measured. It is only required that a full-scale, or slightly lower than full-scale meter reading be obtained when the chosen precision resistor is used for $R1$ when switch S is open, and that some other scale reading occurs when S is closed.

The meter scale value with S open is noted as I_{MO}, and with switch S closed as I_{MC}. Enter these values, along with the value of R_S, into the following equation:

$$R_X = \frac{R_S\ (I_{MO} - I_{MC})}{I_{MC}}$$

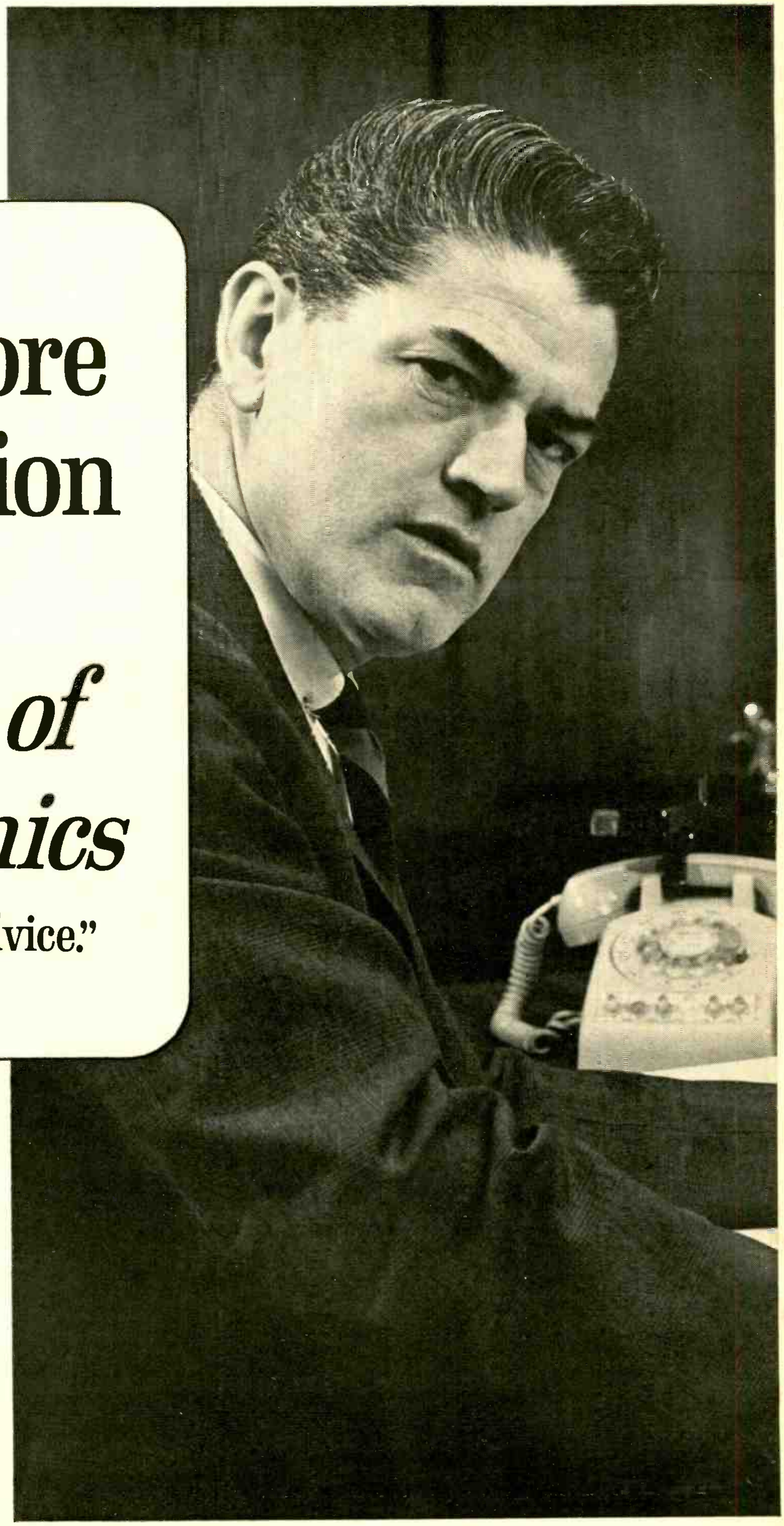
Once the value of R_X is determined, enter it into the following equation for finding the value of the meter resistance:

$$R_M = \frac{R1 \times R_X}{R1 - R_X}$$

Therefore, from just two meter readings and knowing the values of precision resistors $R1$ and R_S, the value of the meter resistance (R_M) can be determined. ▲

"Get more education or *get out of electronics*

...that's my advice."



JOHN FRYE

Maintaining communications in the face of a disaster is a job calling for both radio amateurs and CB operators.

EMERGENCY RADIO SERVICE

THE day promised to be another hot one. Mac was sitting at the service bench reading the paper when Barney, his assistant, came in. "Good morning," Mac greeted him. "The *Morning Blabber* here says you spoke at a CB club meeting last night. For a crusty old ham like you, doesn't that come under the heading of consorting with the enemy?"

"Heck, no. I have a CB license myself, and a CB rig sits right next to my ham station. Since we're going into CB service, I want to get the feel of CB operation; and, anyway, this is the second time I've been invited to talk to CB'ers. The first time was last winter. Then I tried to put across the idea that in a real emergency hams and CB'ers would need each other and the community would need both of us—working together. I warned that dependable CB working range would be drastically reduced when sunspots started to climb and the rare skip conditions of the past became a continuous nuisance."

"Did they believe you?"

"Not really, I'm afraid. You see, most CB operators have never known any conditions except those prevailing the past three or four years as we passed through the bottom of the 11-year sunspot cycle. I could see smiles of disbelief on their faces when I said they would be lucky to work mobiles three or four miles away when signals started pouring into the Midwest from Texas, Florida, California, and New York. But they believe me now."

"What changed their minds?"

"It was a long siege of sporadic-E skip that occurred around the end of April and the beginning of May. Day after day, every CB channel was jammed with dozens of stations skipping in from all over the country. The heterodynes sounded like cats quarreling over a fish head, and this went on for days. A local signal had to be at least S-7 to get over the top of this, and there were times when even an S-9 signal couldn't cut the mustard. Trying to monitor a channel was enough to drive you crazy because of that bedlam of voices continually tripping a very stiff squelch setting. It was next to impossible to sort a local signal of medium strength out of the welter of signals skipping in from distances of 500 to 1500 miles away."

"And things will probably get a lot worse before they get better."

"That's what I told them last night. Sporadic-E ionization is chiefly a spotty, short-term, seasonal phenomenon; but now we're in the increasing part of the sunspot cycle, and in two or three years 11-meter skip will be a winter-and-summer, around-the-clock affair. Intense ionization will extend skip distance to thousands of miles. From my experience on ten meters, I know West Coast stations will be rolling in with unbelievable and overwhelming strength."

"What's the point of all this calamity howling?"

"It does sound like that, doesn't it?" Barney admitted with a grin. "The point is I'm concerned because some CD and other groups are tempted to build up emergency communications nets using *only* CB stations. These groups have been over-sold by CB'ers who have gone all out to demonstrate how CB stations can handle emergency communications. Some of the CB'ers have been motivated by a genuine desire to be of help; others, possibly, have been trying to justify their hobby use of the band; but whatever their reasons, they have done a bang-up job of displaying their wares to public officials. They have volunteered for Halloween 'ghost patrols'; they have taken part in search and rescue missions; they have worked with traffic-control officials; and they have helped with charity fund-raising endeavors. Some CB'ers have told me it is their aim to put a CB rig in every police station and sheriff's office in the country.

"And CB'ers have a lot going for them in an emergency. Number is one thing. Even the smallest community usually sports one or two CB stations. Another thing is the great number of mobile units. Still another asset is their habit of monitoring the band almost continuously."

"If all this is true, why *not* build an emergency net of CB stations?"

"Because of the things CB operators cannot do. Remember, demonstrations given CD and legal officials have been made during low sunspot activity when interference on CB channels from skip stations is at a minimum. Under these conditions, mobiles can be worked fairly dependably out to ten or fifteen miles and base-to-base contacts over 25 miles are common. But these distances may be reduced to one-fourth or one-fifth these values at the peak of the sunspot cycle. Any realistic evaluation of an emergency communications system must be based on minimum conditions. CB operators are confined to fixed frequencies on a single band, and they are limited to five watts input. These things handicap them seriously when it comes to providing dependable communications under difficult conditions."

"You think hams can do a better job?"

"I know they can do a better job covering distance. Why not? They can run up to 1000 watts of input power; they can employ AM, SSB, c.w., FM, or radio-teletypewriter transmissions; they can choose any one of many bands and can slide about on those bands with their v.f.o.'s to dodge interference or static and to provide the best frequency for covering a required distance."

"You sure you aren't a little prejudiced in favor of the hams?" Mac quizzed.

"Not in this case," Barney answered soberly. "After working in the emergency that followed those Palm Sunday tornadoes that killed 137 people in this state this past spring, all I want to do is make sure that we have the best possible emergency communications system. I'll use whatever means of communication is best for the particular job, be it telephone, telegraph, ham radio, CB radio, or smoke signals. When people are depending on you to bring help or to find out as quickly as possible if their loved ones are injured or dead, that's no time to be pushing a hobby at their expense."

"Excuse my foolish attempt to be funny," Mac said.

"That's okay. There are other good reasons why some hams should be included in any emergency setup. For one thing, there's not nearly the turnover in ham ranks there is in CB operators. That means it is easier to maintain a seasoned cadre for training new people if there are hams in the group. Hams are better prepared technically to improvise and 'make do' under emergency conditions when antennas may be down, power may be off, and transmitting and receiving equipment may be damaged.

"But it's just as important that emergency arrangements include CB'ers. They can do a wonderful job of collecting information about the extent of a disaster with their mobiles and of directing help to where it is most needed. And CB mobiles, working with law officials, can keep sightseers and looters out of the disaster area. Hams, on the other hand, can quickly establish communications in and out of the disaster area so that officials may know the amount and kind of help needed. After a few telephone and telegraph wires have been restored, hams can still relieve these overloaded circuits by handling health and welfare inquiries. CB'ers can check out these inquiries with their mobiles if the local telephones are out—which is usually the case. Then the hams can return reassuring messages to anxious relatives. Working together, the two services can do a far better job than either could do alone."

"By 'working together' I take it you mean there should be a good liaison between the hams and the CB'ers rather than that they should actually be talking to each other."

"That's right. Each group should work separately, but their activities should be coordinated by a CD or other official so there's no duplication of effort. I'm convinced it's a mistake to try to mix the two groups directly together. By the way, there's one other proposed emergency use of the CB band I think is excellent. I'm talking about the HELP program proposed to the FCC by the Automobile Manufacturers Association.

"Originally I heard some talk that channel 9 was supposed to be used as a calling frequency for cars in distress, and I didn't think much of this. Because of QRM from local and skip stations, that would be next to useless. But the AMA proposes that two little-used channels between CB channels 22 and 23 be turned over exclusively for emergency traffic to and from cars.

"As I understand it, all cars would transmit on channel A and be 'crystal-locked' for receiving on channel B. All monitoring receivers in police stations, sheriff's offices, highway garages, toll-road plazas, etc., would transmit on channel B and receive on channel A. This would insure that there would be no car-to-car talking. The two frequencies would be used only for emergency calls from cars or for warnings to cars of dangerous conditions on the highway."

"Sure sounds like a fine idea to me," Mac remarked. "Think what a comforting thing that would be to women driving alone, to handicapped and elderly drivers, and so on. And we radio technicians would doubtless pick up quite a bit of extra business keeping these mobile units going."

"Depend on my canny Scottish boss to think of that!" Barney said, grinning broadly. "But you're right. It would create a lot more business for manufacturers and service people."

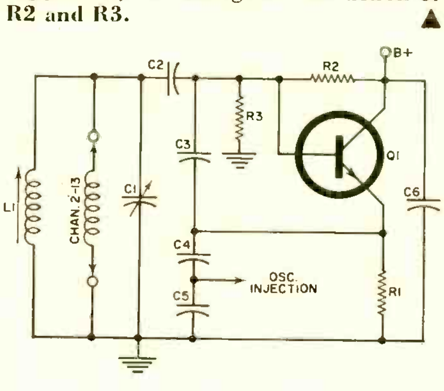
Mac stood up and stretched. "We'd better get to work, but I want you to know I agree with you. Any emergency organization not including hams in its plans would have to blind itself to their long and honorable record for being in the midst of every national emergency down through the years. They may not be very good at beating their own drum, but anyone the least bit curious can find out how hams train themselves day in and day out by working in emergency and traffic nets. On Field Day each year, they check out their ability to provide communications with emergency power. Their Amateur Radio Emergency Corps is specifically designed to work with CD and Red Cross people in emergencies. For my money, hams are near-professionals when it comes to providing emergency communications, and I expect their experience and know-how to be used in any community where I live." ▲

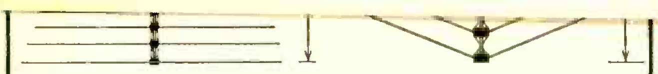
NEW U.H.F. OSCILLATOR

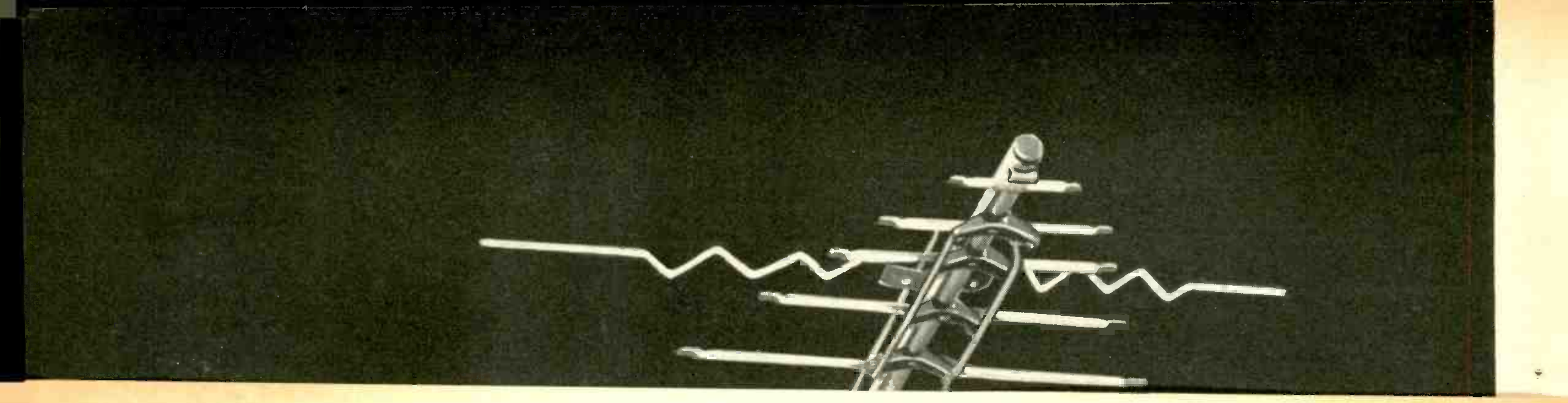
THE local oscillator used in the G-E 9-inch transistor TV is shown in the diagram below. The oscillator tank coil, switched for each channel to be received, is fine-tuned by C1 and is shunted by L1 which contains an adjustable core for alignment. Each of the 12 v.h.f. channels can be coarse-tuned by brass screws mounted on the individual coil strips.

The tank coil is shunted by C2, C3, C4, and C5. The base of Q1 is connected to the junction of C2 and C3 while the emitter is connected to the junction of C3 and C4 and is returned to ground through stabilizing resistor R1. The a.c. return for the collector is provided by C6, C4, and C5.

Oscillator injection is taken from the junction of the capacitor divider composed of C4 and C5, while base bias is supplied by the voltage divider action of R2 and R3. ▲







OSCILLOSCOPE CALIBRATOR

By LOUIS E. FRENZEL, JR.

Designing a built-in oscilloscope calibrator using a zener diode and one resistor. Multiple output voltages can be obtained if desired.

ONE of the most annoying things about using an inexpensive oscilloscope is its lack of vertical gain calibration. This makes it difficult to determine the peak-to-peak value of a waveform being displayed on the CRT. Most expensive oscilloscopes have a calibrated vertical gain control switch and an accurate grid graticule on the CRT face. With this arrangement, a glance at the CRT face will reveal not only the waveform shape but the peak-to-peak value of the wave as well. This is a handy feature since it eliminates the need for having to determine the amplitude of the signal by other means, usually in a separate measurement.

Many inexpensive scopes have a calibration terminal on the front panel to which is connected 6.3 v.a.c. r.m.s. from the filament supply. This can be applied to the vertical input, and the continuously adjustable vertical gain can be set so that the CRT grid is calibrated. This is a satisfactory calibration for simple, not-too-accurate measurements, but for more critical, wide-range tests, something better is needed.

This problem was solved recently on a large number of low-cost scopes used in a technical-school laboratory. The circuit

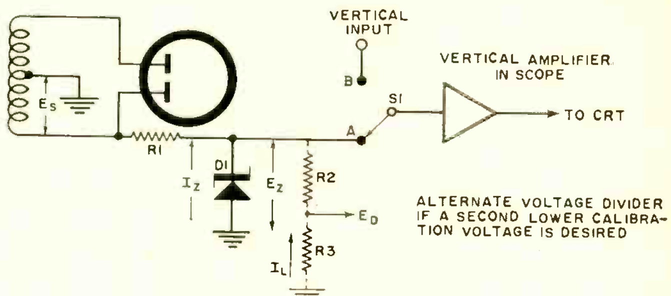


Fig. 1. Resistors R2 and R3 can be added for other voltages.

of Fig. 1 was installed in each oscilloscope to enable the students to get accurate voltage waveform measurements for their lab experiments.

A high-voltage, 60-cps sine wave from the secondary of the power transformer in the oscilloscope is applied to a zener diode through current-limiting resistor $R1$. The waveform across the zener is a clipped sine wave with a peak-to-peak amplitude equal to the zener voltage.

Diode $D1$ can be any inexpensive low-power zener with the desired voltage and tolerance. Voltages from 3 to 200 volts are available with tolerances of 5%, 10%, and 20%. A 5% unit is recommended for greater accuracy.

The value of resistor $R1$ will be determined by the transformer secondary voltage E_S (r.m.s.) as measured between the grounded center tap and one end of the transformer secondary, the zener voltage E_Z, and the zener current I_Z. In turn, I_Z will be a function of the zener voltage E_Z and power P_Z. Therefore, $R1$ is equal to $(1.4E_S - E_Z)/I_Z$ where I_Z equals $(P_Z/2E_Z)$.

Assume that E_S equals 200 volts and that a 20-volt calibration signal is needed at the output. Select a 20-volt, .4-watt zener diode (1N968B, for example). Calculate $I_Z = P_Z/2E_Z = .4/40 = .01$ ampere. Resistor $R1$ then equals $(1.4E_S - E_Z)/I_Z = 260/.01 = 26{,}000$ ohms. A conventional 27,000-ohm resistor can be used. The power dissipated by $R1$ equals $I^2R = (.01)^2\ 26{,}000 = 2.6$ watts. A three-watt unit can be used.

Switch S1 provides a convenient means of switching the vertical amplifier input between the calibration signal and the external signal to be measured. For an economy installation where the convenience of S1 is not desired, the calibrator output can be routed to a terminal post on the front panel and attached to the vertical amplifier input when calibration is desired.

To use the calibrator, set S1 to the calibrate position (position A) and adjust the vertical amplifier gain control to the desired number of volts-per-CRT-grid division. Once this has been determined, S1 can be returned to position B and the peak-to-peak value to the input signal can be obtained.

If more than one calibration voltage is needed, a resistive voltage divider ($R2$ and $R3$) can be added across the zener. The exact values of these resistors are not critical, but they should be selected to provide the desired lower calibration voltage. The voltage output from the divider network (E_D) is found from E_D equals $(E_Z \times R3)/(R2+R3)$, I_L equals $E_Z/(R2+R3)$, and I_Z equals $1/10\ I_L$.

Care should be taken so that the value of I_Z does not exceed its maximum current rating of P_Z/E_Z.

The accuracy of the measurements obtained with this calibrator depends upon the tolerance of the zener diode (and divider resistors $R2$ and $R3$ if used), as well as the care with which the vertical amplifier gain is set and the CRT grid read. With the values used here, measurements with an accuracy of 5% to 10% are possible. ▲

REGULATED LOW VOLTAGES

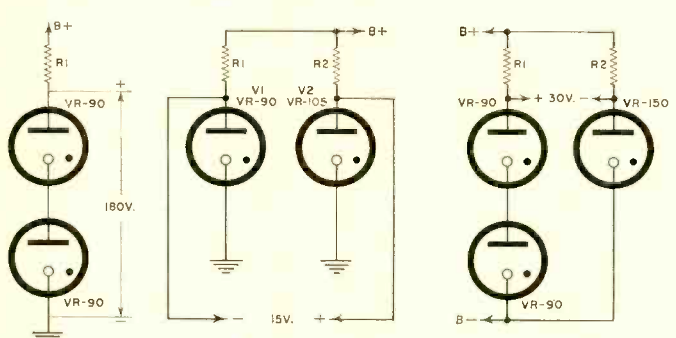
By IRWIN MATH

When using voltage regulator tubes, it is often desired to obtain voltages other than the conventional 90, 105, and 150 volts. This can usually be done by adding VR tubes in series as shown by the 180-v. supply in (A).

There are many times when regulated voltages below 90 v. are desired. An easy way to accomplish this is shown in (B). Here, $R1$ and $R2$ are the conventional VR tube current-limiting resistors while $V1$ and $V2$ are voltage regulator tubes whose voltage difference is the desired voltage. A VR90 and a VR105, for example, will produce 15 volts. Note that this supply is *above* ground.

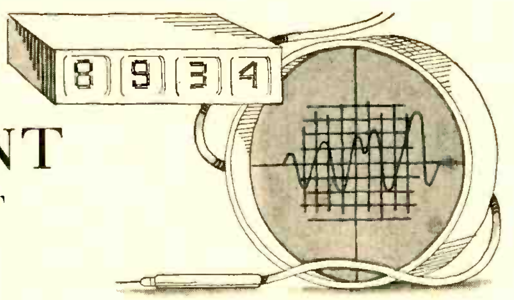
In another example (C), a regulated 30-v. supply is produced. Here again, the supply is *above* ground.

By using this idea and various VR tubes, a wide range of regulated voltages can be produced. Remember that when using some of these circuits, both the positive and negative outputs may be above ground. ▲



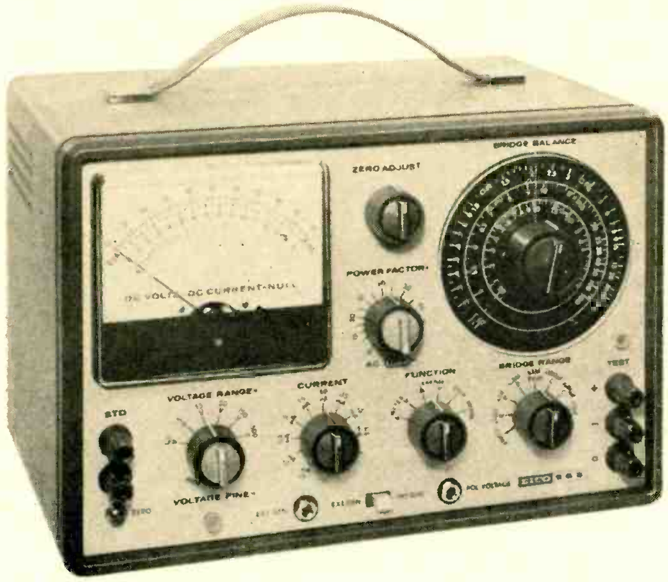
(A) (B) (C)

TEST EQUIPMENT
PRODUCT REPORT



Eico 965 R-C Bridge Analyzer

For copy of manufacturer's brochure, circle No. 26 on Reader Service Card.



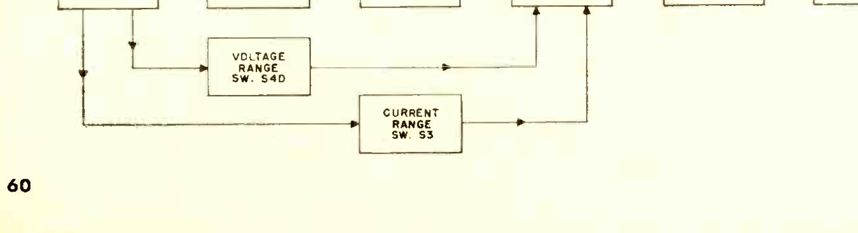
THE new *Eico* Model 965 "Farad-Ohm" is an unusually versatile instrument which can be used for measuring resistance, capacitance, inductance, power factor, d.c. voltages, and current. It is designed for servicing, production testing, and inspection, as well as for use in school and design laboratories.

As a *bridge*, the 965 can be used to measure capacitance from 5 pf. to 5000 μf., and resistance from 0.5 ohm to 5000 megohms; and, by employing its built-in metered variable d.c. power supply, resistance up to 100,000 megohms can be measured. This latter feature is useful for measuring leakage resistance of insulating material. It can also be used as a *comparator* to measure inductance as well as resistance and capacitance. Since the bridge voltage is only 0.45 v.a.c. (at 60 cps), even the lowest voltage transistor capacitors can be checked safely. An internal d.c. polarizing voltage can be applied to capacitors where necessary.

The built-in d.c. v.t.v.m. has six full-scale ranges from 1.5 to 500 volts and an input impedance of 10 megohms. The meter can also be used as a low-current milliammeter with eleven full-scale ranges from 150 nanoamperes (0.15 μa.) to 15 ma., making it possible to measure currents as low as 3 nanoamperes.

The instrument employs a two-stage, balanced d.c. amplifier utilizing four triode sections (*V2*, *V3*) to drive a 0-1 d.c. milliammeter. The bridge detector/amplifier stage employs a pentode (*V1*).

An internal d.c. power supply for measurement purposes has six metered, variable, overlapping output ranges to provide from 0.4 to 500 volts at 10 ma. maximum. In addition, VR-tube-regulated d.c. is provided for powering the instrument amplifier and bridge detector.



All controls and terminals are on the front panel, including an "Instant Zero" push-button which makes it possible to zero the meter at any time without having to change any of the other adjustments or remove any of the connections. A switch position for discharging tested capacitors is provided. In addition, a panel lamp blinks to provide a warning when there is voltage at the test binding posts. The circuit is so designed that it is impossible to overload the meter by more than 200%. Furthermore, for operating convenience the bridge detector/amplifier incorporates a.g.c. to keep the meter needle on the scale in the out-of-balance condition, yet without loss of sharply defined null indications.

By using an external standard, the instrument can be employed to measure inductance without fear of saturating coils with magnetic cores because of the low a.c. bridge voltage. Also, diode reverse current and the quiescent current of transistors can be readily measured.

The 965 is compact, measuring 8½" x 12½" x 9", and weighs 15 pounds. It sells for $129.95, factory-wired and tested. ▲

Ballantine Model 345 V.T.V.M.

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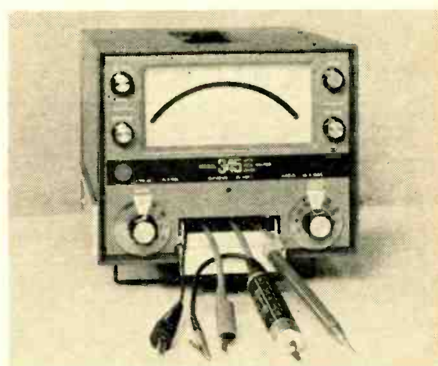


THE *Ballantine* Model 345 measures d.c. and a.c. voltages and resistance with an extremely high accuracy for a multi-purpose instrument. Measurements may be made to 1% *of indication* on d.c. from 1 volt to ±1100 volts, 2% *of indication* on a.c. from 1 volt to 350 volts, and 3% *of indication* on resistance from 1 ohm to 100 megohms. This accuracy, which applies over the entire five-inch meter scale, has been made possible by using an individually calibrated logarithmic scale indicator. Only one log-voltage scale is required for a.c. or d.c. volts and one for ohms. Auxiliary scales in red are used for voltages and ohms from one to zero because a log scale never reaches zero. A.c. voltage measurements may be made at frequencies from 20 cycles to 1000 megacycles.

The instrument is basically a d.c. differential voltmeter whose input is a ½-

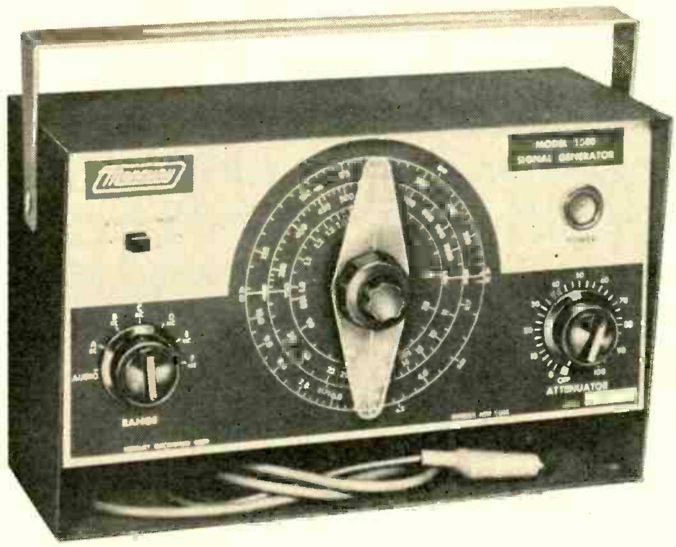
meg attenuator. The d.c. probe contains a 1-meg resistor at its tip to reduce the effects of probe-cable capacitance on any circuit to which it may be connected. The a.c. probe contains a thermionic diode whose d.c. output is fed to the attenuator and differential amplifier. The ohmmeter makes use of a zener-regulated d.c. source which allows current to flow through the resistor to be measured. The voltage developed is measured by the same instrument that is used to measure d.c. voltages.

An accurate instrument for use in a laboratory or on the production line must be independent of the line-voltage changes that are bound to occur throughout the day. *Ballantine* uses a *Sola* regulating power transformer that maintains all a.c. and d.c. voltages to within .5% for a ±10% change in line voltage. With a fixed a.c. or d.c. voltage being measured, the input line voltage can be varied from 150 volts to 80 volts without any movement of the indicating needle. This regulation also makes it possible to operate tubes below the nominal heater and plate voltages and thus to increase the expected life to more than 20,000 hours.

All probes are stored in a drawer which may be pulled out for extraction of the desired probe and then closed, thus keeping the instrument free of dangling unused cables and probes. Price is $350 including all probes. ▲

Mercury Model 1500 R.F. Signal Generator

For copy of manufacturer's brochure, circle No. 27 on Reader Service Card.



THE new *Mercury* Model 1500 signal generator is a low-cost, wide-range instrument for the service technician. The unit can be used for quick alignment of radios as well as a marker generator for TV and FM sweep generators. The instrument was designed to have a high output on all bands, including the higher frequency ones.

The generator has five overlapping fundamental frequency ranges, from 115 kc. to 37 mc. A sixth frequency range is calibrated on the instrument's dial from 30 to 110 mc.; this is the third harmonic of the highest range.

The circuit is simple and conventional. It uses half of a 12AU7 as an r.f. oscillator. Output from this section is applied to the second triode section of the tube operating as a cathode follower. A variable attenuator in the cathode circuit permits output level to be adjusted.

A built-in neon-lamp audio oscillator at about 400 cps modulates the r.f. section of the generator. Audio output is also available separately from this circuit for audio testing.

The power supply uses a simple half-wave rectifier with *RC* filtering. The supply is line-isolated by means of a power transformer so that the instrument is safe to operate with any equipment.

The Model 1500 is housed in an attractive metal case with a convenient storage space for test cable and line cord. The unit is available for $37.50. ▲

GREASE EQUALIZES TRANSISTOR TEMPERATURES

By CHARLES C. MORRIS

MANY times while working with parallel, bridge-type, or balanced transistor circuits, the transistor case temperatures must be equalized to assure stability. In many instances, heat sinks are either not needed or are impractical due to small area design. To equalize the case temperatures, apply a thick coating of silicone grease (Dow-Corning "Hi-vac") on each case, solder the transistors into the circuit, and then butt the cases together. Apply additional grease around the "butt joint." If the cases must be electrically insulated from each other, apply a coating of G-E "Glyptal" paint prior to the silicone grease. ▲

EUROPEAN SEMICONDUCTOR CODE

By PATRICK HALLIDAY

KNOWLEDGE of the standard European code for semiconductor type numbers, now gradually coming into general use throughout Europe, will be found useful when dealing with tape recorders, radios, and other electronic equipment imported into the United States. The code type number shows useful information about the type and function of the device.

Although the code is still not universally adopted even in Europe and some earlier semiconductor designations may still be encountered, almost all the newer devices marketed by European firms now conform to this code.

The first letter of the device type number immediately identifies the semiconductor material. A device beginning with the letter *A* is germanium. Silicon diodes or transistors, on the other hand, begin with the letter *B*. Photoconductive materials using compound materials begin with an *R*.

The second letter of the device designation shows the general construction or application, in accordance with the following code: *A*, diodes (except certain special types having their own identification letter; *C*, audio-frequency transistors, other than power types; *D*, audio-frequency power transistors; *E*, tunnel diodes; *F*, radio-frequency transistors, other than power types; *L*, radio-frequency power transistors; *P*, photodiodes, phototransistors, or photoconductive cells, including the light-dependent resistors sometimes used to provide automatic contrast control for different ambient light values in television receivers; *R*, control and switching devices, other than power types; *S*, power transistors for switching application; *T*, control and switching devices with specified breakdown characteristics; *U*, power transistors (switching); *Y*, power diodes or rectifier diodes; Z, zener or reference diodes.

The remainder of the device designation consists of a serial number. For "entertainment" devices used in consumer goods this usually consists of three figures. Professional or industrial semiconductors have one further letter (usually *X*, *Y*, or *Z*), followed by two figures.

Thus a device with a designation AF117 can be immediately identified as a germanium r.f. transistor for "entertainment" applications; in fact this is a small *p-n-p* transistor widely used in the mixer and i.f. stages of small broadcast-band radio receivers. An AD140 could be identified as a germanium a.f. power transistor, and this is a type often used in the output stage of car radios and is also a *p-n-p* device.

A BF115 code shows us that this is a silicon "entertainment-type" r.f. transistor and is one of the very recent silicon *n-p-n* transistors introduced for use in portable and car radios. The BY100 is a silicon diode rectifier (with 800-volt p.i.v. rating) commonly used in European television receivers for operation from 240-volt power-line supplies.

Perhaps unfortunately the code does not indicate whether a transistor is a *p-n-p* or an *n-p-n* device. The great majority of the European "entertainment" transistors have in the past been *p-n-p* types, although more recently a number of matched *p-n-p*/*n-p-n* types have been introduced for use in the popular complementary-symmetry output circuits.

Until the recent introduction of low-cost silicon r.f. transistors, practically all r.f. germanium types for consumer goods have been *p-n-p* types, but many of the newer silicon units are *n-p-n*.

Many of the older European entertainment devices introduced before the new code came into general use begin with *OC* (transistors) or *OA* (diodes). There have also been a number of designations used by individual makers. ▲

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Lasers

(*Continued from page* 35)

Fig. 9 shows the pertinent sections of the energy-level diagrams for helium and neon with the transitions indicated. Note that when the (3) level is well populated by pumping energy, there is amplification for two different frequencies, f_{34} and $f_{34'}$. Note also that the alternate route 1, 2′, 3′, 4′ should result in amplification at the frequency $f_{3'4'}$. Lasing action has been observed at all of these frequencies in helium-neon mixtures. Selection of oscillation between these frequencies is accomplished by using feedback mirrors with reflectivities at the different frequencies.

It must be pointed out that the above discussion by no means covers all known lasers. In fact, the list of laser materials grows on an almost weekly basis. Laser action has been observed in other solids doped with small quantities of rare earth ions, almost all the noble gases, and even in some special liquids. In addition, the observation of coherent light generated by injection currents in semiconductor diodes such as gallium arsenide and gallium phosphide has added another important class of laser (called *injection lasers*) to this fast-growing field.

It is interesting to compare in a general way the helium-neon laser to the ruby crystal laser. In the first place, the atoms in a gaseous discharge tube are more widely spaced than the dopant atoms of even a slightly doped solid. A longer path length in the discharge tube is usually necessary to obtain sufficient optical gain for lasing. The helium-neon laser resonant cavity is, therefore, generally larger than that of a ruby laser. However, the over-all efficiency of the helium-neon laser (total laser output power/pumping power) is considerably higher than that of ruby. Consequently, power supplies for ruby lasers are most often larger than those for the helium-neon type.

The most striking difference between these devices is in their outputs. Whereas the ruby laser output is typified by irregular spiking, the helium-neon laser is capable of a continuous wave of extremely narrow bandwidth. This great disparity in emissions has divided the two types of lasers into their respective fields of application. Microsurgery, microwelding, micromachining, and pulsed-type communications systems require high instantaneous powers for short durations and consequently have adopted the ruby laser. On the other hand, continuous communications requiring sophisticated demodulation techniques such as heterodying, as well as the practical usage of light interferometry, find the gaseous type of lasers well suited for this particular application. ▲

Selecting Proper Fuse

(*Continued from page 30*)

soldered directly into the circuit. The second method, and one which is very commonly used, is the open-clip-type mounting where the fuse is supported by metal fuse clips and the circuitry is either wired or attached by screw terminals or solder lugs to the fuse clip. The third refinement is the fuse-extractor post, which is generally panel-mounted, giving access to the fuse from either the front or back panel without danger of shock hazard to the operator. In automotive or low-voltage applications, another method of mounting is offered in the fuse retainer, or in-line type mounting.

When many fuses are used, it is desirable to have some indication of which fuse has blown; therefore, indicating fuse-extractor posts are available. In this type, a lamp in the transparent knob of the fuse post lights up at the time of fuse failure, indicating which circuit has the blown fuse. When the fuse is replaced with a good fuse, the light is no longer energized. There are also available special types of fuses with built-in indicators to show when a fuse has blown.

There are some specialized holders for specific applications, for example, the limited-current fuses and fuse holders used for TV sets. These limited-current fuses are made with a pair of tabs on one cap, which are indexed with a pair of slots in the head of the fuse holder. As the amperage rating is increased, the tab width is increased, thus making it impractical to use a higher rating of fuse.

Common Fusing Errors

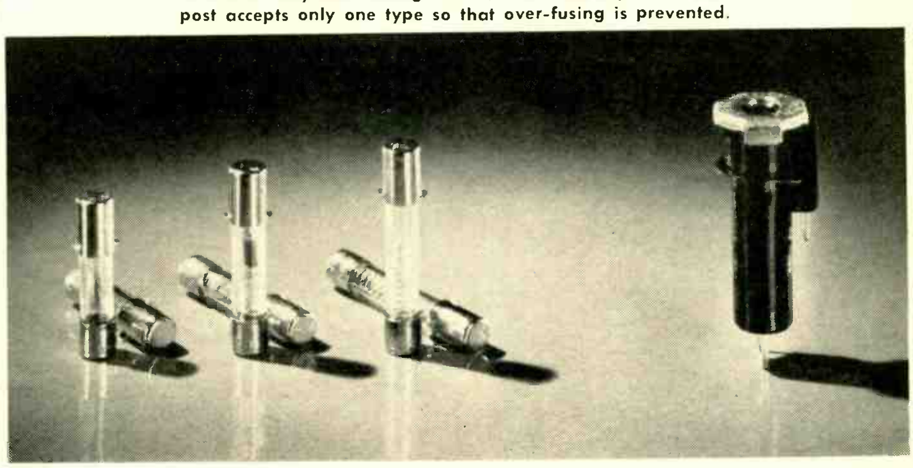
There are some common fusing errors in the use of fuses which create problems for the user and, in some instances, result in damaged equipment. One of the most common errors is over-fusing. A piece of equipment may be designed to use a certain amperage fuse—which gives adequate protection. Because of overloading, the fuse blows occasionally and when the fuse is replaced, the equipment seems to work all right. Because of this, the obvious conclusion to the layman is, "Put in a larger fuse and everything will be OK." A larger fuse is installed and suddenly there is a cloud of smoke due to the continuing overload and the use of a fuse that is not capable of opening the circuit because it is overrated for that particular application.

Always replace a blown fuse with the same rating fuse that was originally designed into the equipment. There have been many instances where ¼-amp. fuses have been replaced by 20-amp. units in order to prevent nuisance blowing. Obviously, over a period of time this can only lead to ultimate failure of the equipment.

Another common fusing error is using the wrong type of fuse in a piece of equipment. For example, a piece of equipment that has a high inrush surge should not use a medium- or fast-blowing fuse. In this type of application, a slow-blow fuse should be used, thus preventing nuisance blowing and the possibility of uprating or over-fusing. On the other hand, for the protection of a delicate instrument or an instrument circuit, we want a fuse that will open the circuit as quickly as possible in order to prevent damage. In this case, the use of a medium- or slow-blow fuse would not be correct. An instrument fuse, or fast-blowing fuse would be the correct choice. Remember, use the right type of fuse for your particular application.

The use of a fuse with the wrong voltage rating is also a common fusing error. The voltage rating of a fuse is the maximum voltage it will break without arcing or bursting. (This is assumed to be in a direct-current system with a 10,000 ampere capacity power supply, unless otherwise indicated.) In other words, 32-volt fuses should not be used in 250-volt circuits. This can be dangerous to the user as well as to the equipment in which it is installed. All voltage ratings on fuses are maximum voltages; fuses may be

These slow-blow fuses have different lengths and different widths of bayonet locking tabs on the fuse caps. The fuse post accepts only one type so that over-fusing is prevented.



used up to and including their voltage rating.

The ambient temperature is a contributing factor in the opening of a fuse. One of the common errors in fusing is a complete disregard of the temperature in which the fuse is required to operate. We have stated that the fuse is actually a thermal device. It operates by virtue of the heat dissipated in the fuse element. Therefore, an increase in ambient temperature can also cause derating of the fuse. Conversely, a decrease in ambient temperature can also cause an increase in rating in the fuse. Thus, when temperatures other than normal room temperature are encountered, they should be taken into account in selecting appropriate fuses.

Other minor considerations often overlooked yet responsible for fusing errors include pulse fatigue, vibration, shock, and exceptional atmospheric conditions. All of these conditions should be considered at the time the equipment is designed and the fuse application determined. This is another good reason for replacing fuses that have blown in service with the same type of fuse that was in the original installation.

In summary, when choosing a fuse for your particular application, select the proper unit by carefully considering the following: 1. size, 2. amperage, 3. voltage, 4. type, 5. ambient temperature, and 6. special characteristics.

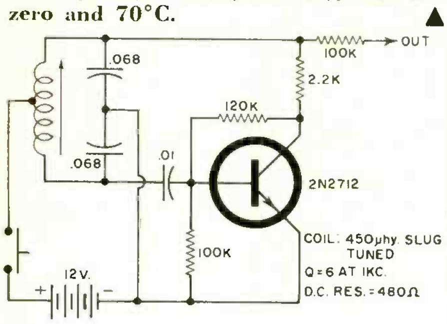
The selection of proper fuses can prevent nuisance blowing, fire hazard, and danger to personnel. ▲

1-KC. OSCILLATOR

SUGGESTED by G-E, the circuit shown in the diagram is useful in applications where a 1-kc. sine wave, or 1-kc. sharp-wavefront pulses are required. Stability is dependent on using high-"Q" inductance and low temperature coefficient capacitors.

The two capacitors connected across the inductor provide a balanced tank to ground resulting in improved waveshape across the resonant circuit. The sine-wave output is sufficient to drive an emitter follower for coupling to low-impedance loads. An additional result of using two capacitors is rapid turn-on of current conduction by the 2N2712 causing the generation of sharp-wavefront pulses, adaptable for driving and synchronization applications.

Frequency stability is .15% between zero and 70°C. ▲



EW Lab Tested

(*Continued from page* 14)

very nearly as good on the SR300. RIAA phono equalization was within ±1 db of the ideal characteristic on all three receivers. The NAB tape playback equalization of the SR600 and SR900 had a broad rise in the upper middle range, resulting in an over-all response of ±4 db from 30 to 15,000 cps.

The IHF Usable Sensitivity of the FM tuner of the SR300 was 8 μv. (rated 4.5 μv.); the SR600 was 3 μv. (rated 1.95 μv.); and the SR900 was 2.9 μv. (rated 1.85 μv.). The stereo channel separation of the SR300 was good in the middle range (33.5 db at 1000 cps), but fell off considerably at lower and higher frequencies. The SR600 and SR900 had exceptionally good separation, −38.5 and −33.5 db respectively, over most of the important audible range.

The FM-tuner hum levels of all the receivers was low, between −57 db and −60 db referred to 100% modulation. The capture ratio of the SR300 was 10 db and that of the SR900 was 3 db. We measured the capture ratio of the SR600 at 1.8 db, one of the best in this respect.

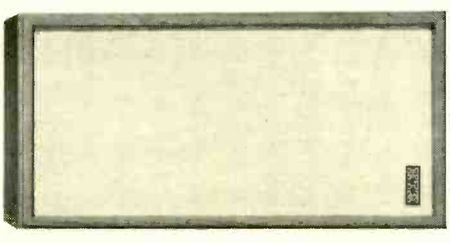
As far as their operation is concerned, all the receivers performed well. The SR600 and SR900 were noticeably more sensitive than the SR300, which is nevertheless well suited for use in urban and suburban areas. The audible FM-stereo separation of the SR300 is not as good as that of the other two, but is quite adequate for a satisfying stereo effect. All three have excellent sound quality. The low power output of the SR300 requires the use of moderately high efficiency speakers, such as are likely to be used with a budget-priced stereo system.

None of the receivers had any apparent vices or operating idiosyncrasies. Their FM-stereo indicator lights are illuminated on interstation noise (except when muting is used on the SR900), and flicker on high-frequency modulation peaks even in mono reception. However, they will remain lit only when tuned to a station broadcasting in stereo, so their purpose is served.

The prices of these receivers are: SR300, $279; SR600, $389; and SR900, $469. ▲

KLH Model 17 Speaker System

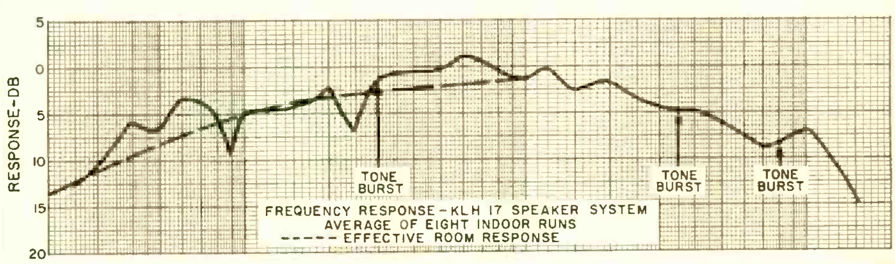
For copy of manufacturer's brochure, circle No. 25 on Reader Service Coupon.

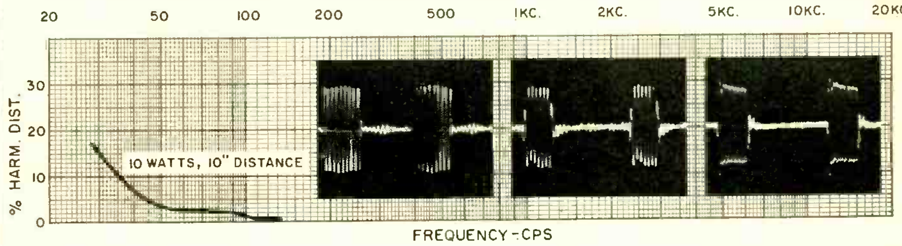


THE *KLH* Model 17 speaker system is the successor to the manufacturer's Model 10, offering even finer performance at a lower price. It is a true "bookshelf"-sized system, housed in an oiled walnut cabinet measuring 23" x 11¾" x 9".

The Model 17 has a 10" acoustic-suspension woofer and a 1¾" cone-type tweeter. A three-position toggle switch on the rear of the cabinet provides increased or decreased treble response, relative to the "normal" setting.

We measured the frequency response of the system in a "live" room, averaging eight sets of data taken at different microphone positions. It has a remarkably smooth over-all response, within ± 5 db from 25 to 4000 cps, and falling off gently at a 3 db/octave rate above 2000 cps, at the "normal" tweeter setting. The dashed line in the plotted response curve is the inherent response of our room and test setup, averaged from measurements made on dozens of speakers. It clearly shows the flat bass response of the speaker, free from any significant peaks or holes. The high-frequency response





is even smoother, and with the tweeter level at its increased setting would be nearly flat to the limits of audibility.

The Model 17 has the very low bass distortion which is a property of a well-designed acoustic-suspension woofer. At 10 watts electrical input (far more than would ever be used in normal listening), the harmonic distortion is under 5% down to 45 cps, rising then to 15% at 30 cps.

All the *KLH* speakers we have tested in the past have exhibited outstandingly faithful response to tone-burst signals (as indication of good transient response). The Model 17 is no exception. The tone-burst photos, taken at 300 cps, 3500 cps, and 8000 cps, are typical of its response throughout the audio range, and are as nearly perfect as we have ever observed on a speaker system.

Based on the test data, one would expect top-quality sound from the Model 17, and that is just what it delivers. Although we were not able to compare it directly to its larger and more expensive relative, the Model 6, it appears to come very close to matching it in over-all sound quality. The Model 17 is a delightfully smooth, balanced speaker system. It needs no bass boost in the amplifier to give it a solid, tangible "bottom-end" response. We found it most satisfying with the normal tweeter level setting, but the available range of adjustment should be adequate to match the requirements of unusually "live" or "dead" rooms.

This speaker does not sound in any way like a small box. It delivers a full, open sound, with outstanding clarity and definition, and enough low bass to satisfy anyone but the most confirmed pipe organ "buff." Although it is priced just above the least expensive high-quality speaker systems, its sound matches or surpasses most other speakers we have heard which sell for twice its price.

The *KLH* Model 17 is an outstanding value at $69.95. ▲

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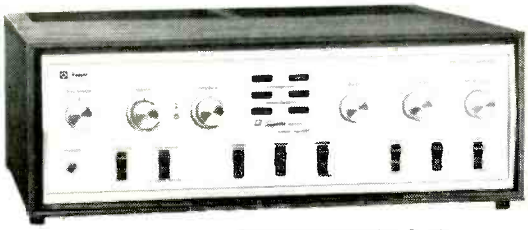
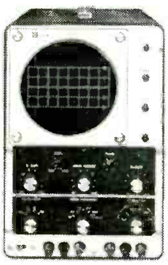


KG-895 Superba Series 120-Watt Solid-State Stereo Amplifier Kit. $149.95

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



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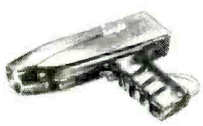

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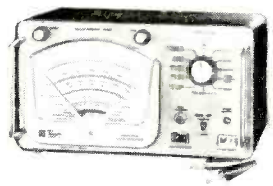

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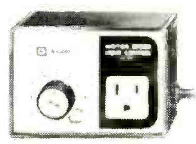
KG-221 FM Monitor Receiver Kit (police, fire, marine, weather bands, etc.) $39.95



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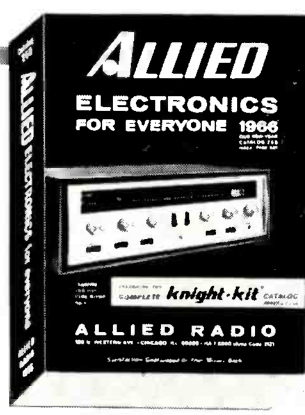

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ALLIED RADIO

CIRCLE NO. 125 ON READER SERVICE CARD

Economy-Line Transistors

(*Continued from page* 36)

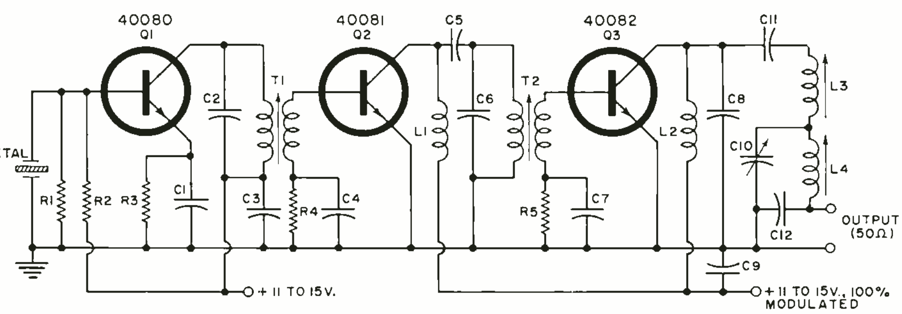
When the output is adjusted to 3.5 watts unmodulated, it will kick up to about 4.8 watts with 100% modulation. At least one CB equipment manufacturer is currently using the 40082 in his equipment.

There are six other types in the economy family. The 2N3241 and 2N3242 are high-gain, low-noise transistors for use in audio and low r.f. (to 30 mc.) applications. The 40231, 40232, 40233, and 40234 are high-gain, very-low-noise (2 to 2.8 db at 10 kc.) audio amplifiers. They make excellent preamplifiers in hi-fi systems. The cases are identical and the 40231 is shown in Fig. 1.

Although most of the transistors discussed here have house numbers, rather than JEDEC-registered 2N numbers, they are readily available from regular RCA semiconductor distributors and mail-order electronics supply houses.

The present efforts to reduce the cost of transistors make further reductions seem likely. Original equipment manufacturers are already buying some transistors for as little as 22 cents in orders of 100 or more where they once had to order 1000 to get the price break. It may not be long before you can buy a single transistor for that price. ▲

Fig. 3. Suggested circuit for 5-watt CB or 29-mc. ham transmitter r.f. section. Note that circuit must not be used in a home-built CB rig unless the unit meets with FCC approval. A heat sink is recommended for the 40082 output transistor.



R1—510 ohm, ½ w. res.
R2—5100 ohm, ½ w. res.
R3—51 ohm, ½ w. res.
R4—120 ohm, ½ w. res.
R5—47 ohm, ½ w. res.
C1—75 pf. ceramic capacitor
C2—30 pf. ceramic capacitor
C3,C4,C7,C9—0.01 μf. ceramic capacitor
C5—47 pf. ceramic capacitor
C6—51 pf. mica capacitor
C8—24 pf. mica capacitor
C10—90-400 pf. var. capacitor (Arco 429 or equiv.)
C11—100 pf. ceramic capacitor
C12—220 pf. ceramic capacitor
L1,L2—15 μhy. r.f. choke (J. W. Miller 4624 or equiv.)
L3—Var. inductor (0.75 to 1.2 μhy.); 11 t. #22 wire wound on ¼" CTC coil form having "green dot" core; "Q"=120
L4—Var. inductor (0.5 to 0.9 μhy.). 7 t. #22 wire wound on ¼" CTC coil form having "green dot" core; "Q"=140
T1—R. f. trans.; pri. 14 t., sec. 3 t. #22 wire wound on ¼" CTC coil form having "green dot" core; slug-tuned (0.75 to 1.2 μhy.); "Q"=100
T2—R.f. trans; pri. 14 t., sec. 2¾ t. #22 wire wound on ¼" CTC coil form having "green dot" core; slug-tuned (0.75 to 1.2 μhy.); "Q"=100
Xtal.—27 or 29 mc. crystal
Q1—40080 transistor (RCA)
Q2—40081 transistor (RCA)
Q3—40082 transistor (RCA)

Receiver Noise

(*Continued from page* 48)

supply voltages available, it is not possible to duplicate the manufacturer's test conditions exactly. In this case, the best conditions must be arrived at.

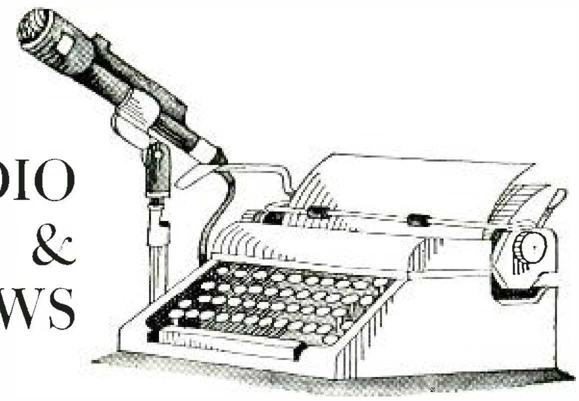
A triode tube usually produces the best noise figure when it is biased for class A operation where the gain is maximized, consistent with linearity. In a transistor, it is most often found that the best noise figure is obtained when the collector current is quite small, usually around 1 to 2 ma.

Depending upon the circuitry, it is usually advantageous to adjust the matching transformer and its loading for best noise figure. By observing a signal (either on an oscilloscope, or modulation through a 400-cycle filter), adjust for the greatest signal-to-noise ratio for a given generator output. When the noise match has been optimized, the smallest input signal will be seen above the noise.

The noise figure may be further improved in a grounded-cathode tube circuit, or in a common-emitter transistor circuit, by neutralization. This reduces the effects of the grid-plate or base-collector capacitance upon the input impedance. The usual practice is to place a small inductance between the grid and plate through a series-blocking capacitor. When the reactance of the inductor is equivalent to the reactance of the grid-plate capacitor, the two will be in parallel resonance, and the effect is the same as replacing the capacitive reactance with a very high series reactance of the value of QX, the "Q" of the inductance, and the reactance of either the coil or capacitor.

It will be found that the maximum noise voltage, maximum gain, and maximum sensitivity will result simultaneously with the best noise figure. Do not look at the noise voltage alone when adjusting for best noise figure, as this is deceiving. A signal must be visible with the noise in order to determine whether or not the ratio of signal to noise has increased or decreased with an increase in noise voltage. See Fig. 5. ▲

RADIO & TV NEWS



IT looks like TV has taken a firm grip on modern civilization as the total number of TV transmitters and TV receivers in world-wide use grows by leaps and bounds.

The number of overseas TV stations increased more than 34% last year to a total of 4628, while the number of TV sets in use rose more than 17% to 94,474,000.

At the start of 1965, 90 countries or territories abroad had TV stations in operation. Liberia, Ethiopia, Pakistan, Aden, Barbados, and the French Antilles started TV broadcasting in 1964.

This world-wide census does not include the U.S., Canada, or the Armed Forces stations abroad.

The top six countries overseas in number of TV sets as of January 1, 1965 are: Japan (17,710,000); United Kingdom (14,616,200); Soviet Union (11,800,000); West Germany (10,024,000); France (5,585,000); and Italy (5,406,300).

In Latin America, Brazil leads with 2,156,000; Argentina is second with 1,360,000; and Mexico is third with 1,071,000 TV sets.

Almost half of the overseas TV sets in use are in Western Europe, which has 45,931,600. The Far East, because of Japan's eminence, is second with 20,977,200. Eastern Europe is third with a total of 19,704,000.

There were an estimated 67,100,000 TV sets in use in the U.S. and 4,950,000 sets in Canada at the end of 1964.

Solid-State Vidicon

Researchers at NASA have come up with a new approach to the vidicon TV-camera tube using a single sheet of silicon containing 2500 light-sensing elements arranged in an approximate half-inch square. Each element is a three-layer phototransistor that conducts current as a function of the amount of light impinging on it. After amplification, the signals are processed for transmission. Resolution of this system is equivalent to a 50-line system.

Engineers at *Westinghouse* feel that it is possible to place up to 40,000 light sensors in the same half-inch square to raise the resolution to about 200 lines, equivalent to present-day commercial television standards.

New Battlefield System

Radar and infrared equipment aboard reconnaissance aircraft can detect many things that an unequipped human can't.

However, having this information and being able to use it immediately has been a problem. The tactical situation can change drastically during the hour or so that it takes to gather the information from the aircraft and pass it along to the field commander.

According to Arnold Kashar of *General Precision Aerospace*, a unique digital data-transmission system has been tied to an existing data link so that radar and infrared readouts can be transmitted to a ground console simultaneously with aircraft coordinates and flight conditions.

The new system interrogates the aircraft-position system to determine its coordinates in *X* and *Y* references and altitude. The digital data derived from this interrogation is processed into the proper format for telemetering during a blanking-time interval (a period when no other information is being sent).

The composite signal consisting of aircraft radar or infrared display, together with moment-by-moment aircraft position and altitude information, is then sent to the ground station.

Space Fallout

We are well acquainted with the large number of new electronic circuits and components arising from our continued research into space-vehicle communications. However, there is one non-electronic fallout that may be of interest.

Space-vehicle researchers at the NASA Goddard Space Flight Center have recently applied for patents on a new type of paint that will adhere to most metals and many non-metals and that will not crack, peel, chalk, flake, or fade when subjected to temperature extremes ranging from 1800°F to −320°F. These paints are also washable, can be made in any color, and have long shelf-storage life.

When these paints will be available and under what name is unknown. ▲

Touch-Plate Lighting Switch

(*Continued from page* 44)

the box can be run several feet to one or more touch-plates. Because any number of touch-plates can be added, the device becomes a practical addition to a lamp which needs control from several points. One touch of any plate first turns the light on, while the second touch turns the light off.

The unit is made up of four general-purpose transistors and one inexpensive relay. No particular precautions are necessary in constructing the unit. The challenge comes in making efficient use of space to obtain the compact size.

Construction

The unit is constructed on a small piece of perforated circuit board 2½" x 3⅜". It is then mounted in a 4" x 2" x 2¾ box (*LMB* #102). An a.c. receptacle, phono jack, and a.c. cord are then connected.

Since this is a transformerless device, make sure that the chassis is not connected directly to the a.c. line, but through C9 only. (See Fig. 1.)

When running the touch-plate wire, use a small insulated shielded wire. This shield must be grounded at the phono jack and not at any other point. The metal touch-plates are then connected to the inner conductor. Keep the touch-plates small if several of them are to be used. It is best to mount the touch-plates in a way that they are insulated from the wall to prevent them from being grounded out should high humidity or moisture cause the wall to become conductive. Several objects on shelves or tables, such as metal lamp bases, small metal models, or even conductive ore samples can be easily wired as touch-plates.

Circuit Description

The human body has a certain amount of capacitance to earth ground. If we build a sensitive device that operates as a result of this capacitance to ground, then we have the capacitance-operated switch.

In this device, the a.c. plug is polarized so that one side of emitter resistor *R*3 is in the live or hot side of the a.c. power line. A voltage will now appear across *Q*1 from base to emitter when any one of the touch-plates is capacitance-coupled to ground by the body. The small value of *C*1 limits the amount of current flow into the base of *Q*1. *Q*1 takes the high-impedance input and reduces it to the low impedance necessary to saturate the following transistor.

*Q*2 accomplishes two things. It is an amplifier and a pulse generator. The base is biased through *R*4 so that the transistor is normally cut off and the collector and *C*3 are at supply potential. When an a.c. signal comes in, the negative peaks from *Q*1 cause *Q*2 to conduct and rapidly discharge *C*3, thus creating a large positive-going pulse at the collector of *Q*2. This transistor must be a fairly high-gain unit such as the 2N1305.

*Q*3 and *Q*4 form a bistable multivibrator. The positive-going pulse from *Q*2 is limited by *R*7 and applied through *C*4 and *C*5 to steering diodes *D*1 and *D*2. To best understand their action, assume *Q*3 to be cut off. This means that its collector will be at supply potential (negative) as will be the anode of *D*1 through *R*9. Under these conditions *D*1 cannot conduct. On the other side, however, *Q*4 is in strong conduction and the relay is energized. Its collector will be near 0 volts potential as will be the anode of *D*2 by way of *R*10. This means that the positive pulse would pass through *D*2 and cut off transistor *Q*4, thus reversing the circuit and de-energizing the collector relay.

Every time the plate is touched, then, the circuit is reversed and the relay is alternately energized and de-energized.

*C*6 is a stabilizing capacitor to prevent r.f. interference from triggering the bistable multivibrator prematurely.

The unit will handle 200 watts of power using the relay shown in the parts list. The control line may be extended up to 30 feet using the values shown in the schematic.

When plugging the unit in for the first time, you will notice a tendency for the relay either to stay de-energized or to pull in due to the particular unbalance in the bistable circuit. By wiring the relay contacts to take advantage of this fact, the unit will return to the "off" position should a power failure occur. Short power failures of less than 10 seconds may reset the bistable circuit in the opposite state. Also, when plugging the unit in, it may show some insensitivity. Merely reverse the plug to solve this problem. ▲

"Am I glad you're home! Our set went on the blink today."

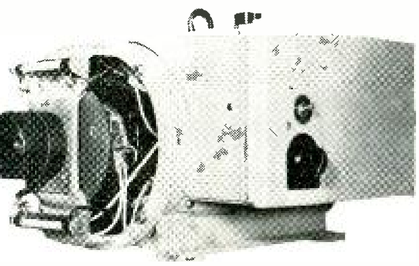
NEW PRODUCTS & LITERATURE

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

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

D.C.-TO-A.C. POWER SUPPLY

Kato Engineering Company has developed a compact, 1-kw. motor-generator set for d.c.-to-60-cycle a.c. applications, including standby for vital communications equipment; emergency signals, alarms, and timing devices; essential lighting in hospitals, furnace controls, etc. It can also



be used to power equipment in the field or used as an isolated load source for testing and laboratory use.

The 2-hp, shunt-wound, 220-volt d.c. motor drives the 1-kw., single-phase, 115-volt 60-cycle generator. Motor and generator are on a common shaft within a common frame. Operating speed is 3600 rpm. A speed governor controls the speed and maintains output and frequency within one cycle.

Units with closer regulation are available on special order. Sizes extend to 17.5 kw. output.

Circle No. 1 on Reader Service Card

INEXPENSIVE TUNER CLEANER

Coleman Electronic Products Inc. has come out with a low-cost tuner cleaner that is guaranteed to be harmless to plastics used in tuners. This new formula, called "Kleen-It," consists of long-lasting protective silicone lubricants which have been carefully selected to provide the best possible protection without detuning the tuner.

The product is not flammable, contains no carbon tet, and has a very low toxicity rating. It comes in a handy caddy-sized container and is packed with a shockproof, flexible extension.

Circle No. 2 on Reader Service Card

MAGNETIC LATCHING RELAY

Milwaukee Relays, Inc. has developed a new magnetic latching relay which is claimed to be virtually free from mechanical failures. The unit, a low-cost multiple general-purpose relay, uses a magnet instead of interlocking metal levers. In operation a one-piece armature on the magnet rocks up and down with a seesaw movement. In normal operation the armature is attracted to the coil side energized. It also operates in the opposed mode at about half the voltage or a quarter the power.

The unit is available in all these variations: electrical or mechanical operation or both; polarized; center-off up to 6-pole d.t., 10-amp contacts; plug-in dust cover; push-to-reset feature.

The company will supply complete mechanical and electrical specification on these new units upon request.

Circle No. 126 on Reader Service Card

METALLIC-OXIDE CAPACITOR

Syncro Corporation has developed a completely new metallic-oxide capacitor, the MO-1 which the company claims is directly competitive with mica, glass, ceramic, plastic, and paper capacitors. The new units are available as buttons or encapsulated with leads.

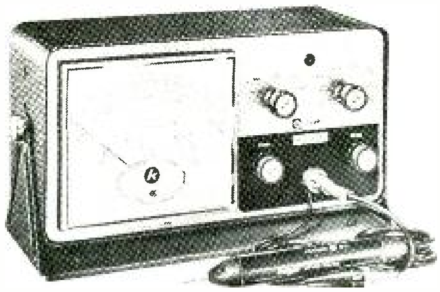
These new components have a metallic substrate with the oxide of the substrate acting as the dielectric. These units are stable over an unusually broad temperature range, being essentially linear from $-50°$ to $+125°C$.

Literature with complete characteristics and performance graphs is available from the company.

Circle No. 127 on Reader Service Card

SIX-INCH V.T.V.M.

Allied Radio Corporation has released a new 6-inch v.t.v.m. which is being offered both as a kit and in factory-assembled form. The "Knight-Kit" Model KG-625 has a ½-volt full-scale d.c. range for transistor servicing. The meter has a 200-μa. movement with a fluorescent



knife-edge pointer, ten separate color-correlated scales, and 100° meter arc for larger scale area and easy viewing from all angles, plus a gimbal mounting bracket.

Specifications and pertinent details will be supplied by the company on request.

Circle No. 3 on Reader Service Card

DIFFERENTIAL-AMP TRANSISTORS

Sperry Semiconductor has introduced a new line of low-level "p-n-p" differential-amplifier transistors which have a typical gain of 100 to 200 at 10 μa.

The devices contain two electrically isolated "p-n-p" silicon triode transistors designed primarily for small-signal, low-power (-45 volts) applications. Packaged in TO-5 cans with six leads, the devices are designated SMT-100 through SMT-105.

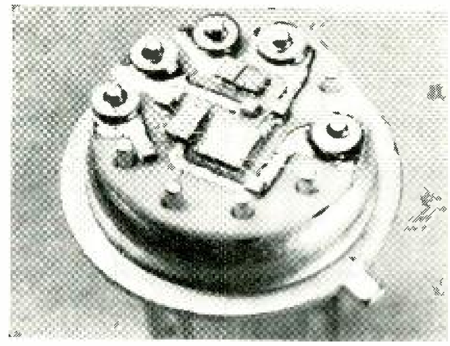
Full performance specs are available from the company.

Circle No. 128 on Reader Service Card

INTEGRATED-CIRCUIT POWER AMP

Motorola Semiconductor Products Inc. has developed a one-watt, integrated-circuit power amplifier, packaged in a single TO-5 can, with a usable frequency range from d.c. to well above 100 kc. and harmonic distortion as low as 0.5%.

The amplifier, designated MC1524, has three external taps which offer a choice of three internal, negative-feedback loops. These feedback



arrangements assure low distortion and excellent gain stability under a variety of conditions over the temperature range $-55°$ to $+125°C$.

As an audio amplifier, its output of one watt is more than adequate for normal room listening levels. The complementary class-B output circuit permits direct coupling to low-impedance loads, thus avoiding the use of bulky output transformers or capacitors.

When connected as a d.c. power amplifier, the MC1521 may be used to drive low-power servo systems, or as an operational amplifier when power output and very low source impedance are required.

The data sheet specifies maximum, minimum, and typical values for all important parameters. It is available on request.

Circle No. 129 on Reader Service Card

DESOLDERING TOOL FOR PC'S

Ungar Electric Tools has introduced a new desoldering tool for printed-circuit board repair that melts and vacuums away solder with easy, one-hand operation.

Named "Hot-Vac," the tool speeds and simplifies PC repair. No tinning of the tip is necessary since it has the firm's special coating that resists solder.

On plastic-coated PC boards, the unit melts through the plastic, melts and removes the solder, all in one operation. The complete assembly, Model #7800, includes a "clean room" handle with clean-cool grip, standard heating unit, special tip, and a rubber aspirator bulb. A stainless-steel check valve is provided in the tip to prevent molten solder from being drawn up into the bulb.

For further information on this new tool, contact the company.

Circle No. 4 on Reader Service Card

10-AMP SILICON TRANSISTORS

Motorola Semiconductor Products Inc. has introduced "p-n-p" silicon power transistors with 10-amp and 3-amp current ratings. The 10-amp units permit the immediate conversion of existing high-current germanium "p-n-p" transistor equipment to silicon and will create new high-current applications where the "p-n-p" configuration and temperature stability of silicon are essential.

Further details on these new transistors are available in the form of data sheets from the company.

Circle No. 130 on Reader Service Card

PLASTIC-FILM CAPACITOR

Union Carbide Corporation's Kemet Department has developed a new plastic-film capacitor that is one-fifth the size of polystyrene capacitors and up to 1/20th the size of glass, mica, or porcelain capacitors.

The "Flat-Kap" film-foil capacitor is made by a novel process whereby the plastic is vapor-deposited on a thin aluminum foil in thicknesses less than 2 microns, producing a higher capacitance per unit volume than is possible by any other means, according to the company.

These new capacitors are being offered in ratings from 0.001 to 0.1 μf. and in tolerances of $\pm$10, 5, 2, or 1 percent. Capacitance shift versus temperature is less than 2% from -55°C to $+125$°C.

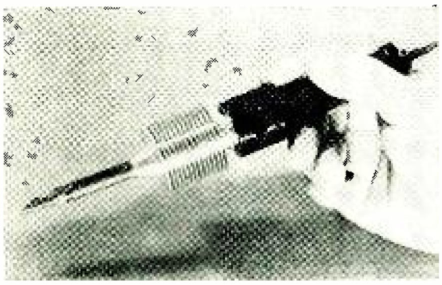
For additional infomation on the "Flat-Kap" line

Circle No. 131 on Reader Service Card

FLAMELESS TORCH

Henes Manufacturing Co. has developed a lightweight, pencil-type hot-air torch which is capable of producing temperatures to 750°F. Only 9" long and weighing but 4 ounces, the torch handpiece has a changeable tip enabling the user to vary hot-air flow and temperature for selective heating applications.

Air is supplied from a small remote pump with adjustable air output up to 7 cubic feet per hour. The torch and pump operate from a 115-volt, 60-cps line and are connected by four feet



of coupling line. The pump itself is designed for long duty cycles and features all-metal construction, stainless-steel bellows, nylon valves, and complete insulation for quiet running.

The torch comes with pump and 24 torch tips ranging in diameter from 0.037" to 0.093".

Circle No. 132 on Reader Service Card

ADJUSTABLE-STOP SWITCH

Grayhill, Incorporated is now offering an adjustable-stop rotary switch which adds new flexibility to circuit design. The 44D stop system lets the designer select the circuitry desired, then change the experiment with other combinations by simply re-adjusting the stops (no tabs to bend). The 44D series is suitable for prototypes, laboratories, test fixtures, and experimental systems. It is completely interchangeable with the firm's fixed-stop 44A series which can then be used for production runs.

The switches comes in 1 to 12 decks, 1 to 4 poles per deck, shorting or non-shorting contacts with 30° angle of throw, and of enclosed explosion-proof construction.

The company will supply complete details.

Circle No. 133 on Reader Service Card

MINIATURE SELENIUM RECTIFIERS

International Rectifier Corporation has made available a low-cost miniature selenium rectifier for radio and phonograph service. Suitable for the OEM or replacement market, the TO65U is rated for 65 ma. d.c. output and 130 volts maximum r.m.s. input or 380 volts peak reverse voltage. The maximum cell operating temperature is 105°C (221°F) and a series resistor of 22 ohms is recommended as a surge suppressor.

Excluding the mounting tab and terminals, dimensions of the rectifiers are 1 7/32"x1/2"x5/16". Quantity orders and prices can be obtained from the company on request.

Circle No. 5 on Reader Service Card

TOROIDAL TRANSISTOR XFORMERS

Bundy Electronics Corporation has introduced a new toroidal transistor transformer for use in d.c.-d.c. and d.c.-a.c. power supplies. These new epoxy-molded units exceed MIL-T-27A, Grade 5, requirements. They are designed to give reduced noise level, increased efficiency, increased life expectancy and reliability—all with appreciable reduction in size.

Normal operating frequencies are in the range between 1500 and 5000 cps but specially designed units can be obtained with operating frequencies up to 10,000 cps.

For full details on this new line of components

Circle No. 134 on Reader Service Card

THERMOELECTRIC MODULE

Energy Conversion, Inc. is now in production on a small thermoelectric module, the H9-65. Designed for the component cooling market, the new module combines small size with reliability, performance, and economy, according to the manufacturer. Suggested applications include the cooling of semiconductors, infrared detectors, dew point sensors, tissue samples, etc.

The Model H9-65 measures 9/16 inch square by 3/16 inch thick. It can attain a maximum unloaded temperature differential of 65°C with the heat-sink temperature equal to 27°C; maximum current is 9 amps; maximum loaded heat-pumping capacity is 3.9 watts; weight 7 grams.

Technical bulletin 20, which describes the unit more fully and includes design nomographs and procedures, will be sent on request.

Circle No. 135 on Reader Service Card

SUBMINIATURE SILICON PHOTOCELL

International Rectifier Corp. is in production on a line of ultra-small silicon photocells for counters, position indicators, readouts, and light-activated switches.

Typical currents of 0.2 ma. at 0.3 volt are generated when a 0.01-square-inch photocell is activated by 500 footcandles illumination. For increased system sensitivity, the cells can be used in the reversed bias mode and driving a transistor. The devices can be obtained in the "n on p" or "p on n" type as an aid to design requirements.

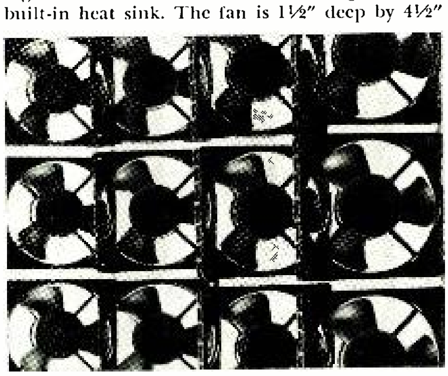
Packing densities of nearly 90 units per square inch are possible if lead connections are neglected. The cells are typically 0.025 inch thick.

Full details on this new line, including prices, are available from the manufacturer.

Circle No. 136 on Reader Service Card

VENTILATING FANS

Rotron Manufacturing Company, Inc. is in production on the new "Mark 4" muffin fan which provides static air delivery of 100 cfm. New design features for longer life include a totally enclosed stator, "Pyre-ML" magnet windings; lubricated-for-life sleeve bearings; and a built-in heat sink. The fan is 1½" deep by 4½"



square. The unit is available in four basic styles: skeleton, venturi, grille, and filter. In addition, it may be equipped with any of a complete line of accessories.

For information on the fan and related accessories, or for assistance in determining suitability, contact the manufacturer.

Circle No. 6 on Reader Service Card

ELECTROLYTIC-CAPACITOR BOX

Sencore, Inc. is now offering an electrolytic-capacitor substitution box which is designed to be used with all types of transistor as well as

vacuum-tube circuits. The ES-132 "Electro-Sub" provides 10 dual electrolytics from 2 μf. to 250 μf. to operate from 4 to 450 volts d.c. The electrolytics can be used singly, as duals, or paralleled to provide up to 32 different combinations.

The unit is housed in an all-steel case and is simple and quick to use. The leads are simply hooked up, the selector switch is set to the desired capacity value, and the "push-to-test" switch operated. A surge protection switch prevents arcing, sparking, or accidental healing of the electrolytic under test. The unit also discharges its electrolytic to prevent shock.

Circle No. 7 on Reader Service Card

CIRCUIT-BOARD KIT

Vero Electronics Inc. has just come out with a handy kit containing six of the company's "Veroboards," a spot-face cutter, and instruction sheet for building various circuit-board projects. The boards consist of a high-grade synthetic-resin-bonded paper laminate with a number of copper strips bonded to it. The strips are pierced with a regular matrix of holes. Components are placed across the board according to the circuit plan, interconnections being made by the copper strips. Where the circuit must be broken, the copper strips are cut with the spot-face cutter. This cutter is a precision, hardened steel tool which has a pilot pin that fits any hole, and two cutting edges.

The entire kit is packaged in a clear plastic bag. A data sheet on Kit-Model BK-6 will be forwarded by the manufacturer on request.

Circle No. 8 on Reader Service Card

MINIATURE REED RELAY

General Electric Company has announced the availability of a new miniature reed relay that has been specifically designed for the military market. The new component features a unique lead design, small size, and exceptional reliability.

A sectional spool body enables the capsule leads to be formed prior to insertion in the spool body. This step also permits precise fixturing necessary to form the leads without damage, thus eliminating any possible abuse to the leads during relay assembly.

The relay is being marketed in a package only 1.33 inches long by 0.405 inch high. Additional poles increase the width by only 0.15 inch per pole. The unit will last through 50 million operation at low level and 20 million operation at 0.4 amp, 25 volts.

Complete specifications are available.

Circle No. 137 on Reader Service Card

METAL FILM TRIMMER

Miniature Electronic Components Corp. has just introduced a microminiature metallic-film trimmer pot which is ¼" in diameter, with infinite resolution, low-temperature coefficient, as well as a full range of resistance values from 10 ohms through 100,000 ohms.

This single-turn unit is housed in a molded diallyl-phthalate case and is being offered either with or without stops. It is designed for printed-circuit mounting, is "O" ring sealed, and will withstand vibration, shock, and humidity conditions as specified in MIL-STD 202B.

Complete details on the various units comprising this line will be supplied by the manufacturer.

Circle No. 138 on Reader Service Card

PRECISION MINIATURE TRANSFORMERS

Microtran Company, Inc. has added a new line of "Pico" miniature transformers built to MIL-T-27B, Grade 5, Class S. Size of the new units is only $\frac{5}{16}$"x$1\frac{3}{32}$"x$1\frac{5}{32}$" high. Weight is 0.1 ounce.

The new series has leads on 1" grids and have been developed for printed-circuit board application where class-S temperatures are required. Gold-plated 0.020" diameter, high-tensile nickel alloy leads permit reliable soldered joints and high-density welded packaging. Of epoxy-molded construction, these units are designed for a minimum life of 10,000 hours. The line is available in impedance ratings from 3.2 to 100,000 ohms.

Additional information on this new line, including all mechanical and electrical specs, will be supplied by the company on request.

Circle No. 139 on Reader Service Card

SELF-LOCKING CONNECTORS

Harvey Hubbell, Incorporated has available a complete line of self-locking, self-adjusting connectors designed to insure uninterrupted electrical circuits. Because the connectors are locked in until purposely released, the possibility of accidental disconnects is eliminated.

The line consists of four basic types and designs. Type A includes plugs and connectors, both insulated and non-insulated crimp terminal devices, panel jacks, angle plugs and jacks, terminal strips, eyelet panel jacks and insulated plugs. Type B includes the same equipment in miniature sizes while Type C are subminiature versions. Type S consists of larger size automatic locking plugs and jacks.

A new catalogue covering this complete line is available on request.

Circle No. 140 on Reader Service Card

HI-FI AUDIO PRODUCTS

BASS ENERGIZER

Altec Lansing Corporation has recently introduced a low-cost bass energizer which is designed to compensate for low-frequency deficiencies in small speakers by providing an increase in very-low bass levels relative to the rest of the spectrum.

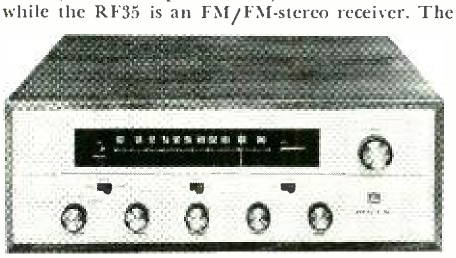
The Model 100A is a passive device requiring no additional electrical power. It connects between the amplifier output and speaker input. It can be attached either to the back of the speaker enclosure or can be hooked up next to the amplifier. The unit becomes effective only below 150 cycles and builds to full efficiency from 60 cps down to the speaker's cut-off.

The company will supply full details on request.

Circle No. 9 on Reader Service Card

35-WATT STEREO RECEIVERS

Bogen Communications Division has added two moderately priced stereo receivers to its line of audio components. Both receivers are rated at 35 watts (17½ watts per channel). The RP235 is an FM-AM/FM-stereo unit while the RF35 is an FM/FM-stereo receiver. The RP235 has a frequency response of 20-20,000 cps ±1 db with distortion less than 1% at rated output. Inputs are provided for phono, tape, or auxiliary. Stereo headphones may be connected to an outlet on the front panel. There are nine controls as well as electronic-eye tuning and an automatic stereo indicator. Sensitivity is 3 μv. and stereo separation is 38 db at 1000 cps.



The RF35 is similar to the RP235 except that it does not include the AM section or the headphone outlet.

Both units are equipped with brushed gold front panels with walnut wood enclosures or wood-grained vinyl-clad metal enclosures available as accessories. Dimensions are 16" wide x 15" deep x 5¼" high.

Circle No. 10 on Reader Service Card

RECORD/PLAYBACK TAPE HEAD

Michigan Magnetics has added the 4NL-300 record/playback tape recorder head to its Series 300 laminated heads. This two-track mono head is suitable for professional applications. It utilizes a special glass-filled composition to resist tape wear. According to the company, the heads will last five times as long as heads made with conventional metal or Bakelite materials.

All heads in the new series are made to a standard mechanical size and offer versatile mounting to fit all brackets, with or without shielded leads. Each head is also available in a wide range of impedances.

Further information on the new line may be obtained from the manufacturer.

Circle No. 11 on Reader Service Card

LOW-COST MONO RECORDER

Superscope Incorporated has put the new **Sony** Model 135 tape recorder on the market for those who want a versatile instrument without sacrificing features to price.

This economical recorder offers new simplified controls which make recording virtually foolproof. The a.v.c. circuit self-adjusts all recording levels without need for a knob. The instrument is a dual-track mono machine with two capstan-driven speeds: 3¾ and 1⅞ ips. The machine will record up to 3 hours of material on its full 5-inch reels.

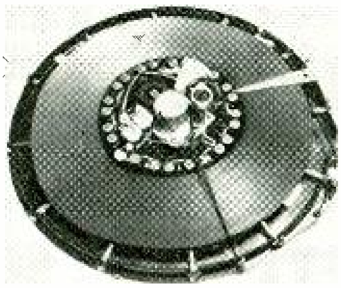
The unit, which comes complete with vinyl carrying bag and dynamic microphone, measures 9½" wide x 11" deep x 5½" high and weighs 7¾ pounds. Frequency response is 90-9500 cps at 3¾ ips and signal-to-noise ratio is better than 40 db. The tube amplifier is powered from a 117-volt, 60-cycle source.

Complete specifications and price are available from the distributor.

Circle No. 12 on Reader Service Card

PHONO-DRIVEN TAPE TRANSPORT

Casco Music Systems, Inc. has developed a unique continuous-loop cartridge system which can be driven by any phonograph or turntable,



allowing such units to be converted into a tape-playing system.

Known as "Tape-Top," the cartridge is actually a complete tape transport incorporating capstan, feed and take-up mechanism, and tape heads. According to the company, the large capacity and varied speeds of operations will permit the unit to be adapted to many commercial and industrial applications. The cartridge is normally available with 3200 feet of ¼-inch tape and can be supplied with 1- to 8-track heads. As much as 88 hours of program material may be recorded.

The mechanisms and preamplifiers are available in a number of models and the company will supply full details on request.

Circle No. 13 on Reader Service Card

ALL-SILICON-TRANSISTOR PREAMP

Bogen Communications Division has developed a portable, all-silicon-transistor preamp with a frequency response of 20-20,000 cps ± 1 db.

The Model RTP-1 has been specifically designed for p.a. systems, sound recording, broadcasting, and for use with portable tape recorders. Two of the units can be paralleled to mix six signals.

The circuit can be powered by internal or external batteries or from the 117-volt a.c. line. The unit comes complete with an a.c. line cord, headphone monitor jack, calibrated output meter, built-in 500/600-ohm output transformer, an attitude stand that serves as a carrying handle, and a push-button light to check battery condition.

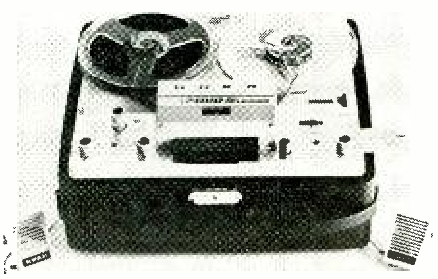
Inputs include two high- or low-impedance microphones, two auxiliary on fader control, and one bridging. Battery drain is 30 ma. and output into a 600-ohm line is 100 mw. maximum.

For additional information and complete performance specs, the company will supply a data sheet.

Circle No. 14 on Reader Service Card

TRANSISTORIZED TAPE RECORDER

Martel Electronics is handling distribution of the new **Uher** Stereo 7000, a two-speed, fully transistorized tape recorder which features both single-channel mono record/playback and four-track stereo record/play. Recordings can be made from microphone, tuner, or phono inputs.



This 3¾ and 7½ ips unit features sound-on-sound, automatic end-of-reel shut-off, two built-in speakers, illuminated vu meter for recording levels, tape lifter for fast modes, and a four-digit counter with push-button reset. Frequency response is 40-18,000 cps at 7½ ips and 40-14,000 cps at 3¾ ips. Channel separation is 50 db and wow and flutter is ±0.2%.

Those wishing further information on this recorder may request it from the distributor.

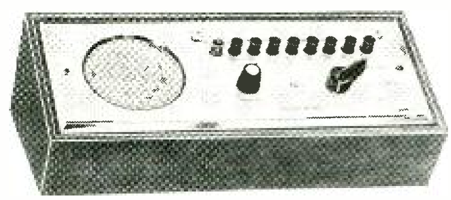
Circle No. 15 on Reader Service Card

FLEXIBLE INTERCOM SYSTEM

Bogen Communications Division has just introduced its new "Executive Series 9," a flexible intercom system that can accommodate up to nine master and remote stations in any combination. Master stations can talk selectively to any station and remote stations can reply without operating the controls.

In operation, the caller simply touches the push-button station selector on the master station, presses the lever, and starts to speak. The called master station can converse "hands-free" after its remote talk-listen switch is placed in the non-private position. The remotes—which are non-private—can always reply "hands-free."

The master station is housed in either a low-profile solid walnut wood cabinet or in a metal box for flush wall mounting in existing or new



construction. Only the control amplifier, solid-state Model OA-1, requires connection to a 117-volt outlet.

Information on the various units comprising this system is available from the manufacturer.

Circle No. 16 on Reader Service Card

CB-HAM-COMMUNICATIONS

FIVE-BAND LINEAR AMPLIFIER

Heath Company has come out with a full-kilowatt SSB linear amplifier which is housed in a cabinet that measures just 3 3/16" high x 12 3/16" wide x 10" deep.

The HA-14 "KW Kompact" is offered in kit form. The five-band linear amplifier (80 through 10 meters) develops 1000 watts p.e.p. to a pair of 572-B's in parallel. It features provisions for a.l.c., a tuned input circuit, and built-in antenna changeover relay. There is also a built-in s.w.r. meter.

The amplifier can be powered either by the HP-14 d.c. supply for mobile applications or by the HP-24 a.c. supply for fixed-station operation. Both provide automatic reset circuit-breaker protection.

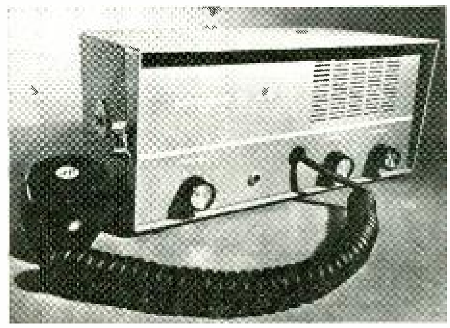
The company will supply complete details and specifications on request.

Circle No. 17 on Reader Service Card

COMPACT CB UNIT

Hammarlund Manufacturing Company has added the CB-214 to its line of two-way radio equipment. This moderately priced unit comes complete with mounting bracket, d.c. cable, and high-quality ceramic microphone.

The unit has been shock-tested to withstand



15 G's in any plane. Switching is all-electronic. Six channels are covered in both transmit and receive functions and both modes are crystal-controlled. The unit interchanges from 12 volts d.c. to 117 volts a.c. Power consumption is 6 amps on d.c. and 70 watts on a.c.

The 14-pound unit measures only 5¼" high x 12" wide and is less than 7" deep.

Circle No. 18 on Reader Service Card

FM BUSINESS RADIO

Electronics Communications, Inc. is now offering a two-way FM business radio designed to provide small business and professional men with a low-cost means of two-way contact with off-premises personnel and associates.

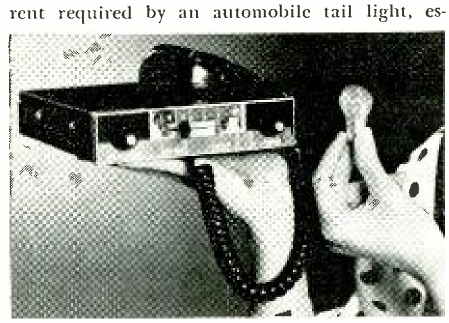
The "Courier 50 FM" operates in the 25-50-mc. range and is rated at 50 watts. The unit is being offered with either a.c. or 12-volt d.c. power supplies.

Price and complete specifications on this new unit will be supplied by the manufacturer.

Circle No. 19 on Reader Service Card

TWO-WAY RADIO FOR "HELP"

Raytheon Company has designed a two-way radio that uses less than half the electrical current required by an automobile tail light, es-



pecially for the "HELP" emergency highway service.

This completely transistorized unit, the "Ray-Tel" TWR-7, covers five channels including channel 9 for emergency calls. The circuit incorporates 11 silicon transistors and 6 silicon diodes. Current requirements are 0.03 amp on standby, 0.8 amp on receive, and 1.3 amps on transmit.

Circle No. 20 on Reader Service Card

2.5-WATT PORTABLE CB UNIT

Lafayette Radio Electronics Corporation has just introduced a compact, solid-state CB transceiver which uses 12 transistors (8 of them silicon) and 5 diodes, as the Model HA-450.

Measuring 10⅜" w. x 2¾" h. x 6" d., it is powered by a battery pack which can be removed when the unit is used in mobile applications. Six crystal-controlled transmit and receive channel positions are provided with 2.5 watts input. Other features include: single rotary channel selector, a.n.l and adjustable squelch, "S" and battery condition meter, volume control, and whip antenna. Sensitivity is 1 μv. at 10 db signal plus noise/noise. The unit is powered by 8 "D" cells for portable operation. Rechargeable cells and charger are available extra.

Circle No. 21 on Reader Service Card

MANUFACTURERS' LITERATURE

CHURCH MICROPHONES

Turner Microphone Company is currently offering a new 4-page catalogue featuring gold microphones and accessories specially designed for church and synagogue installations. Printed on heavy-stock paper, the brochure is illustrated with full-color drawings and offers three microphone models which were selected by the company after field trips and consultation with sound contractors specializing in church applications. Acoustical performance, beauty, and functionality are the main advantages of these microphones.

Circle No. 22 on Reader Service Card

FERRITES

Kearfott Division of General Precision Inc. has recently published a 16-page, 2-color booklet describing in detail the company's line of ferrite products. Entitled "Ferrites," the brochure includes high-permeability types, magnetic recording-head and memory-drum ferrites, permanent-magnet focusing arrays for traveling-wave tubes, and ferrite composition for ceramic magnets.

Circle No. 141 on Reader Service Card

LABORATORY EQUIPMENT

Cole-Parmer Instrument & Equipment Co. has issued an extensive, new 1965-66 catalogue containing information on 2000 laboratory instruments and appliances for use in biochemistry and clinical labs, chemical processing plants, and agricultural research facilities.

One special 30-page section describes a wide variety of pumps, while another 30-page section is devoted to plastic items and utensils. Also included in this comprehensive volume are numerous kinds of magnetic, mechanical, and electronic mixers, a wide range of temperature controllers and indicating instruments, and special equipment, ranging from baths and environmental test chambers to incubators and ovens.

Circle No. 142 on Reader Service Card

COAXIAL RELAYS

Magnecraft Electric Co. is now offering a new 6-page engineering bulletin (No. 465) covering a wide selection of r.f. switching relays. Fifteen variations of five basic styles are presented, including coaxial relays designed for minimum size and weight as well as for great operating sensitivity. Flat, bulkhead, and "Thru Panel" mounting constructions are offered.

The booklet contains complete technical data, detailed illustrations, a number of circuit diagrams, and a special section on coaxial-relay characteristics and definitions.

Circle No. 143 on Reader Service Card

CAPACITOR CATALOGUE

Republic Electronics Corp. is currently offering a comprehensive 12-page 2-color catalogue on its "Mucon" line of subminiature ceramic capacitors. Ten different types are presented, including "Thinline" temperature-compensating and general-purpose capacitors, molded-box and uncased varieties, monolithic capacitors, and u.h.f. standoffs and ribbon-lead units. Complete technical information is supplied for all devices listed.

Circle No. 144 on Reader Service Card

WIRES & CABLES

Belden Manufacturing Company has announced publication of a new wire and cable catalogue, No. 865. Over a dozen new items are introduced, including a four-conductor, polyethylene-insulated shielded cable suitable for strain gauges and a miniature 75-ohm coaxial cable ideal for short-length installations.

In addition, a handy "Cable Finder" chart appears on the inside front cover. This chart employs color coding to separate different types of shielded and unshielded cables, thereby speeding up cable selection.

Circle No. 145 on Reader Service Card

COMPONENTS CATALOGUE

Automatic Coil Company is now distributing copies of its new 12-page catalogue covering a wide range of coils, toroids, r.f. and i.f. transformers, delay lines, and electronic assemblies. Complete specifications on products available from stock are included.

In addition, the brochure contains a section devoted to special custom-designed assemblies.

Circle No. 146 on Reader Service Card

SPECIAL PROBE

American Electronic Laboratories is now making available a new technical bulletin (No. 80-8) which discusses the use of the company's "Tri-Contact" probe with all types of in-circuit semiconductor testers.

Circle No. 105 on Reader Service Card

Housed in a lightweight, high-impact, polycarbonate resin-plastic case, the probe is designed specifically for tests to be conducted on printed-circuit boards and can be operated with only one hand. Two conveniently located thumb wheels control the lateral and vertical extensions of the stainless-steel probe tips.

Circle No. 23 on Reader Service Card

MICRO INDUCTORS

Collins Radio Company is now making available a bulletin discussing the firm's new line of high-frequency micro inductors. Designed to meet MIL Spec MIL-C-15305, Type LT7J, the new units offer inductance values from 1.0 μhy. to 1.0 mhy. and provide "Q" values of approximately 100 in the preferred frequency range from 1 mc. to 10 mc.

Packaged in hermetically sealed, tall TO-5 cases, the micro inductors may be inserted either manually or mechanically.

Circle No. 147 on Reader Service Card

Radar Imagery

(*Continued from page* 43)

However, present Doppler navigators provide drift-angle and ground-speed information to accuracies on the order of 1 to 2 percent. After this information is further processed by the radar system, this error may be increased by another 1 or 2 percent.

A number of higher order distortions are often apparent in a radar photograph. Such second-order effects as slant-range distortion and calibration accuracy and third-order effects such as cathode-ray tube and lens pin-cushion or barrel distortion, film shrinkage, and other factors may be present. Although a trained interpreter with suitable viewing equipment can often compensate for such distortions, the radar system design should minimize them as far as practical.

For practical, day-to-day utility, a mapping radar requires other characteristics often overlooked by systems designers. Foremost among these is stability—freedom from drift of important parameters such as video gain, CRT intensity and focus, etc. Since the map is recorded photographically, it is not feasible for an operator to "tweak" controls to obtain optimum imagery.

The future of radar holds much promise in improving radar surveillance imagery. Fig. 4 demonstrates the dramatic improvements in map realism now consistently obtainable through better scanning geometry, higher resolution, and longer grey scale. Further improvements in resolution could result from the use of shorter wavelengths and/or longer antennas. The first is negated by rain and fog attenuation and the second by aerodynamic considerations.

The effects of long antennas can be synthesized by complex signal processing. Although such techniques hold the promise of future resolution improvements, equipment based on these principles is not yet dependable enough for field use by military personnel. ▲

ELECTRONICS
MARKET PLACE

COMMERCIAL RATE: For firms or individuals offering commercial products or services. 60c 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.
READER RATE: For individuals with a personal item to buy or sell. 35¢ per word (including name and address). **No Minimum!** Payment must accompany copy.
GENERAL INFORMATION: First word in all ads set in bold caps at no extra charge. Additional words may be set in bold caps at 10¢ extra per word. All copy subject to publisher's approval. **Closing Date:** 1st of the 2nd preceding month (for example, March issue closes January 1st.) **Send order and remittance to:** Hal Cymes ELECTRONICS WORLD, One Park Avenue, New York, New York 10016

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JUST starting in TV service? Write for free 32 page catalog of service order books, invoices, job tickets, phone message books, statements and file systems. Oelrich Publications, 6556 W. Higgins Rd. Chicago, Ill. 60656.

GOVERNMENT Surplus Receivers, Transmitters, Snooperscopes, Radios, Parts, Picture Catalog 20¢. Meshna, Nahant, Mass.

INVESTIGATORS, free brochure, latest subminiature electronic surveillance equipment. Ace Electronics, 11500-J NW 7th Ave., Miami 50, Fla.

CANADIANS—Giant Surplus Bargain Packed Catalogs. Electronics. Hi-Fi, Shortwave, Amateur, Citizens Radio. Rush $1.00 (Refunded). ETCO. Dept. Z, 464 McGill, Montreal, Canada.

INVESTIGATORS—Electronic surveillance devices. Price breakthrough on ultra miniature professional devices. Free details. Trol Electronics-EW, 342 Madison Avenue, New York, N.Y.

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.

NEW supersensitive transistor locators detect buried gold, silver, coins. Kits, assembled models. $19.95 up. Free catalog. Relco-A22, Box 10563, Houston 18, Texas.

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A.R.C. 12 #22 Command rcvr 540-1600 kc. **17.95**
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Panadapter 5.25 mc for above. 60 cy..... **69.50**
APR-4 rcvr, plug, book, 38-1000 mc......**179.50**
Add $65.00 for 975-2200 mc. Add $125.00 for 2175-4000 mc. Add $30.00 for AM/FM w/60 cy pwr.
RA-62-B is AC pwr sply for **SCR-522**, only.. **17.95**

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TDZ 60 cy xmtr 225-400 mc 30 w Po, new ....**PUR**
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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.

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Light sensitive Power transistor TO-3 case, with circuit instructions...........**$1.95 ea.**

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Partial list—Send for New '65 catalog

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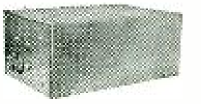

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CMV2F5 6/12 volt 30 watt vibrator power supply FULLY NARROW BANDED (TX & RX) complete with all accessories.

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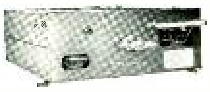

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Complete with all accessories, less crystals & antenna.

FMTR80D, 30 watts, 6 volt **$78**
(Less accessories, $48.)

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Add $55.00 to narrow band transmitter, tuning of transmitter and receiver to desired frequency and new antenna.

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6/12v dual dynamotor 60 watt. Fully narrow banded complete with all accessories, less crystals & antenna. **$178**

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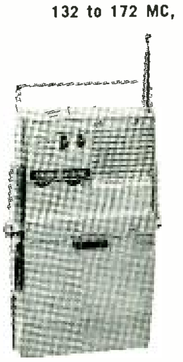

PRICE, including Brand New rechargeable Nickel-Cadmium Battery Pack

$178

If crystals and tuning is desired, add $40.00.

We also have the proper charges for these units, GE Model #4EP27A10, Price: **$18.**

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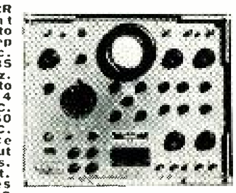

OS-26/USM-24: 3 inch CR Tube 3JP1; recurrent sweep, 8 cyc. per sec. to 600 KC. Triggered sweep 1.25—125 M Microsec. vert. deflec. sensitivity .035 horz. deflec. 4.0 V. horz. response .5 cyc. per sec. to 700 KC., Vert. response 4 cyc. per sec. to 10 MC. Beam mod. response 50 cyc. per sec. to 10 MC. Horz. input impedance 300,000 ohms. Vert. input resistance 300,000 ohms. Beam mod. input resist. 56,000 ohms. Operates from 115 Volt 50 to 1000 cycle radio freq. & mod. Circuits use BCN series coaxial connectors. Size: 17x15x15"; Wt.: 60 lbs. USED, serviceable. Prices given below are less blowers, probes, cables, coaxial fittings and as offered:

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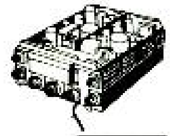

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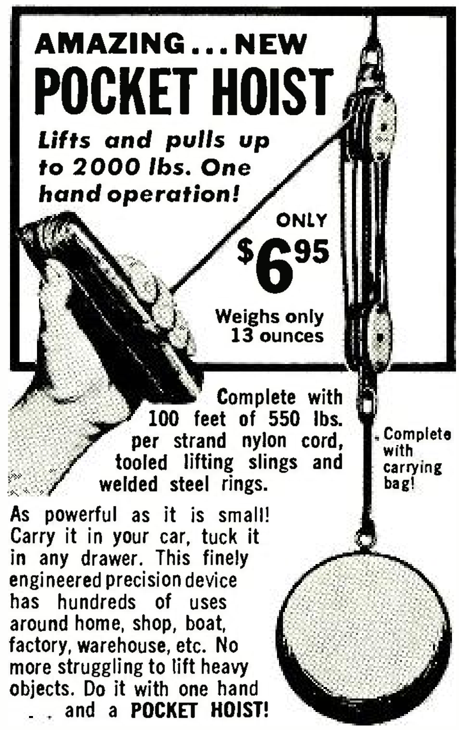

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